CHINA-BRAZIL

PARTNERSHIP ON AGRICULTURE AND FOOD SECURITY

Editors:
Marcos Sawaya Jank
Pei Guo
Sílvia H. G. de Miranda

In the last 50 years, Brazil and China's agricultural and food sectors have undergone profound reforms and transformations. As two of the top four largest global producers and exporters, China and Brazil are important actors in the future landscape of global agriculture. Rapidly intensifying trade and investment relations mean that these countries have become increasingly interconnected within the field of agribusiness: China is the principal destination of Brazilian agricultural exports, representing one third of the almost US$ 100 billion exported by the South American country in this sector. Agri-food products account for half of total Brazilian exports to China. Today, Brazil is the main supplier of agri-food products to the Asian giant – nearly 20% of China's imports – and ranks #1 in the trade of soybeans, beef, poultry, cotton, sugar, and cellulose.

A large share of the Brazilian supply of agricultural and food products is "married" to Chinese import demand, and both parties are very aware of their mutual dependence. Thus, China has also become an increasingly important investor within Brazilian agribusiness.

This book presents a series of perspectives from both countries, which outline the promising potential for constructive encounters on a broad range of issues related to trade, investments, infrastructure, innovation, and sustainability that will shape our current agriculture and food security challenges in these difficult times of a global pandemic.

The Editors

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Universidade de São Paulo (USP)
Escola Superior de Agricultura "Luiz de Queiroz" (Esalq)

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Content

Foreword

University of Sao Paulo (USP)

Over the last 50 years, agriculture has suffered a major increase in productivity, granting some countries to become self-sufficient in food production, and sometimes with surplus yield for exports. However, with the continuous increase in the world population and personal income, particularly in developing regions of Asia and Africa, demand for food is expected to grow over the next decades. This poses a challenge for agriculture and animal production and will require improvements in trade and logistics of food distribution around the globe. On the other hand, the concern today with environment preservation and pressure for sustainable agricultural practices is increasing.

With these problems in mind, a group of top five-ranked (US News & World Report, 2016) agricultural universities established the *A5 Alliance* in 2017. The major goal of this association is to integrate efforts on promoting high level training for the next generation of world leaders in agriculture and generate key knowledge for increasing productivity and sustainability of agri-food systems, especially in developing regions of the world. The *A5 Alliance* includes China Agricultural University (CAU), Cornell University (Cornell), University of California-Davis (UC-Davis), University of Sao Paulo (USP) and Wageningen University & Research (WUR).

Stimulated by the *A5 Alliance*, USP, CAU and Hainan University established the China-Brazil Agricultural Innovation Center in 2018, for cooperation in research, education and innovation, mainly on Tropical Agriculture. China and Brazil are among the largest producers of agricultural products in the world, with strong bilateral trading and mutual interests in enhancing agricultural productivity, sustainability and trade.

Brazil-China relationships in agriculture, food and bioenergy are among the main topics of debate and activities carried on by Dr. Marcos S. Jank, the second holder of the Luiz de Queiroz Chair ("Cátedra Luiz de Queiroz"). The chair is an academic arrangement established at the Luiz de Queiroz

College of Agriculture (Esalq/USP), in order to promote interdisciplinary discussions on regional and global development and sustainability of integrated agricultural and animal production systems, alongside their social and environmental repercussions. The Luiz de Queiroz Chair on Integrated Agri-Food Systems has started in 2017 and first held by the former Brazilian Minister of Agriculture, Dr. Roberto Rodrigues, who made use of the opportunity to produce a book (*Agro é Paz*) on the key role of agriculture for global food security and peace. Another former Minister of Agriculture, Dr. Alysson Paolinelli, has been already appointed as the third holder of the Luiz de Queiroz Chair, and he will start his activities on June 3, 2020, at the celebration of 119th Anniversary of Esalq.

The present publication, coordinated by professors Marcos S. Jank, Pei Guo and Sílvia Helena Galvão de Miranda, consists of a series of articles from a team of Brazilian and Chinese experts presenting in-depth analyses about the agri-food sectors in both countries and the strategic importance of cooperation in trade, investments, infrastructure innovation and sustainability in order to secure bilateral and global food security. The book represents the major output of Dr. Jank's leadership at the Luiz de Queiroz Chair, and shall serve as a benchmark for further studies on China-Brazil relationships, identification of opportunities and areas of complementary expertise for technological advancements, as well as for the definition of priorities for investments in infrastructure and sustainability.

Vahan Agopyan
President, University of Sao Paulo (USP)

Durval Dourado Neto
Dean, Esalq/USP

João Roberto Spotti Lopes
Vice-Dean, Esalq/USP

China Agricultural University (CAU)

2019 marks the 45th anniversary of the establishment of diplomatic relations between China and Brazil. In the past 45 years, with the active efforts of the two governments and all sectors of society, bilateral relations have developed smoothly, economic, trade and education cooperation have flourished, and cooperation has expanded into a number of different fields. As the largest emerging market countries in the Eastern and Western hemispheres, China and Brazil share a wide range of common interests.

Important forces in the BRICS cooperation mechanism, the two countries are the representatives of the largest emerging market economies in Asia and South America, respectively. Both sides have established a good cooperative partnership in the field of agriculture, and this cooperation is increasingly attracting the world's attention.

The cooperation between China and Brazil in the field of agriculture is highly complementary. Brazil is placed among the top agricultural and animal husbandry producers and exporters, while China is the world's largest importer of agricultural products. With the continuous upgrading of China's consumption structure, there is a strong demand for high-quality agricultural products and a long-term gap between supply and demand. Brazil is one of the major exporters of soybeans, corn, sugar, beef, poultry, cotton and coffee. It ranks first or second in world exports of these products. As a major importer of Brazil's soybeans, nearly half of the soybeans imported each year by China come from Brazil. According to the figures released by the Brazilian Ministry of Agriculture, China has become by far the largest export destination of Brazil's agricultural products.

As the leading universities within agriculture and food related subjects in the two countries, China Agricultural University and the University of Sao Paulo have continuously promoted cooperative research and faculty-student exchanges in recent years, and reached some productive results. China Agricultural University and the University of Sao Paulo of Brazil are optimistic about the development prospects of agricultural education and science and technology cooperation between the two countries. They are confident in the future of China-Brazil cooperation, and will continue to work together to share development experiences with each other. The two universities will share the fruits of development and achieve common development and prosperity.

Working together over the course of a year, professors from China Agricultural University (CAU) and the University of Sao Paulo (USP) have compiled research on the China-Brazil Partnership on Agriculture and Food Security, which is a new achievement in the level of cooperation between the two universities. It is also a fine gift presented by the faculty of these two universities for the great celebration of Esalq's 119th anniversary. In this book, they put forward new views and suggestions on agricultural cooperation between China and Brazil. We look forward to more and greater achievements in education and scientific research cooperation between our two universities in the future.

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President, China Agricultural University (CAU)

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Chapter 2: The Brazilian agri-food sector: an overview

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Chapter 3: Adding value to agricultural exports in China: the fruits and vegetables sector

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Chapter 4: Key success factors for the Brazilian grains and meat industry

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Chapter 5: Agriculture 5.0 in China: new technological frontiers and the challenges to increase productivity

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Chapter 6: The energy cane revolution in Brazil: delivering food, bioenergy, and biomaterials

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Chapter 7: The Chinese appetite for global agriculture investments: the role of Brazil

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Chapter 8: Transport infrastructure: opportunities for a close partnership with China

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Chapter 9: Opportunities and challenges to strengthen bilateral agri-food trade: the Chinese perspective

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Chapter 10: Opportunities and challenges to strengthen bilateral agri-food trade: the Brazilian perspective

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Chapter 11: China: investing in sustainability to preserve natural resources and prevent natural disasters

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Chapter 12: Sustainability in Brazilian agriculture: key challenges and potential collaborations with China

Rodrigo Carvalho de Abreu Lima
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At the time of this book's release, the world is undergoing profound transformations and facing new paradigms arising from the Coronavirus pandemic. Its aim is to strengthen cooperation between Brazilian and Chinese academic communities, particularly within the field of agriculture, food chains integration, and food security. The cooperation initiative between the **Luiz de Queiroz College of Agriculture – University of Sao Paulo (Esalq/USP)** and the **China Agricultural University (CAU)**, as part of the *A5 Alliance*, is based upon an extensive analysis of the relations between China and Brazil within the field of agriculture and food security, and the presentation of policies which both broaden and solidify this unavoidable long-term partnership.

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[1] **Aurora Foods** (Cooperativa Central Aurora Alimentos) is one of Brazil's largest industrial complexes and global reference in meat processing technology, with 11 affiliated cooperatives, over 65 thousand associate farmers and 40 thousand collaborators. Its broad mix consists of more than 850 products from pork, poultry and dairy categories. Ruled by the Principles of Cooperativism, which is based on collective work and sharing results, it conquered the Brazilian market and became a global player.

To **China Agricultural University (CAU) –** President Qixin Sun, Vice President Yuanshi Gong and Vice President Xian Xin have been strongly supportive to faculty and student exchanges on the platform of A5, encouraging the launch of China-Brazil Agricultural Innovation Center (CBAIC) and the initiation of joint research on Sino-Brazilian agricultural development and food security. Following President Qixin Sun's visit to the University of Sao Paulo and Esalq in March 2019, CBAIC has hosted three Esalq delegations of senior professors and leadership. Meantime, CAU has organized two student groups to Esalq, representing the most important partner from China and contributing to Esalq's expanding network worldwide.

To the **Education Department of Hainan Province**, where Director General Xiankun Cao led a senior delegation to visit Esalq in October 2018. She actively promoted CBAIC to take advantage of the unique tropical agriculture resources and policies of International Education Innovation Island in Hainan Province, exploring the collaboration opportunities on agriculture technology, agricultural demonstration parks, competence training, and research on international agricultural trade to the modernization of agriculture in China and Brazil, and shared experience with Latin American countries.

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We are especially thankful to Mrs. **Luciana Joia de Lima**, Chief of Public Relations at Esalq, who has contributed significantly to the production of this book, and who undertook the challenging task of managing the connections between its editors, the Esalq Directory, the Fealq, and the coordination with China Agricultural University. We recognize her essential role in the materialization of this project.

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To Professor **Shenggen Fan**, from China Agricultural University, and former General Director of the IFPRI, and to Professor **Roberto Rodrigues**, first holder of the Luiz de Queiroz Chair and former Brazilian Minister of Agriculture, who wrote this book's prefaces and who have always been enthusiastic supporters of Sino-Brazilian agricultural cooperation and of the approximation between the two universities.

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Sao Paulo, June 3rd, 2020

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In the relations between nations and people, certain inevitabilities will eventually become contemporary dogmas. As they assume the character of rules, norms, or contracts, their efficiency comes to depend on one simple factor: confidence. Confidence, in turn, is the result of coexistence. It is never born spontaneously out of a new relation, but rather constructed over time, and proven in countless instances until its existence is no longer called into question. So, it is with marriage, commercial or financial societies, trade, sports, politics, and everyday social interactions. No one will seek out a doctor or a lawyer whom they do not trust, and no one will hire an accountant or a financial intermediary in which they do not confide. No one will vote for a candidate who does not inspire trust.

A loss of confidence equals betrayal or being betrayed. There is no remedy for this. It is definitive. Amongst the contemporary inevitabilities are those that concern the trade and investment relations between Brazil and China. In fact, Brazilian agriculture and livestock production, and its agribusiness sector, have been growing noticeably within recent years. Data provides extensive proof for this.

From 1990 until today, the area planted with grains in Brazil grew 71%, while agricultural production grew 5-fold, or 335%. If these numbers are impressive, what lies behind them is even more astonishing. Today, 65 million hectares of grains are cultivated in the country. If we had the same productivity as in 1990, an additional 100 million hectares would be needed to collect the record harvest of 2020, of 252 million tons of grains. In other words, that area has been spared from deforestation. This demonstrates the high degree of sustainability of our agriculture.

This change did not only take place within grain production, but within all agricultural and livestock activities. During the same period, chicken production grew spectacularly, 491%, and pork, 296%.

Fine, then. This explosive growth was nurtured by the research activities conducted in public and private institutions for technological innovation. But it was also spurred on by a growing consumer market in developing countries. Exports have been surging in a spectacular fashion, and here the numbers are also impressive. In the year 2000, the Brazilian agribusiness exports amounted to US$ 20 billion. Less than 20 years later, in 2019, this number had reached almost US$ 100 billion. This growth was not least due to the demand from developing nations, and amongst them, mainly China. In 2000, this Asian giant was responsible for 2.7% (US$ 0,56 billion) of our agricultural exports. Last year, this number was 32% (US$ 31,0 billion).

But this is logical! Here we have an inevitability, just as the one that was cited in the first paragraph. China has a huge population, whose purchasing power is growing year after year. It will have to import large amounts of products from the entire world in order to sustainably and permanently guarantee both its food security and food safety. Brazil, on the other hand, is a large country which has managed to increase its agricultural output every year. It has significant additional potential, due to its endogenously developed tropical technology (no-till, two crops per season with no irrigation, crop-livestock integration and others), and due to the area still available for planting, as well as its highly skilled human resources in all links of the production chain.

It is therefore logical that China and Brazil should be good trading partners: they are both large countries, and one has something to sell which the other wants to buy. On the other hand, China possesses resources to invest abroad and Brazil need such resources in public/private partnerships to improve its infrastructure and logistics, not least of all to ensure more competitive transportation of our harvests. Everything indicates that for both parties, this will be a relationship with increasing mutual benefits. It is essential that this eventually consolidates into an increasing level of mutual confidence.

It is obvious that Brazil, as the great producer it is, should also supply other large countries and regions, such as the European Union, the Middle East, and large Asian countries (India, Indonesia, the Philippines), as well as traditional partners such as the USA, Japan, and South Korea. There is no problem with that. The need to add value to our raw materials is also part of the broader picture. This does not mean that we should refrain from exporting commodities, but it is also essential to process them, in order to further exploit our natural potential.

This book, written by a highly qualified group of Chinese and Brazilian technicians and thinkers, resulting from the excellent coordination by the competent Brazilian, Marcos Jank, an individual with a deep knowledge of international agri-food issues, is of crucial significance to those who dream of a more competitive and globally integrated Brazil, and who need a more thorough understanding of the highly relevant partnership with China.

Shenggen Fan
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I am honored to accept the invitation by the editors to write a preface for the book *China-Brazil Partnership on Agriculture and Food Security*, the crystallization of academic cooperation between the College of Economics and Management at China Agricultural University, and the College of Agriculture at the University of Sao Paulo, in Brazil. Agriculture and food security are eternal topics for mankind. Global agricultural production is always volatile, and potential threats of food crisis are still looming. Ensuring a stable and sustainable food supply has become the primary objective of agricultural policies in many countries. As two vital forces in the BRICS cooperative mechanism, China and Brazil are the largest emerging economies in Asia and Latin America, respectively. Even with the backdrop of anti-globalization trends and increasing trade protectionism, the two countries have continued to strengthen a productive cooperative partnership and carried out substantive collaboration in agricultural production and marketing. Therefore, this book bears witness to the ongoing development of agricultural cooperation between the two countries.

Both China and Brazil are undoubtedly two of the world's main agricultural producers, yet, their resource endowments differ substantially. These two countries have their own comparative advantages, as well as strong mutual agricultural complementarity. In recent years, China and Brazil have been exploring diversifying agricultural cooperation in many areas.

First of all, agricultural trade plays an important role in the bilateral relationship between these two countries. China has been Brazil's largest export market for agricultural products since 2008. In 2019, agricultural products accounted for half of total Brazilian exports to China. The country has been the largest buyer of Brazil's soybeans for many years. Brazil exported 74 million tons of soybeans in 2019, of which 58 million tons were sold to China. Besides, China is also a major market for Brazil's sugar, cotton, and animal protein exports, which supports a large number of Brazilian producers and operators in the agricultural sector.

Secondly, China's increasing investment in the Brazilian agricultural sector has generated jobs and income in Brazil, which promotes mutual benefits. For example, COFCO International, Dakang Agriculture, and other Chinese enterprises are now investing in the Brazilian agricultural sector, and actively integrating into local agricultural industry chains.

Thirdly, China and Brazil's agricultural research institutions have continuously enhanced mutual cooperation and technology exchange. For example, the China Agricultural University and the College of Agriculture at the University of Sao Paulo established the "China-Brazil Agricultural Innovation Center" in 2019, which laid a solid foundation for the two universities to carry out cooperative research in the field of agronomy, animal sciences, and agricultural trade policy.

Now, let me switch the gear to China. When I worked at IFPRI as the Director General, I had the chance to visit many countries in the world. Because of abundant natural endowments and limited population size, many countries do not share the same intensive concern about agricultural production and food security as that of China. Food security for Chinese people is related to a deep sense of crisis in collective memory, an inexorable pursuit under the constraint of natural endowments, and is the cornerstone of political stability and economic prosperity. To review the history of agriculture, China's reform and opening-up began in 1978 in the Xiaogang Village, where the local farmers worried much about their food security. Now, after more than 40 years of development, China's grain production has been growing continuously, and farmers' income has been increasing year by year. Nonetheless, it also raises a number of challenges, such as degradation of cultivated land resources, shortage of water supply, and the overuse of chemical fertilizers and pesticides. Since 2013, the Chinese government has advocated agricultural supply-side structural reform, promulgating the strategy of "storing grain in the land, storing grain in technology". The new approach continues to safeguard food security by stressing that China's agriculture should keep insisting on the pathway of "focusing on ourselves, based on the domestic market, ensuring production capacity, moderate utilization of imports, and support science and technology." At the same time, China will continue to import certain amounts of food from global markets, including Brazil, to meet the increased demand for meat and high value food products.

Thanks for the hard work behind all the authors' inputs to this book. I am sure this book will bring inspiration and enlightenment to our readers. A long-standing and prosperous partnership between the two countries would genuinely benefit the agricultural producers and consumers on both sides. Finally, I sincerely wish that the cooperation in agricultural sectors between China and Brazil becomes even closer and stronger in the future.

Book summary

In recent decades, trade ties between China and Brazil have grown at a remarkable pace, as a relation of deep economic interconnectedness has developed between these two countries. While Chinese exports of manufactured goods have become ever more common on the Brazilian market, Brazil has established itself as a key supplier of primary commodities to fuel Chinese growth. Brazilian agribusiness has become an important component of this trade, accounting for an explosive surge in sales to this rapidly emerging Asian economy, which has become the single biggest destination for Brazilian agro-exports.

Despite wide-reaching reforms and productive restructuring within Chinese agriculture, the country's quickly growing food needs have created a demand, which in large measure has been covered by Brazilian exports. Internally, Brazilian agriculture has undergone a thorough process of transformation, as agricultural reforms, territorial expansion, capital intensive modes of production and technological innovations have generated an exportable surplus which constitutes an essential precondition for Brazil's international competitiveness, and for its ability to keep up with the Chinese demand for agricultural produce. In the past decade, part of this growth has been reinforced by Chinese investments, which particularly within the field of processing, logistics and infrastructure exposes the complementarities and the untapped potential for cooperation and mutually beneficial development between these two countries.

Although the large volumes and rapid growth of commercial interactions between China and Brazil often draws much attention, the list of potential partnerships between these two nations exists well beyond the realm of trade. In this book, we seek to highlight the multiple areas within agriculture, in which fruitful avenues exist for intensified cooperation and interchange of valuable experiences. We therefore initially seek to provide a comparative perspective of the historical evolution of the agri-food sectors in China and Brazil, in order to paint a broader picture of the successes and lessons learned since the impressive agricultural reforms and transformations, which both started in the 70's. Each country provides stories of how sectorial efforts of internationalization led to the establishment of a firm global foothold, as has been the case with the Chinese fruit and vegetable sector, and the Brazilian grains and animal protein complex. Other contributions within this volume also emphasize how groundbreaking technological innovations within the field of Agriculture 5.0 in China, and sugarcane bioenergy production in Brazil, can provide an important platform for mutual learning and technical improvement. The field of investments in infrastructure likewise offers significant potential for constructive encounters between Chinese capital and knowhow and Brazilian experience, in projects based on mutual strategic interests aimed at strengthening the logistics underpinning the agricultural sector in this South American country. In spite of surging commercial interactions, this area still provides room for increased cooperation, not least in terms of facilitation of market access and benefitting from Sino-Brazilian complementarities within food production. Finally, this volume also engages with the increasingly salient and important environmental dimension of agricultural production, aiming to assess how interchanges based on experiences of sustainable production in these two countries can be enhanced.

As the increasing importance of the Sino-Brazilian interconnectedness within the field of agriculture has drawn much attention from practitioners and scholars, this volume seeks to address the wider implications of this relation. A broad range of economic, political, and technical issues and questions have thus arisen in parallel to the surge in trade and investments, which are likely to define the future nature of this relationship. In this book, we asked a group of Brazilian and Chinese academics to address a series of overarching questions: How can policy interventions support rural development and the expansion of food production? To what extent can processing and supply chain integration help increase the value-added factor of agricultural products? How can production expansion and intensification be reconciled with increasingly important environmental considerations? Which strategies can ensure that positive experiences in both China and Brazil are shared for mutual benefit? And finally, how will structural economic complementarities between the Chinese and Brazilian agricultural sectors shape the future modes of economic integration of these countries' food systems?

The deep economic transformations which have swept across China since the "Opening Up" and the adoption of certain market economic institutions have had profound repercussions within all areas of the Chinese economy. Agriculture is no exception to this. In **Chapter 1** of this volume, Pei Guo analyses the evolution of the Chinese agricultural sector through different periods of reform, as governmental initiatives have led to the introduction of private property rights, rural exodus, the implementation of private management styles within agricultural enterprises, and the accession to the multilateral trade system at the WTO. Through analysis of a wide array of data, Guo provides an ample overview of this process of change, as Chinese agriculture has been faced with the challenge of feeding a rapidly growing urban population, demanding an increasingly diversified and protein-rich diet. The author revisits a series of structural economic transformations, spanning new modes of cultivation, productivity increases, intensified use of inputs and R&D, as well as the role of public policies in shaping the contemporary economic landscape of Chinese agriculture.

In recent decades, Brazilian agriculture has undergone a profound transformation, comprised of territorial expansion, farmers migration, large productivity increases, and intensification of production and the use of technology. In **Chapter 2**, Geraldo Barros provides an account of this process. Through analysis of Brazilian economic history, he illustrates the significance of the rise of Brazil as an agricultural powerhouse. Barros explains the role of technological innovations and the enhancement of production practices, which has resulted in large increases in food production and lower food consumer prices in recent decades. Beyond elevating domestic supply, this profound agricultural restructuring led to the development of a globally competitive agri-food sector, which also became an important source of external revenues, helping to shield Brazil against the most dramatic effects of international economic crises. Considering future scenarios, Barros assesses a series of important challenges which the Brazilian agribusiness sector faces, including environmental challenges, deficient infrastructure, and the continued incorporation of cutting-edge technologies. He broadly outlines some avenues for addressing these questions.

With a sectoral focus on fruits and vegetables, in **Chapter 3**, Yueying Mu and Juewen Jin analyze how the rapid Chinese economic development in recent years has led to changing consumer habits, which in turn has been reflected in growing horticultural consumption. Through examination of recent data, the authors show that initially most of the production growth to meet this demand came from expansion of the net sown area, but productivity improvements have accounted for an increasingly important contribution. As both China and Brazil have taken the stage amongst the world's largest agricultural producers and exporters, possibilities for new partnerships and mutual commercial opportunities have become evident. These complementarities in fruit and vegetable production are assessed by the authors, who point towards future paths for strengthening Sino-Brazilian bilateral trade relations within agriculture.

In spite of the wide variety of foodstuffs and other products which make up modern Brazilian agricultural production, this sector's economic significance is strongly associated with the large production increases of certain bulk commodities and meat products, of which Brazil has become a sizeable exporter. In **Chapter 4**, André Pessôa and Debora Simões scrutinize the essential conditions which explain the dramatic rise in Brazil of an integrated grain and meat production complex in recent decades. The authors explore a wide array of data in order to assess the role of structural factors in positioning Brazil as a major global agricultural producer, such as natural resource endowments, research and development, public policies, entrepreneurship, and value chain organization. The increasing significance of the commercial interconnectedness with China is highlighted by the authors, who also point to a large potential for deepening cooperation within the fields of regulation, infrastructure, digital technologies and telecommunications, in order to support the future development of Brazilian agribusiness.

With the swift advance of Chinese innovations in biotechnology, communications, data processing, and robotics, the agricultural sector is also facing a profound process of modernization. In **Chapter 5**, Jianjun Lyu presents this as "Agriculture 5.0" and accounts for how these upheavals have become felt within the stages of cultivation, harvesting, processing, distribution, and consumption of foodstuffs. This implies a deep transformation of how we think about agriculture, as new ways of integrating technologies within the food sector offer an increasing variety of sustainable and knowledge-intensive modes of production and product circulation. Jianjun Lyu presents a series of telling examples of how innovations can help to connect producers with consumers of food products, and how traceability, transparency and ultimately, trust, is enhanced by the application of new technological solutions within the Chinese food sector.

The intersection between energy production and agriculture is treated in **Chapter 6**, in which Eduardo Leão de Sousa and Luciano Rodrigues provide a remarkable account of the development of the Brazilian sugarcane sector. This story of the evolution of the modern sugarcane production takes us back to the developmentalist period when scarcity of petroleum spurred a search for alternative fuel sources. Strategic considerations of energy security thus sparked a variety of innovations, meaning that beyond sugar production, the cane sector would become the source of production of different vehicle fuels, electricity, fertilizers and other chemicals materials. Sousa and Rodrigues also address the different policy mechanisms that have supported this sector's development, and which in recent years have been aimed at harnessing its full potential as a renewable energy source. Finally, the authors outline the opportunities for future cooperation with China based on sustainable pathways which Brazilian sugarcane biofuels can offer in order to meet the rapidly rising energy needs of this emerging Asian economy.

The Chinese economic opening and the subsequent internationalization of companies from this emerging country has also been strongly felt within the field of agriculture. In **Chapter 7**, Yijun Han, Jian Luan, Chengming Ji, and Yu Li analyze the Chinese agricultural "going global" strategy. The authors scrutinize the recent historical developments that have given rise to this international engagement, and provide a broad overview of the flows of capital and investments which increasingly have connected the Chinese agricultural sector with global food markets. The Chinese role in agricultural foreign aid is also treated within this chapter, and the potential scope for cooperation with Brazil as an emerging partner is assessed with the aim of evaluating the prospects of mutually beneficial solutions for contemporary dilemmas and challenges.

In Brazil, with its wide territorial extension, agricultural production and export is largely dependent on efficient infrastructure. In **Chapter 8**, José Caixeta-Filho and Thiago Péra focus on the role of infrastructure and logistics in lowering the costs of Brazilian agricultural exports. The authors present a series of measures which they deem necessary as part of an overarching logistical strategy, in order to strengthen connections of rural production zones in the country's interior regions with ports in the coastal areas. Illustrating the Brazilian infrastructural landscape, Caixeta-Filho and Péra also conduct a comparative analysis with reference to the Chinese capacities and achievements within this field, and the potential room for cooperation between these two countries. A detailed list of logistical needs is presented for this purpose, which highlights opportunities for deepening the Sino-Brazilian partnerships and cooperation projects.

The rapidly intensifying trade relations between China and Brazil since the turn of the millennium have given rise to a deep commercial interdependency and economic interconnectedness between these two countries. In **Chapter 9**, Honghua Chen and Yixing Tian explore the general trends within Sino-Brazilian agricultural trade. Through analyses of Chinese and Brazilian agricultural exports to third party markets, and examinations of the comparative advantages of these countries, Chen and Tian provide an ample overview of the overlaps, competition, and complementarities between these two nations' exports. The authors also examine the potential for cooperation between China and Brazil within this field, highlighting the growth in Chinese investments in Brazilian agribusiness, but also underscore how an underexplored potential – not least for private Chinese investors, – still exists.

In **Chapter 10**, Sílvia Miranda, Marcos Jank and Niels Soendergaard explore the potential avenues for strengthening agri-food trade between Brazil and China. For this purpose, an initial evaluation of the trade flows between these two countries is conducted, and major trends with strategic economic implications are emphasized. As the volumes of Brazilian agro-exports to China have grown exponentially in recent years, obstacles to market entry such as tariffs, tariff rate quotas, agricultural support policies and sanitary, technical, and bureaucratic barriers have attracted a growing amount of attention. The authors evaluate the general profile of these challenges, as well as the complexities of confronting them. The chapter concludes by outlining the wider prospects for integration of agricultural production and consumption patterns between Brazil and China, as well as the strategic opportunities which a broad series of complementarities of agri-food production systems provide for future Sino-Brazilian cooperation.

An increasingly salient and important dimension of agricultural production, trade, and consumption relates to environmental issues and the efforts to enhance the sustainability of food systems. The speed with which the Chinese growing population and changing food consumption has reshaped rural landscapes and taken up natural resources is examined in **Chapter 11** by Li Gao and Yuquan Chen. These authors analyze how scarcity of land and water availability has become of central importance to the Chinese agricultural development, and provide a range of illustrative examples of how governance interventions have confronted such problems. The interconnectedness between social, economic, and natural processes also means that it has become relevant to discuss natural disruptions and disaster management in the light of broader agricultural and natural resource use policies. The Chinese experiences thus provide a basis for the presentation of different policy proposals, which are meant to inform future efforts to ensure sustainability of agricultural production and rural development.

In **Chapter 12**, the final contributors to this book, Rodrigo Lima and Laura Antoniazzi reflect upon the challenges of reconciling the rapid expansion and intensification of Brazilian agricultural production with the evermore visible environmental and social concerns. Within the social dimension, the authors outline the problems of rural poverty, inequality and lacking productivity amongst smallholders, and in the environmental field, they point to issues such as land use change, deforestation, and soil depletion. Such challenges have given birth to a series of initiatives for social and technical innovation through both public policies aimed at alleviating rural poverty, as well as new productive and environmental practices within the agribusiness sector. Lima and Antoniazzi engage with these initiatives, emphasizing how pasture recovery, no-tillage plowing, biological nitrogen fixation, integrated production systems with livestock and cropping, as well as reforestation have yielded valuable experiences, which can provide an important basis for constructive knowledge exchanges with China in future agricultural cooperation projects between these two countries.

While we do not seek definitive answers or to propagate specific political action plans with this volume, we have aimed to provide timely and empirically grounded inputs for the debate on Sino-Brazilian agricultural relations. In a similar vein, we hope that the processes and development trajectories identified in the following chapters can yield important perspectives on future trends, and inform policy makers with sound and pragmatic analyses. Each of the contributions have thus addressed a specific issue below the wider thematic of the book, with an eye to presenting the economic trends, the governance experiences, and the potential avenues for supporting mutually beneficial and sustainable development within the realm of agriculture. The analytical insights thereby aim towards informing pundits and policy makers with regards to the challenges and opportunities for the China-Brazil partnership on agriculture and food security, both bilaterally and globally.

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Part 1

Evolution of the Chinese and Brazilian agri-food sectors: a comparative perspective

Chapter 1

Pei Guo

The agricultural and rural sector in China: an overview

Abstract

This chapter reviews the evolution of the development of the agricultural and rural sector and related public policies in China. The agricultural sector was the first step within the reform package, and the land rights reform, market-oriented reform, rural industrialization and transformations of the agricultural structure have all made a great contribution over the last 40 years. The grain per capita production, and the urban rural income ratio are two of the highest concerns of policy makers, and a policy package focusing on agriculture, rural areas and farmers has been implemented since 2004. The chapter also discusses agricultural support and subsidies, agricultural production capacity, and rural infrastructure and development, to provide a preliminary descriptive evaluation of the impact of the policy package on food security and farmers' income. Recent challenges faced by the agricultural and rural sector are illustrated and the conclusion is outlined.

1. Introduction

The People's Republic of China was founded in 1949. In 1952, the Chinese government formulated and implemented the first five-year plan. As a consequence, the total output value of agriculture and manufacture increased significantly, accompanied by rising national income and average consumption level. However, China was still one of the most underdeveloped countries in the world, for example, the GDP per capita in 1978 was merely USD 190. Fortunately, a new administration took office, and as a result, in late 1978 the Reform and Opening-up policy was launched. From this point onwards, China entered a new era. Along with the policy package, a series of small and step-by-step changes with the trial-and-error approach characterized the Chinese philosophy of "crossing the river by feeling for stones at each step". The learning-by-doing approach ensured that the policy instruments were developed and implemented in a prudent manner.

Between 1979 and 2018, the period investigated in this chapter, the rate of economic growth in China has averaged 9.4%, and more than 770 million people have been lifted out of poverty. After 40 years reforming and opening-up, China has now miraculously accomplished more in the past 40 years than what any country or civilization has accomplished in history, which makes the country vital, and permits a rich and affluent lifestyle for a large part of its population. From 1979 until today, the economic development in China can be divided into four stages. In the first stage of economic adjustment (1979/1992), the right to private property was gradually recognized and protected, the rural labor surplus was allowed to enter the urban areas or townships and village enterprises (TVEs) to generate income and stimulate the urban economy, and the state-owned sector undertook reforms aiming at improving economic efficiency. In the second stage of market-oriented transition (1992/2001), reform of the tax system was carried out to stimulate the local governments to pursue the development and restructuring of deficient state-owned enterprises, private enterprises, and joint ventures. Foreign-owned enterprises became important parts of the whole economy, and the market-based economy was initially established. At the third stage of steady economic growth (2002/2012), with the accession to the World Trade Organization (WTO), the labor, capital and technology stocks grew steadily, and balanced development ensured with sound and rapid economic growth. As a consequence, China became the world's largest exporter and the second largest global economy. Furthermore, the Internet-led economy entered a quick and stable growth cycle characterized by a wave of Internet-related entrepreneurship. The fourth stage of economic transformation started in 2013, with a slight slowdown in the pace of economic growth, but the Internet-led economy still grew rapidly with a rising share in E-commerce market. The "mass entrepreneurship and innovation" policy promoted the optimization and upgrading of the economic structure. China’s basic social and economic indicators in 2019 are shown in Table 1.

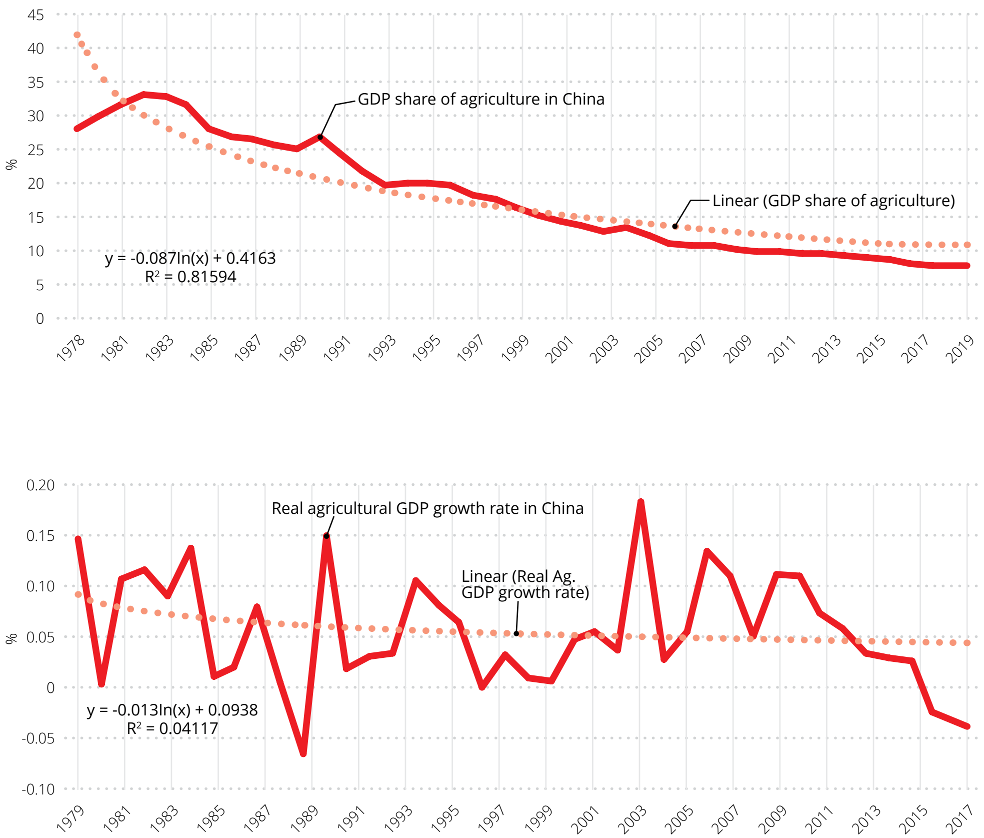
Table 1. Basic facts of China (2019)

Indicator	Number
Population	14.0005 billion
GDP (total)	US$ 14.36 trillion
GDP growth	6.10%
GDP per capita	US$ 10.276
Exchange rate	USD 1 = RMB 6.8985
Official foreign exchange reserves	USD 3.1079 trillion
Urbanization rate	60.60%
Migrant workers	290.77 million
Inflation (CPI)	2.90%
Unemployment	5.20%
Poverty incidence	0.60%

Source: China Statistical Bureau, Statistical Communique of China on the National Economic and Social Development, Feb. 28, 2019.

Reform of the agricultural sector was the first step within the wider reform process. The balance of the population has shifted towards urban areas that now contain 60.6%, up from 19.99% in 1979. Rising income has rapidly expanded the demand for higher valued food commodities such as vegetables, fruit, and especially animal products. Consistent with the development theory, the share of agriculture in the whole economy in China went down from nearly 30% in 1979 to merely 7.2% in 2018. While at the same time there has been a slight reduction in agricultural land and a steep decline in agricultural labor, the agricultural sector has grown at an annual rate of 5.33% over forty years. The agricultural GDP growth rate fluctuates widely, but the tendency is to gradually slow down and converge with the “new normal” of the Chinese economy. Agriculture reached the “new normal” stage in 2012. Since that time it has been confronted with the high prices of the domestic agricultural product market, the low quality of agricultural products, dispersed and incoherent fiscal and financial supports to the agricultural sector, etc. For example, the agricultural growth rate was 11.2% in 2011, and sharply declined to -3.1% in 2018.

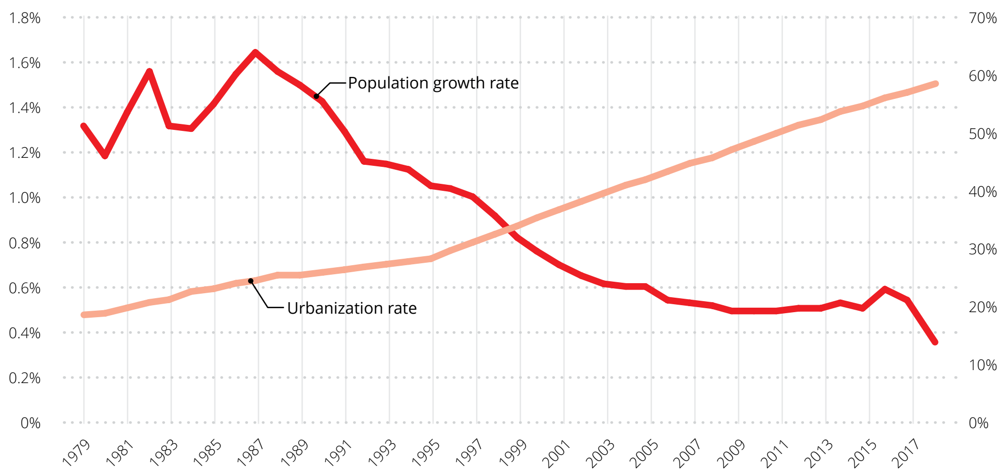
Figure 1. GDP share of agriculture and agricultural GDP growth rate



Source: China Rural Statistical Yearbook (2000, 2010, 2019).

Over 40 years, the population growth rate displayed a declining trend, although it peaked at 1.67% in 1987 and ebbed at 0.38% in 2018, thanks to the One-child Policy introduced in 1979 as a tool of controlling the population in order to alleviate the social, economic, and environmental problems associated with the rapidly growing population. As a result, the rapid decrease in the birth rate, combined with stable or improving life expectancy, led to an increasing proportion of elderly people and an increase in the ratio between elderly parents and adult children. Consequently, China allowed a second child in 2015. In China, the urbanization rate is an important indicator for assessing the percentage of the population which is residing in the urban areas for more than 6 months in a year. As shown in Figure 2, in 1979 this rate was only 19.4%, but jumped to 59.6% in 2018, an increase of 40.2% in 40 years, which simply means that the urbanization rate increased by one percent each year. Yet, close to 14 million people still migrate into urban areas each year. It is expected that this rate will reach 70% by 2035, when China completes the transformation into a high-income country.

Figure 2. The population growth rate and urbanization rate



Source: Chinese Statistical Yearbook (2000, 2010, 2019).

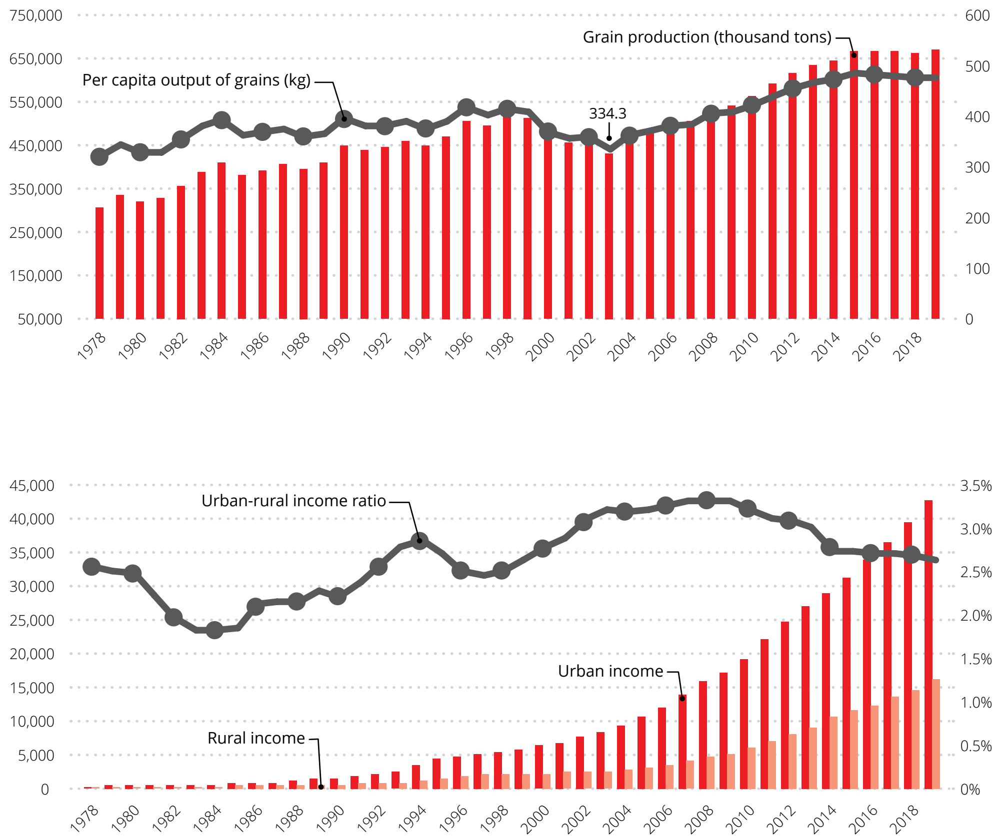
For the agricultural and rural sector, the reform process can be categorized into the following four stages. During the first stage from 1979 to 1984, the land use reform was being implemented across the country to empower the farmers to lease land from village collectives, abolishing the former people's commune system. This new land system motivated farmers who invested enthusiastically in diversified agricultural production. Consequently, grain crop production was greatly enhanced, and the agricultural output grew at 7.7% annually over the whole period. The second stage from 1985 to 1991 saw market-oriented reform as well as rural industrialization. The major changes could be summarized as the following: allowing farmers to transfer their land use rights; liberalizing agricultural input and output markets; encouraging rural labor transfer to urban areas; encouraging agricultural diversification by reducing the crop production and increasing the production of animal livestock raising; establishing rural financial institutions to provide the initial investment for farming and farm support activities, and; promoting the development of Township-and-village Enterprises (TVEs). The TVEs, a driving force for rural industrialization, absorbed a large share of the rural surplus labor, and helped them generate income. As a result, the labor productivity of agriculture improved due to the smaller number of workers. The grain market system was also developed by defining price protection and a strategic grain reserve, thus gradually releasing control of the grain market in the third stage from 1992/2003. At this stage, rural enterprises continued to grow at a fast pace and its share of the total domestic production value reached 26% in 1998, at which point it employed 130 million people. The fourth stage, from 2004 to the present was dedicated to a process of agricultural structural transformation and modernization. A noticeable feature of this period was that various types of agribusiness, such as large and specialized family businesses, family farms, farmers' cooperatives and agricultural companies, came into being for the production or operation in a larger scale and at a lower cost in a bid to increase efficiency and profits.

Between 1979 and 2018, per capita food grain[1] production in China fluctuated, reaching its lowest level in 2003. On the other hand, the urban rural income ratio rose rapidly between 1984 and 2009, when it reached a record high of 3.33 (Figure 3). Yet, in 2003 it was still higher than most of the previous years. These trends – implying a fall in grain production per capita and a wider income gap between rural and urban areas, – clearly alarmed the policy makers who regarded grain self-sufficiency and farmers' income generation as their highest priorities.

In the early 2000s, Chinese leaders prioritized the coordination of the urban and rural economic and social development, and the creation of new solutions related to agriculture, rural areas and farmers, establishing preferential policies and fiscal supports to increase grain production, and made efforts to lift farmers' income. In response, from 2004 the Chinese Government devoted its annual *Number 1 Policy Paper* to issues of agriculture

[1] In China food grains are defined to include the cereals rice, wheat and maize, as well as potatoes and edible beans.

Figure 3. Food grain output trends and urban rural income ratios



Source: China Rural Statistical Yearbook (2000, 2010, 2019).

and rural development. By the end of 2018, there had been 15 papers dedicated to agricultural productivity, farmer's income, and hard and soft infrastructure in rural areas, which also are the three pillars of the *Number 1 Policy Paper*.

The key phrases that capture the main emphasis of each of the policy papers are listed in Table 2. With these measures, implemented between 2004 and 2006, policy makers sought to increase farmers' income, improve production capacity, and institute a push towards the "new countryside" which involved upgrading the rural infrastructure and living environment. The other key phrases also repeatedly expressed these same concerns, focusing on balancing rural and urban development, and later on specific sources of agricultural productivity, namely, irrigation and agricultural technology. The policy paper of 2013 prioritized the diversification of production patterns in China and emphasized family-run holdings as the main agricultural production modality, aiming to link farmers with professional organizations to achieve mutual benefits and facilitate agricultural modernization. In the papers of 2014, 2015 and 2016, agricultural modernization was further stimulated to encourage large-scale land holding production and environmentally friendly technology adoption for agricultural practices. With rising income and a higher demand for quality products, more efforts should be dedicated to structural changes on the supply side to better meet market demands, while the high production costs and overstock should be addressed in the 2017 paper. For promoting the mass campaign to advance the agricultural and rural development, the central government released the Rural Revitalization Strategy to help the all-round development in the agricultural and rural sector, including hardware and software.

Table 2. The key phrases of *Number 1 Policy Papers* (2004/2019)

	Key phrases		Key phrases
2004	Increasing the farmers' income	2005	Improving the agricultural production capacity
2006	Improvement of infrastructure	2007	Developing modern agriculture
2008	Consolidating the foundation of agriculture	2009	Improving the rural development & farmers' income
2010	Balancing the urban and rural development	2011	Enhancing the rural irrigation system
2012	Encouraging agricultural technology innovation	2013	Innovating the agricultural production pattern
2014	Advancing agricultural modernization	2015	Promoting innovation to speed up agricultural modernization
2016	Reaching the goal of better society by agricultural modernization	2017	Promoting the Structural Reform of the Agricultural Supply Side
2018	Implementing the Rural Revitalization Strategy	2019	Prioritizing Agricultural and Rural Development

Source: Summarized by the author based on the *Number 1 Policy Papers* in previous years.

In short, in line with the key concerns of food security and farmers' income, the *Number 1 Policy Papers* started with a strong emphasis on measures encouraging crop production, in particular food grains, and boosting farmer income. Over the years, the full range of agricultural productivity and rural development issues, often present within several of the *Number 1 Policy*

Papers, were gradually addressed. Enhancing agricultural competitiveness and narrowing the income gap between rural and urban areas in China to realize the integrated development will be the focal points in the *Number 1 Policy Papers* in the years ahead.

2. Agricultural and rural development in China

2.1. Agricultural support and subsidies

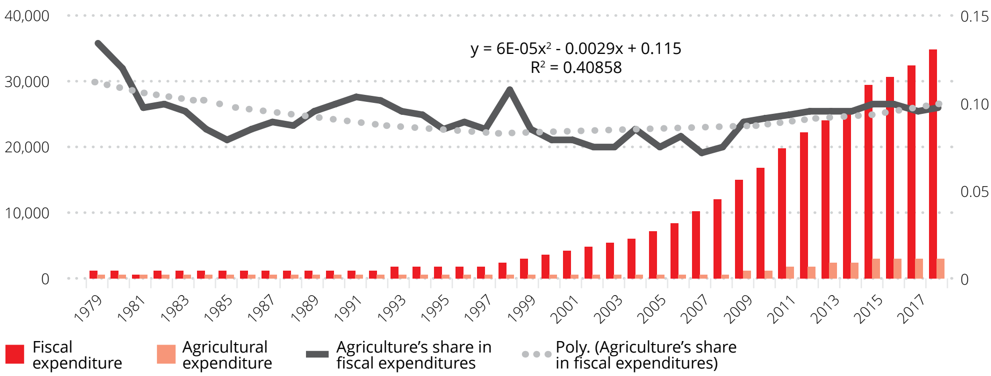
From 1979 to 2018, the share of agriculture in total public expenditures fluctuated widely, with peaks in 1998, 2015 and 2016 and troughs in 1985 and 2007 (Figure 4). The total public expenditures in real terms grew at 8.58% annually during the whole period. Fiscal expenditures on agricultural growth averaged 7.63%, 0.95% less than the public expenditure. It is noted that the *Number 1 Policy Papers* started with a temporary public expenditure spike in 2004, but it was not sustained in 2005. Thereafter, it grew rapidly to a plateau at about 10% of total public expenditures until 2016, and dropped slightly afterwards.

With the aim of stabilizing and boosting production, fiscal subsidies for the agricultural sector were introduced in China in 2004 after the first *Number 1 Policy Paper* was published. Since then, support measures which consisted of direct subsidies for grain, improved seed subsidies, comprehensive input subsidies and machinery purchase subsidies, have risen from USD 2.1 billion to USD 24.3 billion, an increase of roughly 11.6 times in real terms. In 2016, the agricultural subsidy program had been improved and three kinds of subsidies, namely, direct grain subsidy, improved seed subsidies, and comprehensive inputs subsidies were combined into a new modality called agricultural support and protection subsidy. Of the four subsidies, the direct grain subsidies remained basically stable in real terms throughout the period, while subsidies for inputs grew (fertilizer, pesticides, seeds, and fuels).

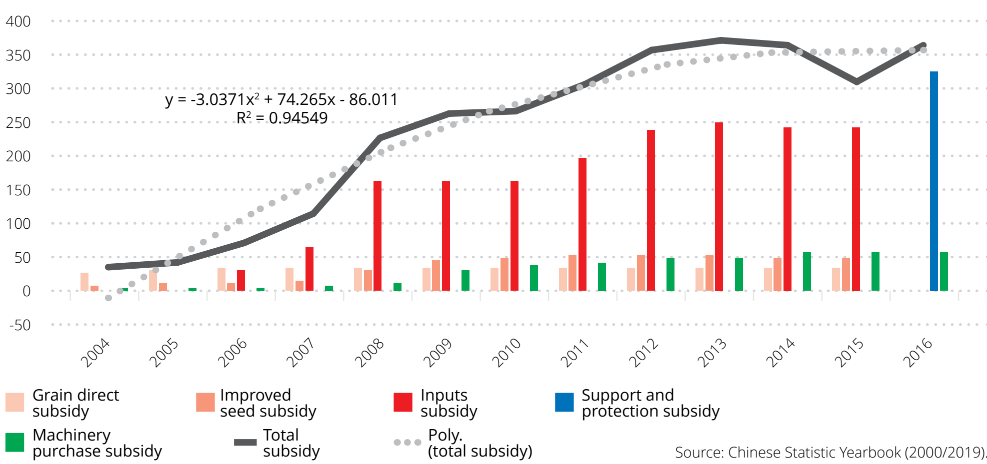
Today in China, there are two kinds of agricultural production subsidies: support and protection subsidies, and machinery purchase subsidies. The former four types of agricultural subsidies had played an important role in mobilizing farmers' enthusiasm for grain production, increasing farmers' income, stabilizing the fluctuation of grain prices, and ensuring national food security. With the transformation of the agricultural sector, the agricultural subsidy programs in China will be more supportive for farmland conservation, agricultural mechanization, vocational training of farmers, tree-industry integration development, and green technical services.

Figure 4. Agricultural public expenditures and subsidies

(A) AGRICULTURE'S SHARE IN TOTAL PUBLIC EXPENDITURES



(B) SUBSIDIES IN AGRICULTURAL EXPENDITURES



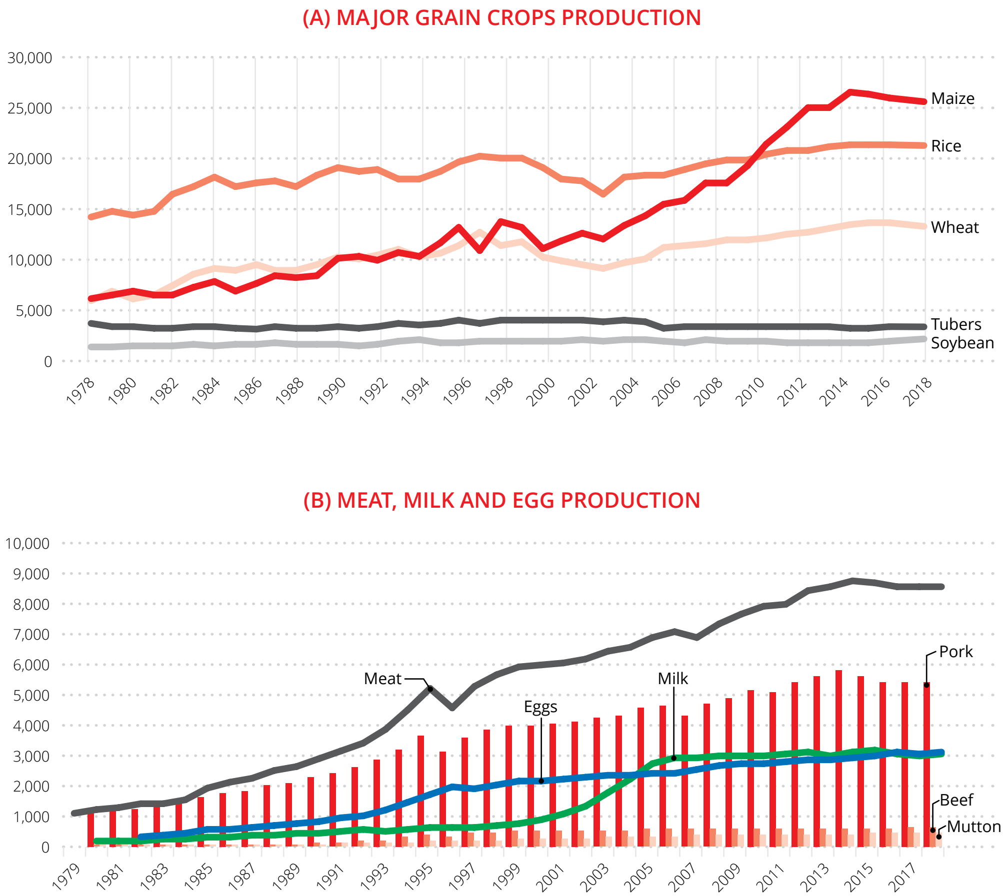
Source: Chinese Statistic Yearbook (2000/2019).

2.2. Agricultural production capacity

Chinese grain supply capacity has been increasing steadily. The total grain output has further increased as is displayed in Figure 5A. From 1979 to 2018, China's grain production almost doubled from 332.12 million tons to 657.89 million tons, with an annual growth rate of 1.72%. Regarding the major grain crops over 40 years, rice output increased 1.48 times from 134.75 million tons to 212.68 million tons, wheat output increased 2.1 times from 62.73 million tons to 131.43 million tons, and corn output increased 4.3 times from 60.04 million tons to 257.13 million tons. Grain yield has been increasing significantly as well. In 2018, the average grain yield was 5,621 kg/ha, an increase of 2836.3 kg/ha, or slightly more than 100%, compared with that of 1979, with a rice yield of 7,027 kg/ha. The wheat yield increased with 5,416 kg/ha and corn yield with 6,108 kg/ha in 2018. Besides, the grain planted area was basically stable, and the positive impact of grain planting adjustment can be observed with the so called "the structural reform of agricultural supply-side". In light of this, the Chinese agricultural structure would change from the combination of grain and cash crops, to the combination of grain, cash, and cropland feed, guiding the farmers to change from focusing on quantity to focusing on both quality and quantity to better meet market demand, improving the price formation mechanism, subsidy policy, and storage pattern of the main agricultural products, and promoting land transfer from small scale farmers to the new agribusiness enterprises, and enhancing the competitiveness of agricultural products.

As shown in Figure 5B, the production of meat, egg and milk products in China has greatly increased since 1979. Over the whole period, meat production has risen more than 8 times from 10.6 million tons to 86.2 million tons, egg production more than 10 times, from 2.8 million tons to 31.3 million tons, and milk production from 883 thousand tons to 30.7 million tons, especially since 2000. These data show that the Chinese dietary structure has changed greatly, and the animal protein intake has increased significantly, which is driven primarily by the improvement of income levels and the rapid development of nutrition and health education. It can safely be concluded that pork is still the main source of meat for Chinese residents, with a per capita pork production of about 40 kg. Beef and mutton production is rising rapidly, displaying a trend toward the diversification of meat consumption. The rapid

Figure 5. Major agricultural products production in China (unit 10,000 tons)



Source: China Rural Statistical Yearbook (2000, 2010, 2019).

growth of meat, egg and milk products generates a need for more of feed grain in China. The government should pay attention to the new cultivation patterns and provide financial and technical supports for producers.

China has successfully left grain shortages in the past, obtained a balanced grain supply, and even become an "over-supplier" in some good harvest years by utilizing 9% of global arable land to feed 20% of the global population. Much literature has highlighted that four factors have made a great contribution to the grain miracle in China, namely; (1) land system reform to give farmers more land rights and stimulate their incentive to produce more;

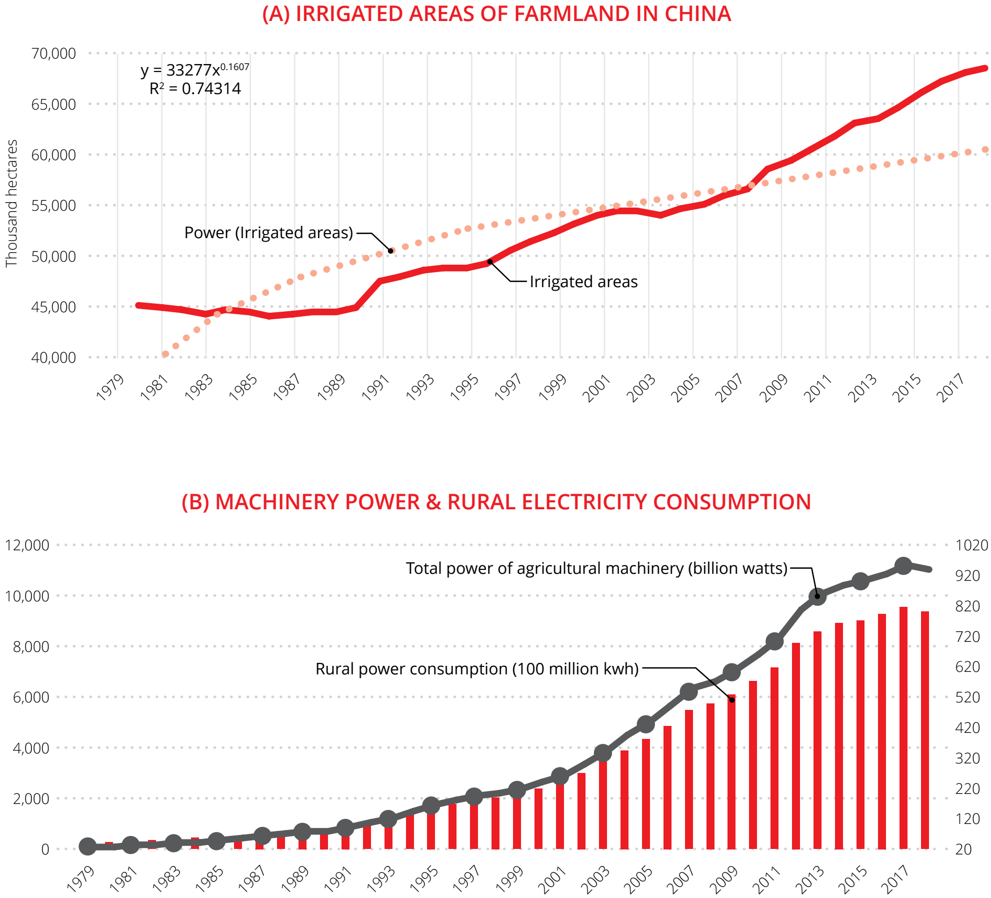
(2) technological progress in the form improved seeds, fertilizer, pesticides and machinery; (3) market-oriented reform to push forward structural adjustment, price system establishment and WTO accession, and; (4) public investment for rural irrigation, land quality, education, etc.

Agricultural production capacity has been improved considerably. First, over the period as a whole, irrigation grew at the annual rate of 1.05% (Figure 6A). After slowing down in the early years of the 1980s and 2000s, it accelerated after 1990 and 2004, in spite of the fact that it had not yet been singled out specifically in the policy papers before 2011, when the *Number 1 policy paper* emphasized the improvement of the rural irrigation system. Secondly, the comprehensive mechanization rate of cultivation and harvest of major crops has increased significantly (Figure 6B). In 2016, the comprehensive mechanization rate of crop cultivation and harvest was 65.2%, while the mechanization rate of rice, wheat and corn was 79.2%, 94.2% and 83.1% respectively. The comprehensive mechanization rate reached 69% in 2018. The mechanization rates of rice, wheat and corn were 81.9%, 95.9%, and 88.3%, thus, pointing to significant changes in merely two years. Secondly, the effective irrigation area of farmland has been further expanded, and the increases in these areas were 1.27 million hectares, 67.5 million hectares, and 45.6 million hectares respectively, from 2016 to 2018.

Since the agricultural reforms in 1979, considering the large population, the huge food demand, and the low land productivity, the application of chemical fertilizer and pesticides encouraged by the local governments has become one of the important factors in the stimulation of agricultural production growth, especially Chinese grain production. However, the overuse of chemical fertilizer and pesticides not only increased production costs, but also wielded negative impacts on the environment. Resource conservation and environmentally friendly agriculture was further promoted by both central and local governments, and the campaigns for reducing chemical usage in agricultural production are intensifying across China.

Some positive results have been observed (Figure 7). First, the agricultural nonpoint source pollution prevention and control has achieved remarkable results. From 2011 to 2015, there was negative growth in the use of pesticides and chemical fertilizers in China. In 2018, the use of agricultural chemical fertilizer was 56.5 million tons, while the pesticide use was 1.5 million tons; 3.5% and 9.2% less than that of 2017, respectively. Secondly,

Figure 6. Irrigated areas of farmland and agricultural machinery power & rural electricity consumption

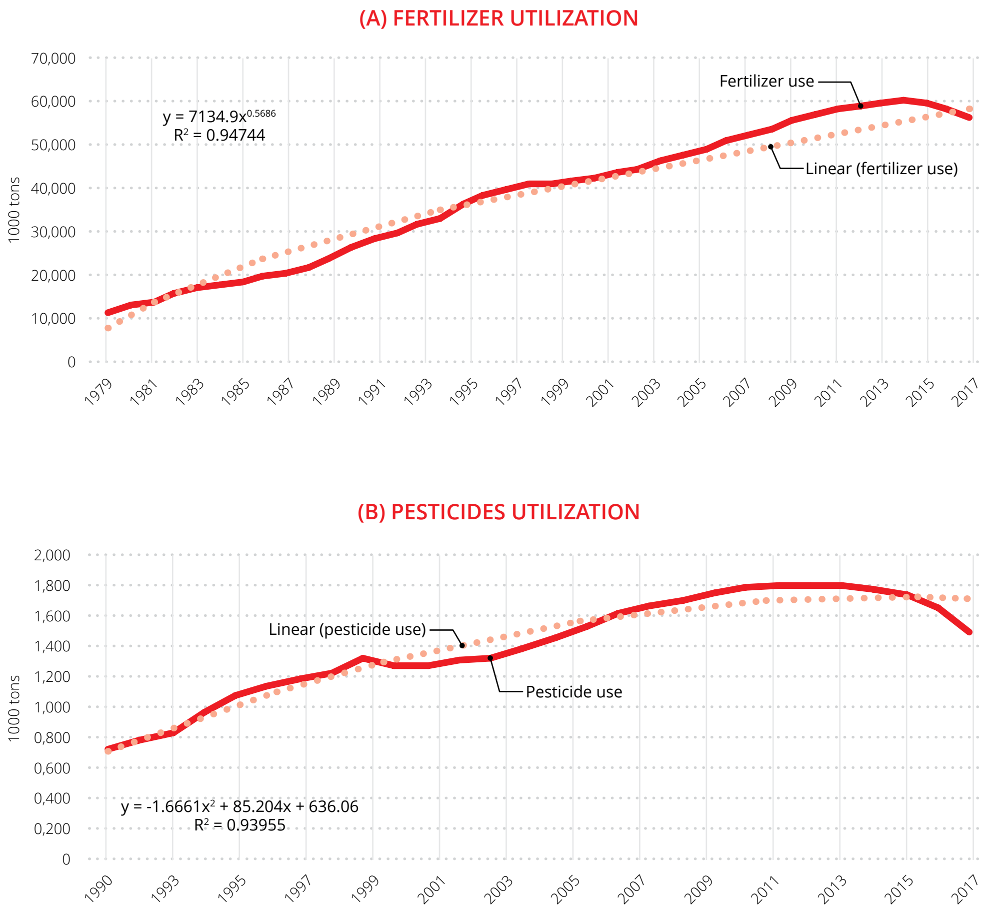


Source: China Rural Statistical Yearbook (2000, 2010, 2019).

green production and cost reduction technologies such as water saving, fertilizer saving, and pesticide saving technology was scaled up nationwide, a pilot experiment on heavy metal pollution prevention and control was carried out, efficient measures such as soil amendment restoration were embraced, and comprehensive utilization of crop straws was extended. Thirdly, the utilization of livestock and poultry excrement as a resource has been comprehensively promoted in the major animal husbandry areas. It has been shown that the comprehensive utilization rate nationwide has reached

70%. Fourthly, the extension and application of green and efficient products, such as slow-release fertilizer, water-soluble fertilizer, and other new types of fertilizers has been accelerated in China. Moreover, the specialized service organizations, such as the unified application of fertilizer, the unified control of pests and diseases and so on, have developed rapidly, which effectively improved the level of fertilization and application technology.

Figure 7. Utilization of chemicals in agricultural production in China



Source: China Rural Statistical Yearbook (2000, 2010, 2019).

Fertilizer use grew by 520% over the period as a whole, at an annual rate of 1.4%. However, it is clear that a turning point was reached in 2015.

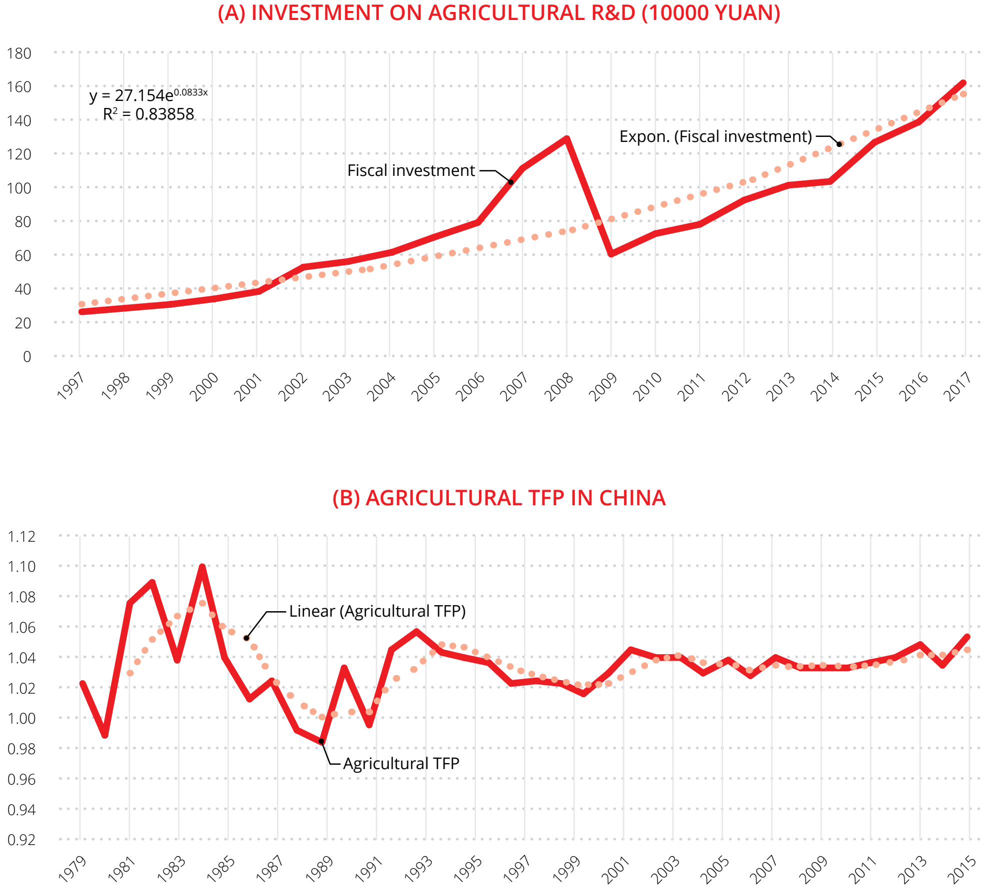
It is expected that the use of fertilizer will decline further, due to strict policy control in order to improve the agricultural ecology and environment. Concerning pesticide usage, data is available for the period between 1990 to 2018, and during that time the pesticide utilization grew quickly at an annual rate of 1.8%, increasing roughly 2.05 times from 733 thousand tons to 1504 tons from 1990 to 2018. It also displayed a break in growth after 1998, and then a resumption after 2001 and subsequent acceleration, on account of both higher profitability of agriculture and the specific input subsidies.

In order to feed a quickly growing population and realize the sustainable and stable development of agriculture while ensuring the effective long-term food supply, agricultural science and technology becomes essential to ensure national food security. China is trying to promote leapfrog development of agricultural science and technology, and create a strong impetus for agricultural production, farmers' income and rural prosperity. Therefore, fiscal investment in agricultural science and technology should be ensured. Figure 8A shows the Agricultural R&D support peaking in 2008 and decreasing in 2009, but quickly rising again starting from 2010. The investment in agricultural R&D usually takes a long time and may imply losses or lower returns. As a public good, the government needs to invest more in this vital area to ensure food security and food safety for the population.

Agricultural total factor productivity (AGTFP) is the ratio of total output to total input of all agricultural factors. The improvement of AGTFP means the enhancement of production and resource allocation efficiency, and to a certain extent, it can reflect intangible production factors such as technological progress, system optimization, and organizational and management improvements. It can be read from Figure 8, that in the early stage of reform and opening-up, ATFP rose significantly and peaked in 1984, indicating that agricultural technology played an important role in promoting output improvement during this period. Hereafter, the AGTFP showed less fluctuation. The main driving force of agricultural development resulted from the increase in labor, land and other inputs. After entering the new century, China's AGTFP has stabilized in a spectrum of slightly more than 1, which shows that technological progress always has played an active role in agricultural output.

The cost of agricultural production, including grains, keeps rising. First, the price of land rent has increased. With the development of new types of

Figure 8. The Agricultural R&D and total factor productivity in China

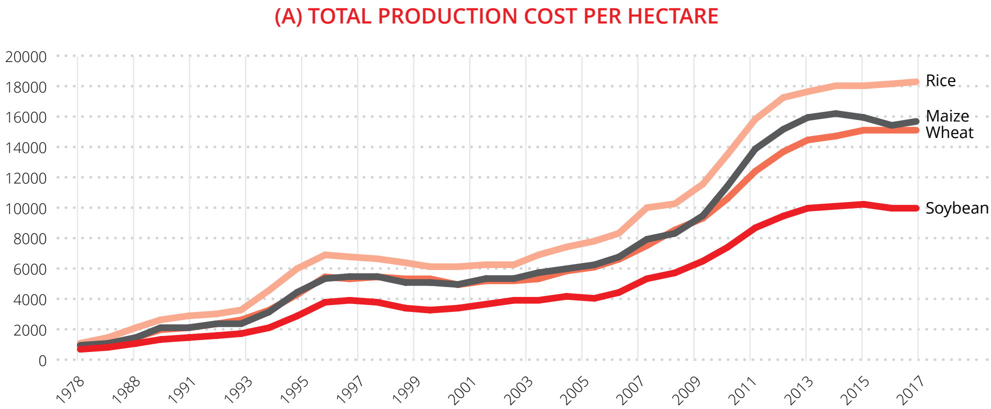


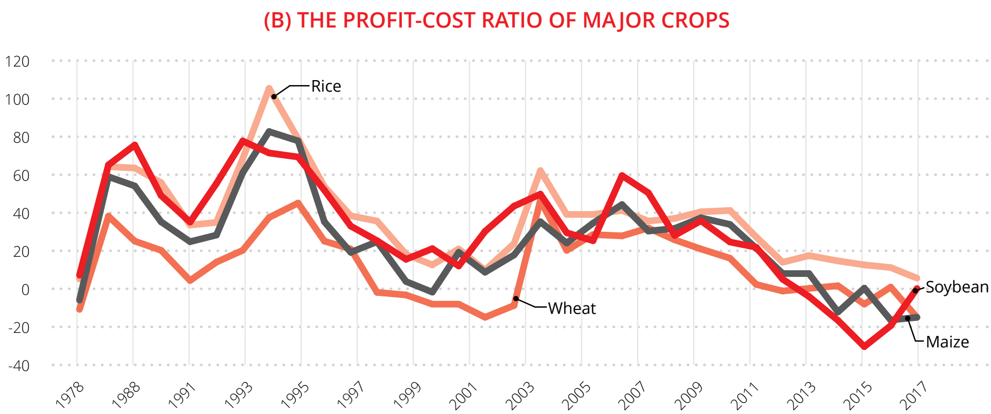
Source: 8A is from China Science and Technology Statistical Yearbook (2010/2019). 8B cited the result from a paper as following: Wang, Juan and Xiuyun Yang. The Dynamic Evolution and Convergence Analysis of Agricultural Total Factor Productivity in China Since the Reform and Opening. Statistics & Information Forum, Vol. 34, No. 11, Nov., 2019.

agribusiness (such as family farms, co-ops, agricultural companies etc.), the demand for leasing farmland has increased significantly, and as a result, the rent has also risen and directly increased the total cost of agricultural production. Secondly, the agricultural wages have also risen. According to official statistical data, the annual wage of agricultural labor rose from USD 4870 to USD 5284 from 2016 to 2018, with an increase of 8.5%.

As can be seen from Figure 9A, since 1978 the cost of major grain crops in China has shown a rapid upwards trend. According to the constant price

Figure 9. The total production cost and the profit-cost ratio of major grain crops

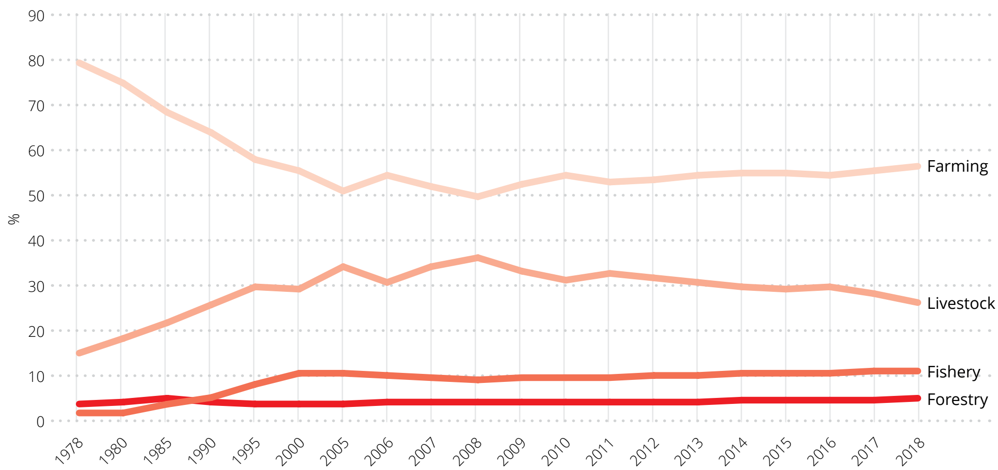




Source: China Statistical Compilation on Cost and Return of Agricultural Products (1990, 2000, 2019).

calculation in 1978, the cost of corn per hectare in 2018 was three times that in the early stage of the reform and opening up, and the planting cost of rice, wheat, and soybean increased by more than 180%. The main reason for the rising costs is due to the increasing price of inputs, such as labor force and agricultural materials, which gradually seizes the profit of farmers. The Figure 9B shows that the profit-cost ratio has been in a downward trend in fluctuation since 1978, and the profits of the grain crops cultivation has been gradually reduced. In 2018, wheat, corn and soybeans operations were actually generating losses, resulting in a reduction of farmers' enthusiasm for grain production. Therefore, the central government presented direct and indirect supports to grain production in a bid to sustain a high degree of self-sufficiency.

Figure 10. The changing structure of agriculture (% in output values)



Source: Chinese Statistic Yearbook (1995, 2000, 2005, 2012).

With increasing income and awareness, Chinese people have realized the transformation from "eating enough" to "eating well" and are now on the way to reach "eating healthy", paying more attention to the nutrition and health of their diets. The agricultural sector has begun to emphasize the improvement of the quantity, quality and social benefit. The modern diversified agricultural economic structure, which integrates grain crops, cash crops, livestock and fishery, has already taken shape, and the quality of agricultural products, the concentration of production, and the level of processing have been significantly improved. From 1979 to 2018, the crop industry took the lead, but the proportion of output value decreased from 90% in 1979 to 57.1% in 2018. The proportion of forestry output value increased from 3.4% to 4.6%. The proportion of livestock output values initially increased, but later decreased, rising from 15% in 1978 to 36.8% in 2008, and then falling 26.6% in 2018. The proportion of fishery output value increased rapidly in the early stage, then basically stabilized and fluctuated slightly in the range of 10% to 11%.

More importantly, it should be highlighted that the arable land per capita in China is quite small. According to the data released from FAO, the indicator of arable land per capita is 313 ha in Canada, 167 ha in US, 66 ha in Brazil, 14 ha in the EU (27) and a mere 0.59 ha in China.

2.3. Rural infrastructure and development

In China, it is very clear that the construction of rural infrastructure should be strengthened. That means improving the "hardware", such as rural water supply security, power supply, information infrastructure, rural paved roads, rural living environment, as well as the "software", such as the rural education quality, rural medical and health services, rural social security, and rural public cultural services.

Remarkable achievements have been made in rural road construction. In the past decade, great changes have taken place in transportation in rural China. By the end of 2018, the country's rural roads had reached 4.04 million kilometers. Across China, 99.64% of townships have access to paved roads and bus access reaches 98.6%, at village level these numbers are 99.47% and 97.1%, respectively. In addition, China has invested about 710 billion yuan from the vehicle purchase tax to support the transportation programs in poverty-stricken areas. The rural dilapidated houses renovation has basically been completed. In the past decades, the Chinese government focused on ensuring safe housing. These programs effectively do in fact help ensure a safe life for people of limited means.

China has a long history of continuously strengthening the construction of water conservancy facilities, and implementing projects to guarantee safe drinking water safety and disease prevention. In particular, in 2000 China started to implement a series of rural water supply projects in order to ensure the safety of rural drinking water. By the end of 2018, more than 11 million water supply projects had been completed and the rural water coverage rate nationwide increased from 34% in 2004 to 81% in 2018, indicating that China has completed the Millennium Development Goals in advance.

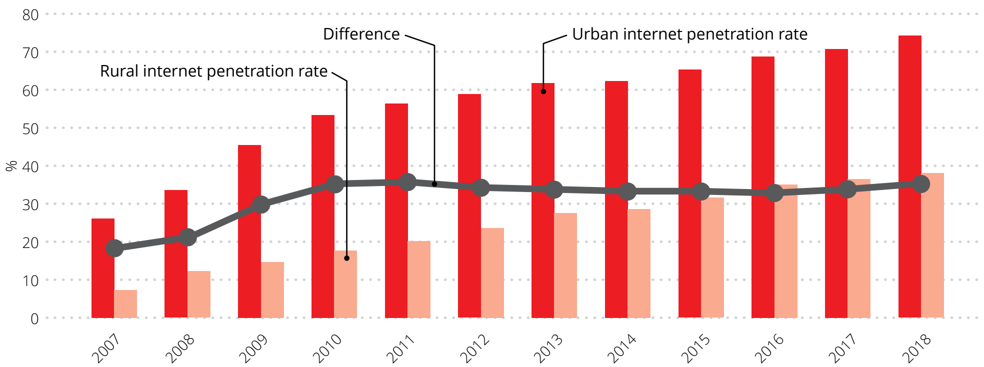
Significant progress has also been made in the construction of rural information infrastructure. First is the promotion of the construction of a rural information network. The related central government agencies jointly carried out some pilot projects of universal telecommunication services to support the construction of optical fiber and 4G network coverage in remote rural areas. More than USD 7.25 billion will be invested by the central government and major telecommunication enterprises. By the end of 2018, 98% of the administrative villages had access to broadband networks. Secondly, an information access project aiming to cover villages and households was promoted. Ten provinces were selected to carry out province-wide demonstration in 2017, and it expanded to 18 provinces. This information access project focuses on providing the public welfare services, convenience services, e-commerce services, and training services for rural residents, which has been very helpful to the local farmers. In addition, upgrading of the rural power grid was undertaken.

The internet penetration rate in rural areas of China has been rising rapidly since 2007. In 2018, the number of Internet users reached 802 million, and the number of mobile internet users reached 788 million, including 74.6% in urban areas and 38.4% in rural areas (Figure 11A). In the past decade, the internet coverage in rural areas more than tripled, but in urban areas it is significantly higher than in rural areas. Due to the economic disparity between the urban and rural areas, the urban netizens are characterized by a more frequent utilization of online shopping, travel booking, online payment, and internet financing than rural netizens.

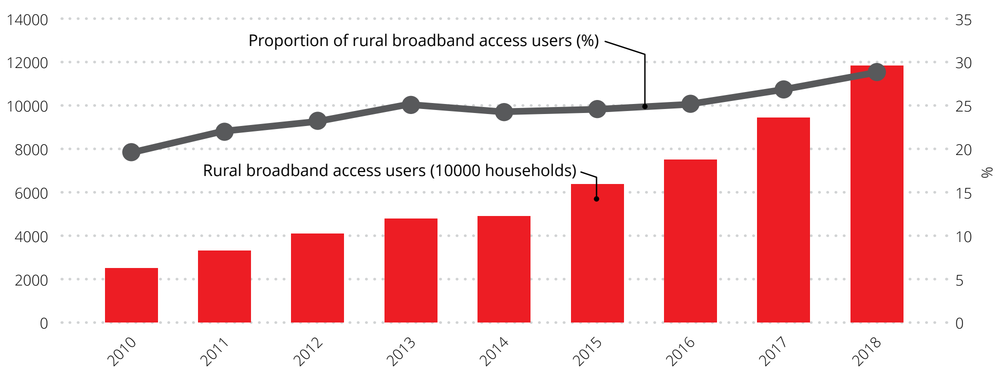
The penetration of rural internet continues to improve, and rural e-commerce develops rapidly. As can be read from the Figure 11B, by 2018 the number of rural broadband users in China reached 117.4 million, accounting for nearly one third of the total number of rural broadband users in the country, indicating the rapid development of rural communication infrastructure. Again in 2018, the ratio of optical fiber in administrative villages increased to 98%, and the ratio of broadband in poor villages reached 95%. The threshold for rural residents to access the internet keeps declining, consequently, narrowing the digital gap between urban and rural areas and promoting digital development in rural areas. In terms of express logistics, "express to the countryside" was further promoted, and the coverage rate of township express outlets reached 92.4%. The rapid development of rural infrastructure provides support to develop rural e-commerce. From 2012 to 2018, the total online retail sales of agricultural products in China has been on the rise year by year. From 2013 to 2015, retail sales increased by more than 70%. Since 2016, the growth rate of online retail sales of agricultural products has stabilized slightly. In 2018, the national online retail sales of agricultural products reached 235 billion yuan, with an increase rate of 33.8%, – 7.5% age points higher than the national online retail sales.

Figure 11. Internet infrastructure and broadband access in rural China

(A) RURAL INTERNET PENETRATION RATE



(B) RURAL BROADBAND ACCESS

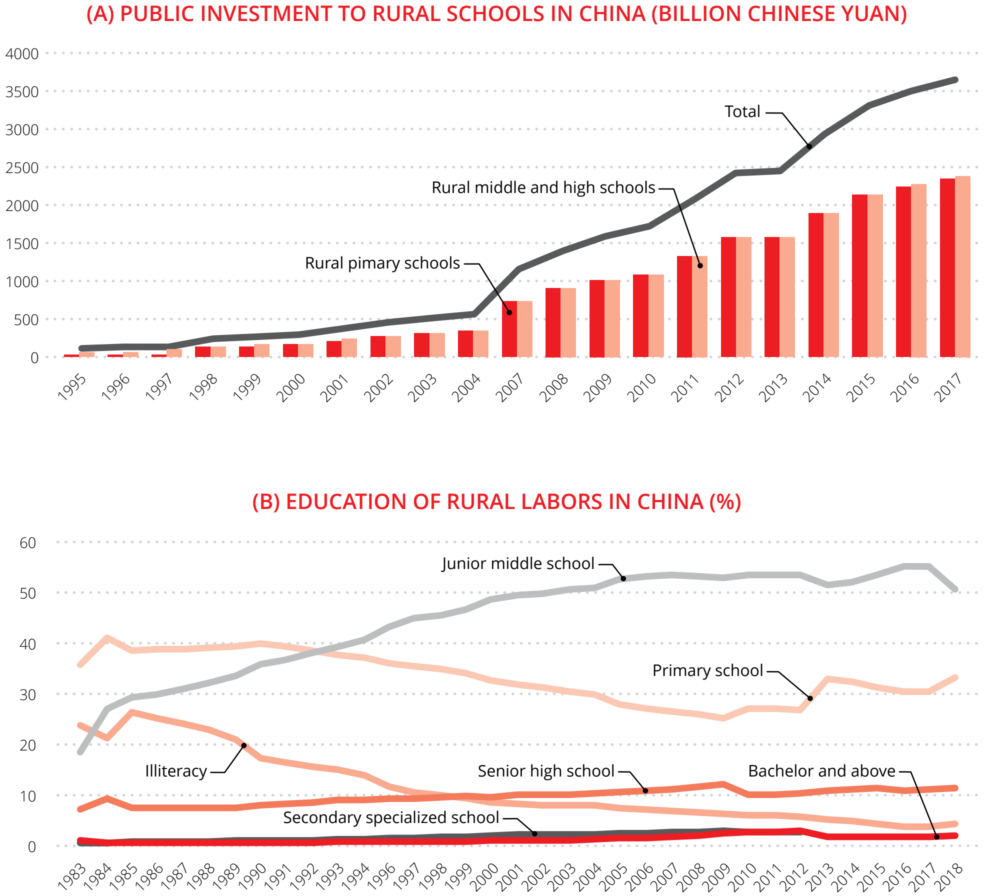


In 2006, China launched the public fund guarantee mechanism for rural compulsory education, which not only effectively reduced the economic burden of rural households of having their children in compulsory education, but also broke the funding bottleneck restricting the popularization of rural compulsory education. All students in the suitable age for rural compulsory education are exempted from school fees, textbooks are provided free of charge to students from the poor families, and the boarding expenses are subsidized. From Figure 12A, the public investment in rural primary schools and middle and high schools kept increasing in real terms and grew at an annual rate of 17.8%.

The available data on the education level of rural workers in China begins in 1983 (Figure 12B). The proportion of the illiterate population has been declining from 23.5% in 1983 to 3.9% in 2018, as has the proportion of people with only a primary school education, declining from 40.73% to 24.44% in 2009, and then rising to 32.8% in 2018. The data clearly indicates that the share of rural workers with junior middle school education has been constantly rising, climbing to a peak of 54.7% in 2017, and it is noted that more than half of the rural workers have received junior middle school education. Besides, the share of rural workers with education levels higher than junior middle school, such as secondary specialized school, senior high school, and even college shows an overall upwards trend. This achievement relies on the relevant measures taken by the central and local governments, such as increasing investment in rural education infrastructure, improving the salary of rural teachers, subsidizing students in need, and implementing compulsory rural education. It is believed that the Chinese government will continue to allocate more investment for rural education, and thus promote human capital growth in rural areas.

China has continuously improved the rural social security system since 1978, and established a social security system covering the largest population and the largest scale of government expenditure in the world. The majority of rural residents benefit from three social security schemes: new rural social endowment insurance; new rural cooperative medical care; and the rural social assistance system. By the end of 2018, 523.9 million people in China had participated in the basic endowment insurance for urban and rural residents, 1.34 billion people had participated in the basic medical insurance, 35.2 million people had enjoyed the minimum living security system for rural residents, and 4.55 million people had enjoyed the assistance and support for the extremely poor people in rural areas. With the strategic background of Rural Revitalization and regional coordinated development, China will continue to speed up the strategic, forward-looking, and systematic development of social security in rural areas in the face of the accelerating process of social aging, in order to meet farmers' social security needs.

Figure 12. Rural Education in China



Note: Based on the constant price of year 1995.
Source: China Education Statistical Yearbook (2010, 2018).

3. Challenges for the agricultural and rural sector in China

Since the reform and opening up, China has formulated and implemented a series of effective policies to strengthen agriculture. Domestic agricultural production has continued to develop rapidly, the comprehensive agricultural production capacity has been significantly improved, and the agricultural economic structure has been continuously optimized, making important contributions to ensuring global food security and promoting global agricultural development. However, China's agricultural development is also facing many unprecedented challenges. The structural excess of agricultural production capacity, the weak international competitiveness of agriculture, and the serious pollution of the agricultural environment have become important factors in restricting the sustainable development of Chinese agriculture.

3.1. The national economy enters into a downward cycle

China's economy has shifted from high-speed growth to medium high-speed growth. The effective consumption demand is far from sufficient, while the supply of high-quality products cannot meet the strong market demand. The traditional export-oriented industries are hard to transform, and the emerging industrial growth is slowing down. The downward pressure on the economy is rising, and as a result, the hidden risks are gradually emerging. When considering agricultural and rural development, the slowdown in GDP growth cannot be ignored. Agricultural production costs, including labor wages, land rents, agricultural material prices, financing interest, and the like, are continuously rising, which has brought great challenges to the supply of important agricultural products and income generation of farmers in the short and medium term.

3.2. Unilateralism in international trade is inevitable

In recent years, the rise of protectionism and unilateralism in international trade has seriously impacted the normal operation of the global market for agricultural trade. Soybean undoubtedly became one of the key points of Sino-US trade friction, leading to the change of China's soybean supply structure. In addition, there is uncertainty about the external supplies of grain, and the possibility of grain price fluctuation. In order to ensure food security and price stability of agricultural products, China has to optimize the structure of grain planting, and improve its capacity to control grain sources on the international market.

3.3. The epidemic prevention and control in animal husbandry becomes more severe

The animal husbandry industry in China is moving towards a larger-scale and more intensive operation. As it does so disease prevention and control are becoming more and more important. With the expansion of the scale and density of animal husbandry, added to inadequate operation management and biosafety measures, disease prevention and control becomes more demanding, and to a certain extent threatens food safety and public health.

3.4. Extreme weather becomes more frequent and engenders a heavy impact

Climate change becomes a key factor affecting the fluctuation of food production. Agriculture is the most sensitive and vulnerable industry to climate change. Extreme weather, such as drought, flood, severe convective weather, low temperatures and cold damage, high temperature and heat waves, snow disaster, freezing rain, forest fire, acid rain and so on, can easily cause large-scale crop reductions or even crop failure. This will definitely affect farmers' income generation and domestic food security.

3.5. The rural labor force faces structural contradictions

There are challenges related to ensuring the "successors" of agricultural development. In recent years, the rural labor force has migrated into urban areas on a large scale, and as a result, the number of rural workers engaged in farming activities is decreasing, the quality of rural workers is declining, and those who stay in rural areas are mainly women and middle-aged people in general. Measures must be taken to train the agricultural producers and operators by releasing preferential policy to attract people from urban areas.

3.6. The constraints on resources and the environment become increasingly severe

With the rapid expansion of industrialization and urbanization in China, maintaining specific amounts of cultivated land for agriculture is difficult, and serious soil pollution often happens. During water shortages, there is a deficit of more than 30 billion cubic meters of farmland irrigation water. The impact of agricultural production waste on the environment is getting more severe. The excessive and inefficient use of chemical fertilizers, pesticides, and agricultural film causes nonpoint source pollution and soil degradation. The negative impact of the pollution from livestock and poultry is increasingly significantly. Excessive usages of offshore fishery resources lead to the ecological deterioration of fishery waters. The trend of grassland ecological deterioration has not been fundamentally reversed. The current development mode of resource consumption has to make agriculture sustainable.

4. Conclusions

In this chapter, the following indictors have been discussed: farm household income, absolute urban rural income differences, the urban-rural income ratio, the agricultural growth rate, grain production, subsidies, agricultural mechanization, fertilizer input, irrigation, and TFP growth. Agricultural growth, grain production and farmers' income in China have experienced an astonishing turnaround from a deteriorating situation before 2003 to positive trends thereafter. The simultaneous turnaround of a large number of indicators in that year is striking. One of the clearest impacts of the *Number 1 Policy Paper* packages was China's ability to maintain its self-sufficiency in cereals. Despite the clear emphasis on this policy goal in the subsidies, China's trade has moved in the direction of its comparative advantage. Labor intensive exports of processed foods have grown quickly, while the import of land intensive soybeans has increased at a rapid pace.

Moreover, as the policy measures in favor of farmers' income and grain production took some time to become implemented and scale up, they could not have exerted a strong impact already in 2004, or even in 2005. It therefore stands clear that in terms of farmers' income and food security, the policies were not the factor that initiated the turnaround, although the subsequent acceleration of a number of trends suggests that they may have contributed significantly in the following years. The rapid growth throughout the period, and the acceleration of rural-urban migration from 2003 also had a major influence on the observed trends, such as the accelerating overall agricultural growth rate (as fueled by rising domestic demand), and the extremely rapid agricultural mechanization.

The recent trends in some of the above-mentioned indicators are encouraging for the prospects of both food security and farmers' income. The latter's growth rate has further accelerated in 2010. The agricultural growth rate and grain production, areas and yields have continued to rise. Fertilizers and especially mechanization continue their growth unabated, and farm sizes are growing due to the new types of agribusiness. Subsidies also continue to rise, as does total factor productivity. The favorable food security and farmers' income trends will continue in the near future.

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Chapter 2

Geraldo Sant'Ana de Camargo Barros

The Brazilian agri-food sector: an overview

1. Introduction – Brazilian agribusiness today

The Brazilian agricultural system is today a set of production chains, each one linking rural producers with consumers and foreign importers, being mostly well structured, modern and competitive. These characteristics range from grain and oilseed chains, meats, sugar, biofuels and fiber to fruits and vegetables.

In 2018 the agricultural activity in Brazil – farming, which produces raw materials, accounted for just over 5% of Brazil's $ 1.8 trillion GDP. It should also be borne in mind that agribusiness[1] – understood as the set of economic sectors that partially or totally interact with agricultural activity, upstream (input industry) and downstream (processing industry), plus the agro-services segment – is responsible for 21% of Brazil's GDP. Agribusiness employs 20% of the Brazilian workforce; 46% of them work on farms. In recent decades, Agribusiness role in containing inflation, and reducing inequality and poverty in the Brazilian society results from the combination of increasing production levels at falling real prices, the result, of course, of continued advancement of

[1] The concept of agribusiness, in this text, involves all activities of production of goods and services related to agriculture, incorporating the input segment plus the processing and the distribution of products of origin in the primary segment. It does not exclude any categories of farmers and processors whatever their size (in terms of area or volume) and type of production. In other words, agribusiness includes what has been referred to as commercial farming, small farming, family farming, etc.

productivity and efficiency. High rates of productivity have yet to reach all of Brazilian agriculture, however, which results in, a significant contingent of low income and low productivity laborers who depend on income transfers from the public sector, but which account for a small share of overall farm production.

Since the beginning of the present century, agribusiness has generated trade balance surpluses of more than $ 1 trillion, sufficient to cover the deficits of other economic sectors and of the service and capital accounts of the balance of payments, contributing 91% of the US$ 380 billion of foreign exchange reserves currently held by the country. In foreign trade, China represents (in 2018) 1/3 of the Brazilian agribusiness export revenue, which includes 70% of soy exported by Brazil, in addition to 30% of beef, 32% of pork, 18% of poultry meat. The Eurozone represents 16.2% of Brazilian agribusiness exports, being a major buyer of soybeans, forest products, coffee and fruits. The United States comes next with 7.4% of revenues, mainly from forest products, coffee, sugar and fruits.

As for land use in Brazil, 30% is used in production (crops and planted forests, 9%; planted pastures, 13% and native pastures, 8%); preservation areas represent 33.6%; indigenous areas, 13.8%; unregistered native vegetation, 19%. World demand for agricultural products is projected to increase significantly in the coming decades as the population increases, incomes rise and urbanization expands. Brazil can and will help fulfill this demand – maintaining its support for agricultural science and innovation and infrastructure, and strengthening institutions linked to the agricultural sector. Aside quantity and food security, there will be increasing demands for quality (including sanitary issues), environmental sustainability and human rights.

2. How it all started – the coffee boost

According to Prado Jr. (1945), Brazil's economic history up until the 1930s is usually explained in cycles (all with a high export bias): (a) Pau-Brasil or redwood (16th century), (b) sugar (16th and 17th centuries), (c) gold (18th century), (d) cotton (18th and early 19th century), (e) rubber (late 19th and early 20th century), and (f) coffee (from 1870 to early twentieth century). Looking at the 19th century, in 1820, 30% of the value of exports came from sugar, with cotton and coffee accounting for about 20% each. By the end of the century, coffee accounted for 60% of exports; sugar, 10%; and rubber, 8% (Abreu, s.d.). Brazil relied almost exclusively on imports for the supply of industrial goods (mainly cotton and wool products, beverages, fish, wheat and wheat flour and coal). Average import tariffs increased from 25% -30% to 40% by the end of the century. These tariffs were fundamental as a source of tax revenue, representing 40% to 70% of the total collected by the public sector (Abreu, s.d.). The export tax was much lower – from 5% to 7% – but it represented up to 25% of the total tax collection. Poverty of the vast majority of the population and inadequate food supply were a constant throughout all these cycles, a characteristic of the Brazilian economy, which exists still today, although significantly attenuated by overcoming the antagonism between agricultural production for export and domestic consumption.

As Girardi (2014) recalls, in Brazil, the process of occupation of new territorial areas was mainly due to the amplification of agricultural activities. In the 16th and 17th centuries, the Northeast and Southeast coasts were occupied where Pau-Brasil was abundant in the Atlantic Forest. Farming began in the Northeast (where colonial occupation began) – with sugar (in part due to aggressive measures undertaken by Dutch traders to meet high demand in Europe) – and then also in the Southeast – with sugar and cattle and some mining. In the 18th century, sugar began to decline (with the Dutch moving away from the Northeast of Brazil to produce in the Antilles) and lost importance to mining, which expanded in Bahia, Minas Gerais, Goias and Mato Grosso, taking with it the agricultural production to supply the surrounding population. In 1870, the northeastern sugarcane sector received support from the imperial government for the structuring and modernization of the central mills in place of the colonial mills, with funding for upgraded industrial machinery. Suppliers offered raw sugarcane to the mill on a contract basis. The scope of this production was limited (Durham, Bomtempo, Fleck, 2010).

Cotton stood out in the second half of the 18th century (with the impetus of the English Industrial Revolution) and early 19th, when it declined, especially in the face of excessive taxation (up to 22%, Insper, sd), losing market-share to the North Americans. It is a fact that, beginning in the 19th century, the Northeast began to cede population, as well as economic activities, to other regions of the country. During this period, livestock retreated in the Northeast – dividing the land with cotton – and developed in the South, focused primarily on leather. At the other extreme of the country, rubber extraction was expanding in the Amazon region, fueled by the industrial revolution, especially with the emergence of tires (1890/1900), accounting for up to 60% of world supply and up to a quarter of Brazilian exports. Rubber exports continued into the beginning of the 20th century, when the product lost competitiveness to rubber plantations cultivated in Asian and African countries (Bueno, 2012).

In 1880, agriculture represented 80% of Brazilian GDP, and 60% of its production was destined for the foreign market (Villela & Suzigan, 2001). The production of staple foods – not commodities – was directed for self-consumption within rural establishments without focusing on the small urban population, which was essentially supplied with surplus from the farming regions.

Coffee was planted in the state of Maranhao in the 18th century and taken to several states in the Northeast, before it was established in southeastern Brazil in the mid-nineteenth century. In the 1880s, when Sao Paulo began to lead the country in coffee production (Stein, 1990), it became responsible, in large part, for the creation and expansion of the Brazilian domestic market. In addition, coffee reinforced the capitalist form of production in the countryside – replacing African slave labor with wage laborers, many of whom were immigrants from Europe, and latter from Asia (Delgado, 2009). Immigration to Brazil – largely promoted and subsidized by the government, reached nearly 2 million people between 1885 and 1906. Over 60% of immigrants were Italians (Taunay, 1939). These immigrants made important contributions of human capital to industrialization, especially in Sao Paulo, where most of them located (IGBE, 2006). Coffee in Sao Paulo began to benefit from research activities with the creation in 1887 of the Agronomic Institute of Campinas (IAC)[2], which permitted soil fertilization and the adoption of new production and post-production practices.

Coffee was a great source of foreign exchange and savings for the country. In the second half of the 19th century, Brazil had a surge of railroad

[2] Following the creation of the IAC, several other research and higher education institutions were created: Luiz de Queiroz College of Agriculture (Esalq) – 1901, School of Agriculture of Lavras (ESAL) – 1908, Federal University of Viçosa (UFV) – 1927, the first seed company in Brazil (Agroceres) – 1938, National Council for Scientific and Technological Development (CNPq) – 1951, The Sao Paulo Research Foundation (FAPESP) – 1962, the beginning of Graduate Studies at Esalq – 1963, Brazilian Seed and Bud Association (Abrasem) – 1971, and the Brazilian Agricultural Research Corporation (Embrapa) – 1973. See Vieira Filho and Vieira (2013).

development: as of 1877, 1,120 kilometers (km) had been built; in 1889 there were 9,500 km (Ministério da Infraestrutura, 2019[3]); in 1920, 28,500 km (Lanna, 2005); in 1930, 34,000 km, the peak railway extension achieved in Brazil. Today there are 30,000 km of railways (Campos Neto, 2010). Infrastructure development – railways, ports, communications, energy – was largely due to the synergies brought about by coffee (Bresser Pereira, 2003). The potential of coffee to generate income and foreign exchange attracted foreign capital (from England and United States) to these infrastructure works. From 1880 to 1930 the value of the annual flow of this capital multiplied by seven (Dean, 2002). In both years, the annual values of these foreign investments amounted to five years of coffee exports.

The coffee businesses experienced ups and downs in the late 19th and early 20th centuries, even after its migration from Rio de Janeiro – where it declined due to soil depletion and scarcity of labor (Stein, 1990) – to Sao Paulo. In 1890, Sao Paulo accounted for just over 60% of production; Minas Gerais produced around 20% and Rio de Janeiro about 10% (Pires, 2007). By 1930 Rio de Janeiro's production was negligible.

In the final decades of the nineteenth century, world demand for coffee grew significantly with the expansion of income and the increasing popularization of coffee consumption among industrial workers (Topyc & Clarence-Smith, 2003), especially in the United States. Prices fluctuated widely, with big highs followed by corresponding lows. Even so, given the steady increases in production in the last decade of the 19th century, national production doubled; from 1882 to 1905 Brazilian coffee exports grew by 93% even in the face of modest consumption growth (Saes, 1995). This led to an overproduction of coffee. The fall in revenues in foreign currency resulted in a currency devaluation – also due to a highly expansive monetary policy – which eventually mitigated the crop's loss of profitability and maintained excess production.

From 1906, a coffee valorization policy was implemented (Ribeiro, 2011) with purchase and storage of surpluses by the government. Financing was provided by foreign capital and paid for with taxes collected on exports. A mechanism for exchange rate control was also established. This policy,

[3] In: https://infraestrutura.gov.br/conteudo/136-transportes-no-brasil-sintese-historica.html (13/09/2019).

which became known as the "Taubaté Agreement", lasted until 1913. More significant interventions occurred again from 1919 to 1926. Following a rise in international prices of around 170% from 1917 to 1929, there was a strong expansion in production, not accompanied by an increase in exports (Bacha, 1992), resulting in a substantial increase in inventories. Coffee – as well as corn and beans – had spread from Sao Paulo to Paraná in the late 19th and 20th centuries, where occupation was controlled by a British development company, involving railroad construction and based on the predominance of small producers.

In parallel with coffee developments in the Southeast, other initiatives were taking place in Brazilian agriculture. As reported by Chaddad (2017), in the 19th century, there was a significant flow of immigrants – Italians, Germans and Slavs – to the south of the country. The cooperative system brought from their regions of origin was reproduced, enabling the production of grains, livestock and their derivatives. In Paraná and Santa Catarina, the production of milk, poultry and pigs also flourished.

The growth of coffee production continued up until the world economic crisis of 1929. During this period the Brazilian product was considered inferior to Colombian coffee and losing market to the superior product. In 1930, 50% of the farmers' debt was canceled by the government. Between 1931 and 1944, it is estimated that 100 million bags of coffee were purchased by the government – equivalent to 38% of national production in the period (Bacha & Greenbill, 1992; Ipeadata) – and 80% (Saes, 1995) was destroyed (burned), a strategy financed by currency issuance. In spite of this there was no significant price improvement (FGV[4]).

3. The food crises and the industrialization project

The history of Brazilian agriculture was linked to the history of industry, in a relationship of interdependence involving the use of productive resources, voluntary or forced flows of income and competition for public sector

[4] Fundação Getulio Vargas. Café. Centro de Pesquisa e Documentação de História Contemporânea (CPDOC). In: http://www.fgv.br/Cpdoc/Acervo/dicionarios/verbete-tematico/cafe-1.

resources. The leap in Brazilian agriculture in the second half of the 20th century was due, in large part, to the need to make the process of industrialization and consequent urbanization viable while maintaining acceptable living conditions for Brazilian society and the economic performance of the country healthy.

In Brazil, as in many other countries, development has been synonymous with industrialization. Following this strategy, since the 1930s, a vigorous process of industrialization, led and coordinated by the public sector, was initiated, with the allocation of internal savings – from agriculture – and external savings – from direct investments and loans – to industry.

It should by recalled that, in 1900, the Brazilian state was relatively small, with a tax burden of 10% of GDP, and imports as a primary source of revenue. About 45% of Brazil's GDP came from the agriculture, a figure which did not include agricultural-based industry (coffee, rubber, cotton and food and beverages, – Bonelli, 2006). The industrial sector as a whole approached 12% of GDP. About 52% of Brazil's working population was employed in agriculture. It can be assumed that labor productivity in the countryside and in the city were similar.

As industrialization progressed, the traces of the agro-exporting economy that had characterized Brazil since colonization by the Portuguese began to decline. In 1920, about 75% of the manufacturing industry was agricultural based; in 1940 it was 63% (according to data in Baer, 2009). In 1930, 75% of the value of exports came from coffee, an eminently export-oriented crop – 65% of its production was exported (IBGE, Ipeadata). Brazil accounted for three-quarters of the world's coffee supply (Fristch, 1990). In the early decades of the 20th century, its major consumers were the United States, followed by a handful of European countries.

The sugar and alcohol sector suffered from an attack of the mosaic disease, which in the 1920s reduced production to less than a quarter of its previous levels. This very nearly impeded the creation of the fuel ethanol market in that decade. The creation of the Piracicaba Sugarcane Experimental Station (EECP), in the state of Sao Paulo, working in a network with several sugarcane mills, was successful in the variety selection process. The Campinas IAC succeeded EECP's attributions in 1953, creating new varieties. The compulsory addition of alcohol to gasoline began in 1931, with incentives to import equipment. In 1937 cooperation between sugarcane mills with national equipment industries was organized, which would prove to be a fruitful and lasting relationship, with a subsequent and important impact on the industrialization of Sao Paulo. Anhydrous alcohol production from 1930 multiplied by a factor of eighteen as of 1936 and by fifty by 1940 (Durham, Bomtempo, Fleck, 2010).

With the global economic crisis, the fall in coffee income and the currency devaluation negatively impacted the Brazilian ability to import, which has been interpreted as the opportunity that arose to produce internally what until then was imported (Furtado, 1968). A program of industrialization based on import substitution was established. By the same token, coffee-related expansionary fiscal and monetary policies had a Keynesian effect on Brazil's recovery from the effects of the global crisis. In the two years of crisis 1930/31 Brazilian GDP fell 5.4%; over the next 3 years (1932/34) it grew by 24% (Ipeadata). The reasons for this rapid recovery have been widely debated. Among them monetary expansion (with currency devaluation) brought about recovery of the coffee sector, the diversion of demand for imports contributed to the establishment of a domestic market (where there was strong idleness fueled by unmet demand), the ease of cheap importation of already used capital goods from developed countries, etc.

From 1930 onwards, but even more so since the 1950s, Brazil would make the strategic option for road transportation. The railroads were overlooked in an attempt to attract foreign capital for local car, bus and truck production. The assumption was that this strategy would generate multiplier effects leading to the installation of related industries of parts and components. This decision would have highly significant impacts on the Brazilian economy and society in general, from the point of view of logistics costs and competitiveness, social investments and environmental issues.

Since the 1940s there has been a genuine concern established with the issue of food, nutrition and cost of living in Brazil. Castro (1946) published his book "Geography of Hunger", which generated international repercussions. He built a Hunger Map that ranked the country in five regions in relation to hunger and malnutrition related to the usual diet based on regional foods and habits: (a) Amazon and Sugar producing-Northeast (northeastern coast): endemic hunger (at least half of the population with permanent nutritional deficiency – with low calorie consumption),

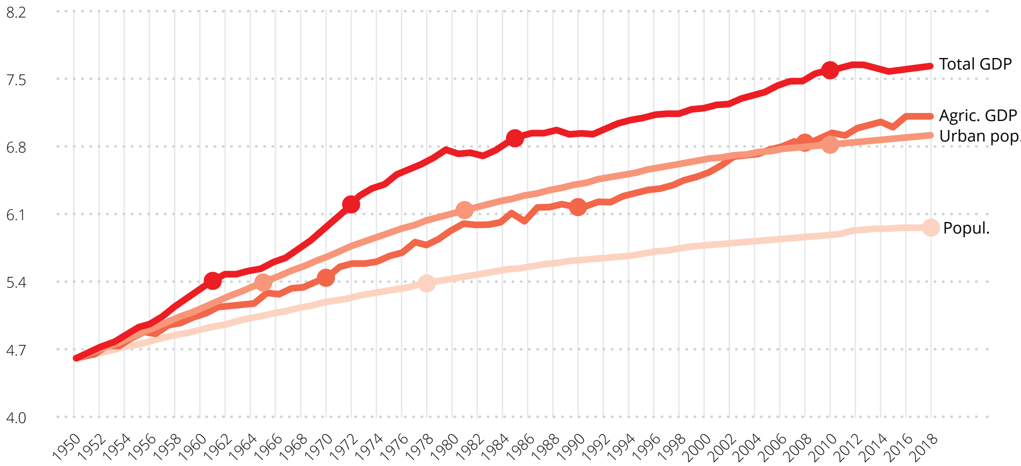
(b) Northeastern "Sertão" (Northeast interior): epidemic hunger (at least half of the population with nutritional deficiency), (c) Center West, Southeast and South: Malnutrition (lack of protein and vitamins for certain classes or social groups).

In the 1930s, the Brazilian population was still growing at 1.5% per year. By the following decade (1940), total population growth had accelerated to 2.3% per year, while urban population growth had accelerated to 3.9% per year. Accelerated rural-urban migration was made up of a subsistence-based rural labor force. More and more people who once produced for self-consumption in the countryside now had to find jobs in the city to pay for their food at a price that now included the rural-urban cost of transportation and commercialization. From 1939 to 1950, Sao Paulo families spent 58% of their income on food (Yuba, Sarti, Campino & Carmo, 2013).

From 1950 to 1960, Brazil's total GDP grew by 7.1% per year; agricultural GDP increased by 4.4%; since the relative price of agriculture fell by 0.6%, the share of agricultural GDP in total GDP went from 22.8% to 16.1%. In the following decade (1960 to 1970), the economy grew by 5.6% per year, agriculture expanded by 3.9% and its relative price fell by 2.2%; the share of agricultural GDP fell to 10.4% of the total. Hitherto agricultural growth had taken place and, although lower than that of the economy, had not raised real producer prices. As shown in Figure 1, the GDP of the Brazilian economy doubled (approximately) from 1950 to 1961, from 1961 to 1971 and from 1971 to 1980, that is, it doubled every decade[5]. Agricultural production doubled in 1969 and 1985; i.e. after 19 years and then again 16 years later. Population doubled in 27 years. The three variables would double once more before the end of the period considered. The urban population, in turn, grew faster than the total population and also than the agricultural production: it doubled between 1950 in 1966 and again in 1982. Roughly speaking, although the GDP of agriculture grew in relation to the total population, it basically kept up with the urbanization process.

[5] Figure 1 has the vertical axis in units of ln (2), so each time the curve crosses a horizontal line (indicated by a marker), the variable it represents will have doubled in magnitude.

Figure 1. Indexes of total Brazil GDP, agricultural GDP, total Brazilian population and urban population, 1950/2018



Data in neperian logarithmic scale. Sources: IBGE and World Bank. Author's calculations.

In urban centers undergoing rapid industrialization, such as Sao Paulo, the rising cost of living, had a severe impact on labor costs, threatening the viability of industry. The production of staples – with the exception of milk and pork – was growing sufficiently to increase per capita availability; nonetheless, from 1940 to 1948, the cost of living in Sao Paulo grew 48% in real terms (that is, compared to the GDP deflator – a measure of producer prices[6]). This meant that it was more difficult for the urban productive sector to remunerate labor in proportion to the rising consumer prices. From 1940 to 1970, prices rose 83% (FIPE, IBGE, Ipeadata).

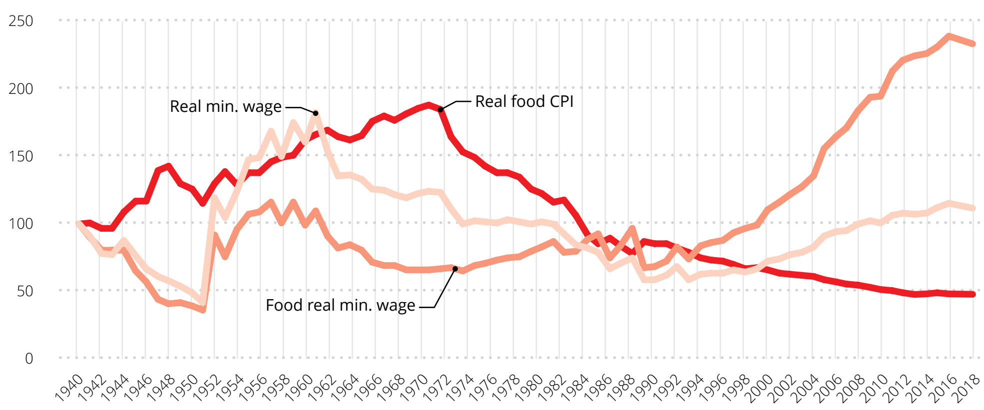
The cost of living for laborers and the scarcity of foreign exchange for imports constrained the industrialization plans. The productivity per hectare of the staple foods of Brazilian families had had a very weak performance as of 1930. From 1930 to 1950, the productivity of rice grew by 10%; bean productivity decreased by 50%, and for orange and cotton it fell by 15% to 20%. Even so, per capita availability increased, with the exception of milk, but

[6] The evolution of the cost of living compares the growth of the consumer price (CPI) for the city of Sao Paulo (from the Institute of Economic Research Foundation – FIPE) and that of the implicit GDP deflator. (IBGE, Ipeadata).

at increasing cost, due to a substantial increase in planted area (IBGE). More importantly, this availability, although increasing, was clearly insufficient to meet the food needs of the majority of the population.

In Figure 2, we can see how the cost of food impacted the growing urban populations. In Sao Paulo, from 1940 to the mid-1970s, real food costs (CPI discounted by a GDP deflator) increased by 89%. In the 1940s, the official minimum wage fell by 60% in real terms (compared to the food price index in Sao Paulo). To mitigate this impact, the government began to grant larger nominal increases in the minimum wage and was able to recover its value from the mid-1950s. However, these wage increases created greater costs for the employer: to restore the 1940 real value of the wage, it had to be raised to the point of increasing the wage cost by 55% (relative to product prices, reflected in the GDP deflator). In the 1960s, wage policy was restrained, and real wages fell as food costs continued to rise. Thus, the cost of labor was also contained, stabilizing in the second half of the 1970s.

Figure 2. Real food consumer price index, real food minimum wage and real minimum wage. Sao Paulo/Brazil, 1940/2018



Sources: Fundação Instituto de Pesquisas Econômicas (Fipe), Instituto Brasileiro de Geografia e Estatística (IBGE). Author's calculations.

Alongside the barely sufficient (albeit significant, due to expansion of the area) growth in food production, the commercialization cost was substantially increased due to market concentration and logistical deficiencies. The government decided to act on the problem in the urban environment by setting up a complex price control apparatus, which escalated with increasing and prolonged intervention in the market economy. Minimum producer prices and maximum consumer prices were stipulated, but both proved ineffective. Milk, for example, had its price controlled since 1945 to around 1990. As is often the case, such interventions disturbed the market, but did not improve supply or reduce the cost of living.

The strategic occupation of the Center West region of the country was pursued in the 1940s. On the one hand, it was a matter of occupying a "huge empty space" – actually, indigenous lands (Batista, Martins Jr. & Ziliani, 2007)–, whose productive resources could be put into production, helping to increase the food supply, although requiring heavy investments. On the other hand, it represented the alternative of settling on small farms for a large population of landless and extremely poor farmers, especially in the Northeast, which would otherwise perpetuate the intense and excessive rural-urban migratory flow. The assessment of this first experience in the Center West, however, is that it was a failure. The government failed to provide infrastructure and education and health services. Technical assistance and funding were also lacking.

The agricultural sector in Brazil has been for decades penalized in pricing policies used to artificially control the inflationary process. Since the 1950s, price control has expanded even further over food (Mata, 1980). Even after the creation of the agriculture price support program in the 1960s, consumer food price controls continued. When inflation became high and chronic in the Brazilian economy – from the 1970s to the 1980s – price control became widespread, and came to include wages. Soon the degree of indexation – both informal and formal – was intensifying, which aimed to discipline inflation, but reduced the power of any policy aimed at reducing it. In fact, with prices and wages driven by past inflation, the trend was for continued acceleration of inflation.

Of course, such interventions did not solve the problem of real food costs that resulted from both the low income of the urban population and the low productivity and efficiency in agricultural production, coupled with deficiencies in logistics infrastructure. They resulted, moreover, in price and margin distortions that greatly impaired the functioning of markets and the allocation of resources in the economy.

Another factor that, as a rule, has impaired the overall efficiency of the Brazilian economy, has been the exchange rate policy, aimed at controlling the real exchange rate. Important currency devaluations tended to occur at times of financial crisis, often based on political crises, institutional insecurity or events that disrupted the normality of trade or capital flows between countries. Aside from such abnormal conditions, what was observed was a tendency to keep the exchange rate overvalued, either to help the industrialization process or as an instrument to contain the chronic inflationary process. This meant that to be successful in exports, the productive sector had to maintain increasing levels of productivity and efficiency.

4. Productivity as a lever for agricultural growth

A more focused look on the needs of the agricultural sector and its transformative potential of the Brazilian economy can be seen as of the 1960s. Hitherto treated as conservative and traditionalist, a source of savings to fund other sectors, now the bet was that investments in agriculture could result in positive net benefits for society as a whole. Two mechanisms of public support for agriculture were created. One of these was the program of minimum prices and regulatory stocks to contain the effects of output fluctuations and market risks. Its relevance though was very small in the 1960s (like previous experiences in the 1940s); from the 1970s onwards it gradually expanded and became very important, reaching its peak in the late 1980s. This program was generally implemented with limited efficiency because of the lack of timely government action in setting minimum prices, making resources available, and performing purchasing and logistics operations (Barros, 2000).

The subsidized rural credit program was also created. Intended to encourage the use of modern inputs and mechanization, it had a marked evolution from the 1960s to the 1970s: from less than 40% of agricultural GDP to over 70%, peaking in 1979 when it reached 77% (Brazil's Central Bank, IBGE, Ipeadata). The amount of subsidies granted has also reached impressive figures: small interest rates in the 1960s turned into negative real rates – between 30% and 40% per year in the late 1970s, when the amount of rural credit subsidies reached 20% of agricultural GDP (Shirota, 1988). It is clear that under these conditions, the demand for rural credit was immense, and rationing systems were adopted that favored the largest producers, contributing to the concentration of income in the sector.

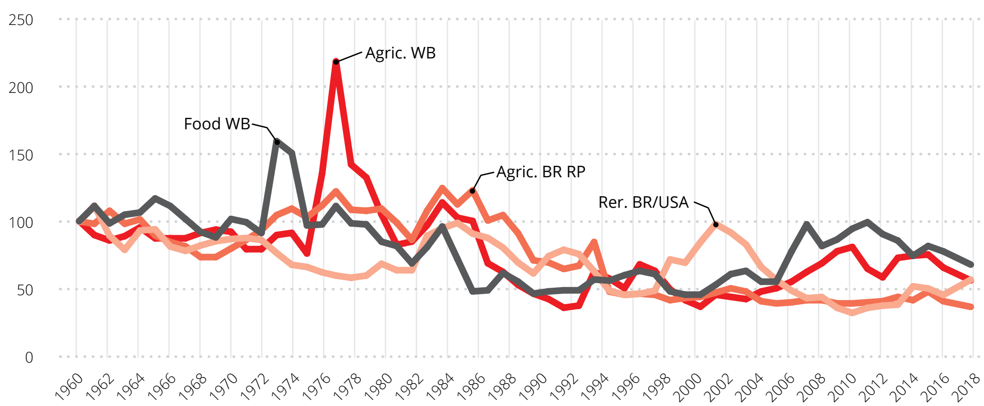
The minimum price and rural credit programs, together with the work of research and extension institutions, allowed important steps towards modernization, with excellent medium-term results for Brazilian society. Alves and Contini (1988) indicate that agricultural research institutions in the state of Sao Paulo created technologies and knowledge that were incorporated in the Southeast, South and Northeast. The transfer of genetic resources from other countries and the diffusion of the use of fertilizers and pesticides represented the beginning of the modernization of Brazilian agriculture. Up until the 1970s, therefore, Brazilian agriculture had been able to use technologies generated in other countries. The development of national technology was still incipient.

In the 1960s, there were also two initiatives focused on the problems within the agriculture (or rural environment): one was the Land Statute – aimed at land reform and property regularization – and the other, the Rural Labor Statute, an effort to extend to the rural worker the rights already granted to the urban worker. On the one hand, a process of land distribution began, predominantly in terms of colonization of new areas, quite tumultuous and ineffective (Martins, 2000). On the other hand, along with the improvement of the working conditions for the rural worker, there has been an increase in the labor costs and a strong incentive for its replacement in a context of cheap credit for mechanization, biased towards the largest farms (Rezende, 2006).

As with energy (coal, oil and gas), the dollar prices of agricultural commodities rose rapidly in the 1970s; but much less than the oil price: while real energy prices increased by 230% from 1960 to 1974, the agricultural products price rose by 30% (for food, 67% and grain, 79%). However, from 1974 to 1980, energy prices grew by 92%, those of agriculture fell by 30%, food prices fell by 40% and grain by 50% (World Bank). Figure 3 shows the evolution of agricultural and food international prices (in dollars), the Brazil-United States real exchange rate (taking the respective GDP deflators as price parameters) and the relative agricultural price (ratio between deflators of agricultural and of total GDP). Increases in international food prices preceded those of agricultural products in general by a couple of years, but both had retreated by the end of the 1970s. The Brazilian exchange rate appreciated during the same period, which contained the transmission of the external increase to the domestic market.

The first phase of higher prices, despite its effects on the cost of living, may have been strategic for agricultural growth considering the scenario at the time. First, it sharpened the sense of urgency to address hunger, malnutrition and poverty. Secondly, it signaled that the foreign market could be exploited if the problems of agricultural productivity were solved – from 1960 to 1980, world GDP grew at 4.5% per year (IMF). Thirdly, it induced the country to look for sugarcane ethanol as an alternative to reduce dependence on fossil fuel. These last two possibilities were viewed with pessimism at the time, as they would represent two resource deviations from scarce food production. Even so, both began to be explored in light of Brazil's dependence on oil imports, albeit attenuated by the substitution by ethanol.

Figure 3. World prices of agricultural products and food, relative agricultural price in Brazil, real exchange rate against the US dollar



Sources: IBGE, World Bank, Ipeadata.

Soybean showed signs of significant surplus production capacity and sugarcane had an important alternative in ethanol to limit its exposure to volatility in international commodities. The composition of Brazilian agricultural production was skewed towards soybean, oranges, sugarcane, tobacco and cocoa, all products with prices formed in foreign markets, where prices rose faster than the prices of local agricultural products in Brazil (Melo, 1982). While soybean was growing in the South and Center West, sugarcane and oranges stood out in Sao Paulo.

Soybean had its first expansion in the South as a wheat-associated crop for technical and economic reasons. Since wheat was favored by public policy in the mid-1950s, soybean also benefited (Embrapa-Soja[7]). In the 1950s, the Agronomic Institute of Campinas (IAC) began its research on soybeans, which until then had focuses on varieties brought from the United States (IAC, 2000). The process continued in the 1960s, when soybean production multiplied by a factor of seven (the soybean area expanded fivefold) and consolidated in the 1970s, when it multiplied by ten, and the area grew sevenfold (IBGE, Ipeadata). In those years, Embrapa (established in 1973), universities and regional institutes also turned to soy work. In 1980, 20% of soybean production was in the Center West.

The increased production of crops, especially grains – mainly due to the expansion of cultivated areas, not productivity – helped in the evolution of the production of animal products. Along with the increased availability of feed, cattle slaughter age reduction, genetic improvement, pasture and management practices, including different forms of finishing and confinement, were observed. Poultry and pigs have gained from genetic advances and new models of farm-industry integration. The food and beverage industry has been able – at least until the 2000s – to maintain its share of Brazilian GDP (3% on average) practically stable since the 1970s, while the manufacturing industry share as a whole has fallen since the mid-1970s.

Growth, however, was not homogeneous among producers: only those with physical capital (in machines, equipment), land (large enough to exploit economies of scale and size) and human capital (schooling and experience) could use productive resources efficiently. Concerns about poverty persisted: essentially among those without land and also among rural employees, whose living conditions were socially unacceptable. From 1960 to the mid-1970s, Value Added per household was 5 to 7 times higher in non-agricultural than in agricultural activities. A nonagricultural manual worker earned a salary that was twice that of the agricultural worker (Pfeffermann & Webb, 1983). As a result, rural-urban migration accelerated (quadrupled approximately from 1950 to 1980), with the share of rural population falling from 55% to 32% between 1960 and 1980 (IBGE).

[7] In: Embrapa-Soja https://www.embrapa.br/soja/cultivos/soja1/historia. (25/09/2019).

In the face of poverty and food scarcity – to which were added the ambitions related to exports and the ethanol program – the perception of the need to tackle the problem at its roots prevailed – seeking productivity and efficiency throughout the entire Brazilian territory, beyond the South and Southeast. On the basis of agricultural price and credit policies of the 1960s, in the early 1970s, the National Agricultural Research System was established, headed by the newly created Brazilian Agricultural Research Corporation (EMBRAPA) and composed of all sub regional research institutions in this area. Embrapa's budget increased 270% over its first seven years. Average increases were highest in the 1990s: more than four times the first year budget (Alves & Oliveira, 2005). In 2010, it had grown 25% compared to the 1990s (Embrapa, 2014). Although it oscillates, Embrapa's budget has maintained a fairly robust level over time.

According to Alves (2007), EMBRAPA was organized in regional centers focused on specific products (soybean, corn, beef cattle, etc.) and types of natural resources (Brazilian savannahs – the so-called "cerrado", semi-arid tropics, humid tropics and lowlands) in order to integrate researchers and farmers. Partnerships with universities and the private sector also made up part of the system. This research system was coupled with the Brazilian National Rural Extension and Technical Assistance Corporation (Embrater), aggregating the regional public institutions (institutes, universities) involved in these activities.

After the failure of the first attempt to integrate the Center West into the national agricultural system, a more robust attempt was made from the 1970s, which now received more attention due to the transfer of the federal capital from Rio de Janeiro to Brasilia, located in the Center West, in 1960. At the interface with the new advance in the Center West, the research and extension system played a significant role in enabling the use of its acidic soil, by way of correction, plus the use of seeds of varieties adapted to the conditions of the region. Only 462 thousand hectares – about 2% of croplands (Ferreira, 2015) – were irrigated in Brazil (63% in the Southeast and 26% in the Northeast) in 1960. In the mid-1970s, the so-called second crop (known as "safrinha", meaning "small crop") was adopted in the same year, with corn planted after the soybean harvest. During this period, Embrapa began research on the selection of bacteria for use in the biological nitrogen fixation process in soybeans, which increased productivity and reduced the amount of fertilizer used, predominantly imported). Modern and efficient crops were implanted where the traditional extensive beef cattle production had predominated (Alves, Contini, & Gasques, 2009).

Government programs focused on logistics, electricity, mechanization and soil repair catalyzed regional growth. There are 204 million hectares in the region, of which 125 million are potentially suitable for agriculture (Resk, 2002). The population in the Center West grew by 46%, while in Brazil as a whole this growth was 26% from 1970 to 1980. In addition to the large number of migrants from the Northeast, who were seeking government land grants, farmers from the South and Southeast, holders of financial and human capital and technical and administrative skills, were also attracted to the region. Migrants from the South and Southeast were able to make use of new technologies and to acquire greater quantities of the cheaper land in the Center West with the funds obtained from the sale of their more expensive farms in the South and Southeast.

From 1970 to 1980, the cultivated area (crops and pastures) grew by 20% relative to the total area of Brazilian farms; in the Center West land occupation doubled during this period (Shiki, Graziano & Ortega,1997). In Brazil as a whole, the tractor stock more than tripled during this period. Rural credit volume quadrupled in Brazil and grew 6.5 times in the Center West (Brazil's Central Bank). Total consumption of chemical fertilizers more than doubled between 1975 to 1980, exceeding 4 million tons per year (Alves, Contini, & Gasques, 2008). In the 1970s, the 50% growth in crop production was still determined essentially by increasing farming area, with productivity per hectare remaining practically constant. Soybeans were an exception with a 50% productivity growth per hectare. There was also a substantial increase in the number of people employed in agriculture, of 21%, reaching 21.2 million people in 1980 (IBGE).

Two important technological changes that would mark Brazilian agriculture had their first experiences and initiatives in the 1960s. One of them was the no-tillage system (NTS) for crops; the other was the formation of pastures with *Brachiaria decumbens* from Africa for cattle raising.

The NTS – a conservationist system, reducing soil erosion, increasing farm productivity and efficiency – was first used at the Agronomic Institute of Campinas (IAC) in Sao Paulo as early as 1943. But in the 1960s, a dynamic and progressive process began in Rio Grande do Sul, Paraná, and Sao Paulo, through the work of research institutions and universities. Since the 1970s, with the assistance of Embrapa, the necessary herbicides, machinery and management techniques such as crop rotation, etc., have been developed for this technique. In the Center West, in the 1980s, the no-till system reached the “cerrado”. Where the introduction of the so-called “safrinha” (second corn crop) is feasible there is a strong complementarity with the NTS. The Integrated crop-livestock systems involving corn and *Brachiaria* would come in the 1990s (Cruz et al., Rede Agronomia).

From the 1960s, various species of *Brachiaria* were being implanted in the Center West – due to their resistance to acid and low fertility soils and adaptability and low susceptibility to various pests and diseases – in a system including non-irrigated rice crop. The studies and dissemination of this grass in the 1970s took place within the framework of regional development programs such as Polocentro and Prodecer[8]. In the 1980s, crop-livestock integration (CLI) began to be used, enabling the recovery of degraded pastures and a reduction in greenhouse gas generation (Kluthcouski et al., 2013). The reduction in slaughter age of the animals was a result.

5. Industrialization results disappoint and agribusiness takes the lead in the economy

The contribution of the industry to the improvement of the population’s living conditions was disappointing. From 1930 to 1980, when it reached its peak, industry grew at 8.2% per year, increasing its share from 15% to 34% of Brazil’s GDP, which expanded at an average rate of 6.5% per year in this period (see Figure 1). Agriculture’s share of the economy shrunk from 36% to 9.8% of GDP, despite its growth of 3.7% per year (Bonelli, 2006). From 1970 to 1980, total GDP grew at 9.4% per year; the agricultural segment, 4.7%; the agriculture relative price increased by 3.2% per year. Between 1950 to 1980, the total economy grew in volume more than agriculture did, although the agricultural GDP grew steadily over that period. Agricultural prices fell in the 1950s and 1960s and increased in the 1970s, but not enough to prevent its relative share of GDP from falling.

[8] Development of the Cerrados Program (Polocentro) and Japanese-Brazilian Cooperation Program for Cerrados Development (Prodecer).

The urban population, which in 1940 represented 31% of the total, increased to 68% in 1980. It was a population with a very low level of education: 56% were illiterate in 1940 (IBGE, Ipeadata). In 1980, 26% were still in this situation, and the workforce's average number of years in school was three (De Nigri & Cavalcanti, 2014). Thus, despite the large investment effort made in physical capital – from 14% to 24% of GDP between 1940 and 1980 (Bacha & Bonelli, 2004) – human capital did not evolve correspondingly, a mistaken public policy for which Brazil still pays very dearly.

Although real per capita GDP in Brazil grew by 3.9% per year between 1930 and 1980 – from US$ 1,210 to US$ 8,320 (measured in 2013 prices, Ipeadata), income concentration has increased so substantially that only a minority saw an increase in purchasing power during this period. In 1980, due to labor-saving technology imported from developed countries and the low average qualification of the Brazilian workforce, the industrial sector employed 25% of the economically active population (Aggio, Barbosa & Lambert, p.89). This meant that most of the urban population was poorly remunerated, that is, only 25% had access to industrial employment, where labor productivity was 13 times higher than in agriculture (Menezes Filho, Campos & Komatsu, 2014). From 1970 to 1980, labor productivity grew 50% in industry (Menezes Filho, Campos & Komatsu, 2014) and 32% in agriculture (IBGE). It was an important step from the point of view of increasing overall worker income, but it reinforced the sectoral productivity gap. The number of people employed in agriculture, after reaching the historical peak of 23.4 million in 1985, fell 23.5% to 17.9 million in 1990. This is partly explained by the fact that the stock of tractors in use in agriculture grew until 1996, while the planted area peaked in 1988, only increasing again from 2003 on. From 1960 to 1980, the Gini Index of income concentration in Brazil grew from 0.535 to 0.589 (Neri, 2011). The proportion of poor (insufficient income for basic needs) in 1980 was 43.1% (Barros, Henriques e Mendonça, 2011).

Another negative legacy of the industrialization effort was financial: the foreign debt (net of reserves), which grew 53% in the 1960s and increased tenfold in the 1970s (World Bank[9]). The external current account deficit was

[9] World Bank, International Monetary Fund (2019): https://data.worldbank.org/indicator.

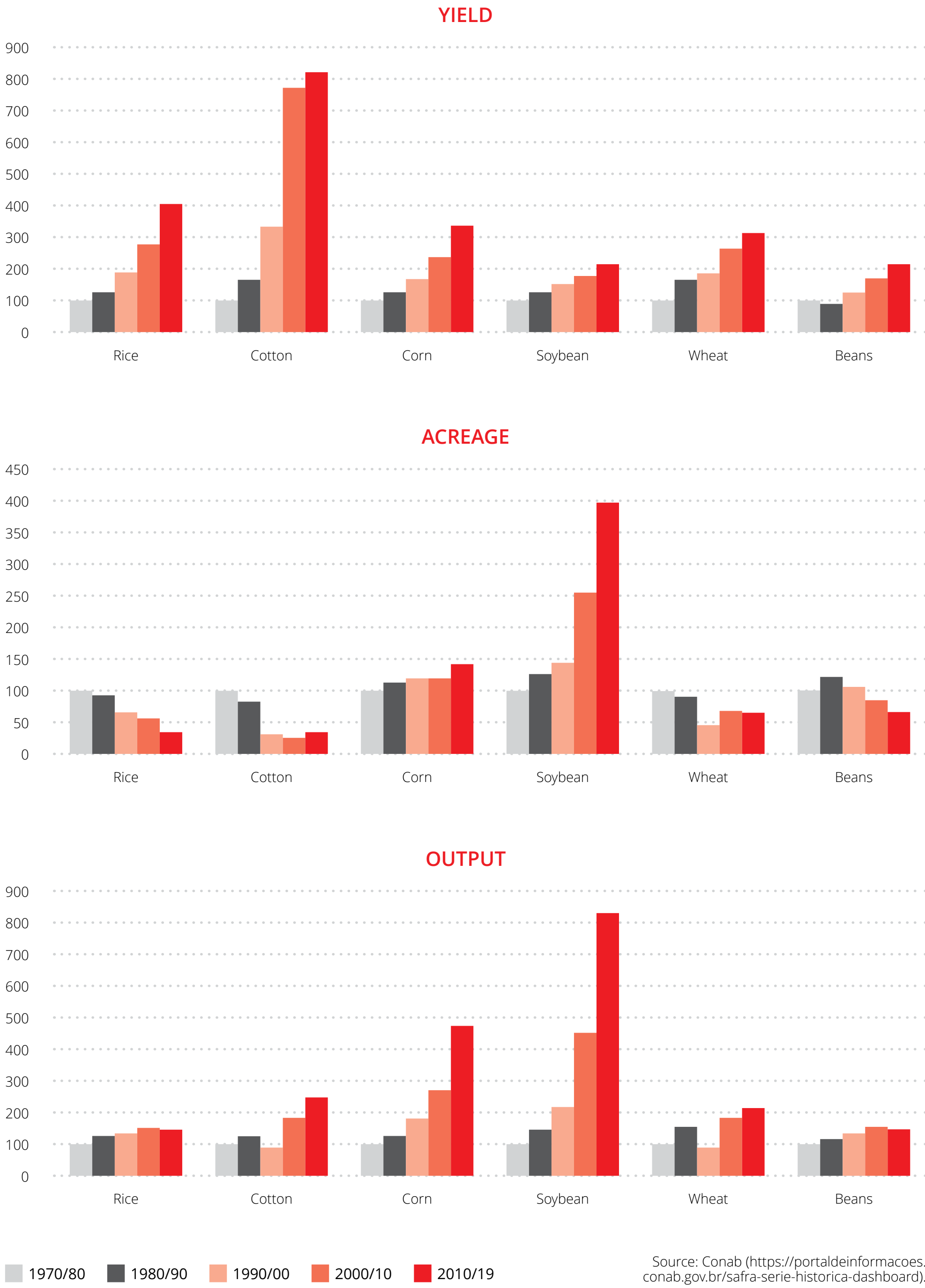
multiplied by 13 in the 1970s, foreshadowing the need for debt renegotiation within a few years. Average annual inflation was over 40% in these two decades (from 1960 to 1980). Inflation and the external debt problems had to do with the continued intensification of industrialization and the maintenance of growth even in the face of the oil crisis, during which the price of this commodity went from US$ 1.20 per barrel to US$ 37.00 between 1970 to 1980 (World Bank).

From 1980 onwards in agriculture output and cultivated area followed different trends: from 1980 to 1990 the constant prices value of crop production increased by about 30% while the harvested area remained essentially unchanged (Bragagnolo & Barros, 2015). The production of cereals and oilseeds grew 65% in the decade, the production of beef advanced 126% and poultry 58%. Milk production expanded 29.5% (Alves, Contini & Gasques, 2008).

Figure 4 shows that from the 1970s to 2010 soybean yield doubled, rice yield quadrupled, cotton yield increased eightfold (especially after its expansion with climate adaptation in the Center West), while the yield of maize more than tripled, that of wheat doubled and that of bean production doubled. Only corn and soybeans saw an expansion of planted area – soybeans almost quadrupled and corn had a 40% increase. These were the two crops whose output increased the most: maize production was multiplied by almost five (in the 2000s, corn's second crop ("safrinha") reached 40% of the total and, in the following decade, more than 70%, Conab) and soybeans by a factor of eight. In the other crops increased outputs were the result of improvements in productivity.

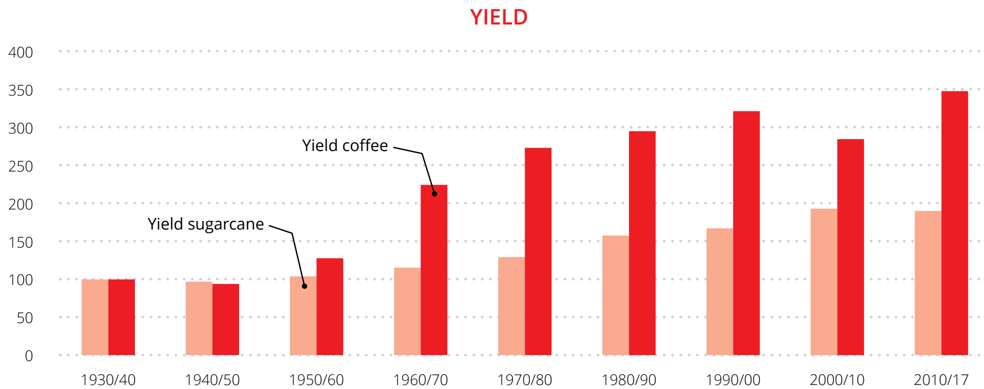
Evolution between 1930 and 2017 of two important perennial crops, sugarcane and coffee, is shown in Figure 5. Over these 87 years, sugarcane production has increased by a factor of 43, having grown on average 61% per decade. The harvested area has expanded by a factor of 23, 48% per decade. Productivity expanded by 90% over the period or 8% per decade on average. The expansion of harvested area was three times more important than that of productivity for sugarcane. In the case of coffee, production doubled over the entire period, but while the area harvested fell by 42%, productivity increased 3.5 times.

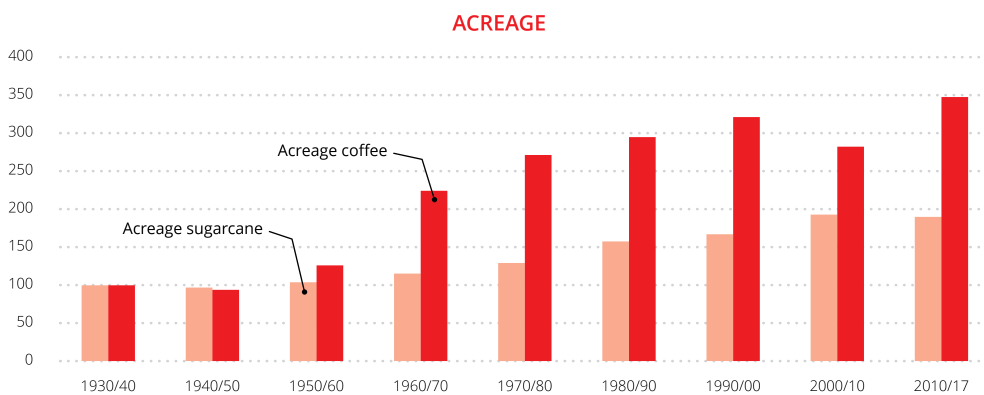
Figure 4. Yields, area and production of some temporary crops, Brazil, 1970/2019

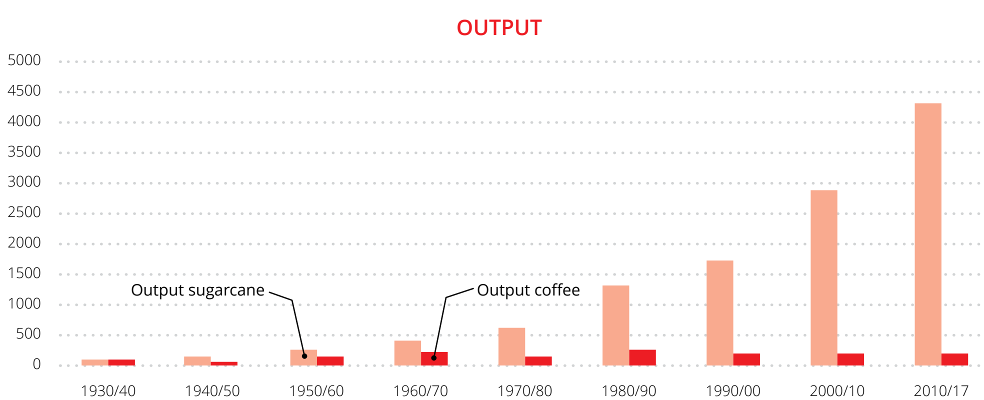


Source: Conab (https://portaldeinformacoes.conab.gov.br/safra-serie-historica-dashboard).

Figure 5. Productivity, area and production of sugarcane and coffee, Brazil, 1930/2017







Source: IBGE, Ipeadata.

6. Due to the fiscal crisis, the government reduces its role in the economy and agriculture advances in the foreign market

Throughout the 1980s, the public sector no longer had the resources to maintain support for industry and agriculture. Brazilian foreign debt in the 1970s went from 12.5% of GDP to 23% of GDP (Cruz & Chagas, 1982). Domestic debt fell from 6.8% to 4.6% (Goldsmith 1986). In the mid-1980s, there was a jump in both: external debt was above 30% and domestic debt was at 20% of GDP (Giambiagi & Beyond, 1999). Both needed to be and were contained with a downward trend.

The focus of the government was no longer on growth based on the protection of industry and subsidizing agriculture, but on stabilization (control of inflation, public deficit and external debt). Stabilization efforts failed, however (Suzigan & Furtado, 2006). Inflation escaped attempts to control it, as a sequence of unorthodox plans – including price freezes – were unsuccessfully implemented. There was practically no room for industrial or agricultural policy in Brazil. Strong fiscal controls were implemented by drawing support from both industry and agriculture. The Alcohol program ended in 1985. Between 1987 and 1989, the policy of minimum prices and regulatory stocks was cut by 78%; the total volume of agricultural support policies fell 46%; and the rural credit volume, by 36% (Barros, 2000).

Brazil could no longer rely on debt (domestic or foreign) to grow. Moreover, domestic production of general industrial goods was in most cases not competitive internationally. In the case of capital goods, this meant that a given savings level corresponded over time to lower levels of investment because of the high and rising prices of domestically produced capital goods (Bacha & Bonelli, 2004). When the low and almost stagnant industrial productivity is added to the equation the low growth of Brazilian industry since 1980 is explained. In the 1980s, the share of industry in Brazilian GDP fell from 34% to 30%. The agricultural GDP grew by 2.4% per year, industry by only 0.2% and the service sector by 2.7%. The share of agriculture's GDP in the 1980s changed little: from 9.8% to 10.5% (Figure 1).

During the 1980s, Brazilian agriculture increased its integration with the external market. In fact, in 1990, agriculture – or agribusiness, since many raw materials are exported after some processing, storage, transportation, etc.

– accounted for 41% of the value of Brazilian exports (US$ 13 billion); of the US$ 10.750 billion total trade balance surplus, 91% was due to agribusiness.

The prices of the commodities produced in Brazil were influenced by foreign markets: soy and derivatives, meat (beef, poultry, pork), sugar, coffee and orange juice. The prices of these commodities directly affected their production and indirectly (substitution effect) impacted the production of several others traded exclusively in the domestic market. Between 1975 and 1990, the GDP of agriculture doubled in volume. At the same time, real international food prices fell by 60% (IMF); real producer prices in Brazil fell by 36% (ratio between deflators of agricultural and total GDPs (IBGE)); real consumer prices in Sao Paulo fell 60% as well (FIPE). This positive production response to the fall in prices is explained by the evolution of productivity: agricultural TFP expanded 56% between 1975 and 1990 (Gasques, Bacchi, Bastos, 2018). Fertilizer consumption grew by 59% (IBGE). The fleet of agricultural tractors increased 90% (Anfavea). Irrigated area in 1980 reached around 2 million hectares or 4% of total croplands (Ferreira, 2015).

From the 1970s to the 1980s, the growth of the Brazilian economy changed completely from an annual rate of 8.6% to one of 1.6% (IBGE), characterizing what became known as the lost decade. Brazil was caught in the so-called middle income trap. Oliveira, Matni & Caetano (2014) estimate that from 1950 to 1980 the TFP of the Brazilian economy accumulated growth of 130% – or 2.8% per year. In the 1980s, it fell by 3% per year. For comparison purposes, from 1975 to 1990, while the TFP of the total Brazilian economy fell by 33%, the TFP of agriculture rose by 56% (Gasques, Bacchi, Bastos, 2018). It should be remembered that Brazil's TFP showed a common behavior worldwide: growth over 3% per year from 1950 to 1970; continuous deceleration from 1970 to 1990 until the annual rate was reduced to zero; acceleration until around 2005, reaching the annual rate of 3%, which quickly fell back to close to 2% (Cusolito & Maloney, 2018).

Agricultural GDP, which in the 1970s grew at 4.7% per year, in 1980 grew at 2.4%, compared to the 1.6% already mentioned for the entire economy. In 1990, agribusiness exports totalled US$ 13 billion – with a trade balance surplus of US$ 9.8 billion (Mapa) –, contributing significantly to a $ 10.7 billion trade balance surplus for the economy.

Poverty reached 32% of the population and illiteracy 19.7% in 1990. There was, therefore, a significant fall in poverty compared to 1970, when it characterized 70% of the population (Rocha, 2103), improving to 43% in 1981 (Barros, Henriques & Mendonça, 2001). In 1980, 32% of the Brazilian population lived in the countryside, and in 1990, 25%. Of the rural population, 63% were poor (Neri, 2011). In 1990, agriculture and industry each employed just over 20% of the workforce. In industry, labor productivity was 5 times that of agriculture.

In the passage from the 1980s to the 1990s, Brazil was still battling its mega-inflation through a sequence of unorthodox shocks – strong intervention in the goods and services and financial markets – all unsuccessful. After this phase, in the early 1990s, economic policy trended liberal. This was as much a result of tendencies in the economic thought (among academics, opinion makers and international organizations) as well as a response to the lack of public resources. The opening up of the economy led to a reduction in protectionism: the average import tariff decreased from 32.1% in 1990 to 13.1% in 1995 (Averbug, 1999). The 13% tax on agricultural exports was extinguished in 1996, as already was the case with products from other sectors. The Mercosur agreement (Brazil, Argentina, Uruguay and Paraguay) was signed in 1995.

Twenty-four – a significant number – state-owned companies were privatized. A considerable segment of the public sector apparatus aimed at market intervention for both specific products (coffee, sugar, cocoa, wheat) and broader economic sectors – monopolies and oligopolies – was dismantled. Federal public spending on agriculture decreased from 5.6% of the total budget to 2.4% from 1985/89 to 1990/94 (Gasques, Villa Verde, Bastos, 2006). Government spending cuts, which in the late 1980s fell on pricing, inventory and credit policies, this time weighed on rural extension programs (with the closure of EMBRATER) and on those targeted at selected products mentioned, including health defense, seed production, etc.

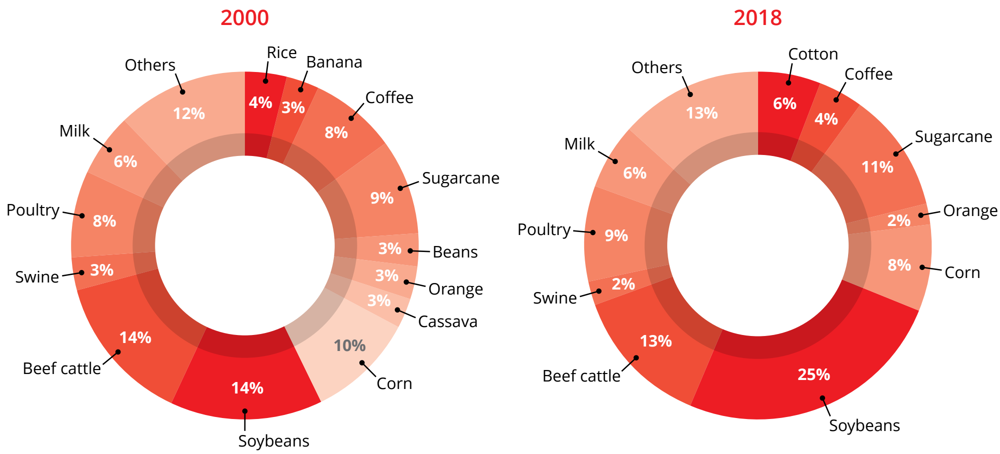
As minimum prices ceased to be indexed to inflation and the government moved away from purchasing and logistics functions, spending was limited to the difference between minimum prices and market price. Also with regard to credit, the government began to limit its activity to the difference between the interest rate on fundraising and the rural credit rate. Overall, public spending on agriculture fell by 52% between 1995 and 2000 (Gasques and Bastos, 2009). In 1996, a preferential interest credit program targeting family farms (small producers who rely predominantly on family labor, making up almost 70% of farmers), known as PRONAF (National Program of Fortification for Family Farming) was created. In the early years, PRONAF absorbed about 25% of total rural credit. A process of consolidation of the cooperative agribusiness system with government support was also implemented during this period. Thus, medium and small producers could improve their performance in obtaining credit, buying inputs, selling products and using technology (Chaddad, 2017). The cooperatives would come to prominence in the production of pork and poultry, wheat, corn, cotton, rice and milk.

In 1994, the so-called Real Plan was finally successful in containing inflation without resorting to price controls, but rather by substantially reducing the degree of indexation that had become widespread in the Brazilian economy. With deindexation, a tax reform (public spending and revenue) was necessary to replace the so-called inflationary tax. Since this reform was not done with the necessary intensity, it was necessary to resort to (a) increases in the tax burden, (b) monetary policy focused on extremely high interest rates (46% in 1996) to contain aggregate demand, which (c) kept the exchange rate highly overvalued. These have been the three main macroeconomic traits in Brazil since 1995: high taxation, high interest rates and overvalued exchange rates.

The 1990s saw some recovery for both the economy (whose growth rate increased from 1.6% per year in the 1980s to 2.6% per year in the 1990s) and for agriculture (whose growth rate went from 2.4% to 3.2% per year). In the first half of the 1990s, prior to the Real Plan, the average annual inflation rate (measured by the IPCA) was 1320%; in the second half, after the Plan, it was 9%.

During the 1990s, the Gross Farm Income (GFI) of soybean had grown by 60%; corn, 51%; and rice, 46%. Physical production of cereals and pulses grew by 38%. Beef, pork and poultry advanced 55%, 10% and 105%, respectively. In 2000, the Brazilian agriculture was diversified, being led by beef cattle (with 14.3% of the GFI), soybean (14.1%), corn (9.8%), sugarcane (9.2%), poultry (7.9%), coffee (7.8%), milk (5.7%). Figure 6 shows the changes in the composition of the agricultural GFI from 2000 to 2018, which will be discussed below.

Figure 6. Composition (%) of gross farm income, Brazil, 2000/2018



Souces: Mapa, FGV, Cepea/Esalq/USP.

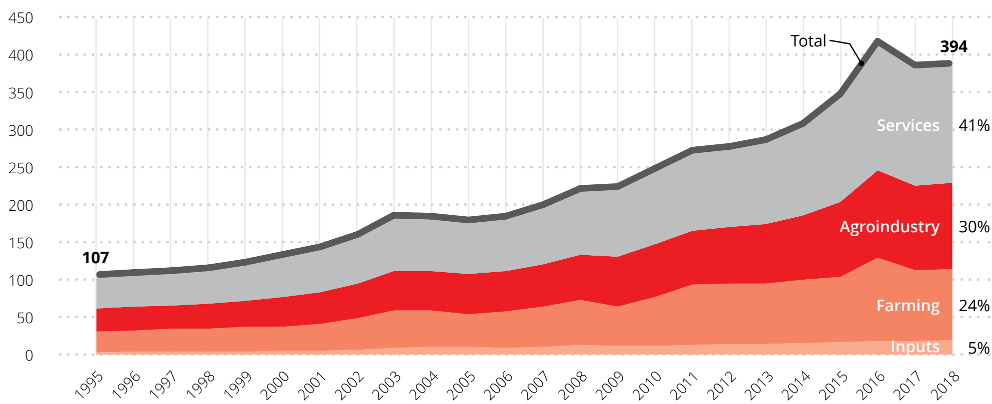
The no-tillage system had developed throughout the 1990s and multiplied by 10 to about 18 million hectares. This system favored the crop-livestock integration and the crop-livestock-forest integration and the so-called "safrinha" (second corn crop) (Denardim, s.d.). The use of biotechnology started to be implemented in Brazil, having grown after the adaptation of legislation in 2003.

Agribusiness GDP has been calculated since 1995 by Cepea/USP[10]. As shown in Figure 7, in 1995, its value of US$ 108 billion (in 2018 dollars) corresponded to 37% of Brazilian GDP. In agribusiness GDP, agriculture (or farming) represented 14% – or 5% of Brazil's total GDP, with 20% of Brazil's workforce. Within agribusiness other segments shares were: agroindustry, 38%, agri-services, 47%; and the inputs segment, 2%. In other words, the agroindustry and the agri-services predominated in agribusiness with 85% of its GDP. By 2000, agribusiness GDP (of US$ 137 billion) had fallen to 30% of the economy's total GDP, and its composition had changed little (farming 15%; agroindustry, 36%; agri-services, 46%; and inputs, 3%). The relative fall in agribusiness GDP was due to the fact that from 1995 to 2000, while the

[10] For information regarding the methodology and data series, access: https://www.cepea.esalq.usp.br/br/pib-do-agronegocio-brasileiro.aspx.

total GDP of the economy grew by 11.2%, agribusiness grew by 3.9% (both in volume); the relative price of agribusiness fell 17.1%. It is important to note that the farming segment grew by 21.3% in volume (for which it was important a 29% increase in the volume of inputs), but its relative price fell by 22.1%. This fall in agricultural prices was softened by the 22.3% increase in the segment's TFP (in order to maintain its share of around 5%). The economy as a whole had its TFP reduced by about 18% (Veloso, 2013).

Figure 7. GDP of Brazilian agribusiness and its segments (1000 US$ 2018)



Source: Cepea - Esalq/USP.

From 1990 to 2000, the harvested area hardly changed, the stock of tractors fell 15%, but the consumption of fertilizer (land-saver) by Brazilian agriculture doubled (Ferreira & Gonçalves, 2007), even with the supply of rural credit varying little in the decade (Gasques, Bacchi, Bastos, 2018). These results in terms of TFP are matched in terms of labor productivity: from 1995 to 2003, this productivity grew 6.2% per year in agriculture (farming segment), while in industry the rate was -1.6% and, in the whole economy, 0.2% (Veloso, Matos, Coelho, 2015). Even so, agricultural labor productivity was a quarter of that in industry.

The rapid growth of farming segment relative to the whole agribusiness showed that the sector was not advancing in value added terms (agroindustry fell 1.1% in volume and agri-services increased 1.1%). On the other hand, as the use of inputs increased, its price grew rapidly: 13% in real terms between

1995 and 2000, while the real price of the agriculture/farming segment fell by 22.1%, as already mentioned.

In any case, both agriculture specifically and agribusiness as a whole had a fall in real income, but even so their production volumes increased. Agribusiness has made an important contribution to curbing inflation and improving the population's food consumption conditions – in Sao Paulo, the real cost of food fell by 22.3% between 1995 and 2000 (FIPE, Ipeadata). In 2001, 27.4% of the population was poor, compared to 35% in 1992. In the countryside, where 19% of the population lived (15% of the national workforce), 53.5% were poor (Neri, 2011).

The falling price with rising food production provided a unique opportunity to launch two policies aimed at reducing inequality and poverty. One was the strategy of raising the real minimum wage, which at the time was around $ 100 a month (Figure 2). The other was to implement income transfer programs, which evolved into the well-known Bolsa Família (Family Grant), which imposed on the recipients conditions related to income and care for the education and health of children.

The increase in agricultural production with a relative price drop generated competitiveness in foreign markets. Exports grew in relation to the sector's GDP. From 1996 to 2000, they went from 54% to 71% of agricultural GDP. This method of measurement, however, overestimates the relative importance of the exports of agriculture; the correct procedure is to compare agricultural-based exports with agribusiness GDP, which includes grain and animal products processing and logistics activities. With this correction made, the importance of exports – in relation to agribusiness GDP – becomes 8% and 11% in 1996 and 2000, respectively. For comparison purposes, for the Brazilian economy as a whole the exports/GDP ratio went from 6% to 8.5% from 1996 to 2000. This year agribusiness provided a trade balance surplus of US$ 14.8 billion; the remaining sectors had a negative balance of US$ 15.6 billion, so Brazil had a negative total trade balance (-US$ 0.8 billion).

Currency generation became urgent in the early 21st century. In just five years, from 1995 to 2000, foreign debt (net of reserves) had risen from US$ 113 billion to US$ 203 billion (from 26.7% to 36% of GDP). This increase was basically due to the use of foreign savings in the context of the Real Plan: from 1995 to 2000, current account deficits totaled US$ 155 billion, which resulted from growth in imports (which grew at rates above 20% per year) and the inflow of direct and portfolio (public and private bond applications) investments in a scenario of overvalued exchange rates and exceptionally high interest rates (Giambiagi, 2011). This situation would culminate in a currency crisis and a major devaluation of the national currency in 1999, which risked a return of previous inflation rates.

Concrete steps were taken to advance the education system of the population in the 1990s. The 1996 National Education Plan (Durhan, 1999), effective until 2010, guaranteed the provision of compulsory elementary education in eight grades, ensuring entry and the permanence of all children from 7 to 14 years old in school. The Plan also included the eradication of illiteracy, reaching also those Brazilians who had not had access in the past or who had not completed elementary education. Strategies and goals were also established for the other educational levels, including also teacher training, use of new technologies and improved school management. Special attention was given to school meals and the timely distribution of textbooks. The Plan was funded by the Fund for Maintenance and Development of the Fundamental Education and Valorization of Teaching (FUNDEF), which guaranteed minimum resources to operate the system through state and municipal taxes supplemented by federal ones. For the Northeast, there were significant loans from the World Bank. From 1991 to 2000, illiteracy in Brazil fell from 20.1% to 13.6% (IBGE). Helene (2012) calculated conclusion rates for each level of education, that is, the relation between the number of graduates of a certain school level and the number of people of minimum age to complete this level. From 1990 to 2000, in approximate numbers, the conclusion rate of elementary school rose from 39% to 75%; high school from 20% to 50% and higher education from 8 to 10%.

7. The trade boom and the financial crisis

From an economic perspective, the 2000s began with concerns about (a) maintaining inflation at socially acceptable levels, (b) returning to economic growth, halted since 1980, (c) contention of foreign debt, (d) reducing income inequality and poverty. With respect to inflation and its natural relation to fiscal balance, the following were established: (a) a monetary regime based on inflation targets, (b) a fiscal responsibility regime applied to the various spheres of the public sector, (c) a flexible exchange rate regime and (d) a strengthening of minimum wage and income transfer policies. The inflation targeting regime demanded high interest rates (up to 13% in real terms to keep inflation within the desired limits) which added to the uncontrolled public spending that led to subsequent tax increases – tax burden evolved from around 24% of GDP in the early 1990s to 31% in 2000 and 33% in 2010 – so that the primary surplus fiscal targets – around 3% of GDP, but decreasing since 2005 – could be met. The growing burden of taxes had not as yet prevented substantial successes from being achieved on these varied issues and agribusiness has played a key role in this process.

Agriculture also performed well: it grew 5.4% per year from 2000 to 2011. This time the cultivated area increased 30% (IBGE), the tractor stock 19% (ANFAVEA, author's calculations) and fertilizer consumption 68% (ANDA). As agroindustry grew by only 1.7%, agribusiness as a whole grew by 2.6% yearly. Farming TFP grew 55% from 2000 to 2011, together with a 176% increase in rural credit (Gasques, Bacchi & Bastos, 2017). Total economy TFP has grown by only 3.2% over these 11 years (Veloso, 2013). As for labor productivity (from 2000 to 2010), in agriculture it grew by 6.4% per year, in industry, 0.6%, and in the whole economy, 2.2%. But in absolute value, industrial labor productivity was still three times higher (Veloso, Matos, Coelho, 2015).

From 2000 to 2010, soybean production doubled, corn production increased 71% and cotton production 46%. The cattle herd grew 23%. Gross Farm Income (GFI) shares in 2010 changed to: soybean (16.9%), beef cattle (14.1%), sugarcane (11.7%), poultry (10.7%), corn (6.4%), milk (6.1%), oranges (5.8%) and coffee (4.2%). Regionally, the Southeast (with sugarcane, coffee, orange, beef cattle and milk) and the South (with soybean, corn, beef cattle, rice, milk, wheat) each accounted for 30% of GFI of Brazilian agriculture. The Center West was ranked third (soybean, beef cattle, cotton, corn, poultry) with 23% of the national total. The Northeast (beef cattle, sugarcane, soybeans, corn, cassava) appears in fourth place with 10%. Finally, the North (cassava, banana, soy, coffee, rice, milk) held 6%.

In the 2000s, the use of GMOs has grown exponentially in Brazil, with multinational companies dominating seed production and Embrapa being the source of primary genetic material. Modified seeds were used and extended in 2015 to 93% of soybean, 83% of corn and 67% of cotton produced in Brazil (Vieira Filho, 2019). No-till area increased from 17.4 million hectares in 2000 to

25.5 million in 2005 (FBPD[11]) and 33 million in 2017 (IBGE). In 2001, 2.95 million hectares were irrigated – 7.7% of the total planted area in Brazil (Ferreira, 2015).

The acceleration in the world economy, from 1.4% a year in 1991 to 5.3% in 2007 – with middle-income countries going from 1% to 8.5%, and China boasting rates between 8% and 14% (World Bank) – provided opportunity for increases in Brazilian exports: 15% per year for both agribusiness and non-agricultural industry between 2000 and 2011 (MDIC/Mapa). As a result, the share of total exports in total GDP went from 8.5% in 2000 to 12% in 2008; the share of agribusiness exports went from 11% to 19% of the sector's GDP.

From 2000 to 2011, the Brazilian economy grew at an annual rate of 3.7%, but growth was faster in the subperiod from 2004 to 2011, when it averaged 4.2%, even considering the 2009 recession, with -0.13%. This period was known as the "Commodity Boom", when international commodity prices increased at a rate of 10.3% per year for agricultural products, 15.9% for energy-related products and 14.7% for metals and ores (World Bank). This period has also been called the "External Bonanza" for Brazil because the improved terms of trade (39% between 2002 and 2011) were seen as a gift for Brazil, which had its import capacity significantly increased.

From 2000 to 2011, agribusiness – farming and agroindustry – exported US$ 578 billion; the non-agricultural industry, US$ 936 billion. On the other hand, agribusiness imported US$ 92 billion, while the non-agricultural industry, US$ 1.1 trillion. In other words, agribusiness generated a surplus of US$ 486 billion and non-agricultural industry a deficit of US$ 180 billion (Mapa). Also from 2000 to 2011, terms of trade (export prices/import prices) increased by 34% (IBGE). At the same time, the national currency appreciated by 63% (Ipeadata). Considering this set of facts, it can be inferred that[12]:

1. transfers through terms of trade: (a) the non-agricultural industry as a net importer benefited from the increased terms of trade (the same volume that the country exports allowed for a growing volume of imports), (b) part of this benefit came from agribusiness, which generated part of the resources used in the importation of non-agricultural industry.

[11] No-till Brazilian Federation (Federação Brasileira de Plantio Direto, in portuguese) (FBPD). In: https://febrapdp.org.br/area-de-pd, (21/10/2019).

[12] See Barros (2016) for a detailed description of the method used for the calculation of the transfers mentioned in the text.

2. transfers through exchange rate appreciation: the currency appreciation led to a loss of income for exporters (because the real value in national currency they received per export dollar fell) that was transferred to importers who bought dollars at a lower real value in national currency. In the latter case, (a) part of the transfer due to exchange rate appreciation takes place within non-agricultural industry and may be disregarded from the distributive point of view; (b) another part of the transfer is from agribusiness that loses income by transferring it to the non-agricultural industry.

From 2000 to 2011, due to the generation of currencies with higher purchasing power abroad (in dollars) and cheaper (in national currency) for domestic importers, agribusiness increased import capacity of non-agricultural industry, transferring to it US$ 149 billion (from 2000 to 2011 in 2000 values), corresponding to 28% of total agribusiness export, or 15% of total non-agricultural industry imports.

Brazilian imports grew significantly from 2000 to 2011, a growth comparable to that of exports. Imports totaled US$ 1.2 trillion and exports totaled US$ 1.5 trillion. In 2011, 70% of the industrial sectors had trade deficits; only those with low technology (agribusiness and ores and metals) presented a surplus. These imports were strategic for the accelerated growth of the period. From 2003 to 2011, while retail trade doubled sales, the manufacturing industry grew by only 27%, indicating that imports covered this gap (IBGE, Morceiro, Gomes, Magacho, 2012).

Individually, from 2001 to 2010, through foreign trade, agribusiness, as was pointed out, provided a surplus of US$ 486 billion; the other sectors presented a deficit of US$ 180 billion; services and capital accounts, presented a US$ 13.5 billion surplus. As a result, international reserves increased by US$ 319.5 billion as of 2011 (96% due to agribusiness), reaching a total of US$ 352 billion.

Brazil, like most countries, suffered in 2009 a halt – a drop of 0.13% – in its accelerated growth – an average of 3.8% per year – which it had been experiencing in the 2000s. This impact was already overcome the following year: the world grew by 5.8% in 2010; Brazil, 7.5%. From then on, to try to maintain a desired level of 3% growth, very expansive credit and fiscal policies and market interventions (such as in energy) were carried out. There was a 70% increase in National Financial System (Central Bank) balances from 2008 to 2011 and a 42% reduction in the primary fiscal surplus in 2009 (Brazil's

Central Bank). However, the positive effects of these stimuli – which provided a strong recovery in 2010 – soon ceased: excessively indebted consumers, dangerously deranged public accounts (with primary deficits from 2014 on and consequent increase in the relation between Gross Public Debt and GDP from 51.5% to 76.5% from 2013 to 2018) and the need for corrective action in previously distorted markets forced the adoption of restrictive macroeconomic measures to create greater confidence in domestic and foreign investors in the sustainability of public debt. However, positive responses have not yet occurred after four years of recession or very low growth.

In 2010, 12.7 million families (about 50 million people) benefited from Bolsa Família. Ferraz (2008) estimates that, despite a small share of national income (1% from 1995 to 2005), Bolsa Família promoted a 21% reduction in the Gini Index, which measures the income inequality of the population. The national social security program, in turn, highly skewed in favor of higher-income people and public workers, would have acted in the opposite direction, increasing inequality by 25%, a challenge that Brazil will have to deal with sooner or later due to its undesirable impacts from both redistributive as well as fiscal perspectives[13].

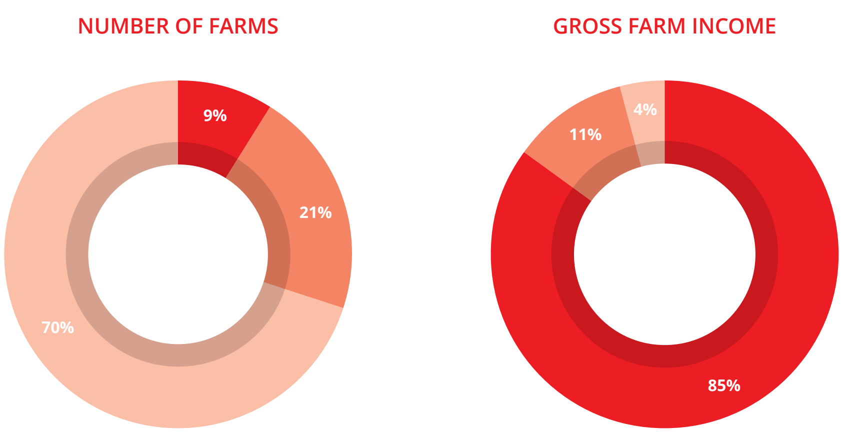
For 2009, Neri (2011) estimated poverty at 32% in rural areas and 15% in urban areas; in 2000 these figures were 53.5% and 27.5%. This degree of rural poverty largely results from very low productivity in most of the farms. The income generated in those farms is too low and not sufficient to guarantee a minimally adequate standard of living for the population involved in farming them. In 2010, the Bolsa Família program played an important role. Almost a quarter of the Brazilian population benefited from the program. Data from Layton (2010) show that in rural Brazil, 49.3% of the families were beneficiaries of the program; in the urban area, 21.7%. In the Northeast, 47% of residents were beneficiaries; in the North 35%; in the other regions, around 15%.

For the year 2006, Alves and Rocha (2010) calculated, in round numbers, that 9.2% of the 4.6 million (productive) rural establishments generated 85%

[13] Brazil approved a Social Security Reform in 2019. A Fiscal Reform and an Administrative Reform are expected for 2020/2021. New projections from the government indicate a stabilization of Gross Public Debt/GDP relation at 67% by 2028. See Almeida, M. 2019. “Contas públicas: uma comemoração e um alerta”. https://braziljournal.com/contas-publicas-uma-comemoracao-e-um-alerta.

of the gross farm income of Brazilian agricultural production. See Figure 8. This group produced the equivalent of US$ 15,000 per farm per year. In the other groups, 21.2% (976 thousand farms) produced 11% of the total or between US$ 2,500 and US$ 15,000 per unit; finally, 69.5% produced 4% of the value, with less than US$ 2,500 per unit – 88% of the Northeast farms were in this situation. In addition, 579 thousand establishments (12.6%) did not declare production[14]. In terms of distribution, the numbers indicate a high concentration of the gross farm income in the Brazilian agriculture. However, high concentrations are also found in, for instance, US agriculture: in 2017, 5% of establishments account for 75% of the gross farm income. The average annual gross farm income per establishments was, however, $ 190,000 per farm (USDA, 2018). In Brazil, as mentioned, the average gross farm income per farm was US$ 15,000 in 2006. Moreover, a possible effect of an improvement in income distribution through the distribution of the basic factor of production – land – has been a historic failure. For example, the Gini Index of land tenure inequality remained at 0,86 from 1975 to the last census of 2006, as can be seen from the work of Hoffmann & Neri (2010).

Figure 8. Distributions of number of farms and of gross farm income, Brazil, 2006



Sources: IBGE, Alves & Rocha (2010).

[14] Hoffmann (2014) estimated, for 2006, the contribution of Family Farming in terms of national production to be 69.6% for beans; 83.2% for cassava; 57.6% for milk; 45.6% for corn; 38% for coffee; 33.1% for rice.

Of course, poverty reduction is not just about handing out a certain amount of money; this money must be turned into income with the necessary purchasing power. In this respect, the role of agriculture and agribusiness – although with major social problems in rural areas, where it operates – has been of great relevance for the improvement of the living conditions of the majority of the Brazilian population thanks to increased production at stable or decreasing prices. Thus, the resources of social programs maintained or increased the purchasing power, of the poor, different from what would have happened if production had not accompanied the distribution of resources. In the city of Sao Paulo, for example, the real cost of food (IPCA food to GDP deflator) fell by 12.5% between 2000 and 2010. For Brazil, there was an increase of 32% in the output of agribusiness (and 77% for agriculture), while its relative price decreased by 18.5% and of farming, 10%. This occurred concurrently with the commodity boom period, when the international dollar price of agricultural commodities grew by 104% and the price of food specifically by 113% (WORLD BANK). These prices, once internalized to the Brazilian producer, were reduced due to the 58% exchange rate appreciation in Brazil: a real drop of about 10% for agricultural products and about 14% for food to the Brazilian exporter.

8. The post-international crisis and the Brazilian crisis: the highlight of agribusiness

From 2010 to 2018, the Brazilian economy had two years of recession (with GDP falling by around 3.5% in 2015 and 2016) – see Figure 1 – and grew on average only at 0.6% per year, with a cumulative fall in per capita income of 7.2% in eight years. From the 2019 socioeconomic and financial parameters, there is no expectation of a likely resumption of steady growth – 3% to 4% per year, an implicit target in society – in the coming years and, less likely still, a return to standards prior to 1980.

The government lacks resources for fiscal incentives and since 2014 has been generating primary deficits and public debt has been growing worryingly. Monetary policy – in view of the substantial fall in the inflation rate associated with high and prolonged unemployment – has been producing historically low interest rates, but it has not been sufficient to induce faster economic growth, a phenomenon also observed worldwide. Regarding employment, the number of employed persons increased by 45% from 2001 to 2011, reaching 88.7 million. From 2011 to 2018, that number increased to 93.1 million; but even so, 12.8 million people (12.2% of the workforce) were unemployed in 2018. That is, as per capita income fell, more people sought employment. In the last five years (2013 to 2018), faced with falling per capita income, the labor force grew by 7.3%, employment by 2.1% and unemployment by 83% (from 7 million to 12.8 million or from 7.3% to 12.3%). In other words, out of ten job seekers, only 3 found employment.

In the 2018 rural-urban breakdown of the Brazilian population (208 million people), 86% lived in cities. From the employment perspective, this division is losing its importance: in 2018, 2/3 of the agricultural workers lived in rural areas and 1/3 in the urban areas, and the number of people employed in agriculture has been falling: 17% between 2012 and 2018, reaching 8.5 million people (9.1% of the total of 93.1 million employed in Brazil). Of these, 32.5% lived in cities (Barros, Almeida & Castro, 2019). In addition, 47.5% of the inhabitants of rural areas work in activities outside agriculture. In 2018, 18.2 million people (20% of the Brazilian employed population) worked in agribusiness activities, of which 8.5 million (46%) worked in primary activities (farming); 3.8 million (31%) in agroindustry and 5.8 million (32%) in agri-services (Barros, Castro, Gilio, Morais, Almeida, Souza Junior, Silva, Fachinello, 2019).

Agribusiness grew in the same period (2010/2018) at an annual rate of 1.1% and its relative price fell 0.85%, so that its share of total GDP remained virtually unchanged from 2010 (21.1%). Farming (agriculture and livestock) grew at 2.6% yearly. The TFP of the economy in the period 2010/2017 accumulated a fall of 4% (Orair & Bacciotti, 2018). For agriculture, TFP accumulated growth of 24%, with the offer of rural credit expanding 100%. In 2018, only a third of the credit generated a tax cost related to interest rate equalization, which is now at historically low levels due to the fall in the Central Bank's basic interest rate to half of the 2015 rate.

The following is what the evolution of the agribusiness component segments looks like in 2018. Total agribusiness GDP in 2018 reached US$ 393 billion, growing by 1.76% per year in real terms since 1995 (Figure 6). The farming segment whose GDP is 24% of the total agribusiness, had annual growth of 4.62% per year; with a balanced growth between crops (4.5%) and livestock (4.9%), with crops accounting for 70% of the GDP of agriculture. The input segment (5% of agribusiness GDP), grew by 3.3% per year. The slowest growth was in the agroindustry segment (30% of agribusiness GDP), with only 0.6% per year. The agri-service segment (41% of agribusiness GDP) grew at 1.2% per year. The interconnection between the segments is clear. On the one hand, the input segment advanced with the strength of modern and efficient agriculture. This is despite the sharp increase in their prices: from 1995 to 2018 the terms of trade of agricultural inputs (agriculture deflator in relation to the input deflator) fell by half. On the positive side, more than offsetting this increase in input prices, it was observed that the TFP of agriculture multiplied by a factor of four between 1975 and 2017 (Gasques, Bacchi, Bastos, Valdes, 2019). On the other hand, the slow growth of agroindustry denotes the difficulty agribusiness faces in terms of value added, a challenge faced by the manufacturing industry in general in Brazil.

Poverty in Brazil as a whole fell from 13.6% in 2010 to 8.4% in 2014; but by 2018 it had increased to 11% (Neri, 2018). Given that the relative price of agribusiness has fallen by 6.9% from 2010 to 2018, the increase in poverty has been attributed to the high level of unemployment – which increased from 7.3% in 2012 to 12.3% in 2018 (IBGE) – with per capita income falling 8% in the four years to 2018. Real consumer food prices barely changed in the case of Sao Paulo (FIPE, IBGE). These results show that agribusiness growth tends to produce better social outcomes if accompanied by growth in the economy as a whole or at least a sustainable cash transfer program even in times of crisis. The Bolsa Família program reached 21% of Brazilians in 2017, and in the Northeast the figure was around 40% (MDS[15]). Its resources were reduced from 2014 to 2018 by 13% and the number of families benefited fell from 14 million to 13.8 million (MDS). In an economy with low growth and reduction in cash transfers, there may be cheap food, which nonetheless cannot be bought by people with no income or very low income because of high unemployment.

In the composition of agricultural gross farm income (GFI), as shown in Figure 6, in 2018 compared to 2010, the relative importance of soybeans

[15] Ministério do Desenvolvimento Social (MDS). In: http://mds.gov.br/area-de-imprensa/noticias /2018/junho/bolsa-familia-beneficia-mais-de-13-7-milhoes-de-familias-em-junho.

grew – from 16.9% to 25% –, cattle maintained its participation (13.5%), oranges almost doubled its importance, and cotton went from 2% to 6%. Rice, beans and cassava had their participation greatly diminished (Mapa). Cotton stood out in 2018 in the Center West and Northeast. Sugarcane is of striking importance in the Southeast and South. Coffee is grown mainly in the Southeast (88% of its GFI); 70% of the orange production is in the Southeast; corn stands out in the Center West, Southeast and Northeast; soybean has 70% of its GFI in the Center West and South, but has evolved significantly in the North and Northeast; beef cattle are relevant in all regions, but stand out in the Center West and North; pigs are concentrated in the South, Center West and Southeast; poultry appears mainly in the South, with 60% of its GFI; milk comes mostly from the South and Southeast. Interestingly, between 2010 and 2018, soybean GFI grew 140% in the Northeast and multiplied by four in the North. Cotton had its GFI multiplied by 4.4 in the Northeast. Beef cattle grew 50% in the North.

Planted area in Brazil grew 51% from 2000 to 2018: from 52 million hectares to 78.5 million hectares (IBGE). The expansions occurred in the following order: Center West (172%), North (55%), Southeast (36%), South (25%); in the Northeast there was a slight decrease (-2%). Thus, the Center West leads agriculture in terms of planted area with 35% of the total, followed by South with 27%, Southeast with 19%, Northeast with 14% and North with 5%. The cattle herd (215 million heads in 2017) is also higher in the Center West (34.5% of the total), followed by the North (22.6%), Southeast (17.5%), Northeast (12.9%) and South (12.6%). This general expansion to the Center West and North – farther from major urban centers and traditional ports – has created major challenges in logistics for agricultural production in general. Irrigation reached 6.9 million hectares during the 2010 decade; the Southeast with 39% of the total irrigated area, South with 24% and Center West and Northeast each with 17%, and North with 3% (Embrapa, 2018).

From a macroeconomic perspective, despite the failure in terms of growth in Brazil, two very positive points have been achieved in the last eight years, both achieved with an important support from agribusiness. On the one hand, inflation fell to rates rarely seen in Brazil, below 4% per year. Contributing to this were the prolonged stagnation – with falling employment and per capita income – due to factors such as high interest rates, fiscal crisis and falling national TFP. The slight devaluation of the exchange rate during the period – in part due to the reserves generated by agribusiness – despite the poor economic performance of Brazil, likewise helped to curb inflation. At the same time, the economy was spared from agricultural supply shocks (two production declines that occurred were reversed in the same proportion shortly thereafter), so that from 1995 to 2018 real farm prices fell 34% even with international prices growing 113% between 2001 and 2008 and 77% between 2001 and 2018 (FMI). Agribusiness competitiveness also increased during this period. In 1995, according to Cepea's data, exports of this sector corresponded to 7.5% of its GDP; by 2018 the figure was 25%. For the total economy, exports went from 6% to 13%. Just over US$ 1.04 trillion dollars in reserves were generated by agribusiness; the other sectors consumed US$ 527 billion. This positive result in foreign trade contributed to prevent the increase of the country-risk factor, thus enabling significant reductions in interest rates, and preventing economic growth from being even lower.

9. Challenges to be overcome

The United Nations (2015) estimates that meeting the food requirements of the 9 billion inhabitants of the world expected by 2050 will require 60% more food, implying 50% more energy and 40% more water. These figures, of course, vary from institution to institution. The United Nations of Brazil (2016) recalculated the necessary increase in food production by 2050: it will have to double. The point to emphasize is that the demand for agricultural products will increase greatly as the population increases, as incomes increase, urbanization grows, and so on. A study conducted by Embrapa (2018) for 2017 showed that Brazilian lands were distributed as follows: 30% in farm production use (crops and planted forests, 9%; planted pastures, 13% in native pastures, 8%); areas under preservation had 33.6%; indigenous areas, 13.8%; and unregistered native vegetation held 19% (the rest were urban and infrastructure áreas). Brazil can and will participate actively and will be one of the protagonists in this effort – maintaining its support for agricultural science and innovation and infrastructure, strengthening institutions linked to the sector –, when beyond quantity (food security), there will be increasing demands for quality (food safety), environmental sustainability and human rights. Globalization raises problems and challenges to the world level, but also makes solutions – especially in the fields of shared governance across nations with regard to institutions, science, technology, innovations – linked to the perception of interdependence between countries and, of course, to world cooperation.

There is a diagnosis made by most of those studying the Brazilian economy that the major obstacle to the country's most robust growth lies in the slowness of total factor productivity (TFP) and, by extension, labor productivity. Greater investment and better management in institutions related to (a) science, technology and innovations and their diffusion to the neediest economic agents, (b) quality of education, (c) infrastructure, (d) business environment and (e) trade openness, would help to overcome the bottlenecks for faster economic growth (Abrão, Lisboa, Carrasco, 2018). To overcome such obstacles, the public sector in Brazil would need to regain investment capacity accompanied by a review of its role in the economy, reaping the gains of closer association with the national private sector and international public and private organizations. There is, on the one hand, an urgency for investments and, on the other, a very severe shortage of resources. This conundrum must be solved in order to restart the development pathway from which the country has strayed after four decades.

As already mentioned, the strategy for the growth of Brazilian agriculture has been to increase production based on increased productivity, making use of technology, economies of scale and with the foreign market for the flow of growing production, thus avoiding a drop in prices that would make this model unfeasible. Although agriculture has proved to be very competitive, it is common to raise a number of points that prevent or may prevent this competitiveness from being maintained or increased in the future.

One of these points refers to the controversial issue of agriculture in the context of environmental sustainability, including themes such as water use, deforestation and fires (with effects on agriculture itself and the global climate crisis) in the Amazon and in the Centre West mainly; soil erosion and excessive use of agrochemicals (with harmful effects to consumers and environmental contamination). Regardless of the severity of the environmental and human damage that actually results from aspects related to the sustainability of agriculture, there is no doubt that the country must take care to minimize – when not eliminate – these damages. Agents and leaders of the sector, as well as a growing part of the political class, have shown themselves to be aware of the economic losses that a poor performance in environmental issues can cause them, either due to the damage to the natural resources that they use in the production process, or to the impacts that they can cause in the perception and preferences of the consumer, or even in the opportunity or pretexts that they provide for protectionist practices on the part of their competitors.

There is a debate among scientists and in society as a whole about strategies and methods for treating causes and mitigating damage associated with the environment. This is a positive sign that such issues will no longer be ignored and appropriate solutions will be found – already with effects in the short term. Society broadly and seriously discusses ways to effectively combat deforestation; the most effective way to do so is the question. Within agriculture itself, important programs have been implemented within the concept of the low carbon economy based on the intensification of land use (two or more crops per year in the same location), recovery of degraded pastures, crop-pasture-forest integration, no-tillage, biological nitrogen fixation, forest planting, animal waste treatment. The National Biosafety Policy, the Forest Code, the Rural Environment Register – known as CAR – are instruments aimed at sustainability. The urgency of the development of biological insecticides, fertilizers and herbicides is widely recognized in scientific circles. Agriculture and agribusiness have also contributed significantly to a cleaner energy matrix in Brazil through the ethanol and biodiesel programs, using part of the production of sugarcane, corn, soybeans and other raw materials. As a result, biofuels represent 23% of the energy matrix of the transport sector (EPE, 2019). Navarro (2016) rightly argues that, along the lines of current capitalism, agriculture necessarily preserves increasing proportions of natural resources, adopting technological models that are becoming "environmentally desirable".

Another point that severely weakens the competitiveness of the Brazilian agriculture is the Brazilian logistics infrastructure, which results from the option made decades ago for highways as the main means of transport and the lack of public resources for the necessary investments in maintenance and expansion of highways and other modes of transport, as well as storage and ports. The logistical cost for Brazilian agriculture can be calculated using the case of soy as an example. According to data from Cepea/Esalq/USP, the price differential, for example, between the Port of Paranaguá and the producing region of Sorriso in Mato Grosso (distance of 2,200 km) was 25% in the 2000s, having decreased to 20% in the following decade, largely due to the implementation of alternative ports in the North and Northeast regions. To this cost to producers, the cost to society in the form of losses due to poor transport and storage conditions must be added.

According to Garcia and Vieira Filho (2019), it is estimated, based on data from 2017, that Brazil has 1.5 million kilometers (km) of highways, with only 12.3% being paved. In total, Brazil has 25 km of highways per thousand square km, 17 times less than the United States and 15 times less than China. The average speed on Brazilian highways is 22 km per hour; in the United States it is 80 km per hour. Even so, 61% of cargo handling in Brazil takes place on highways.

As Garcia and Vieira Filho (2019) also report, the total availability of railways – moving 21% of the total load – reaches 30 thousand km, one tenth of that in the United States and a quarter of that in China. The waterway network in Brazil totals 20 thousand usable km, transporting 14% of the cargo in Brazil. Transport through pipelines reaches 4% of cargo. There are also 8,500 km of maritime coasts. Brazilian seaports exported 135 million tons of agricultural bulk in 2017. The useful storage capacity of various types of agricultural products in Brazil was 145 million tons in 2017 – the year in which grain production was 230 million tons, 95% in the private sector. There is a shortage of warehouses – mainly in the Centre West – which, in Brazil, has been growing over time: grain production grew at 5.2% per year and storage capacity at 3.8% in the 10 years to 2018.

Garcia and Vieira Filho (2019) conclude that the logistics infrastructure, in addition to being quantitatively and qualitatively deficient, are poorly distributed. The South and Southeast are relatively well served; in the Center West and the Northeast, despite recent advances in the ports in the North and Northeast, there is still a great dependence on infrastructure located in the Southeast and South.

A significant challenge for Brazilian agribusiness is to maintain in the future the balance regarding two vectors that have been supporting its growth: productivity and an intense link to the foreign market. As for the first, it is about sustaining itself on the frontier of technological innovation and proceeding with the diffusion of this technology, thus reducing the gap between a minority of highly productive and efficient producers – responsible for more than 80% of production – and a numerical majority (backward and poor) producing less than 5% of the total.

Navarro (2016) talks about a modernization in the form of agronomic technical improvements that immediately produced economic results that took place in the 1980s and extended through the 1990s. Market integration implies acquiring new technology and diffusion of innovations. Navarro speaks of a strategic disorientation in state and federal public institutions (including universities), which still focus on agronomic modernization ignoring or disregarding the economic and financial foundations of the current productive system. An aggravating factor was the mass of researchers and professors that were replaced in the 2000s without the transition between generations being adequately addressed.

There is a discussion that emerges in the mainstream press about Embrapa's role and directions in the present and in the future. The production of agricultural technology has undergone important changes with the increasing participation of the private sector. The Cultivar Protection Law of 1997 has been identified as a fundamental turning point, with the result that the production of genetic material, previously a stronghold of public research institutions, becoming attractive to private companies, which with time has been concentrated in the hands of a few multinationals. It has been argued that this has resulted in an increase in the cost of inputs and less concern with health issues, such as the use of pesticides and other environmental impacts, with the basic research work carried out abroad.

Regarding the frontier technology today, consider the case of Precision Agriculture (PA). Rezende and other Embrapa researchers (2010) indicate that its adoption began in the 1990s in the production of grains and perennial crops, achieving momentum in the years after 2000, with significant areas of annual crops and sugarcane working with georeferenced mapping, optimizing variable rates of application of inputs. Next, there was a certain retraction in investments in PA, which can be attributed to deficiencies in the greater use of technology, including the data it generates. Currently, the use of PA in the United States and even in Argentina is much more expressive. In any case, more recently, a resumption of PA is taking place in areas of the Cerrado that favor the mechanization. The authors even point to a delay in research activities in Brazil in relation to the use of PA on a large scale in agricultural production, which is taking place without scientific validation.

With regards to cutting-edge technology, precision biology – with the production, in addition to plant-based meat, of "artificial meat" or "cell-based meat" (when the meat is produced by the "in vitro" culture of animal cells) – for example, can represent a disruption in the agricultural system as it is organized worldwide today (Steffens et al., 2018). The production of tissues by cell culture is well developed in the field of bioengineering and pharmaceutical production, but has been growing more recently in food production. Animal product prices could potentially fall substantially with an equally substantial drop in demand for agricultural raw materials (grains and others). When such technologies become economically viable – benefits to the consumer in the form of cheaper and better quality food could be very substantial and environmental costs – like greenhouse gas emissions – could also be significantly reduced. It is not yet well known how Brazil is positioned in terms of precision biology and all its developments (Santos, 2019). In the United States, the Department of Agriculture (USDA) and the Food and Drug Administration (USFDA) have already defined the sharing of supervision of the "cellular meat" industry.

The question of the second lever of agricultural progress – in addition to productivity – related to the strong link to the foreign market needs to be seen in perspective. In this regard, Brazilian agriculture is not in an unprecedented position. On the contrary. Historically the propulsion of agriculture has been originated by important events of origin abroad. The sugar cycle in the 16th and 17th centuries was associated with the growing demand in Europe, which was becoming richer with the gold and silver brought from the Americas. One can remember the case of cotton, whose strength in the 18th century was due to the English industrial revolution. The widespread consumption of coffee during the American industrial boom in the 19th century stimulated exports of this product.

The current advances in agriculture and livestock resulted of a combination of two factors: (a) the urge to contain hunger and malnutrition in Brazil and make industrialization possible by lowering the cost of living, and (b) the jump in commodity prices that stimulated the move towards the foreign market. This set of factors led to investment in agricultural education and research. From the point of view of the external exogenous factors, it is well known that they encourage and discourage agricultural exports as markets go through high and low cycles. The great acceleration of Brazilian agriculture from 1990 onwards is associated with the growth of emerging countries, mainly China, especially with its admission to the

World Trade Organization (WTO) in 2001, following the trade agreement between China and the United States, two years before. This time, however, Brazilian agriculture is among the leaders of production, not only because of the possession of natural resources, but mainly due to high productivity backed by technology. The challenge, as already mentioned, is to remain in the leading position of technology, in the face of the disruptive revolution that may be ahead. The search and cultivation of new partners is always an essential strategy.

Accommodation in a comfortable situation sooner or later takes its toll. The trade in agricultural products with China that from 2000 to 2019 evolved from about US$ 1 billion to more than US$ 30 billion, or from less than 3% of the value of Brazilian agricultural exports to around 32% (MIDC). In the meantime absolute losses occurred in trade with the European Union and in relative terms with the United States. Agribusiness (adding agro industry and agro-services to farming) had its relationship between exports and GDP evolving from 11% to 26%. For the whole of Brazil, the ratio changed from 8.5% to 13%. This occurred despite the fact that the real value of exports in national currency was eroded by a real appreciation of the average national currency of 45% from 2000 to 2019, which meant that the income from agricultural exports was subjected to an average exchange rate taxation of around 45%, embodied in a transfer that defrayed part of industrial imports and also part of the stock of international reserves accumulated in the period (Barros and Castro, 2020).

Still hampering Brazilian agricultural exports are the challenges of access to markets. For example, in the case of soybeans, tariff escalations occur, as in the case of China, which purchases soybeans in grain, with strict restrictions on meal and oil. This is a contradiction to the economic principle that dictates that the processing must take place in the region of origin of the raw material, since the logistical efficiency is much greater in the trade of derivatives, with greater economic value in relation to the weight or volume. Restrictions on biological events (such as GM soy) also illustrate challenges. Meat faces problems when it comes to qualifying plants, tariffs and quotas, sanitary and even religious restrictions. Of course much effort must be invested in negotiations, especially considering the political downgrading that the World Trade Organization (WTO) is currently undergoing.

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Part 2

Ensuring global food security: successful internationalization cases

Chapter 3

Yueying Mu
Juewen Jin

Adding value to agricultural exports in China: the fruits and vegetables sector

Abstract

This chapter reviews the evolution of the Chinese fruit and vegetables sector throughout recent decades. As the Chinese income levels have risen, diets have changed, and consumers have demanded a greater variety of foodstuffs, leading to a drastic growth in different horticultures. It presents an analysis of the economic drivers behind the surge in Chinese fruit and vegetables production, focusing on productivity increases and expansion of the net sown area, as well as the challenges of adding value to this production. Recent trends within the export and imports of fruit and vegetables are illustrated, and the chapter concludes with an assessment of the evolution of the relative competitiveness of Chinese producers.

1. Introduction

As two major agricultural traders, China and Brazil play very important roles within global food markets. With its large population, China both produces and consumes a large volume of agricultural products. As the largest country in South America, with abundant natural resources and beneficial climatic conditions, Brazil is also an important agricultural player. The Chinese trade surplus of fruits and vegetables continues to increase, especially in the vegetables sector. The Chinese fruit and vegetables trade with Brazil has been growing steadily, and is the fastest among BRICS countries, with vegetable exports as the main driver. The differences in resource endowments between China and Brazil not only provide the two countries with comparative advantages in fruit and vegetable trade, but also increase the complementarity of bilateral trade, which provides a broader space for the growth of fruit and vegetable sector. In this study, the contribution rate decomposition method, cost-benefit analysis, and trade competitiveness and complementarity indexes are used to analyze the development of China's fruit and vegetable production, and the competitiveness and complementarity between China's and Brazil's fruit and vegetable trade, so as to further explore the development potential of the two countries' trade.

2. Data description

The datasets used by the studies of vegetable and fruit production in China cover the period from the start of China's reform and opening in 1978 to 2017. The analyses of the development of vegetable and fruit production in China are based on the data published by the Chinese Bureau of Statistics, while the studies for the cost-benefit of China's vegetable and fruit production use data published by the National Development and Reform Commission in 2018. The three studies for the vegetable and fruit trade between China and Brazil were based on samples from United Nations Comtrade Database, from 2000 to 2017.

3. Development of vegetable and fruit production in China

Since the reform and opening up, China's vegetable and fruit production has grown strongly. Different factors, such as scientific and technological progress, consumer market expansion, government policy, factors of production, and natural conditions, have led to increases in volumes of vegetable and fruit production. Based on the analysis of the changes of

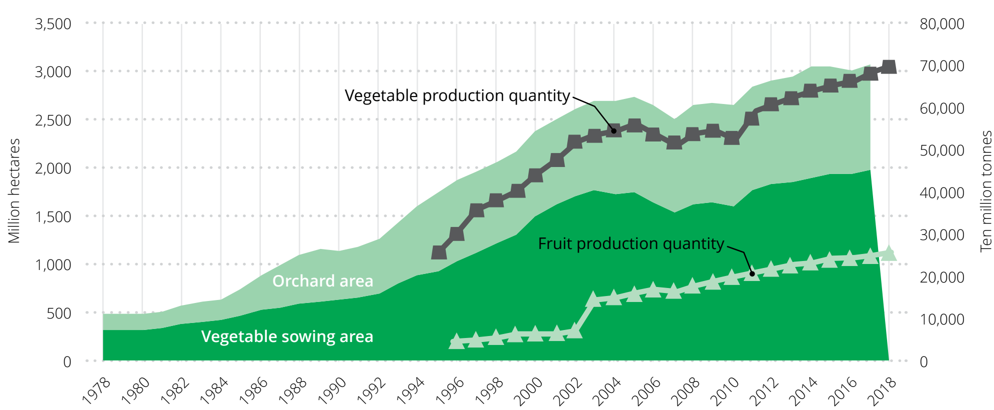
China's vegetable and fruit production, the following chapter will focus on the significance of the net sown area and unit area yields to the growth of China's vegetable and fruit production.

3.1. Production changes in China's vegetable and fruit sectors

The production of vegetables and fruit is an important part of Chinese agriculture and has seen a notable growth in scale since the reform and opening up, driven by rising consumption demands. Thanks to changes in the Chinese diet, and more exigent consumers, the demand for vegetable and fruit is increasing. Furthermore, the added value of vegetable and fruit is relatively higher than that of other crops.

The growth in vegetable and fruit production since 1978 is shown in Figure 1. China's vegetable sown area and orchard area both display a rapid growth trend. The sown area of vegetable increased from 3.3 million hectares in 1978, to 20.0 million hectares in 2017, a growth of 499.9%. The area of orchards increased from 1.7 million hectares in 1978 to 11.1 million hectares in 2017, a growth of 572.1%. The production of vegetable and fruit also displays a similar picture. From 257 million tons in 1995, vegetable production rose to 703 million tons in 2018, an increase of 173.4%. Fruit production increased from 47 million tons in 1996, to 257 million tons in 2018, an increase of 452.1%.

Figure 1. China's vegetable and fruit production



Data Sources: Nation Bureau of Statistics of China (http://data.stats.gov.cn/).

3.2. The contribution degree to the growth of China's vegetable and fruit production quantity

The production quantity (Q) can be divided into two parts: the net sown area (R) and the unit area yield (Y):

$$Q = R \times Y \quad (1)$$

Calculate Q by taking logarithm and difference of R and Y:

$$g_q = g_r + g_y \quad (2)$$

The growth rate of Q is the sum of the growth rate of R and Y. The contribution degree of R and Y is shown as the following:

$$c_r = \frac{g_r}{g_q},\ c_p = \frac{g_y}{g_q} \quad (3)$$

According to production fluctuation and the availability of data, there are three periods to analyze the changes and degree of contribution of vegetables, 1995/2005, 2006/2011 and 2012/2017, and two periods for fruit, 1996/2002 and 2003/2017.

The results of the production increase of vegetable and fruit are shown in Table 1. Between 1995 and 2017, total vegetable production grew by 169.0%, the net sown area increased by 110.0%, and unit area yield increased by 28.1%, which respectively contributed 65.1% and 16.6% to the vegetable production quantity. Two thirds of the growth of vegetable production quantity is derived from the expansion of net sown area, which plays an essential role in vegetable production quantity. The average annual growth rate of vegetable production quantity was 4.6%, with 3.4% deriving from expansion in the net sown area, and 1.1% from unit area yields, which respectively contributed 74.6% and 24.6% to the vegetable production quantity.

Compared with the three aforementioned periods, the contribution of net sown area to the increase of production accounts for about two-thirds, although it recently has decreased slightly. The contribution of unit area yield to the increase of production expansion indicates that with the development of the vegetable industry, the mode of vegetable production growth gradually shifted towards a focus on improving production efficiency.

Table 1. Decomposition of contribution degree of vegetable and fruit production

Period	Vegetable production	Sowing area		Yield	
	Growth rate %	Growth rate %	Contribution degree %	Growth rate %	Contribution degree %
1995/2005	119.43	86.24	72.21	17.82	14.92
2006/2011	10.78	7.46	70.88	2.92	27.06
2011/2017	12.28	8.02	65.34	3.94	32.09
1995/2017	168.95	110.00	65.10	28.08	16.62
Average annual growth rate	4.60	3.43	74.57	1.13	24.59
Period	**Fruit production**	**Orchard area**		**Yield**	
	Growth rate %	**Growth rate %**	**Contribution degree %**	**Growth rate %**	**Contribution degree %**
1996/2002	49.42	6.37	12.89	40.47	81.89
2003/2017	73.87	18.01	24.38	47.34	64.08
1996/2017	442.51	30.20	6.82	316.68	71.56
Average annual growth rate	8.39	1.26	15.08	7.03	83.86

Data sources: Based on the data of Nation Bureau of Statistics of China (http://data.stats.gov.cn/).

The period from 1996-2017 saw an increase by 442.5% in fruit production from 47 million tons to 252 million tons. There was an increase by 30.2% in the orchard area, and an increase by 316.68% in the yield. From 1996 to 2017, the contribution degrees of orchard area and yield to fruit production were 6.8% and 71.6%, respectively. This shows that the rapid growth of unit area yield is significant. The average annual growth rate of fruit production quantity was 8.4%, while that of the orchard area was 1.3%, and that of unit area yield was 7.0%, which contributed 15.1% and 83.9% to the fruit production quantity, respectively. Comparing the three periods, it is evident that the expansion of the orchard area in the second period contributed to an almost three times increase of fruit production, while the contribution of unit area yield to the increase of production had decreased, indicating that with the development of the fruit industry, the mode of fruit production growth gradually shifted towards the enhancement of the scale of production.

4. Cost-benefit analysis of vegetable and fruit production in China

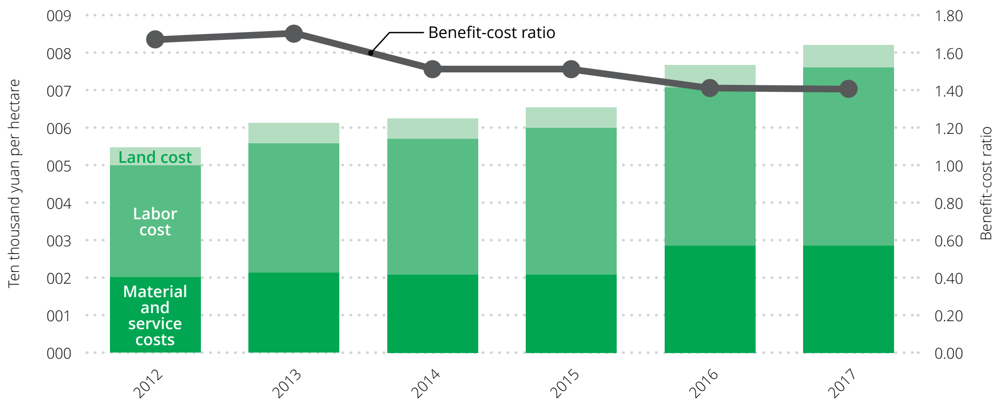
The cost-benefit situation is a comprehensive reflection of the capital input, technology adoption, and management level of agricultural producers. Cost-benefit is not only related to the income of agricultural producers and the sustainable development of production, but also the reference basis for formulating industrial support policies to improve the added value of products.

4.1. Cost-benefit analysis of vegetable production in China

The average cost-benefit assessment of vegetable production in China is shown in Figure 2. In recent years, the cost of vegetable production has increased. In 2017, the total cost of vegetable production was 82,000 yuan/ hm^2, an increase of 49.1% over 2012. According to the contribution of each item to the total cost, the first is labor, which accounts for 58.2% of total costs, followed by material and service expenses, accounting for 34.9%, and land costs, accounting for 6.9%. In 2017, the costs of the three items were 47,000 yuan/hm^2, 28,000 yuan/hm^2 and 6,000 yuan/hm^2 respectively. In addition, labor costs and material and service costs have increased in the past two years, while land costs have remained constant. The ratio of income to the cost of vegetable production has been declining, from 1.67 in 2012, to 1.39 in 2017, indicating that compared with the increase in vegetable production costs, the increase in vegetable production income is relatively small, and that the added value of vegetable production has decreased.

Vegetable production in China is divided into protected and open field cultivation. Amongst the main vegetable varieties (Figure 3), the total cost of protected cucumber was the highest in 2017, followed by cultivation tomato, protected eggplant, and cultivation bell pepper. The total cost of facility vegetable was higher than that of open field production. The labor costs still account for the largest proportion of the total cost, as can be read from Table 2 below:

Figure 2. Costs and benefits of vegetable production in China



Data Sources: National Development and Reform Commission, National Compilation of Cost-Benefit Data of Agricultural Products – 2018, China Agriculture Press.

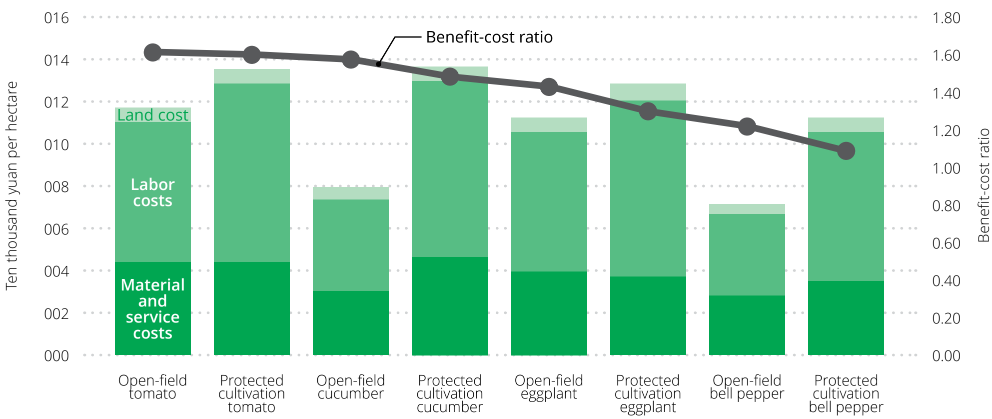
Table 2. Labour costs as proportion of total costs of selected vegetable crops

Crop	Labour costs in %
Open field tomato	56.60 %
Protected cultivation tomato	62.70 %
Open field cucumber	53.60 %
Protected cultivation cucumber	61.40 %
Open field eggplant	58.40 %
Protected cultivation eggplant	65.30 %
Open field bell pepper	53.10%
Protected cultivation bell pepper	62.90%

Data Sources: National Development and Reform Commission, National Compilation of Cost-Benefit Data of Agricultural Products – 2018, China Agriculture Press.

Labor costs of open field vegetables are thereby higher than those of protected cultivation vegetables. In terms of benefit-cost ratio, that of open-field tomato was the highest at 1.60, followed by protected cultivation tomato, open-field cucumber, and protected cultivation cucumber, which were 1.59, 1.57 and 1.48, respectively. The benefit-cost ratio of eggplant and bell pepper was relatively low.

Figure 3. Cost and benefit of different vegetable varieties

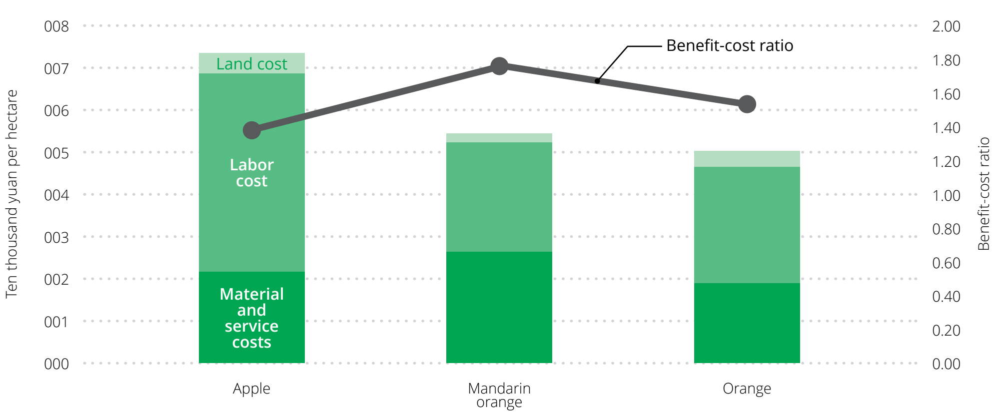


Data Sources: National Development and Reform Commission, National Compilation of Cost-Benefit Data of Agricultural Products – 2018, China Agriculture Press.

4.2. Cost-benefit analysis of fruit production in China

Figure 4 shows the costs and benefits of producing three major fruits in China. In 2017, the total cost of apples was the highest, with 73,000 yuan/hm²,

Figure 4. Cost and benefit of different fruit varieties



Data Sources: National Development and Reform Commission, National Compilation of Cost-Benefit Data of Agricultural Products – 2018, China Agriculture Press.

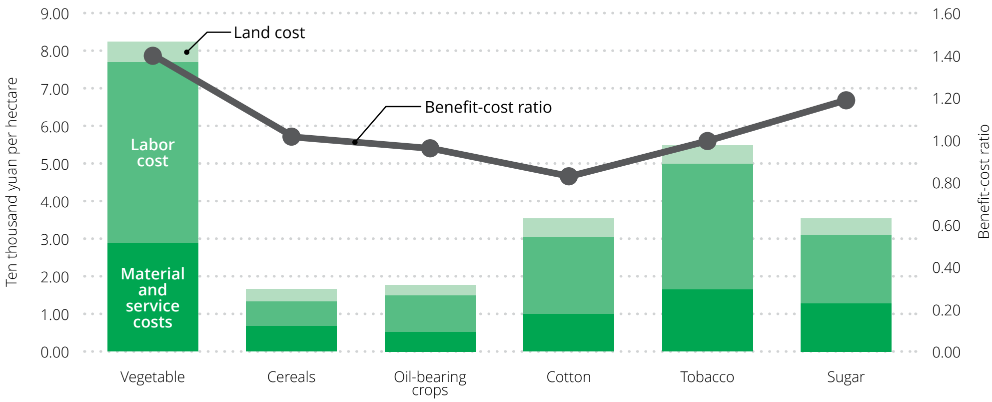
followed by mandarin and orange, at 54,000 yuan/hm^2 and at 50,000 yuan/hm^2. Although the total income per hm^2 of apples is the highest, at 101,000 yuan, the elevated costs mean that the cost-benefit ratio is the lowest, at 1.39. The benefit-cost ratio of oranges is the highest, at 1.76, and the lowest is 1.54. In terms of cost composition, labour costs of apples and oranges were the highest, accounting for 63.7%, and 54.0%, respectively, while the material and service costs of mandarins were the highest, accounting for 49.1%.

4.3. Comparative analysis of costs and benefits of vegetable and other crop production in China

Comparing the costs and benefits of vegetable production in 2017 with other crops (Figure 5), it is clear that the production cost per hm^2 for vegetables is the highest, followed by flue-cured tobacco, sugar, cotton and oil. From the point of view of the benefit-cost ratio, although the vegetable production costs are the highest, the income is also relatively high. This means that the benefit-cost ratio is the highest, reaching 1.39, followed by sugar, at 1.17. For grain, flue-cured tobacco, oil and cotton, this ratio is less than 1, indicating that the total income of these four crops is less than the total cost. Compared with other crops, vegetable production has higher added value, and is characterized by high inputs and high returns.

Compared with other crops, vegetable production has higher added value, but this is not the case for vegetable circulation, especially the acquisition by middlemen, vegetable packaging, preservation of freshness, and initial processing. With the popularization of the notion of a healthy diet, the concepts of green and organic vegetables have gained increasing attention, but they have not been fully implemented in the production link, and due to limits imposed by a decentralized management model, vegetable branding faces a series of difficulties. The added value of vegetable products needs to be further improved in order to face the challenge of rising annual production costs and ensure farmers' income.

Figure 5. Cost and benefit of different crops



Data Sources: National Development and Reform Commission, National Compilation of Cost-Benefit Data of Agricultural Products – 2018, China Agriculture Press.

5. Export characteristics of vegetables and fruits in China

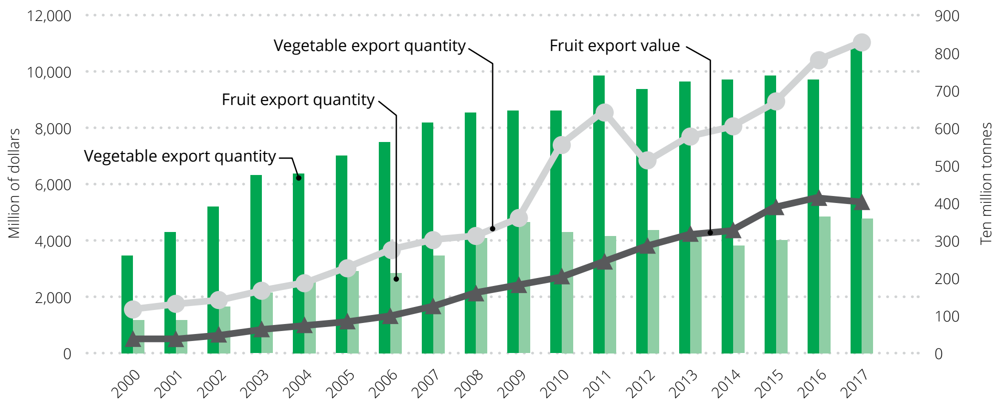
5.1. Overview of exports

Since 2000, China's vegetable and fruit exports have grown rapidly (as shown in Figure 6). The trade volume of vegetable and fruit has increased by 7.6 times, from $ 1.91 billion in 2000 to $ 16.36 billion in 2017, with an average annual growth rate of 13.5%. Among them, the trade volume of vegetables increased from $ 1.49 billion to $ 11.02 billion, with an average annual increase of 12.5%, while in the case of fruit, it increased from $ 420 million to $ 5.34 billion, with an average annual rise of 16.2%.

5.2. The major export destinations

The major export destinations of China's vegetables are shown in Figure 7. The vegetables export volume of China to Japan, South Korea, the United States and Vietnam display a trend towards growth overall. In recent years, the share of exports to Japan has been decreasing, while the share to

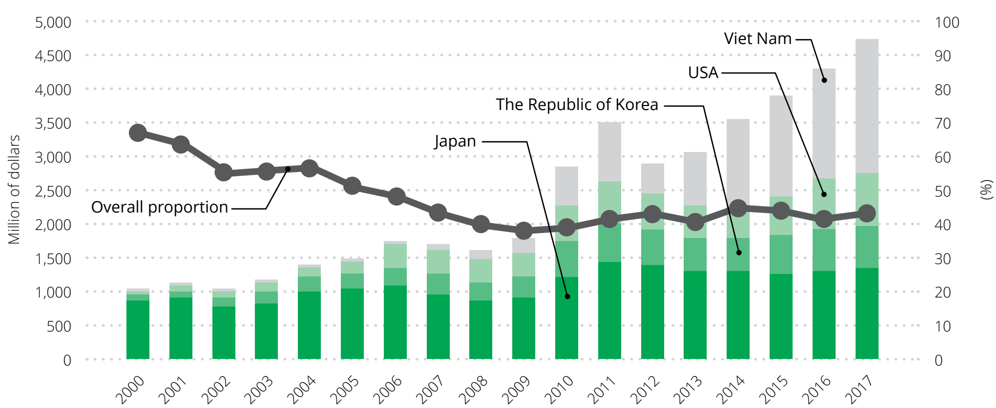
Figure 6. China's vegetable and fruit exports



Data Sources: UN Comtrade Database (https://comtrade.un.org/data/).

Vietnam has grown rapidly. China's vegetable exports to these four countries demonstrated a downwards trend from 67.1% in 2000 to 42.5% in 2017, which shows that China's vegetable export markets are diversifying.

Figure 7. Major export destinations of China's vegetable

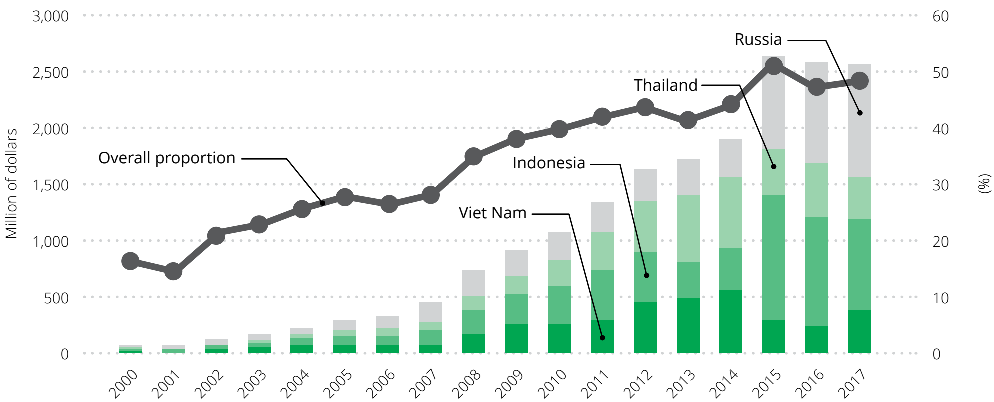


Data Sources: UN Comtrade Database (https://comtrade.un.org/data/).

The major export destinations of China's fruits are shown in Figure 8. In recent years, China's fruit exports to Indonesia and Russia have grown rapidly, while the shares of exports to Vietnam and Thailand have declined.

China's fruit exports to these four countries account for an increasing proportion, rising from 16.1% in 2000 to 47.8% in 2017, nearly half, which indicates that China's fruit export market is highly concentrated.

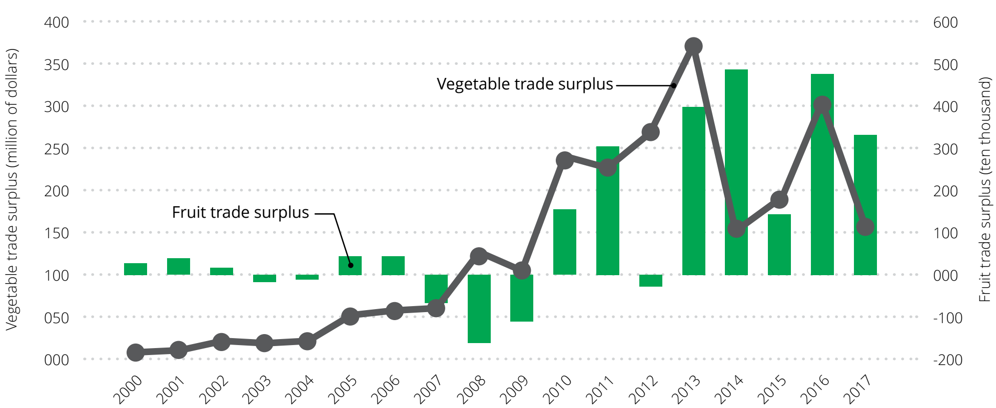
Figure 8. Major export destinations of China's fruit



Data Sources: UN Comtrade Database (https://comtrade.un.org/data/).

It is worth noting, that the vegetable trade between China and Brazil continues to grow (as shown in Figure 9), mainly in China's vegetable exports. From 2000 to 2017, China's vegetable trade surplus with Brazil increased

Figure 9. China's trade surplus in vegetables and fruits with Brazil



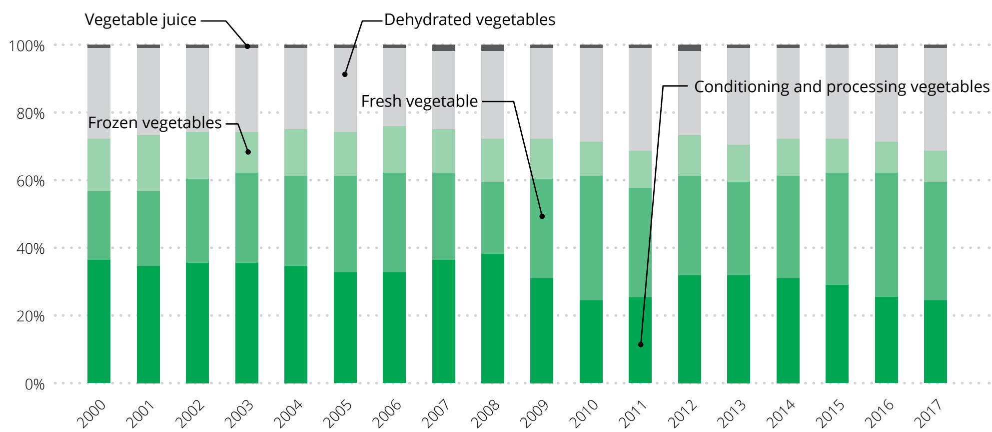
Data Sources: UN Comtrade Database (https://comtrade.un.org/data/).

from US$ 0.7 billion to US$ 1.62 billion, with an average annual growth of 20.5%. Over the same period, China's fruit export trade to Brazil has shown a fluctuating growth trend, as the trade surplus increased from $ 282,000 in 2000 to $ 33,554,000 in 2017, with an average annual growth of 15.7%.

5.3. Structure of export varieties

The export proportion of China's five vegetables categories is shown in Figure 10[1]. Processed vegetables and fresh vegetables exports accounted for the largest proportion, each with around 30%, while dehydrated vegetables account for 25%. In recent years, the proportion of processed vegetables has decreased, while fresh vegetables and dehydrated vegetables have increased. Frozen vegetable and vegetable juice have not changed significantly.

Figure 10. China's export proportion of five kinds of vegetables



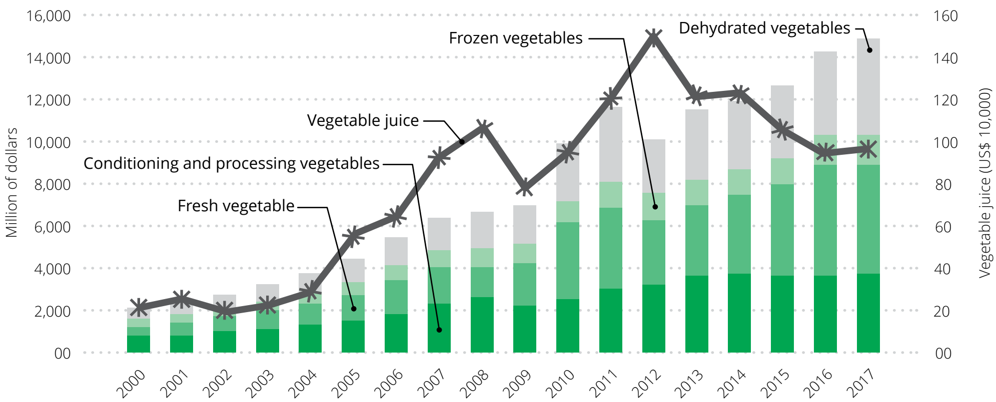
Data Sources: UN Comtrade database (https://comtrade.un.org/data/).

The export volume of five vegetables in China is shown in Figure 11. Since 2000, the absolute export volume of all vegetables has increased. Fresh vegetables and dehydrated vegetables have risen noticeably. While processed

[1] The HS codes of five vegetables in UN Comtrade database are: fresh vegetables (0701-0709, 0714), processed vegetables (0711, 2001, 2002, 2003, 2005), frozen vegetables (0710, 2004), dehydrated vegetables (0712, 0713), vegetable juice (200950, 200980, 200990).

vegetables and frozen vegetables have not changed much, vegetable juice displays a rapid growth trend before 2012, and has declined in recent years.

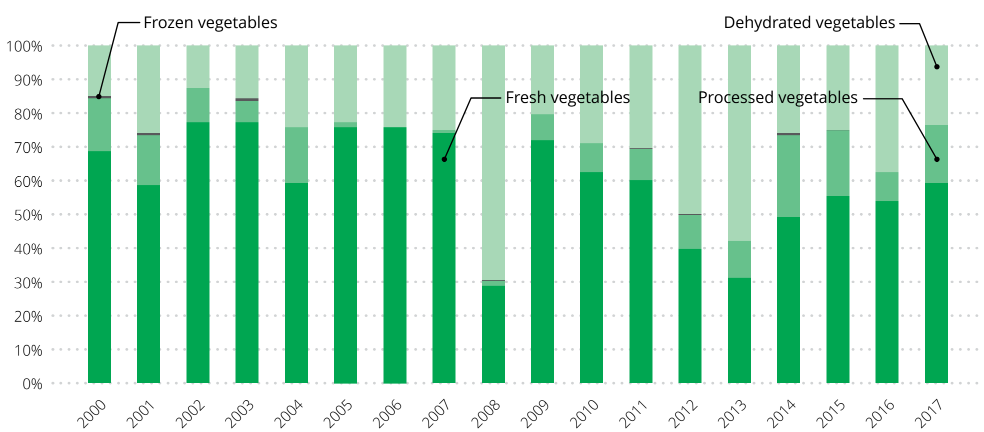
Figure 11. China's export value of five kinds of vegetables



Data Sources: UN Comtrade Database (https://comtrade.un.org/data/).

As shown in Figure 12, in 2017 fresh vegetables accounted for 60% of China's vegetable exports to Brazil, followed by dehydrated vegetables, at around 25%. These two types of vegetables accounted for about 85%. Processed vegetables accounted for about 15%, and frozen vegetables were

Figure 12. China's export proportion of vegetables to Brazil

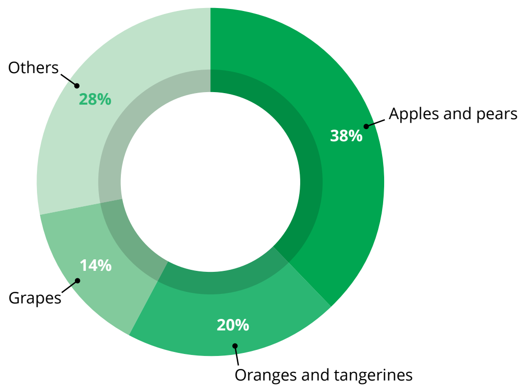


Data Sources: UN Comtrade Database (https://comtrade.un.org/data/).

rare. In recent years, the proportion of fresh vegetables has increased, while that of dehydrated vegetables has decreased.

As shown in Figure 13, apples and pears accounted for the largest share of China's fruit exports, reaching 38% in 2017, followed by citrus and grapes, accounting for 20% and 14% respectively. The four varieties reached 72%.

Figure 13. The export ratio of China's main fruit export varieties



Data Sources: UN Comtrade database (https://comtrade.un.org/data/).

6. Analysis of international competitiveness of China's vegetables and fruits

Based on the examination of the characteristics of China's vegetables and fruit exports, the international competitiveness of China's vegetables and fruits is analyzed by using the Revealed Comparative Advantage Index and Trade Specialization Coefficient focusing on comparative and competitive advantages, and compared with Brazil.

6.1. Indexes of international competitiveness

6.1.1. Revealed Comparative Advantage index (RCA)

The Revealed Comparative Advantage Index measures the share of a country's export value of a good in its total export value and that of the world's export value of that good in its total export value. The RCA of country j for good i in period t is defined by Balassa (1965)[2] as follows:

$$RCA_{ijt} = \frac{\frac{x_{ijt}}{\sum_i x_{ijt}}}{\frac{x_{iwt}}{\sum_i x_{iwt}}} \quad RCA_{ijt} = \frac{\frac{x_{ijt}}{\sum_i x_{ijt}}}{\frac{x_{iwt}}{\sum_i x_{iwt}}} \qquad (4)$$

Where x_{ijt} x_{ijt} is the export value of country j's good i in period t, $\sum_i x_{ijt}$ is the total export value of all goods of country j in period t, x_{iwt} is the total export value of good i in the world in period t, and $\sum_i x_{iwt}$ is the total export value of all goods in the world in period t. It is generally believed that an RCA greater than 2.5 indicates that a product has an extremely strong export comparative advantage, while an RCA between 1.5 and 2.5 indicates that a product has a strong export comparative advantage, and an RCA between 0.8 and 1.5 indicates that a product has a certain comparative advantage, while an RCA less than 0.8 indicates that a product does not have export comparative advantage[3].

6.1.2. Trade Specialization Coefficient (TC)

The Trade Specialization Coefficient of country j for a good i in period t is given by Grubel and Lloyd (1975)[4]: $TC_{ijt} = (X_{ijt} - M_{ijt}) / (X_{ijt} + M_{ijt})$(5).

Where X_{ijt} is the export value of country j's good i in period t, and M_{ijt} is the import value of country j's good i in period t. A TC greater than 0 indicates a competitive advantage, while a TC greater than 0.3 indicates a strong competitive advantage. A TC greater than 0.6 indicates an extremely strong competitive advantage, and a TC of less than 0 indicates a competitive disadvantage. A TC smaller than -0.3 indicates a strong competitive disadvantage, and less than -0.6 indicates an extremely strong competitive disadvantage.

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[2] Balassa, B., 1965. Trade liberalization and "revealed comparative advantage", The Manchester School, Vol. 33, pp. 99-123.

[3] Yun, C., 2003. An Empirical Study on Export Competitiveness of Chinese Vegetable Industry, Huazhong Agricultural University, pp. 30.

[4] Grubel, H.G., Lloyd, P.J., 1975. Intra-Industry Trade: The Theory and Measurement of International Trade in Differentiated Product, New York: John Wiley, pp. 205.

6.2. Data description

Data from the UN Comtrade Database is presented below. Selected main vegetable and fruit varieties with the commodity codes of 07 and 08 are refined into 14 4-item codes, respectively, as shown in Table 3.

Table 3. Commodity codes of main trade varieties

Commodity codes	Commodity
0701	Potatoes; fresh or chilled
0702	Tomatoes; fresh or chilled
0703	Onions, shallots, garlic, leeks and other alliaceous vegetables; fresh or chilled
0704	Cabbages, cauliflowers, kohlrabi, kale and similar edible brassicas; fresh or chilled
0705	Lettuce (lactuca sativa) and chicory (cichorium spp.) fresh or chilled
0706	Carrots, turnips, salad beetroot, salsify, celeriac; radishes and similar edible roots; fresh or chilled
0707	Cucumbers and gherkins; fresh or chilled
0708	Leguminous vegetables; shelled or unshelled, fresh or chilled
0709	Vegetables, n.e.s. in chapter 07; fresh or chilled
0710	Vegetables (uncooked or cooked by steaming or boiling in water); frozen
0711	Vegetables provisionally preserved, but unsuitable in that state for immediate consumption
0712	Vegetables, dried; whole, cut, sliced, broken or in powder, but not futher prepared
0713	Vegetables, dried leguminous; shelled, whether or not skinned or split
0714	Manioc, arrowroot, salep, Jerusalem artichokes, sweet potatoes and similar roots and tubers with high starch pr inulin content; fresh or dried, whether or not sliced or in the form of pellets; sago pith
0801	Nuts, edible; coconuts, Brazil nuts and cashew nuts, fresh or dried, whether or not shelled or peeled
0802	Nuts (excluding coconuts, Brazil and cashew nuts); fresh or dried, whether or not shelled or peeled
0803	Bananas, including plantains; fresh or dried
0804	Dates, flgs, pineapples, avocados, guavas, mangoes and mangosteens; fresh or dried
0805	Citrus fruit; fresh or dried
0806	Grapes; fresh or dried
0807	Melons (including watermalons) and papaws (papayas); fresh
0808	Apples, pears and quinces; fresh
0809	Apricots, cherries, peaches (including nectarines), plums and sloes, fresh
0810	Fruit, fresh; n.e.s in chapter 8
0811	Fruit and nuts; uncooked or cooked by steaming or boilling in water, frozen, whether or not containing added suger or other sweetening matter
0812	Fruit and nuts provisionally preserved, but unsuitable in that state for immadiate consumption
0813	Fruit, dried, other than that of heading no. 0801 to 0806; mixtures of nuts or dried fruits of this chapter
0814	Peel of citrus fruit or melons (including watermelons); fresh, frozen dried or provisionally preserved in brine, in sulphur water or in other preservative solutions

Sources: UN Comtrade database (https://comtrade.un.org/data/).

6.3. Comparative analysis of international competitiveness of vegetables and fruits between China and Brazil

Table 4 shows the values of RCA of vegetable and fruit products in China and Brazil. Compared with all vegetable products, China's onion and dehydrated vegetable products (0703, 0712) have strong comparative advantages, as is the case with carrots and temporarily preserved vegetables (0706, 0711). Cabbage and frozen vegetables (0704, 0710) have certain comparative advantages, while Brazilian vegetable products do not have comparative advantages. In fruit products, China's apples and pears (0808) have strong comparative advantages. Brazil's melons and papayas (0807) and Nuts (0801) also display noticeable comparative advantages, while dates, figs, pineapples, avocados, guavas, mangoes and mangosteens (0804) have general comparative advantages.

Longitudinal comparison shows that the comparative advantages of China's vegetable products have changed from 2002 to 2017 as follows: the comparative advantages of potatoes (0701), tomatoes (0702), lettuce (0705) have increased. The comparative advantages of onions (0703), leguminous vegetables (0708, 0713), frozen vegetables (0710) and temporarily preserved vegetables (0711) have also risen. The comparative advantages of cabbages (0704), carrots (0706) and cucumbers went through a process of an initial rise, followed by a decline. The comparative advantages of dehydrated vegetables (0712) and tuber vegetables (0714) declined, but after some time increased again. In fruit products, the comparative advantage of apples and pears (0808) increased. During the same period, the comparative advantage of Brazil's vegetable products did not change significantly, while the comparative advantage of nuts (0801) and melons (0807) in fruit products declined.

In a comparison between China and Brazil, it was found that the products with comparative advantage in China are mainly vegetable products. The products with strong comparative advantage in China have no export comparative advantage in Brazil, while the products with comparative advantage in Brazil are all fruit products. In terms of comparative advantage, there are great differences between China's and Brazil's vegetable and fruit products.

Table 5 shows the values of TC of vegetable and fruit products in China and Brazil. The competitive advantage of China's vegetable products decreased from 0.81 in 2002 to 0.69 in 2017. Although it still has great

Table 4. The values of RCA of China and Brazil

Codes	China's vegetables and fruits				Brazil's vegetables and fruits			
	2002	2007	2012	2017	2002	2007	2012	2017
0701	0,159	0,263	0,323	0,420	0,013	0,061	0,002	0,082
0702	0,038	0,046	0,087	0,127	0,028	0,034	0,000	0,013
0703	4,279	3,038	3,004	2,807	0,034	0,196	0,002	0,025
0704	0,436	0,583	1,187	1,061	0,003	0,003	0,000	0,000
0705	0,023	0,064	0,176	0,189	0,000	—	0,000	0,000
0706	1,763	1,531	1,900	1,849	0,052	0,051	0,005	0,052
0707	0,049	0,045	0,119	0,093	0,001	—	0,000	0,000
0708	0,559	0,280	0,278	0,147	0,011	0,007	0,000	0,004
0709	0,664	0,247	0,272	0,328	0,036	0,047	0,003	0,005
0710	2,302	1,526	1,426	1,118	0,008	0,003	0,000	0,001
0711	7,470	3,725	2,686	1,761	0,064	0,331	0,213	0,135
0712	6,933	5,243	4,982	5,086	0,420	0,043	0,025	0,006
0713	2,445	1,311	0,921	0,253	0,344	0,387	0,270	0,351
0714	2,427	0,775	0,571	1,338	0,903	0,500	0,187	0,427
0801	0,003	0,000	0,001	0,000	9,591	8,070	2,963	1,667
0802	0,757	0,358	0,249	0,188	0,096	0,040	0,037	0,034
0803	0,025	0,011	0,006	0,009	0,817	0,529	0,304	0,064
0804	0,013	0,011	0,006	0,039	3,253	2,302	1,543	1,163
0805	0,216	0,334	0,483	0,394	0,529	0,645	0,295	0,373
0806	0,048	0,164	0,233	0,571	1,132	3,051	0,715	0,746
0807	0,076	0,074	0,250	0,247	5,378	6,090	5,239	4,218
0808	1,041	1,086	0,894	1,546	0,844	0,840	0,285	0,337
0809	0,032	0,040	0,094	0,190	0,002	0,000	0,000	0,000
0810	0,099	0,060	0,168	0,128	0,048	0,051	0,009	0,012
0811	0,905	0,846	0,692	0,319	0,409	0,424	0,214	0,212
0812	3,877	2,596	2,605	1,344	0,256	0,346	0,445	0,233
0813	0,765	0,692	0,402	0,269	0,014	0,150	0,123	0,128
0814	0,633	0,243	0,246	0,169	4,751	2,231	0,597	2,894
Vegetables	1,590	1,030	1,040	0,935	0,096	0,101	0,057	0,088
Fruits	0,350	0,323	0,325	0,312	1,269	1,375	0,622	0,533
Vegetables and fruits	0,880	0,632	0,585	0,569	0,768	0,818	0,416	0,350

Data Sources: Based on the data of UN Comtrade database (https://comtrade.un.org/data/).

Table 5. The values of TC of China and Brazil

Codes	China's vegetables and fruits				Brazil's vegetables and fruits			
	2002	2007	2012	2017	2002	2007	2012	2017
0701	0,995	1,000	1,000	1,000	-0,803	0,001	-0,946	-0,235
0702	0,999	1,000	—	1,000	0,984	—	-0,845	0,940
0703	0,999	0,999	1,000	0,999	-0,980	-0,878	-0,999	-0,985
0704	0,986	1,000	1,000	1,000	—	—	0,047	—
0705	0,982	0,998	—	1,000	-0,671	—	-0,977	-0,912
0706	0,987	0,999	—	0,998	0,851	0,763	-0,593	0,230
0707	1,000	—	—	1,000	—	—	—	—
0708	0,926	1,000	0,994	—	-0,798	0,790	—	—
0709	0,979	0,994	0,977	0,979	0,723	0,745	-0,752	-0,591
0710	0,929	0,937	0,948	0,940	-0,908	-0,956	-0,998	-0,991
0711	0,984	0,973	0,961	0,959	-0,986	-0,385	-0,844	-0,920
0712	0,965	0,985	0,992	0,994	-0,408	-0,925	-0,958	-0,987
0713	0,833	0,666	0,271	0,090	-0,609	-0,555	-0,786	-0,265
0714	-0,398	-0,763	-0,848	-0,759	0,999	0,931	0,652	0,954
0801	-0,973	-0,993	-0,994	-0,998	0,945	0,977	0,462	0,248
0802	0,502	0,277	-0,024	-0,226	-0,691	-0,893	-0,878	-0,841
0803	-0,863	-0,885	-0,969	-0,945	1,000	0,999	0,999	0,970
0804	-0,873	-0,885	-0,956	-0,692	0,969	0,950	0,947	0,950
0805	0,331	0,650	0,731	0,319	0,930	0,926	0,596	0,585
0806	-0,658	-0,078	-0,117	0,094	0,328	0,623	0,046	0,076
0807	-0,285	-0,208	0,094	0,633	1,000	—	1,000	—
0808	0,804	0,902	0,861	0,879	-0,253	-0,344	-0,708	-0,688
0809	-0,301	-0,135	-0,731	-0,666	-0,996	-1,000	-1,000	-0,999
0810	-0,737	-0,772	-0,759	-0,767	-0,647	-0,505	-0,937	-0,911
0811	0,818	0,452	0,418	0,174	0,314	0,663	-0,090	-0,114
0812	0,950	0,853	0,932	0,928	-0,332	0,036	0,026	0,248
0813	-0,009	0,157	0,019	-0,033	-0,984	-0,846	-0,838	-0,787
0814	0,964	0,723	-0,380	0,278	0,924	0,895	0,799	0,966
Vegetables	0,813	0,670	0,483	0,694	-0,743	-0,658	-0,869	-0,700
Fruits	0,189	0,282	-0,005	-0,090	0,482	0,465	0,037	0,122
Vegetables and fruits	0,620	0,536	0,264	0,325	0,181	0,245	-0,228	-0,125

Data Sources: Based on the data of UN Comtrade Database (https://comtrade.un.org/data/).

competitive advantage, the overall competitiveness is declining. Except for tuber vegetables such as cassava (0714), which have great competitive disadvantage, dry-shelled leguminous vegetables (0713) and other vegetable products have general competitive advantage. In the same period, Brazil's vegetable products as a whole had a great competitive disadvantage. In addition to tomatoes (0702), cassava and other tuber vegetables (0714), carrots (0706) have a certain competitive advantage, while other vegetable products do not have a competitive advantage.

The competitive advantage of China's fruit products decreased from 0.19 in 2002 to -0.09 in 2017, as the overall competitive advantage turned into a to competitive disadvantage. Melons and papaws (0807), apples and pears (0808) and temporarily preserved fruits and nuts (0812) are highly competitive. Citrus (0805), grapes (0806) and frozen fruits or nuts (0811) are generally competitive, while other products are not competitive. In the same period, the competitive advantage of Brazilian fruit products as a whole declined. Among them, banana (0803), figs, avocado, pineapple and guava (0804) and melon (0814) are highly competitive. Citrus fruit (0805), grapes (0806) and frozen fruits or nuts (0811) are generally competitive, while other products are not competitive.

7. Analysis on the complementarities of fruit and vegetable trade between China and Brazil

The differences in resource endowment between China and Brazil do not only produce comparative advantages in fruit and vegetable trade, but also increase the complementarities of bilateral trade to a certain extent, which provides a broader space for the growth of fruit and vegetable trade.

7.1. The Trade Complementarity Index

The Trade Complementarity Index (TCI) is used to analyze the complementarities between China and Brazil[5].

[5] Jinping, Y., 2003. Comparative Advantage and Trade Complementarity between China and Other Asian Economies, The Journal of World Economy, Vol.05, pp.33-40+80.

The TCI between country i and country j is defined as follows:

$$TCI_{ij} = RCA_i \times RMA_j \quad (6)$$

$$RMA_j = \frac{M_j \mid M^i_j}{M_w \mid M^i_w} \quad (7)$$

Where RCA_i is the Revealed Comparative Advantage Index of country i, whose calculation method references Formula (4); RMA_j is the comparative advantage of fruit and vegetable trade of country j measured by import; M_j is the import amount of fruit and vegetable of country j; M^i_j is the total import amount of all products of country j; M_w is the world import amount of fruit and vegetable; M^i_w is the total import amount of all products of the world. The larger TCI is, the stronger the complementarity between the fruits and vegetables export of country i and the fruits and vegetables import of country j.

7.2. Analysis of trade complementarities

In terms of China's fruits and vegetables export, the TCI between China and Brazil shows an overall growth trend (Table 6). China's vegetable exports, and Brazil's vegetable imports are highly complementary; in 2017, the TCI was 1.342, up from 0.912 in 2012. The complementarity between China's fruit exports and Brazil's fruit import is relatively low, but it is growing, indicating that they have a certain trade potential; 2002/2017 saw an increase from 0.198 to 0.376 in TCI. On the whole, China's fruits and vegetables exports and Brazil's fruits and vegetables imports are highly complementary; the TCI increased from 0.599 in 2002 to 0.739 in 2017.

In terms of fruit and vegetables imports, China's fruit has the strongest complementarity with Brazilian exports. In 2017, the TCI was 0.490, up from 0.334 in 2002. The complementarity between China's vegetable import and Brazil's vegetable export is also growing from a relatively low level; in the period from 2002/2017 an increase from 0.017 to 0.036 in the TCI became evident. China's fruits and vegetables import and Brazil's fruits and vegetables export are therefore relatively complementary, as the TCI increased from 0.175 in 2002 to 0.249 in 2017.

Table 6. The TCI of China and Brazil

	Categories	2002	2007	2012	2017
China's export and Brazil's import TCI	Vegetables	1,323	0,671	0,914	1,342
	Fruits	0,198	0,216	0,204	0,376
	Vegetables and fruits	0,599	0,418	0,421	0,739
China's import and Brazil's export TCI	Vegetables	0,017	0,026	0,023	0,036
	Fruits	0,334	0,318	0,230	0,490
	Vegetables and fruits	0,175	0,199	0,160	0,249

Data Sources: Based on the data of UN Comtrade database (https://comtrade.un.org/data/).

8. Conclusions

This study analyzes the development of fruit and vegetable production in China and the competitiveness and complementarity of trade in these products between China and Brazil. We applied the contribution rate decomposition method and the cost-benefit method to analyze the production of fruits and vegetables in China. The Revealed Comparative Advantage Index and the Trade Competitiveness Index were used to evaluate the competitiveness of China's and Brazil's fruit and vegetable trade. We also used the Trade Complementarity Index to reveal the complementarities of fruit and vegetable trade between China and Brazil.

The contribution rate decomposition and the cost-benefit results show that China's vegetable production gradually has changed to rely on the mode of production efficiency expansion. China's fruit production has become more reliant on the expansion of the scale of production. Labor expenditures are the most important cost of vegetable and fruit production in China, which implies a need for different modes of governmental support for vegetables and fruits production. The cultivation of vegetables mainly depends on the improvement of production efficiency, and the cultivation of fruits mainly depends on the expansion of the scale of production. At the same time, measures should be taken to reduce the labor costs of both.

The results of trade indexes analysis show that the products with comparative advantage in China are mainly vegetables, while the products with comparative advantage in Brazil primarily are fruits. Furthermore, the vegetable and fruit trade between China and Brazil has strong complementarities and large growth potentials, especially regarding China's vegetable export and Brazil's vegetable imports. The implication is that China should optimize the industrial structure of fruit and vegetable production. More thorough analyses of Brazilian demand can help China improve fruit and vegetable production and processing, and increase the added value of fruit and vegetable products.

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Chapter 4

André Souto Maior Pessôa
Débora da Costa Simões

Key success factors for the Brazilian grains and meat industry

Abstract

In this chapter, Pessôa and Simões analyze the structural drivers behind the rapid expansion of agricultural production in Brazil during recent decades. With a point of departure in Chaddad (2016), the authors provide an account of how the combination of rich natural resources endowments, R&D, public policies, farmer entrepreneurship, and value chain organization led to a rise in production volumes and the significant export performance of the Brazilian agricultural sector. The complementarities and opportunities provided by the steadily intensifying commercial partnership between Brazil and China are also assessed by the authors, who underscore the potential of this rapidly developing market for Brazilian agricultural exporters.

1. Introduction: an overview of recent growth of the Brazilian agribusiness

In the last two decades, agricultural and livestock production in Brazil has undergone extraordinary growth. From 2000 to 2019, the gross value of production of these sectors more than doubled in real terms[1], rising from R$ 262,43 billion to R$ 609,52 billion (Mapa, 2019). In the same period, grain production nearly tripled, from 83.0 to 242.1 million tons (Conab, 2019) and meat production – including beef, chicken, and pork – almost doubled from 14.8 to 28.5 million tons.

As a result of this performance, agribusiness enhanced its strategic position within the Brazilian economy. The sector contributed significantly to the country's development by increasing food production and its affordability, generating trade surpluses, promoting food safety and security, and by improving standards of living in the countryside. According to the Center for Advanced Studies in Applied Economics (Cepea) of the University of Sao Paulo (USP), between 2000 and 2018[2], agribusiness represented almost one quarter of the country's GDP[3]. In this period, the sector's GDP grew 316.6%, from R$ 346.1 billion to R$ 1,441.8 billion (measured in constant values); an annual real growth rate of 8.3%. In the same period, the agribusiness trade surplus increased from US$ 15 billion in 2000 to US$ 87 billion in 2018, and thereby sustained the surplus in the country's trade balance by compensating for the deficits produced by the industry and service sectors. In 2018, agribusiness exports reached US$ 101 billion[4] and represented 42% of total Brazilian exports. For every US$ 10 dollars Brazil receives from external sales, US$ 4.2 are derived from agriculture and livestock products.

[1] In real terms (i.e. discounting inflation).

[2] Data for 2019 were not available at the time this chapter was written.

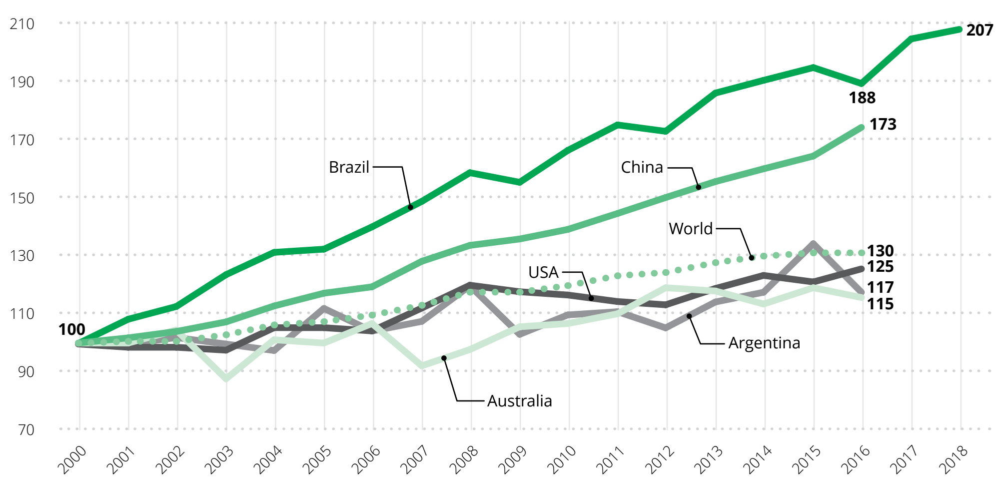
[3] Using the concept of supply chains launched in 1957 by John Davis and Ray Goldberg, researchers at Harvard University, the agribusiness GDP measured by Cepea considers, besides farm production operations, the production and distribution operations of agricultural inputs; storage, processing and distribution of agricultural products and the items produced from them. GDP is calculated from the perspective of value added at market prices, including indirect taxes net of subsidies. Subsequently, the series is deflated by the IGP-DI. The criterion used by the institution considers both the evolution of the volume produced and the prices of each aggregate.

[4] The main agricultural products exported by Brazil are: (1) Products from the soybean complex: soybean grains, meal and oil (39%); (2) Meat: beef, poultry and pork (16%); (3) Forestry products: paper and pulp (15%); (4) sugar and ethanol (6%) and (5) cereals, flours and preparations (6%).

Nowadays, Brazil is recognized as one of the main global agricultural powerhouses. The country is among the main producers and exporters of nearly 40 agricultural products, such as soybeans, corn, coffee, sugar, ethanol, cotton, orange juice, cotton, beef, poultry, and pork. Currently exporting to more than 200 countries, and with a 5.2% share of world agricultural exports in 2018, Brazil is the third largest global exporter, behind only the European Union and the United States. In terms of net exports, the country has occupied first place in the ranking since 2004[5] (WTO Database, 2019).

These great achievements obtained by the Brazilian agribusiness did not occur simply by incorporating more land but, rather, due to significant improvements in productivity. According to Gasques et al., (2019), the gains in productivity have been the leading factor in sustaining the evolution of agriculture and livestock activities in the country. From 2000 to 2018, the annual agricultural total factor productivity increased 4.1% and thereby doubled its efficiency. In other words, more output of food is produced

Figure 1. Agricultural total factor productivity: Brazil and selected countries



Source: Gasques et al. (2019) for Brazil and USDA/ERS (2019) for other countries.
Note: Data from USDA/ERS available till 2016.

[5] Until 1994 the country was a net importer of agricultural products.

with fewer resources. This performance surpasses the results obtained by other countries, such as Argentina, Australia, China, and the United States (Figure 1).

This chapter aims to identify the principal factors that have sustained production and productivity gains in recent years, and to explore the cases of two value chains that serve to illustrate the sector's advances: (1) the grain value chain – focused on soy and corn – and, (2) the meat value chain – with a focus on poultry and pork. Subsequently, China's role in the growth of Brazilian exports is highlighted and, finally, the opportunities for strengthening the relations between Brazil and China within the field of agribusiness are analyzed.

2. The key factors of Brazilian agribusiness success

The rapid growth of Brazilian agribusiness in the last 20 years is internationally recognized as a successful business case. The increase in production coupled with productivity gains in tropical agriculture has made the Brazilian experience a reference for other developing countries. It has therefore been studied by many specialists, economists, and policy makers.

It is true that during this period, the external environment presented very favorable conditions that intensified the demand for agricultural commodities. In fact, the 2000s witnessed a "commodity boom" which was triggered by a combination of key factors: a strong growth of the global population, an intense and rapid urbanization process in Asian countries (especially China), rising per capita income (mainly in developing countries), changing dietary habits towards a higher protein diet, and incentives for greater biofuels production. This favorable environment certainly influenced the speed of growth of Brazilian agribusiness, but it does not by itself explain why Brazil was able to benefit from such a favorable moment, while other countries did not.

Understanding the reasons for the recent performance of Brazilian agribusiness is not a trivial task, as it involves taking a variety of factors into account. According to Fabio Chaddad (2016), the key success in the success of the Brazilian agribusiness can be summarized in 5 main pillars (Figure 2): (1) the availability of natural resources, (2) investment in research and technological development; (3) adoption of supportive public policies; (4) farmers' entrepreneurship, and (5) the value-chain organization.[6]

Figure 2. The key factors of Brazilian agribusiness success

1. Natural resources	2. R&D/ technology	3. Public policies	4. Farmers' entrepreneurship	5. Value chain organization
• Land • Water • Rainfall • Solar irradiation • Temperature	• Good Ag. practices • Inputs efficiency and better use • Genetics • Mechanization	• Economic stability • Openness of the market • Privatization of logistics infrastructure • Credit availability & new instruments • Tax exemption for exports	• Exposure to risks • Adoption of technology • Resilience • Flexibility	• Cooperatives • Contract farming • Vertical integration • Large-scale & corporate farming • Producers associations

Source: Elaborated by the authors based on Chaddad (2016) and our own research.

The first pillar concerns the availability of natural resources, such as land, water, and favorable climatic conditions for the cultivation of agricultural products. According to research published by FAO and the World Bank, Brazil has 176 million hectares of suitable non-cropped, non-protected land available for agricultural expansion (14.5% of the world's total)[7] and a volume of 5,661 km^3 of internal renewable freshwater measured by surface water production (13.2% of the world's total)[8]. In addition, the prevailing climatic characteristics in the country (the rainfall patterns, solar irradiation, and temperature) allow several regions to grow two or even three crops throughout the year, which is a great advantage over other countries.

[6] Most economists and experts highlight the first 3 pillars to justify the recent results obtained by the Brazilian agribusiness. However, Fabio Chaddad (2016) defined these pillars as enabling conditions. They are important factors but are not enough to explain the outcomes observed in Brazil. Thus, after a detailed microeconomic study conducted in several regions of the country, Chaddad identified the two last pillars as relevant factors for understanding the recent dynamics of Brazilian agribusiness.

[7] Fischer, G., and M. Shah. 2010 "Farmland Investments and Food Security: Statistical Annex." Report prepared under World Bank and International Institute for Applied System Analysis contract, Luxembourg.

[8] Aquastat Database. Surface water produced internally is defined by FAO as the "long-term average annual volume of surface water generated by direct runoff from endogenous precipitation (surface runoff) and groundwater contributions".

Regarding the second pillar, the development of technologies adapted to the edaphoclimatic characteristics of the Brazilian territory led to the consolidation of tropical agriculture. Agricultural activities soon expanded from the temperate zones of the South to the Cerrado (Brazilian savannah) of the Midwest, where temperatures are higher, and soils are poorer and acidic. The success achieved is the outcome of the organization of a complex research system composed by Embrapa (the Brazilian Company for Farming Research created in 1973), state institutions, universities, the private sector, and by farmers themselves. The interaction between these entities guided the research objectives towards practical questions and applied solutions, making the innovation process more efficient and dynamic.

Among the results obtained are:

(a) the adoption of good production practices such as no-till, second crop with rotation, integrated pest management, and integrated crop livestock systems.

(b) more efficient use of inputs: adequate application of fertilizer and agrochemicals, improvement in seed quality, biological nitrogen fixation, and nutritional improvement in animal feed with the addition of supplements and precision agriculture.

(c) evolution of genetics with development of new seed varieties adapted to Brazilian conditions (especially the Cerrado), early soybean development (minimizing climate risks from second crop planting), development of genetically modified varieties, techniques for genetic improvement of animals, and artificial insemination in fixed time.

(d) mechanization: availability and access to more powerful machines (tractors, combines, planters, sprayers, etc.) with more advanced technology embedded (GPS, maps, and sensors).

The efforts and initiatives taken to foster the innovation process were possible thanks to a combination of structural reforms and public policies that were adopted in Brazil during the 1990s[9]. This set of policies encompasses the third pillar that sustained the growth of Brazilian agribusiness. From

[9] Some policies adopted in the 70's and 80's also contributed to agricultural development in Brazil such as the creation of a rural credit program and policies of minimum price for certain agricultural products. For a complete historical perspective of the development of agriculture in Brazil, please refer to the chapter The Brazilian Food Sector: An Overview written by Geraldo Sant'Ana de Camargo Barros.

a macroeconomic point of view, the Real Plan, adopted in 1994, stabilized inflation[10], balanced national accounts, and allowed the country to construct a more stable and healthier economic environment, favoring medium and long-term investments in agriculture. The increasing openness of the economy to international trade also forced many sectors to become more efficient, in order to compete on the global market. In addition, the government promoted a series of privatizations of ports, railways and road networks, favoring investments and improving the transportation logistics within the country.

The economic stability, combined with new management practices in public banks, – the Bank of Brazil in particular, – presented the government with conditions to improve credit provision to agriculture and livestock sectors. So, from 2000 to 2018, the disbursements of rural credit grew from R$ 13,8 billion to R$ 120,3 billion according to the Brazilian Central Bank. Meanwhile, the average annual interest rates to cover operational expenses decreased from 8.75% to 7.00%. Besides the improvement in the traditional rural credit system, Brazilian policies enhanced the creation of new instruments and operations to help farms fund their activities. One example of these new instruments is the Farm Product Bond (CPR)[11] which helped to consolidate the "barter"[12] operation in Brazil. Another relevant policy measure emphasized by Jank and Pessoa (2002) is the tax exemption for agricultural exports known as "Lei Kandir," which exempted exports of raw and semi-manufactured products from the ICMS value-added tax. This measure increased the price received by farmers, improved their income, and fostered the expansion of newly planted lands.

The fourth pillar refers to the entrepreneurship of Brazilian farmers, who accepted the inherent risks of this business activity, and faced the ups and

[10] With the introduction of the Real economic stabilization plan in 1994, Brazilian inflation fell from 40% per month to around 5% a year.

[11] "CPR is a bond that facilitates the cash forward contract for agricultural and livestock production, enabling producers to collect resources or inputs beforehand by offering part of their production capacity as collateral to the financers" (Pimentel & Leão, World Bank, 2005). In other words, it is a structured loan agreement between a farmer and a lender in which future crop production is given as guarantee.

[12] Barter can be defined as an operation that involves the exchange of an agricultural input (e.g.: fertilizer, agrochemicals) for a specific agricultural product (e.g.: soybean, corn, sugar). This kind of transaction is very popular in the Brazilian agribusiness' sector and represents about 1/3 of farmers source of funding in the Cerrado area.

downs of the commodity markets. They were the ones who effectively realized the productivity gains. Chaddad (2016) writes: "they had the foresight and capacity to adopt modern technologies, were resilient to several economic crises, and adapted to constant changes in the institutional environment". Some of them decided to leave everything behind to invest in remote frontier regions, contributing to the expansion of livestock and agriculture to the interior regions of the country.

Lastly, the fifth pillar points to the relevance of the organization of agricultural value chains. The different models that have emerged in the country were very important in connecting farmers to the market. In this context, it is worth mentioning the role of cooperatives (especially in the South of the country), contract farming agreements (mostly adopted by poultry and swine sectors), vertically integrated agribusiness (which predominates in sugarcane and citrus, including innovative systems of price formation such as the Consecana model[13]), the emergence of large-scale and corporate farming business in the Cerrado, and the upsurge of producers associations and new-generation cooperatives (aimed at minimizing market failures in the Cerrado area).

The next section of this paper will explore two cases in Brazilian agribusiness. The first is the grain sector, represented by the expansion of soybean and corn. The second is the meat industry, focusing on the evolution of poultry and pork production.

3. Case studies: Grains and meat value chains

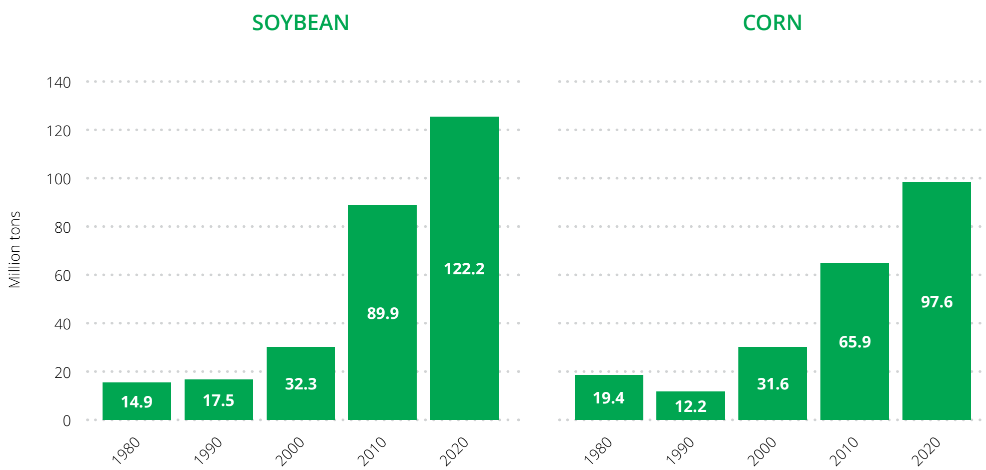
3.1. The grain value chain: soybean and corn

Grain production has undergone unprecedented growth in Brazil over the past two decades. According to Conab data, between 2000 and 2020, Brazilian corn production is expected to triple from 31.6 to 97.6 million tons,

[13] Consecana is a private system created with the purpose of setting minimum rules and procedures to remunerate sugarcane suppliers. It is comprised by Orplana (Organization for Sugarcane Suppliers in South-Central Brazil) and Unica (Brazilian Sugarcane Industry Association) which respectively represent the interests of sugarcane suppliers and the processing industries.

a growth of 65.9 million tons. In the same period, soybean production is projected to almost quadruple, from 32.3 to 122.2 million tons, an increase of almost 90 million tons (Figure 3). As mentioned in the previous section, this fantastic growth was due to a combination of factors: the development of technologies adapted to a tropical climate, regulatory and public policy improvements, opportunities within foreign and domestic markets, and the confidence and initiative of Brazilian farmers.

Figure 3. The evolution of soybean and corn production in Brazil

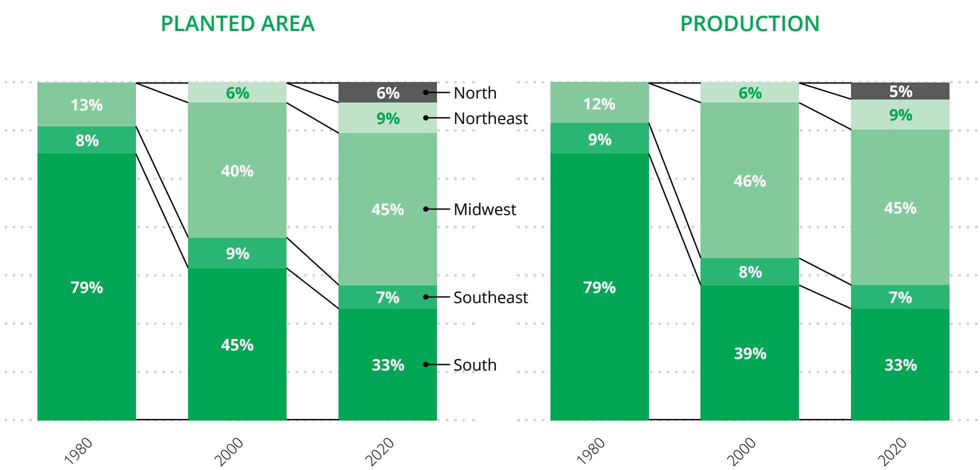


Source: Conab (2019).

Throughout the past twenty years, soybean became the locomotive of Brazilian agribusiness. However, it took years of research to make this possible. Soy was introduced in Brazil in the first half of the twentieth century, with varieties coming mostly from the United States. At that time, most soy fields were in the South and Southeastern regions of the country, being a crop of little economic importance. It was only in the beginning the 1980s that Embrapa and the Federal University of Viçosa obtained – through genetic improvement techniques – the first soybean variety with a long juvenile period adapted to the Brazilian conditions.

This innovation constitutes a landmark in the history of soybeans in Brazil, since it permitted the expansion of oilseeds to regions of low latitude – such as the Cerrado – with good yield levels. In 1980, only 13% of the soybean planted area in Brazil was in the Midwest, while the South and Southeast accounted for 87% of the total planted area. In 2000, after little more than two decades of development of new varieties adapted to low latitudes, the Cerrado of the Midwest and Northeastern regions already represented, respectively, 40% and 6% of the total planted area in the country. The acquisition of this technology, combined with acidity correction techniques and low natural fertility in Cerrado soils, allowed thousands of producers in the South and Southeast of the country to migrate to the vast and cheap lands of Central Brazil (Figure 4). Nornam Bourlaug, a Nobel Peace Prize-winning agronomist and father of the Green Revolution, points to this transformation of the infertile soils of the vast Brazilian Cerrado into one of the most productive agricultural regions in the world, as one of the technological innovations with the greatest impact on humanity in the second half of the 20th century.

Figure 4. The evolution of soybean in Brazil by region



Source: Conab (2019).

In parallel, certain public policies helped in the process of consolidating the agribusiness expansion (Pessôa and Jank, 2002). A broad public program for rural credit provision and the adoption of a program of minimum prices guaranteed by the Federal Government helped to encourage producers to adopt a better input package, and invest in the acquisition of land and machinery. In this context, private credit also played a relevant role in providing credit to farmers through barter schemes guaranteed by CPR[14].

However, as the edaphoclimatic conditions and the scale of operation (much larger areas) were significantly different from the regions of origin of farmers who migrated from Southern traditional regions to the Midwest, it took a long time before a critical mass of producers could fully manage the productive model. During this period, there were many financial frustrations and difficulties in adapting to new forms of production. Thousands of these pioneers went bankrupt and were forced to sell their lands, with several episodes of high indebtedness. The adverse conditions of macroeconomic instability in Brazil during this period, especially high inflation, also made the financial planning capacity of agricultural activities very difficult. But those producers who were successful (and there were many) were ready for a new phase of expansion, since they already dominated the production model in the Cerrado, especially the challenges of managing large-scale production.

In the second half of the 1990s, Brazil underwent profound economic changes. The Real Plan allowed inflation to stabilize, and a series of reforms launched a new phase of economic growth. For agriculture, Lei Kandir (fiscal exemption for exports of primary products) and the reestablishment of private credit lines were two important achievements. Greater openness in the country has also attracted many multinational companies and fostered a broad process of mergers and acquisitions in the sectors of fertilizers, agricultural machinery, pesticides, nutrition, and animal health and seed, helping to internationalize Brazilian agribusiness.

If in the period between 1980 and 2000, the availability of new technologies (which guaranteed a strong boost of productivity) can be associated with agricultural public policies, especially in research and financing; from the turn of the century, the increased presence of large multinationals with extensive technological capabilities guaranteed a flow of innovations for Brazilian producers. With the virtuous cycle of innovating to increase productivity, revenues were further invested in this development, and the flow of technological innovations thus became crucial to maintain the pace of expansion.

[14] See notes 09 and 10.

Even though governmental interventions are not anymore a leading factor in inducing agricultural expansion, it is worth mentioning some public initiatives with significant impact: the laws for the Protection of Cultivars, the Law on Biosafety, and the creation of Moderfrota[15], a governmental program for supporting the modernization and expansion of the agricultural machinery fleet. Laws related to the seed sector allowed companies to launch new technologies associated with biotechnology in Brazil, as was the case with transgenic soybeans. Moreover, this regulation established a favorable environment for companies to multiply new varieties, which significantly improved the capacity to offer farmers more productive seeds and, above all, varieties that are more adapted to new regions of the agricultural frontier, such as the new Cerrado fields in the Northeast Region, the new areas in the North and East of Mato Grosso, and even regions like Rondônia, Tocantins, and Pará.

Amidst this new institutional environment, one of the most creative recent innovations in Brazilian agriculture is the early and super early soybean. At the turn of the century, most of the soy planted in Brazil was still concentrated on varieties of medium and late cycles, which remained in the field for 120 to 150 days. Thus, only a few regions, with a very specific climate, permitted the planting of two crops in the summer/autumn period, notably the West and North of Parana, the South of Sao Paulo, the South of Mato Grosso do Sul, and Southwest of Goias. Even so, the possibility of planting a second corn crop after the harvest of the medium cycle soybean areas, in February, March and even April, was associated with high climatic risks, due to the frequent interruption of the rains beginning in May. The total area of the second crop corn (safrinha) in Brazil in 2000 was only 2.9 million hectares, and production reached an insignificant 3.9 million tons. At the same time, the area for production of summer corn, which competed for the same fields as soy, reached 9.8 million hectares, and production accounted for 27.7 million tons.

With the increased stability promoted by the Biosafety Law and the Law on the Protection of Cultivars, companies invested in research, and made

[15] Moderfrota (Program of Modernization of Agricultural Tractors and Associated Implements and Harvesters) is a financial scheme created by the Brazilian government to stimulate and boost agricultural mechanization. The program finances the acquisition of tractors, harvesters, sprayers, and other tools and equipments such as cutting decks, planters, and seeders.

the so-called early and super early soybeans available to Brazilian producers. These are varieties with a much shorter development cycle, initially between 105 to 115 days, and now as short as 90 days in some cases. This made it possible to shorten the soybean harvest period in several regions by about 30 days, consequently reducing the climatic risks of planting a second crop – usually corn. When planting corn in February, January and even in the last week of December, the risk of facing a drought period at the end of the corn cycle has decreased significantly, and allowed producers to invest more in seeds with greater productive potential, more fertilizers, and management of pests and diseases. As a result, the area for growing winter corn has expanded significantly. In 2020, it should reach 12.9 million hectares, with an estimated production of more than 70 million tons. The average productivity of corn, which was just over 20 bags per hectare in 2000, exceeded 100 bags per hectare in 2019. In 2019, Brazil for the first time overtook the United States as the world's largest corn exporter – albeit due to exceptional conditions that year. In addition to this robust performance in winter corn, early soybeans also allowed the development of a second crop using cotton as an alternative to corn, particularly in the state of Mato Grosso, where approximately 1.0 million hectares are already grown as a second crop, representing about 70% of all production and helping Brazil to consolidate itself as the second largest global exporter.

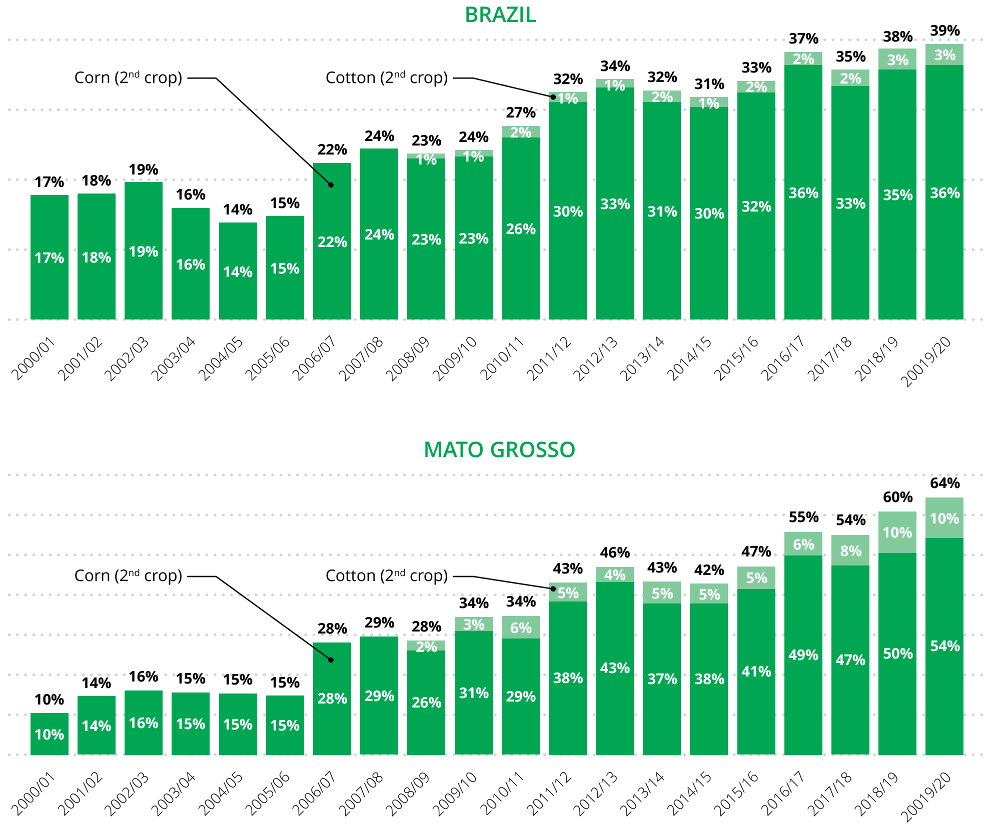
However, the advent of early soy technology, which allowed for a safer second crop, would not have been fully successful if farmers, particularly in the Cerrado, had not counted on Moderfrota. In order to plant parts of their soybean areas in the summer with early and super-early varieties each year, producers had to significantly strengthen their machine fleets, especially planters and harvesters. By anticipating the harvest by one month, it started to coincide with the most intense period of rain, which requires more powerful machines to quickly harvest soybeans to avoid losses, and also requires planting corn or cotton rapidly. In the course of the last two decades, the expansion of a second crop cultivated during autumn and winter, be this either corn or cotton, which occurred on areas planted with soy, also required a larger fleet of machines. The resources made available for this purpose for more than two decades helped producers to expand areas on the agricultural frontier, but also to produce much more in consolidated areas.

The success of the second corn harvest in the Cerrado has significantly changed the production of corn in Brazil. The area sown with summer corn has lost space in favor of soybeans, falling from 9.8 million hectares to 4.1 hectares in 2020. Currently, summer production represents less than 30% of the total corn produced in the country. Winter corn, on the other hand, exceeds 70%. This large availability of second-crop corn greatly increased the competitiveness of Brazilian corn exports, spurred on by recent investments in improving transportation infrastructure, especially through the ports of the Northern Arc. It also led to great opportunities to increase the production of local animal protein (poultry, pigs, and cattle), in addition to initiating a promising production of corn ethanol in the Cerrado.

An additional contribution of the expansion of a second crop on the Cerrado was the proliferation of crop rotation. The planting of corn or cotton after soy has allowed not only for the dilution of fixed costs on properties, but also a considerable improvement in agronomic practices. Two harvests in the same year permit for greater recycling of nutrients, and initiated the practice of fertilization in order to balance the agricultural system rather than just one crop in particular. This practice reduces fertilization costs (for example, soybeans planted in the summer after using cotton in the previous harvest do not require phosphate fertilization) and accelerates the creation of a balanced soil fertility. The rate of reuse of the same area with a second crop (penetration rate) has been growing systematically over the past few years, and has certainly contributed to improve farmers' financial results (Figure 5).

The diversification of activities developed on the same area is bound to continue in the future. A good example of a future system is the Integrated Crop-Livestock Farming. Under this model, grass production becomes an alternative as a second activity in sandier areas with a low presence of organic matter, where the production of corn or cotton as a second crop is considered a risky option. On the more fertile soils, where a second harvest is already taking place, farmers are choosing to plant maize and grass in conjunction. Shortly after the corn harvest, the grass gains more appropriate development conditions and occupies the entire area, allowing for at least 4 months to raise cattle (before the new summer soybean crop is planted). In this way, these more noble areas will have a third source of revenue in the same year. This new model will diversify farmers' outcome, increase their revenue, improve land prices, and contribute to the sustainability of production practices.

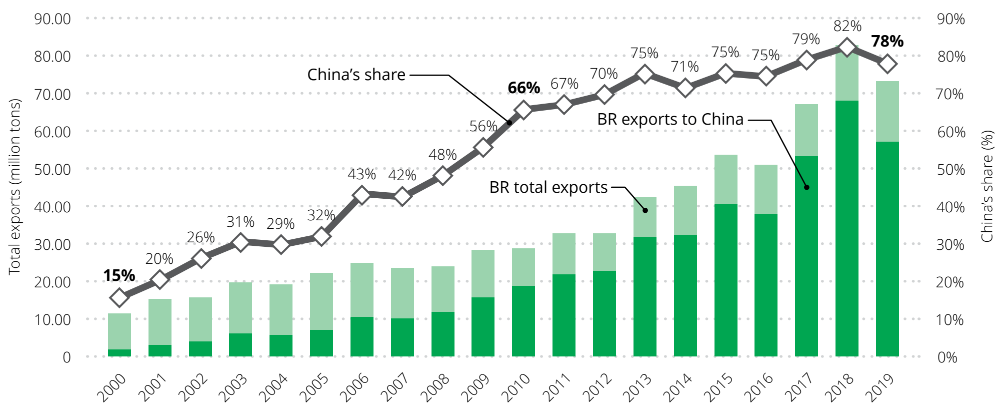
Figure 5. The penetration rate of second crop (corn and cotton) over soybean area in Brazil and Mato Grosso



Source: Conab (2019).

It was also in the 2000s that the biggest driver of the second phase of the expansion of grain production in the Cerrado became evident, with the explosion of Chinese demand. In 2000, China, for the first time in history imported more than 10 million tons of soybeans, of which 1.8 million tons were from Brazil. It was also in that year that Brazil, for the first time, surpassed the mark of 10 million tons of soybean grain sold internationally. In 2018 and 2019 (during the Trade War between China and the USA), Brazilian exports to China were approximately 60 million tons, and represented around 70% of the total imported by Chinese consumers. China, on the other hand, currently accounts for about 80% of the soybeans exported by Brazil (Figure 6).

Figure 6. Evolution of Brazilian soybean exports to the world and China



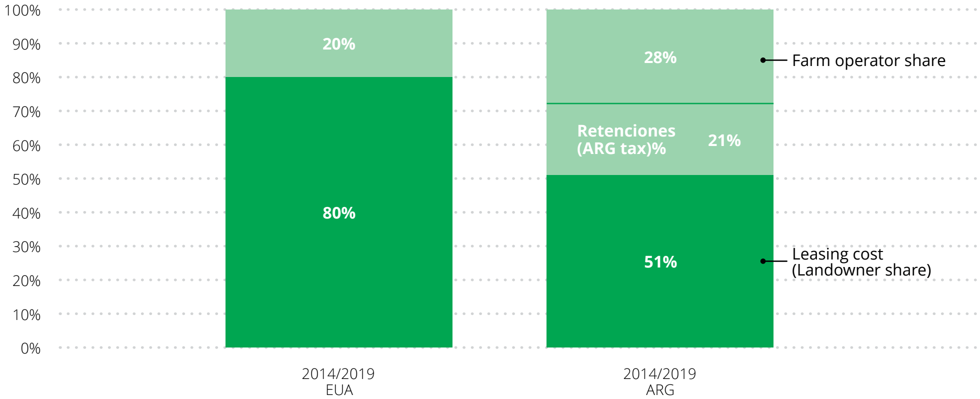
Source: Agrostat.

If, on the one hand, these figures reflect the prominent role that China played as a driver of the expansion of soy production in Brazil, – as its rapidly growing imports constitute a factor in reducing market risk –, on the other hand, the capacity to rapidly and steadily expand Brazilian soy production and exports has come to represent a key element in the Chinese aspirations towards food security. As China is in the midst of a process of urbanization, with an accelerated increase in income, new and more protein-intensive consumption patterns arise.

Another factor which contributed to the success of the advance of grain production in the Brazilian Cerrado, particularly in the last decades, does not refer to technology or even public policies or regulatory frameworks. This is the dynamics of distributing the financial results achieved in agricultural production between the farm operator and the landowner, who are not always the same individual. Generally, in regions where agriculture is already consolidated (Europe, North America and even Argentina) the operator usually gets about 20% to 30% of the results generated by production, and the landowner about 70 to 80%, since land availability is low and land prices are higher (Figure 7).

In a situation where there still is a possibility for agricultural expansion into new areas with productive potential to be developed, as is the case in the Brazilian Cerrado, the dynamics of this distribution change according

Figure 7. Landowner and farm operator average share in operational margin in the US and Argentina (2014/2019)



Note: For Argentina, the payment of export taxes to the Government was discounted.
Source: Farmdoc (USA) and Margenes (Argentina).

to the risks that are assumed by each individual. The value of the land, and consequently its rental value, should correspond to the expected profit generation that the activity to be developed can yield over time, considering the expected interest rate in the given period. However, the risks involved must be considered.

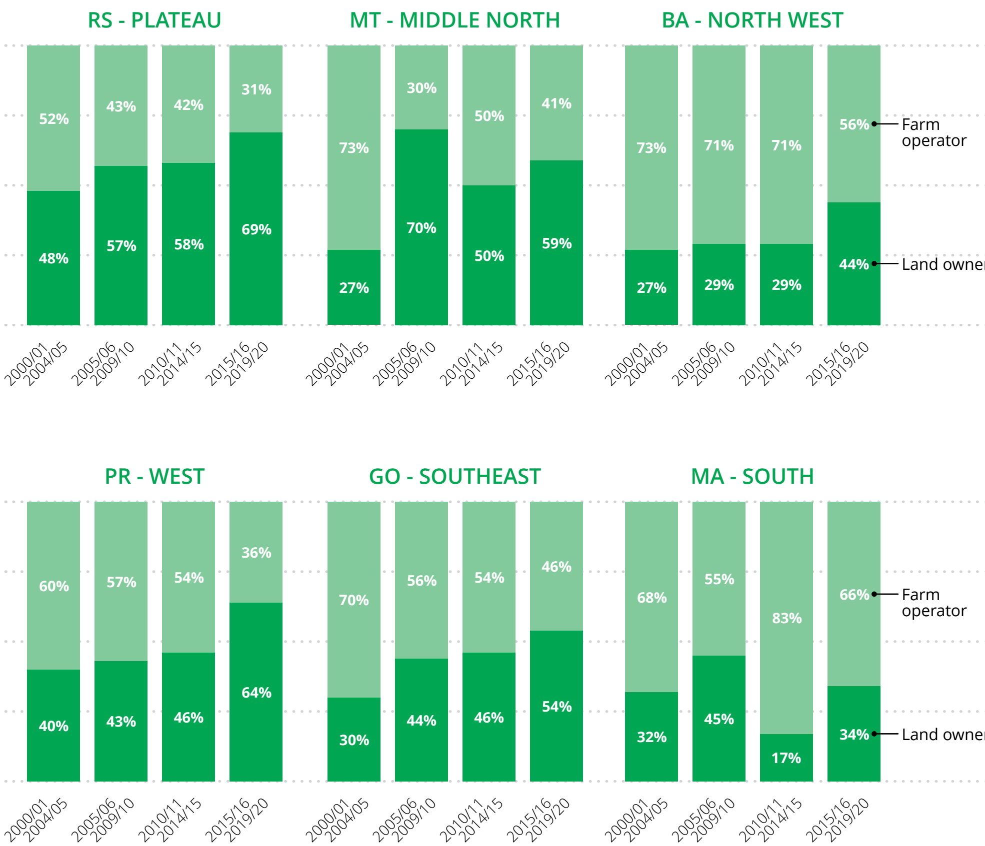
Usually in the first years of productive activity in regions of new frontiers, the agricultural operator is not the owner of the land, especially in Brazil, where there are no specific lines of credit for land acquisition. In many cases, the operator is a tenant, and bears the high costs of the initial investment in suppressing the original vegetation, adapting the soil fertility, purchasing machinery, and setting up productive infrastructure on the farms (Capex). In general, the tenant also faces low productivity in the first years of production and frequently operates in regions that are not yet consolidated clusters in terms of service availability. This often implies the absence of well-established local distributors of inputs, an inadequate supply of technical assistance, precarious storage, transportation and communication infrastructure, and a lack of financial services and of trained labor. The high transaction costs are often underestimated when a productive activity initiates in a new region. These circumstances generally result in significantly lower margins of the productive operation than those reached in more consolidated regions, and often fall below the estimated potential for an activity developed in an environment of low transaction costs, thus raising the level of risk assumed by the operator. To compensate for this higher risk and lower margin, the land price is considerably lower, and the share of the result transferred to the landowner is proportionally lower than in the consolidated regions.

The land transformation operation in agricultural frontier regions can be very profitable for land investors, because once the initial difficulties are overcome and the transaction costs are reduced, the risk reduction adds considerable value to the land asset, as the margin generated in the agricultural operation improves. In an environment of scarcity of credit for land acquisition, this medium and long-term return was extremely profitable for entrepreneurs who took the risks of opening new production frontiers. But the short-term costs associated with the highly diverse sources of risk and volatility have caused frequent failures for many pioneers of agricultural expansion. It is not just a story of winners.

In Mato Grosso and Goias, – areas that received the first waves of migrant producers from the Southern and Southeastern regions during the 1980s and 1990s, – landowners captured around 30% of the result obtained from grain production. In their regions of origin in the south of Brazil, this proportion reached percentages between 40% and 50%. Two decades later, after an extensive expansion process, landowners in these two states of the Cerrado already receive between 50% and 60% of the result generated in the productive operation. In the South, a consolidated region with little or no expansion of new areas, this value captured by landowners is already at levels of 65% to 70%. As displayed in Figure 7, this is practically the same level as can be observed in the United States or in the Argentinean Pampa, regions with low expansions of the agricultural frontier. But it is worth noting that in the region known as Mapitoba, formed by the Cerrados of the Northeast and North Regions (including the states of Maranhao, Piauí, Tocantins, and Bahia), which is the focus of the most recent cycle of agricultural expansion in Brazil, the proportion of revenue captured by landowners is only between 34% and 44% (Figure 8).

The financial dynamics verified in the Brazilian agricultural expansion model is peculiar to Brazil. The particular combination of factors such as technology, land availability, precarious infrastructure, a lack or low availability of credit, macroeconomic instability, high interest rates, and

Figure 8. The dynamics of landowner and farm operator average share in operational margin in Brazil by region and states considering summer and winter crops (2000/01 to 2019/20)



Source: Elaborated by the authors bases on Agroconsult's data.

elevated transaction costs demanded an adaptation in the distribution of the results of the productive activity that could accommodate the interests of both the investor with a long term horizon, the landowner, and the short and medium term risk taker, the farm operator. This dynamic is losing momentum as agriculture in these regions consolidates, and land prices increase. The opportunities generated by the existence of new land, in which risk can be taken with relatively low initial investment, was a factor of attraction – with no parallel – for the entrepreneurial spirit common to agricultural producers who explored the Cerrado.

3.2. Meat value chain: poultry and swine

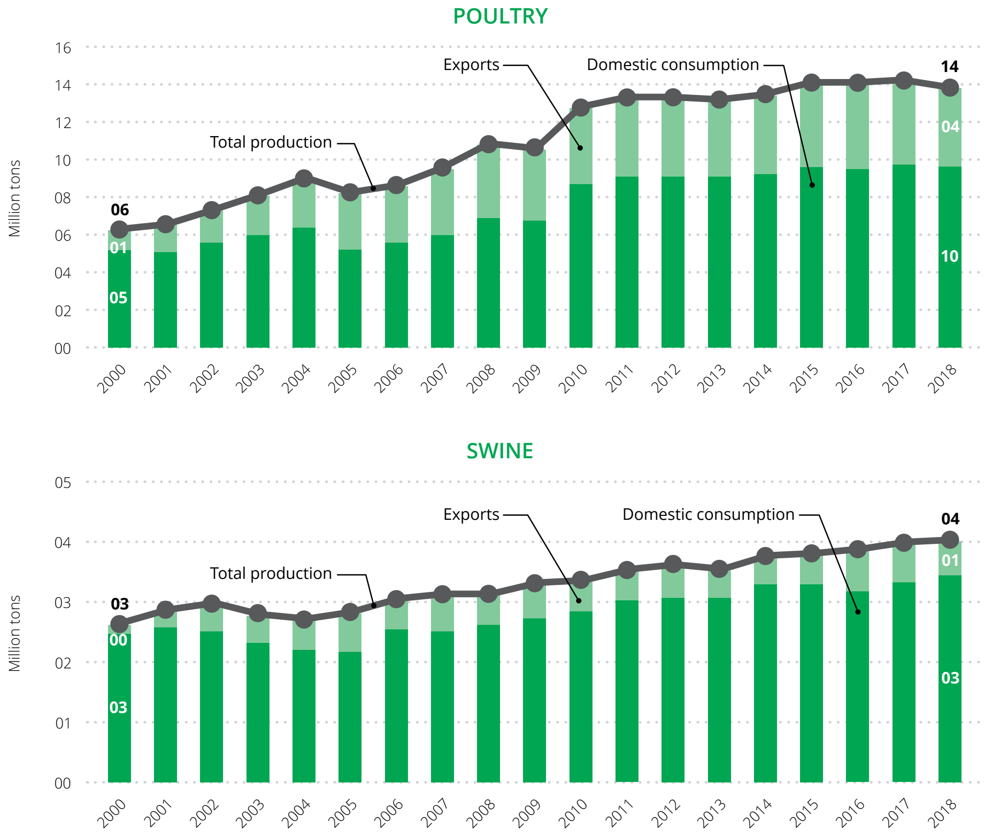
According to the OECD, from 2000 to 2018 Brazilian poultry meat production grew by 122% (4.5% per year) from 6.1 million tons to 13.6 million tons, representing 11% of global production. This growth is due both to the increased demand on the domestic market, which absorbed 58% of the increase in production, and to the expansion and consolidation of Brazil as a relevant supplier on the international market. In the period analyzed, Brazilian exports grew 327% (8.4% per year) and reached 4.1 million tons (Figure 5). In 2018, foreign sales accounted for 30% of production, compared to 16% in 2000. Brazil is currently the third largest poultry producer (behind the United States and China) and the largest global exporter. The country accounts for almost 30% of global exports, and its products reach 164 countries.

Pig production, in turn, grew 52% in the same period, or 2.4% per year. In 2018, Brazil produced 3.9 million tons of pork, compared to 2.5 million tons registered in 2000. This volume makes the country the 4th among the world's largest pork producers, with a share of 3.2%. Domestic demand still accounts for 86% of production, but exports are increasing. The accumulated growth of exports in this period is 352%, which represents an annual growth rate of 8.7% (Figure 9). Brazil currently exports 0.6 million tons of pork to 104 destinations. The country is the 4th largest global supplier and accounts for 6.2% of total sales.

As highlighted in a study published by Ubabef (2011), for many years the poultry and swine sectors were dominated by small producers, and activities were carried out exclusively at a family level. The professionalization, consolidation, and expansion of these sectors is a recent process, and is one of the most successful agribusiness cases in the country. The poultry and swine value chains clearly illustrate the relevance of governance and organization of the value chain, a factor highlighted by Chaddad (2016) as one of the fundamental pillars that explain agribusiness growth.

One of the main examples of coordination of the poultry and swine value chains is the integration between producers and processing industries, whether private or cooperative, through contract farming. The objective of this integration was to improve productivity, zootechnical indexes, and standardize production by establishing quality standards and a pattern of slaughter weight for the animals. Although the first initiatives to adopt this

Figure 9. Poultry and swine in Brazil: production, consumption and exports



Source: OECD Database.

business model date back to the 1960s, contracts have been improved over the years. In 2016 the Integration Law (Law 13.288/2016) was established to make this production model more equal and transparent.

As mentioned by Miele (2013), in a typical production contract the integrator supplies genetics (providing day-old chick and piglets), feed, veterinary inputs, technical support, and external logistics (inputs to the farm and transport of animals to the slaughterhouse). Producers provide investments in housing and equipment, their maintenance, labour, water, energy (electricity, firewood, and gas), litter and manure handling, all according to the requirements established by the industry. According to the Agricultural Census (IBGE, 2017), more than 57.3 thousand poultry producers and 28.6 thousand swine producers managed their business under some kind of partnership. The integration model also contributed to the specialization of some activities in the value chain. Nowadays, there are integrators focusing on breeding, the initial, or final stages of the animal life cycle. This specialization generated greater efficiency in asset management, and more quality in each stage of the process of raising chickens and pigs.

Two other factors related to value chain organization deserve to be highlighted according to Jank (2017). The first is the wide scope and efficiency of the cold chain that ensures the maintenance of food quality from industry to the end consumer in Brazil, or abroad. The second concerns private audits, certifications, and standards that ensure animal quality, health, traceability, and welfare.

In addition to governance and organization aspects, the success of the development of the poultry and pork meat chain in Brazil was also influenced by other factors (Figure 10). In general, Ubabef (2011), Jank (2017) and FAO (2019) emphasize:

(a) Availability and easy access to corn and soybean meal in the domestic market at attractive prices. Corn and soybean are the main components of animal feed and represent over 70% of the total production costs[16]. The purchase price of these inputs directly influences the competitiveness of the Brazilian product on the international market. So, the success of the soybean and corn value chain, highlighted in the previous section, is closely related to the consolidation and results obtained by the poultry and swine sectors in Brazil.

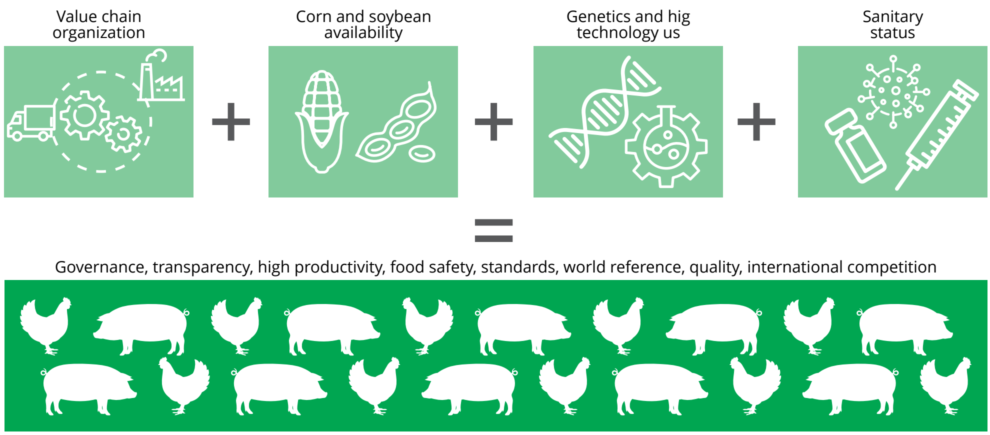
(b) Genetics and advanced technology use are leading to higher productivity. Between 2000 and 2018, there was an improvement in the amount of meat produced per animal, the feed conversion

[16] According to Embrapa (2019), feed costs represent about 70% of poultry production costs and 75% for pigs.

rate (the amount of feed needed to produce 1 kg of meat) and the average time to send the animal to the slaughterhouse[17].

(c) Sanitary status. Brazil has not been hit by serious epidemics such as avian influenza, swine fever, porcine epidemic diarrhea, or African swine fever.

Figure 10. Poultry and swine value chain: key success factors



Source: Elaborated by the authors based on Ubabef (2011), Jank (2017) and FAO (2019).

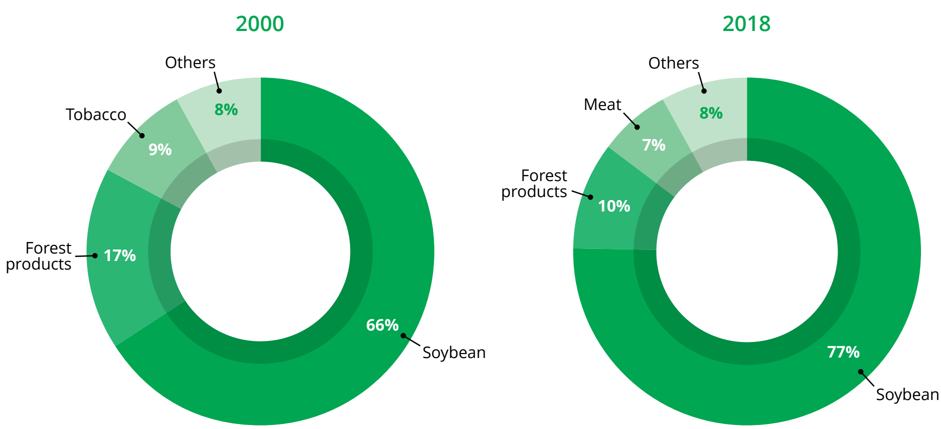
4. The relevance of China for the Brazilian agribusiness

The remarkable growth of Brazilian agribusiness in the 2000s coincides with the rapid development of the Chinese economy. The intense process of urbanization and the improvement in per capita income in this Asian country brought with it a considerable increase in the demand for agricultural commodities, which is directly reflected in Sino-Brazilian trade relations.

[17] Between 2000 and 2018 average poultry productivity increased from 1.93 kg/head to 2.37 kg/head, a gain of 23%. The feed conversion rate has also improved. In 2000, almost 2.00 kg of feed was needed to produce 1 kg of poultry that were slaughtered in 47 days. Currently the conversion is 1.8 kg of feed for each kg of chicken, slaughtered in less than 45 days. For pigs, each head generated about 81.6 kg in 2000, while in 2018 this value increased to 89.1 kg/head. Previously pigs were slaughtered at approximately 180 days with feed conversion above 3.5 kg. Nowadays slaughter occurs nearly 140 days with lower feed conversion.

According to the Agrostat database, in 2000 China accounted for 2.7% of Brazilian agribusiness exports, and was the country's 5th largest trading partner (behind the European Union, the United States, Argentina and Japan). In 2014, China became the main destination of Brazilian agribusiness exports, a position which it maintained during the following years. Currently, the Chinese account for about 35.0% of Brazilian sales on the international market, followed by Europeans (17.6%), other countries in Asia (17%), and the Middle East (9%). The range of exported products from Brazil to China, however, has always been very concentrated on the soy complex, mostly soybeans (Figure 11).

Figure 11. An overview of Brazilian exports to China: agribusiness sector



Source: Elaborated by the authors based Agrostat data.

Analyzing the products treated in this study separately (Table 1), it becomes possible to observe the Chinese predominance within Brazilian soybean exports. Currently, China is the destination of nearly 80% of Brazil's foreign soybean sales. In the case of corn, trade between the two countries is practically non-existent, due to Chinese domestic policies that foster self-sufficiency in maize supply. Currently, 90% of the corn consumed in the country is produced domestically and the remaining supply is imported, mainly from Ukraine.

For chicken meat, a more solid and consistent growth of commercial ties can be observed from 2010. From 2010 to 2018, poultry sales to China grew more than 3.5 times, making Brazil the leading supplier of this type of meat to China. Pork exports are much more recent, starting in 2016. With the advent of the African swine fever, the flow of meat from Brazil to China intensified in 2019. Preliminary data indicates, that China took the lead among the main destinations for Brazilian chicken and pork meat with a share of 14.0% and 32%, respectively (Table 1). According to information from the Brazilian Association of Animal Protein (ABPA). There are 46 poultry slaughtering units and 16 pig slaughtering units currently authorized to export to China.

Table 1. Brazilian exports of selected products and the relevance of China (thousand tons)

Year	Soybean			Corn			Poultry			Pork		
	Total	China	Share	Total	China	Share	Total	China*	Share	Total	China*	Share
2000	11.517	1.784	15%	7	0	0%	916	131	14%	136	52	38%
2001	15.676	3.192	20%	5.629	0	0%	1.266	131	10%	276	50	18%
2002	15.970	4.143	26%	2.747	5	0%	1.625	153	9%	481	53	11%
2003	19.890	6.102	31%	3.566	0	0%	1.960	212	11%	497	63	13%
2004	19.248	5.678	29%	5.031	0	0%	2.470	239	10%	510	61	12%
2005	22.435	7.158	32%	1.071	58	5%	2.846	273	10%	625	63	10%
2006	24.958	10.769	43%	3.938	0	0%	2.713	322	12%	528	74	14%
2007	23.734	10.072	42%	10.933	0	0%	3.162	369	12%	606	106	17%
2008	24.499	11.824	48%	6.433	0	0%	3.437	416	12%	529	108	20%
2009	28.563	15.940	56%	7.782	27	0%	3.438	452	13%	607	122	20%
2010	29.073	19.064	66%	10.819	40	0%	3.630	453	12%	540	99	18%
2011	32.986	22.105	67%	9.487	21	0%	3.750	535	14%	516	130	25%
2012	32.916	22.886	70%	19.802	80	0%	3.741	534	14%	577	128	22%
2013	42.796	32.252	75%	26.625	48	0%	3.713	525	14%	514	122	24%
2014	45.692	32.664	71%	20.655	24	0%	3.806	543	14%	491	112	23%
2015	54.324	40.926	75%	28.924	147	1%	4.046	543	13%	543	129	24%
2016	51.582	38.564	75%	21.873	172	1%	4.126	732	18%	721	252	35%
2017	68.155	53.797	79%	29.266	17	0%	4.089	641	16%	685	205	30%
2018	83.605	68.840	82%	23.566	76	0%	3.923	651	17%	636	318	50%
2019	74.038	57.959	78%	43.282	68	0%	3.993	768	19%	737	412	56%

Source: Agrostat.
*Hong Kong included in poultry and pork import statistics.

The results of the bilateral trade in agricultural commodities between Brazil and China is not the only indicator of the synergy between the two countries within the agribusiness sector. As part of the Chinese aspirations of guaranteeing food security for its population, and due to the existing limitations on foreign land acquisition in Brazil, Chinese companies started to invest in other businesses that facilitate access and disposal of these products. For instance, in recent years, China has acquired companies producing or distributing agricultural inputs (eg. Syngenta, Copebras, Fiagril, Belagrícola) and grain traders (eg. COFCO bought both Nidera and Noble and became one of the most important trading companies in Brazil).

5. Opportunities to strengthen the Sino-Brazilian relationship

According to OECD forecasts, from 2018 to 2028, global demand for agricultural commodities should continue to grow. For soybeans, corn, poultry, and pork the expected increase is respectively 16%, 13%, 15% and 7%. In this context, Brazil and China remain central players in defining the dynamics of the world market. On the one hand, Brazil plays a relevant role in supplying its domestic market and other countries. Of the additional exports expected over the next 10 years, Brazil is expected to supply 66% of soybeans, 40% of corn, 42% of poultry, and 17% of pork. On the other hand, China will continue to drive growth in additional demand for these products worldwide.

Thus, the perspective is that the synergy between the two countries in the agribusiness sector should be perpetuated in the coming years, implying great opportunities for strengthening Sino-Brazilian relations. The uncertainties surrounding Chinese international trade policies – due to the current state of relations with the United States – and its sanitary risks regarding the recovery of its pork production after the African swine fever, may open a window of opportunity for Brazil to gain access in the Chinese meat market. If Brazil succeeds in consolidating its position as a relevant supplier of poultry, pork, and even beef (a sector that was not explored in this chapter) to China, the country will strengthen its presence in Asia as a great food – not only soybean – supplier, and also diversify its portfolio and reach other stakeholders[18].

[18] The issue of market access and its related challenges are deeply discussed by Jank and Miranda in the chapter on international trade.

Nonetheless, a closer relationship between Brazil and China requires a strategic alignment on sensitive issues regarding good agricultural practices, standards, sanitary measures, and compliance and environmental rules. It is of utmost importance that both countries speak the same language when dealing with these themes, so that Sino-Brazilian trade relations can flow easily, benefiting Brazilian producers, Chinese consumers, and all the other intermediate players in the agri-food value chain.

One effort taken by Brazil in the direction of promoting a closer dialogue with China was the creation of a special unit under the Ministry of Agriculture in October, 2019 to nurture and foster the relationship with this Asian country. This unit is currently run by a mandarin-proficient individual, and has a different work time schedule in order to attend the Chinese demand. It also operates according to four priority objectives: developing market access, attracting investments, building an information center about China, and promoting innovation and sustainability initiatives.

As for investments, three areas closely related to the agribusiness sector offer great opportunities for China and Brazil. The first, is the logistics infrastructure. Despite the recent investments and improvements made to "debottlenecking" commodity transportation to the port terminals, Brazil's logistics performance is still only fair. Currently the country occupies the 56th position among 160 countries on the Logistic Performance Index (LPI) created by the World Bank (2019). In the chapter on logistics, Caixeta and Pera highlight specific areas in which China can collaborate with Brazil in road, rail, waterway, and maritime transportation, as well as in the storage system.

Investments in logistics aiming at improving and facilitating the flow of agricultural commodities from the producing zones to the consumer markets (both domestically and internationally) can reduce the cost of soybean and corn used to produce feed worldwide, even in countries that can compete with Brazil as animal protein suppliers. Easy and inexpensive access to soy and corn has always been a competitive advantage for the Brazilian meat industry, and this advantage may decrease. For China, increasing the competitiveness of other players who can supply pork, poultry, and even beef can be advantageous.

The second area which offers good opportunities is telecommunications, a critical element in promoting the change towards Agriculture 4.0. Brazil still lacks good data and voice connection in the countryside, which makes it harder for farmers to profit from all the new technologies available, such as artificial intelligence and the internet of things. These new technologies compose a third area where Brazil and China could establish a close partnership, in order to improve and control agricultural practices, obtain better yields, develop new payment methods, and minimize transactions costs along the entire food value chain.

investment in telecommunications – especially in connectivity – and in the use of digital agriculture and artificial intelligence tools, can create countless opportunities for developing partnerships between Chinese companies and farm investors in the Brazilian agribusiness. At the same time, these new technologies can generate significant reductions in production costs, accelerate gains in productivity, expand the optimal scale of production, and enhance the use of more sustainable practices in the field.

Considering the challenges ahead, it is important to keep in mind that yield improvements will still be the main driver sustaining agricultural growth in Brazil. However, expansion of the planted area may also be required. Within this context, policies that hinder or prohibit the expansion in new agricultural frontiers need to be discussed and debated in order to better understand and measure their impacts. From the point of view of the symbiotic relationship between landowner and farm operator – previously described in this chapter – that fostered agricultural expansion to new frontiers in Brazil, this kind of measures can minimize the appetite of farm operators to continue investing in new areas, since their share of operational results will decrease, favoring the landowner. This happens because the land available in areas that are already consolidated and where transaction costs are lower, are much more expensive than the ones available within new agricultural frontiers. So, on the one hand, there are areas already anthropized in the Brazilian Cerrado to accommodate the expectation of the area to be planted to meet the future demand for Brazilian production. On the other, agricultural production growth may require higher investment or occur at a slower pace, potentially unbalancing world supply and demand.

Finally, it is worth noting that the successful and incredible story of the Brazilian agribusiness sector in the past two decades resulted from a combination of great natural comparative advantage, and a number of efforts and measures adopted both by the government and private players who benefited from a favorable context, internally, and externally. However, those measures have not necessarily been coordinated or planned in advance. That said, it is important to remark that the evolution of the Brazilian agribusiness in the coming years requires a long-term strategic approach, differently from what has been the case so far. In this area, we have a lot to learn from the Chinese long-term planning capacity.

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Part 3

The future is now: investing in innovation and bioenergy

Chapter 5

Jianjun Lyu

Agriculture 5.0 in China: new technological frontiers and the challenges to increase productivity

Abstract

With the rapid surge of digital technologies in recent decades, the field of agriculture is also quickly being transformed, as new applications have been introduced within the production, logistics, and consumption stages. In this chapter, Jianjun Lyu demonstrates how a wide array of technologies such as GPS, GIS, mediation software, satellite imagery, e-extension system, mobile phones, sensing devices, sensors, and aerial images, have been applied within different farming production systems and commercialization platforms. In conclusion, a variety of examples of different applications of these technologies are outlined, with focus on the way they define new consumer relations and consumption patterns.

1. Introduction

The evolution of agriculture from 1.0 to 4.0 is reflected in the "intelligence" of agricultural production. Yet, nowadays, agriculture is no longer just realizing the intelligence in production: Instead, agriculture 5.0 is a smart value chain for information sharing and business linking throughout the whole chain, including production, processing, circulation and marketing through the use of the Internet, the Internet of things, big data, artificial intelligence, etc. The concept of Agriculture 5.0 implies that the agricultural robots integrating artificial intelligence and ground autonomous systems are applied to farms, which is based on Digital Farming (Agriculture 4.0) with the Internet of Things and Big Data.[1] The Agricultural technological revolution started with Agriculture 1.0, based largely on mechanization. The green revolution with its genetic modification defined Agriculture 2.0, passing on to Agriculture 3.0 with precision farming, which consists of applying inputs (what is needed) when and where they are needed, beginning when military GPS-signals were made accessible for public use. The core technologies of Agriculture 5.0 include robotics, some forms of artificial intelligence, autonomous agricultural machinery, integrated systems with self-learning capabilities, and virtual reality. With agricultural robots integrating artificial intelligence, Agriculture 5.0 provides a solution to help with a shortage of workers. Farms are facing a workforce shortage, because society has moved away from an agrarian structure, with large quantities of people living on farms, towards a process of profound urbanization.

The purpose of this chapter is to elaborate on the digital technology, new socialized services for agricultural production, and marketing issues. In order to introduce these three novel issues, the chapter analyzes digital technology applications in agricultural production monitoring systems, in agricultural extension and farming advice, and in precision farming systems. New socialized services for production in agricultural supplies (pre-production), agricultural technology service (in production), and harvest and processing (postpartum) are also studied. This chapter similarly introduces the packaging, tracking and tracing, transportation, and distribution in the process of agricultural product circulation, and finally analyzes the marketing issues in agricultural product e-commerce, new retail of agricultural products, and food safety.

[1] Verónica Saiz-Rubio and Francisco Rovira-Más. From Smart Farming towards Agriculture 5.0: A Review on Crop Data Management [J]. Agronomy 2020, 10(2), 207; https://doi.org/10.3390/agronomy10020207.

China's agricultural sector is undergoing a transformation driven by new technologies, which is very important for agricultural production, as it will lead this sector to a new level of productivity and profit. Precision agriculture will use modern information technology and large amounts of data to make decisions for agricultural production and produce in a profitable and sustainable manner. Nowadays, due to the availability of a large amount of data, and the development of various agricultural information systems, the enhancement of precision agricultural technology has also increased net income and profits. In addition, more environmental considerations are taken into account, and new technologies are increasingly adopted to maintain the sustainability of agricultural production. According to market analysis, factors that promote the adoption of sustainable agricultural technologies include better education and training for farmers, easy access to financial resources, and increased consumer demand for organic food.

2. Sophisticated precision agriculture: digital technologies in agricultural production

China's current agricultural development is turning towards modern agriculture with intelligent agricultural production, networked agricultural operations, and CIT-based agricultural management as inevitable trends, including precision agriculture, digital technology, big data, artificial intelligence, and e-commerce[2]. The government needs to firmly seize the "internet +" strategic opportunities and promote the deep integration of the internet and agricultural production, operation, management, and services.[3]

These digital technologies have also been adopted within Brazilian agriculture. Precision agriculture (PA) technologies are being applied to crops in Brazil, which are important to ensure the country's position in agricultural production[4]. Technology has been more important than climate in explaining

[2] Li Daoliang. Changing the Thinking Mode for the Urban and Rural Integrated Development [J]. Frontiers, 2015(17): 39-47.
[3] Hu Ya-lan, Zhang Rong. The Operation Mode, Problems and Countermeasures of the Wisdom Agriculture in China [J]. Reform of Economic System, 2017(04): 70-76.
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soybean productivity in Brazil.[5] Some crops are planted in both China and Brazil, such as soybeans and sugarcane, so this section mainly treats digital technologies that have been applied to Chinese agriculture, but also briefly introduces Brazilian agricultural technology.

2.1. Digital technologies in agricultural production monitoring systems

Digital technologies have considerable potential to help even small-scale producers prevent losses after investments have been made, by identifying and controlling pests and diseases, receiving timely weather information, and improving resource use.[6] Advances in GPS, GIS, mediation software, satellite imagery and the internet of things are useful for helping farmers improve their farming management.

Big data in the monitoring systems comes from combining large amounts of data collected from various sources for making predictions over time, e.g., pest outbreaks, livestock behavior, and soils and weather data.[7] In addition to the traditional information that is based on collecting environmental sensor data, such as temperature and rainfall, in the future, we may also see warning systems that are based on social media or crowdsourcing, for example, the number of food price-related tweets correlated with real events, like food price inflation.[8] Twitter, blogs, and similar social networks may also provide early signs of emerging disasters. Extracting these early signs requires processing of large amounts of data, a process in which analytical tools developed for big data analysis will be useful. Early warning systems through the internet of things have also attracted growing interest, including climate models that raise public awareness of drought warnings, pest outbreaks,

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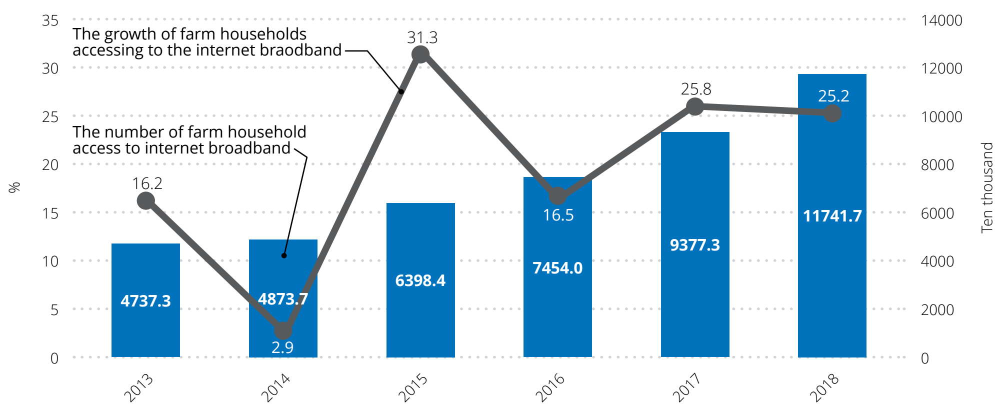
[8] Nakasone, E., Torero, M., Minten, B., 2014. The power of information: The ICT revolution in agricultural development. Ann. Rev. Resour. Econ. 6, 533–550.

forest fire detection, and flood alerts, which all give stakeholders enough time to react to emerging threats.[7] With such information, farmers are able to use timely measures to stem losses from climate change.

Other forms of electronic weather information have the potential to increase productivity, primarily by reducing risks. Many of these systems are being tested in OECD countries. Warning was created through PlanteInfo (www.planteinfo.dk), a Danish initiative supporting decision making in national plant production, which provides farmers with real-time weather information sourced by the Agri-Meteorological Information System and the Danish Meteorological Institute.[6] With these weather information systems, small farming can be efficient in East Asia, especially in China. However, the foundation for the introduction of digital technologies in agricultural production monitoring systems is the popularity of broadband. The number of farm households with access to broadband has been increasing in China. The growth trend is shown in the following Figure 1.

Figure 1. The number of farm households accessing to the internet broadband



Source data: National Bureau of Statistics of China.

2.2. Digital technologies for agricultural extension and farming advice

Farmers must be able to respond productively to the opportunities and challenges of economic and technological changes, including those that can improve agricultural productivity and food security.[5] Producers require relevant knowledge, including technical, scientific, economic, social, and cultural information.[5] Digital technologies offer appropriate channels for rural people in appropriate languages and formats.

Digital tools have to some extent enabled the revival of agricultural extensions and advisory services.[6] For instance, in cooperation with agricultural research and extension services, organizations such as Digital Green, the Grameen Foundation, Reuters Market Light, and Technoserve are able to deliver timely, relevant, and actionable information and advice to farmers in southern Asia, Latin America, and Sub-Saharan Africa at significantly lower costs compared with those of traditional services.[8]

An e-extension system can come in the form of an online repository or information bank, with specific information on best practices for different crops suited to varying agro-climatic conditions, and a database of input retailers and prices. Similarly, an e-extension can also be made as participatory training videos disseminated via farmer groups and cooperatives for sending real-time updates and pictures of damaged crops. This can be used to identify the cause of problems and offer advice for treatment. In rural areas, the additional value of e-extension is often that, with the help of communication tools such as simple mobile phones, the extension offices can reach out to many more farmers than solely through field visits.

2.3. Digital technologies in precision farming systems and automatic control

Rural people making management decisions about discrete areas of a field with the help of site-specific information is called precision farming, or precision agriculture. This information can answer questions pertaining to land preparation (including tillage depth and type, residue management, and organic matter, and reductions in soil compaction), seeding (planting dates and rotation, density and planting depth, cultivar selection), fertilizer (nitrogen, phosphorous, potassium, and other nutrients, as well as pH additives, application methods, and seasonal conditions), harvest (dates, moisture content, and crop quality), and animals and fisheries (pasture management, animal tracking, and school identification).[6]

Sophisticated precision farming systems are more commonly applied at technologically advanced farms and plantations with the underlying objective of combining various remote sensing data and satellite imagery for a given farm parcel to provide precise information for growth (e.g., sensors for soil conditions, groundwater level, and rain water precipitation detectors combined with irrigation optimization systems).[7] A variety of tools can be used in precision agriculture: GPS, satellites, sensors, and aerial images can help to assess variations in a given field. Farmers can match input applications and agronomic practices with information received from these digital technologies.[1] As this can be done remotely, it saves significant time and labour when compared to manual sampling, and the use of calibrated technology makes the system less prone to error when assessing appropriate growth conditions.[9]

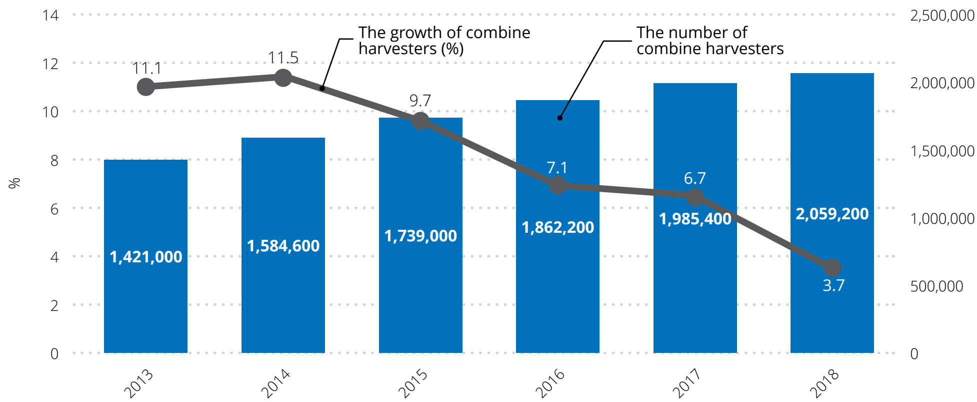
A WSN is a group of small sensing devices or nodes that capture data in a given location. These nodes then send the raw data to a base station in the network, which transmits the data to a central computer that performs analysis and extracts meaningful information. The base station acts as a door to the internet (typically a local area network), providing operators with remote access to the WSN's data.[10] The wide application of WSNs allows them to be used not only for managing agriculture, but also for testing water quality, managing disasters, detecting volcanic activity, and conducting environmental evaluations.

The agricultural mechanization level, which is the basis for precision farming, stems from automatic control. In China, the comprehensive mechanization rate of crop cultivation and harvest across the country exceeds 67%, of which the comprehensive mechanization rate of cultivation and harvest of major food crops exceeds 80%. For example, the combined number of harvesters has been increasing from 1.421.000 in 2013 to 2.059.200 in 2018, as shown in Figure 2.

[9] Hamrita, T.K., Hoffacker, E.C., 2005. Development of a "smart" wireless soil monitoring sensor prototype using RFID technology. Appl. Eng. Agric. 21(1), 139–143.

[10] Dargie, W., and M. Zimmerling. 2007. "Wireless Sensor Networks in the Context of Developing Countries." Paper presented at the 3rd IFIP World Information Technology Forum, Addis Ababa, August.

Figure 2. The number of combine harvesters



Source data: National Bureau of Statistics of China.

2.4. Summary

We summarize and compare the digital technologies presented in the previous three sections, in Table 1 below.

Table 1. Digital technologies applied to agriculture

Three fields of agriculture	Technology	Example
Agricultural Production Monitoring Systems	GPS, GIS, mediation software, satellite imagery	eWarning provides farmers with real-time weather information
Agricultural Extension or Farming Advice	e-extension system mobile phones	Technoserve can deliver timely, relevant, and actionable information to farmers
Precision Farming Systems	sensing devices, sensors, and aerial images	WSN can be used not only for managing agriculture but also for managing disasters

3. New socialized services for agricultural production

Before the emergence of new agricultural operators, the socialized service system of agricultural production mainly provided technical services for small farmers. After China vigorously supported the new main agricultural management body, the agricultural production socialization service system was transformed. The new social service system of agricultural production is based on public service agencies, the cooperation of economic organizations, and leading enterprises as its backbone. It is supplemented with other social forces, including public welfare services and business services, special services, and a combination of comprehensive coordinated services to provide agricultural production support before, during, and after the comprehensive service system. In developed countries, the services provided by cooperatives, companies or enterprises play an important role in the whole socialized agricultural service system. In developing countries, the main forms of the agricultural socialization services are a cooperative and a government service.

3.1. Agricultural supplies (pre-production)

The means of agricultural production (hereafter referred to as agricultural materials) refer to the materials and other items used in the production of agricultural products (crops) including not only pesticides, fertilizers, and seeds, but also agricultural machinery and tools, agricultural film, etc. These materials have many varieties and specifications, and are not easy to display and code. Furthermore, they have high technical content, and strong seasonal and regional variations, presenting after-sales service difficulties.

The means of production are an important agricultural input, a bridge connecting the industry and agricultural production, and an important material guarantee and foundation for the development of modern agriculture. Rural means of production have brought new impetus to the development of labour and market exchanges, and various services, such as product purchase and sale, storage, transportation, capital, technical guidance, and other links. These will gradually become independent and specialized business activities to form an agricultural production service system.

To establish and construct an agricultural production service system, it is necessary to expand the field of contracting, take advantage of the market, and obtain broad market prospects. These include seed cultivation, soil improvements, plant protection, animal and poultry epidemic prevention, storage, transportation and marketing of products, the purchase of agricultural production means and the processing and transformation of agricultural and sideline products for agricultural production. The pattern of rural economic development presents a diversified trend, which drives a new rural economy and increases output value. Therefore, the establishment and development of a rural production service system plays a very important role.[11]

3.2. Agricultural technology service (in production)

With the backdrop of an agricultural supply-side structural reform, the extension system of agricultural technology is an important guarantee to promote scientific and technological agricultural innovations. China's agricultural technology is made available through supply and marketing cooperatives, seed stations, plant protection stations, animal protection stations, soil and fertilizer stations at all levels, and national technology extension, and control institutions and agricultural materials production enterprises. With the rapid transformation of China's agricultural material circulation system from a planned to a market economy, the official promotion of agricultural technology has weakened. Additionally, agricultural material production enterprises and distributors have become the main actors in agricultural technology communication.

Third-party agricultural technology based on modern information technology, including the internet, multimedia technology, and 3G mobile communication technology, the global positioning system (GPS), data exchange technology (EDI), electronic commerce (EC), GS1 bar code technology etc., fully meet the supplier's information and data integration needs. These needs include video diagnosis of the terminal and ease of operation for large-scale producers of visual monitoring technology, to cite one example.

Agriculture constitutes a large, complex system. Third-party agricultural institutions use modern information technology to conduct data analysis and processing, and to evaluate prevention and control measures. This third agricultural organization consists of the following systems: an expert video agricultural consultation system, a network video monitoring system, an organic agriculture participatory production security system, a remote

[11] Zhang Hongjie. A Survey of the Status Quo of the Purchase and Use of Agricultural Production Materials in Hebei Province – Taking the Agricultural Production Data of Datian as an Example [J]. Hubei Agricultural Sciences, 2012, 51(17):3901-3903+3907.

lighting and training system for agriculture and agricultural products trade negotiations, a farmer's union conference system, an agricultural expert intelligence system, a system for spot trading consultation for agricultural commodities, an internet system for agriculture, and a dynamic agriculture database. These systems have carried out all of the steps in the process from production to trading of agricultural products, and are fully automated and transparent.[12]

3.3. Harvest and processing (postpartum)

Since the economic reform and opening up, China has strengthened its research and development of the processing of agricultural products and has obtained a large number of influential, high-level scientific research achievements. With the progress of agricultural technology, the quality of agricultural products has generally been improved. The promotion of superior varieties and advanced practical technologies has greatly improved the quality of agricultural products, and the overall acceleration of agricultural mechanization has raised the production efficiency of farmers. Through the promotion and application of storage and preservation technology, the supply period of major fruits and vegetables in China has been prolonged. The storage period of apples has reached 6-8 months, and the problem of regular preservatives needed for citrus fruit has essentially been solved. Research on fruit and vegetable transportation technology has also begun. Vehicular heat insulation and ventilation independently developed in China has been tested on a large scale, and the yield has reached 90%-95%. Grain storage technology has been greatly developed, with an emphasis on low-temperature grain storage, gas-regulated grain storage, and pest control technology.

Processing of agricultural products to a precision depth and special direction is in development. With the decline in the direct consumption demand of agricultural products, the proportion of processed products has risen. The product structure of the agricultural processing industry has diversified, and

[12] Agricultural Technology [OL]. Baidu Encyclopedia, https://baike.baidu.com/item/AgriculturalTechnology #7.html.

the added value of products continues to increase. The proportion of deep processing or secondary processing of major agricultural products is now above 30%. Various grades of special flour, corn flour, modified starch, special oils, and a series of plant proteins have been developed, as well as a high value-adding low-phenol cotton seed protein foaming powder and emulsifier. New technologies have gradually been applied to the agricultural product processing industry, such as microwaves, quick-freezing, vacuum pressuring, membrane separation, extrusion, ultrafine grinding, microcapsules, and electronic technology.[13]

Table 2. Summary

Three stages of agricultural production	Three types of socialized services for agricultural production	Example
Preproduction	Agricultural Supplies	Pesticides, Fertilizers, Seeds, Agricultural Machinery and Tools
In production	Agricultural Technology Service	The Internet Multimedia Technology And 3G Mobile Communication Technology, The Global Positioning System (GPS), Data Exchange Technology (Edl), Electronic Commerce (EC), GS1 Bar Code Technology
Postpartum	Harvest and Processing	Microwave Technology, Quick-Freezing Technology, Vacuum Pressure Technology, Membrane Separation Technology, Extrusion Technology, Ultrafine Grinding Technology, Microcapsule Technology And Electronic Technology

Case: "The Internet of Things + Farming" to create a new model of intelligent pig raising

With the advent of the internet of things, the development of smart agriculture is in full swing. The rise of the "Internet of Things + Pig" model has changed the production, organization, and development of agriculture. In 2016, Netease Weiyang's original modern breeding model for "efficient production, product safety, resource conservation, environmentally friendly,

[13] Cui Ming, Shen Wei, Li Yanyun, Gao Fengjing, Yao Song. The Status Quo of Chinese Agricultural Products Processing Technology and the Construction of Its Extension System [J]. Transactions of the Chinese Society of Agricultural Engineering, 2008 (10):274-278.

and reproducible" was unanimously recognized by leaders at all levels and by domestic and foreign experts once it was made public. Netease Weiyang has become the representative enterprise of China’s "Internet + modern agriculture" development. Through automation and intelligent means, standardized production and large-scale operations for agriculture have been achieved. The internet of things technologies and IT cards have made important contributions to "smart pig raising."

There is a significant difference between technological pig raising and ordinary farmers. Via IoT technology and IoT cards, and the use of intelligent real-time monitoring equipment in the breeding process, the scope and performance of pigs can be determined. Intelligent sensors can transmit various data in the pig house to managers in real time, and can intelligently control the temperature and carbon dioxide concentration in the environment, so that the pig has more comfortable growing conditions, which improves meat quality.

Another interesting part of smart pig farming is that with an IT card, each pig gains its own digital identity. Managers only need to scan the "pig face recognition" to understand the pig’s body. Project data can effectively warn of diseases through big data and reduce reproduction costs. When these pigs enter the market, they can also use IT cards to complete the safety traceability of pork through RFID technology. The IT card trading platform shows that with these emerging technologies, smart agriculture has also been associated with economic benefits.

4. The circulation of agricultural products

The circulation of agricultural products is a key point linking agricultural production and household consumption, and an indispensable and important link in agricultural products’ supply chain. The total circulation of agricultural products in China is increasing year by year. Statistics show that this reached RMB 3.03 trillion yuan in 2012, and increased to RMB 3.7 trillion yuan in 2017, while by the end of 2018, it had reached RMB 3.9 trillion yuan, rising with 3.5%. Information and communication technologies (ICT) provide strong technical support for optimizing and connecting the circulation link of agricultural products, and help upstream and downstream enterprises cooperate with information sharing. ICT applications can effectively reduce information asymmetry and allocate resources properly in the whole process of circulation, ultimately improving the circulation efficiency of agricultural products. In the following section, we will introduce the applications of ICT in packaging, storage, tracking and tracing, and distribution.

4.1. Packaging

ICT has been applied to the packaging of agricultural products and plays an important role in improving the safety and source tracing, for example, for information anti-counterfeiting technologies. These combine security and digital image processing and communication technologies, as well as intelligent labels, through the provision of product information to identify the authenticity and safety of agricultural products. Starting from the anti-counterfeiting code, many new information anti-counterfeiting technologies have been developed in recent years.

In addition, when packages of agricultural products leave the factory, the RFID reader on the packaging assembly line writes the information of the RFID label on the package, including the order number, production date, agricultural product manufacturer, type, quantity, and expiration date[14]. Such information helps users to know the source of agricultural products and ensure food safety. Additionally, it can reduce the error rate of manual operations in primary and secondary packaging, and also shorten the distribution time of agricultural products, further ensuring their freshness.

4.2. Storage

Storage and inventory control in the circulation of agricultural products play important roles in ensuring the production of agriculture-related enterprises and regulating the relationship between supply and demand.

[14] Zhang, H.D. (2018). Design of intelligent packaging system of agricultural products e-commerce based on RFID technology. Preservation and processing, 18(3):133-138.

ICT applications in inventory can manage the information of basic data, storage, delivery, inventory and control of stored agricultural products, and can effectively improve the level and efficiency of inventory management. On the other hand, coordination and cooperation among member enterprises in the supply chain can be realized to jointly manage the ordering and inventory control of raw materials and agricultural products.

Specifically, for the environmental information of the storage link, real-time monitoring is carried out by deploying a sensor network. Scanners and bar codes can be used as inventory management tools. Inventory management system software can be used to effectively control inventory levels. This software is currently the most widely used, including purchasing software, sales software and warehouse management software. By applying an inventory management software, managers can timely determine the inventory status and manage the inventory business, which includes the delivery and product storage. This can help managers discover problems in time, and prevent excessive amounts of products from being overstocked in the warehouse.[15]

4.3. Tracking and tracing

Food safety and quality issues have recently attracted increasing amounts of attention, and the implementation of tracking and tracing of agricultural products has become an industry consensus in China. Tracking and tracing agricultural products can not only promote the integration of the upstream and downstream parts of the supply chain and improve product quality, but can also enhance consumers' trust and stabilize the market. The applications of information tracing technologies in the circulation of agricultural products can immediately obtain accurate circulation information and realize whole-process monitoring. It can also track and trace agricultural products, and guarantee their quality and safety.[16] Combined with the traceability and

[15] Zheng, J.J. (2015), Research on inventory management optimization based on information technology – HB company as an example. Zhejiang University of Technology, Hangzhou, China.

[16] Xu, T. and Huang, Q. (2016). Application research of information technology in agricultural product quality and safety traceability. Agricultural network information, 6: 29-31.

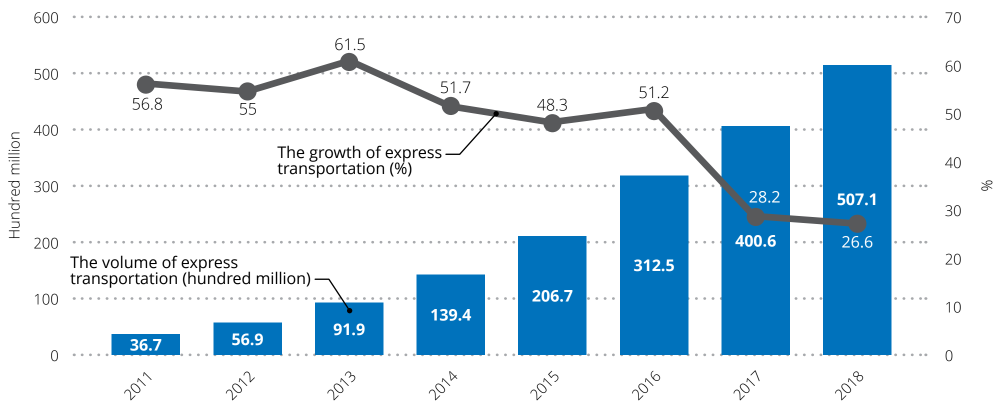
internet technologies, it can also be used to monitor final sales and obtain real-time consumption data. Based on these data, it helps logistics enterprises to make demand predictions and optimize the structure of agricultural products in time. At present, China's tracking technology mainly includes barcode automatic identification and RFID technologies. These tracking and tracing technologies are comprehensive, and based on the development of computers and photoelectric and communications, which are important methods for automatic identification and input information. At present, good traceability systems have been established in China in the tobacco, medicinal herb, floral, and edible oil industries. Some dairy products, high-value fruits and meat products are also gradually establishing traceability standards, but the traceability systems for vegetables are relatively poor.

4.4. Transportation and distribution

Since the 13th five-year plan, Chinese express transportation has increased by 10 billion every year, occupying a leading position in the global express transportation volume for six consecutive years (Figure 3). Applying advanced ICT to transport and distribution systems can effectively optimize the allocation of transport resources, improve the level and efficiency of transport and distribution management, and further promote the healthy, harmonious, and rapid development of the transport system. There are ICT applications in transportation and delivery, such as advanced traffic management systems (ATMS), advanced traffic information service systems (ATIS), commercial vehicle operations (CVO), electronic toll collection systems (ETC), public transport operation systems, emergency management systems, and advanced vehicle control systems[17]. The main service contents of these systems include vehicle management, vehicle safety, intelligent supervision and accident handling[18].

[17] Cao, S.X. (2018). Application of electronic information technology in intelligent transportation system. Digital communication world, 11: 165-166.
[18] Huang, Y. (2019). A brief analysis of the application of computer information technology in transportation system. Information System Engineering, 2: 129-130.

Figure 3. The volume and growth of express transportation in China from 2011/2018



Source data: National Post Office in China.

In vehicle management, the application of ICT mainly includes three parts. The first is the charge for vehicles. The second part is the navigation of vehicles, such as the global positioning system (GPS). By GPS, enterprise managers can control transportation systems and equipment through information about the location, weight, quantity and other information about agricultural products. The third aspect is the scheduling of vehicles to achieve the shortest drive, the lowest cost, and the shortest time.

In vehicle safety, an electronic stability system (ESP), in which the driver's subjective will and the motion of the vehicle condition are compared in ICT can avoid risks. If it is found that there is greater deviation in the movement track of vehicles, ESP can intervene before the drivers do. With intelligent monitoring of the environment and vehicle location information of logistics transportation and distribution, real-time online monitoring can be achieved through integrated environmental sensors and a vehicle-mounted distribution terminal. Offline data collection can also be achieved by developing RFID tags with sensors and placing them in transport carriers. For accident handling, applications of ICT have brought unexpected effects to transportation accident management. In dealing with transport accidents, ICT applications include the analysis of transport accident environments, such as vehicle conditions, casualties, road conditions and the tracing of accidents, simulating the whole process of transport accidents, and then dealing with accidents timely, accurately, and effectively.

Case: The Application of Radio Frequency Identification (RFID) to the Circulation of Agricultural Products

Radio frequency identification (RFID) is noncontact automatic identification technology that can recognize specific targets and collect data from radio signals. RFID automatically identifies electronic tags of objects through a radio frequency signal emitted by RFID readers. It can quickly identify and track target objects moving at a high speed and at a long distance. The technology has the advantages of being highly automatable, durable, reliable, and provides rapid identification.

In China, RFID has been widely used in the circulation of agricultural products. In packaging, RFID technology can achieve anti-counterfeiting for high-value agricultural products. In storage, RFID technology can ensure the accuracy and reliability of inventory information and can improve the inventory utilization rate. In distribution, RFID technology can effectively dispatch vehicles and improve the distribution efficiency. For tracking and tracing agricultural products, RFID technology is efficient in collecting information, tracking the circulation of agricultural products in the whole process, supervising the quality of agricultural products, and improving information transparency.

For example, in a world expo, the host adopts a food logistics RFID monitor traceability system for vegetables, aquatic products, livestock and poultry, milk, eggs, bread, pastry and other foods which need temperature control, and fits them with the appropriate RFID equipment for the refrigerated vehicles. When foods enter the park, managers can quickly trace the source of the foods and raw materials on the site through RFID handheld devices, to ensure safe and reliable supply channels for agricultural products[19].

[19] Shen D.M. (2017), Research on RFID technology and analysis of specific application cases [J]. Digital world, 12: 408.

To learn from China's experience in the circulation of agricultural products, Brazil needs to construct a modern agricultural products circulation system for the development of modern agriculture. The country must also apply advanced information and communication technologies in agricultural products packaging, warehousing, transportation, distribution, and other circulation links. These ICT applications can efficiently connect the production and sales of agricultural products, reduce transaction costs and risks, improve the efficiency of the circulation of agricultural products, and promote the modem transformation of Brazilian agriculture.

5. Marketing

5.1. Agricultural products e-commerce

In 2018, China's online sales of agricultural products reached 300 billion yuan. Online marketing is particularly important. The application of network marketing in the agricultural product industry is mainly supported by the internet and network technology. With the agricultural product industry website, the corporate website and the agricultural information network of all levels of government, a two-way information flow is realized. That is, through the network, fruit farmers and other enterprises can obtain and publish timely visual data about the production, circulation, processing, and relevant commodity supply and demand, and service information.[20] B2B (business to business) realizes online marketing negotiations and offline payments. At present, in the environment where the credit system and online payment methods are not perfect, this form of risk is relatively small, and is more suitable for the characteristics in which the inherent quality of agricultural products varies widely and must be determined by senses.[21]

[20] Ma Chen, Wang Dongyang. Mechanism Research and Implementation Path of Electronic Commerce Promoting Transformation and Upgrading of Agricultural Products Circulation System in New Retail Era [J]. Science and Technology Management Research, 2019, 39(1): 197-204.

[21] Wang Jiaqi. Analysis on the Marketing Mode of Agricultural Products E-commerce [J]. Price Monthly, 2014(4): 58-61.

The ten marketing models common to agricultural e-commerce are as follows:

1. **Agricultural products + rural e-commerce platform:** it is important to use the rural e-commerce platform and the internet platform to display and promote agricultural products, so that more people can understand, know, and help users to place orders and purchase online. An example is shown below:

   > The online shopping platform of the Shanshan Mall Exhibition Center has developed a new model, which will broadcast live video, product traceability, and private custom-made modules through the "online shopping + agricultural products + tourism products" model, which will be cleverly integrated and functioning online. Consumers are brought to the store, and all agricultural products can be placed online, paid for, displayed, and delivered by an offline experience store. At present, the county has more than 30 enterprises in the Shanshan Mall Exhibition Center, and there are more than 100 kinds of agricultural products. The modernization of traditional agriculture has been promoted by means of e-commerce marketing, which has enabled the county to brand, standardize, and inform people about agricultural products. Order production and annual sales have exceeded 10 million yuan.

2. **Agricultural products + microbusiness:** "Visible agriculture" mainly refers to relying on the internet, internet of things, cloud computing, radar technology and modern video technology to present the patterns, means and methods of crop or livestock growth processes to the public. The consumption A model of purchasing quality products with confidence is an example:

   > Known as "the first case of China's agricultural products microbusiness", Zhang Dafa sells cherries. He sold 81,282 boxes of cherries in 15 days, and earned 10,365,950 yuan in revenue. In just 2 months, Zhang Dafa established 10 WeChat groups, and continuously trained and made online presales. He also set up a micro business team to strengthen the promotion and enhancement of personal labels, and then relied on active communication to create personal charm. The realization team,

users, and distributors also trust Zhang Dafa. Therefore, there will be cases in which people will help you sell cherries together.

3. **Agricultural products + visible agriculture:** "Visible agriculture" mainly refers to relying on the internet, the internet of things, cloud computing, radar technology and modern video technology to present the patterns, means and methods of crop or livestock growth processes to the public. Let the consumption model of purchasing quality products with confidence be an example:

    "Visual agriculture" has a reliable futures order function, and many "visual agriculture" investors will use the network platform for remote observation and order placement. They can raise a group of ecological pigs, a group of ecological cows, a group of ecological chickens, or order ecological vegetables, rice, or fruit trees in remote rural areas or forests thousands of miles away. After the harvest, you can enjoy them or expand sales to earn legal profits. This can solve the problem of food safety, and the problem of difficult sales of agricultural and sideline products, and obtain prenatal orders to upgrade agricultural products at good prices.

4. **Agricultural products + net red live broadcast + e-commerce platform:** The internet has spawned many new economic models, and the net red economy is one of them (the equivalent of a youtube influencer). The net red here can be a celebrity star, it can be a popular network anchor, or it can be a "village red" created by the seller himself. An example is shown below:

    At a special exhibition of the Internet Agriculture Town Maker Shake held in Shishan town, Haikou city, Hainan Province, four "creators" became "net red" and sold the featured agricultural products to the whole country through live webcasting. Qiao Shunfa, chairman of Hainan Aishang Rose Industrial Co., Ltd., promoted his own volcanic rose in the live broadcast: everyone saw the finished products of volcanic rose processing: soap, essential oils, and flower cake.

5. **Agricultural products + catering:** Restaurants, catering experiences as a channel or platform, the agricultural product experience, agricultural products consumption, and interactive agricultural products grafting

in a catering store can help crack the agricultural product sales and promotion dilemma. An example is shown below:

> There is a restaurant named "Village Food Experience Restaurant." This restaurant is a catering business. It can serve all kinds of delicious food made from the country's original ingredients. It sells chicken, duck, earth pork, and eggs, as well as duck eggs and other agricultural products. Through the store promotions and combined with the internet, it can stimulate user demand, retain customers, and encourage consumption.

6. **Agricultural products + direct sales stores:** A direct sales store solves the problem of producing from farm to table, reduces the intermediate channels, reduces the unit price of products, and improves the interaction between the agricultural products and the users. Direct investment chain stores have large input costs, and chain management also requires specialized talents. Agricultural products + direct sales stores cannot be done by ordinary farmers. This model requires the government or leading agricultural enterprises to take the lead. Here is an example:

> In January 2014, the Yingying County Supply and Marketing Cooperative established the Yingying County Agricultural Products Direct Sales Center with the idle assets of the unit. The eight professional cooperatives participating in the direct sales center mainly sell agricultural products such as eggs, meat, vegetables, grain, oil, and liquor. Since then, the Yingying County Supply and Marketing Cooperative has guided professional cooperatives to build agricultural product outlets in the county's farmers' market through preferential policies such as guarantee loans, sales subsidies, and project funds. In 2015, Daying County changed its services and other methods, and carefully guided professional cooperatives to set up direct sales of agricultural products in county towns, and actively solved the problem of selling professional agricultural products and residents' expensive purchases. Up to now, it has led 7 professional cooperatives to open 9 pork, poultry, grain, oil, vegetable and flower outlet stores in the county, with annual sales of 3 million yuan.

7. **Agricultural products + community:** What is the concept of the community? It is to bring together people with the same hobbies and the same interests. Their needs are the same and they are all loyal fans of a certain product. If the products are good enough, they will gain more customers. An example can be found below:

> The millet system is built on top of the rice pomelo (mobile enthusiast community), not the mobile phone. Starting from 100 hardcore fans, the real asset of Xiaomi is over 100 million users developed around rice pomelo. Such a large and active user base allows Xiaomi to jump out of the traditional product-centric business model and use people as the basis of the business model to truly tap the needs of users and help them gain access to a large number of users.

8. **F2C mode of agricultural products:** F2C in the agricultural field: F2C is Farm To Customer, an online multichannel mode. For multi-brand agricultural base products, you can use an e-commerce platform such as Taobao to connect farms and families, using presale and ordering models to sell agricultural products. For example:

> The mobile internet of things industry has quietly formed, and its vast application and market prospects are highly valued around the world. In China, the first mobile internet of things shopping platform that uses barcode flashing has emerged, which is a "flashing mobile internet business." Through a bar code and multidimensional marketing system with merchandise, Flash has built a powerful mobile internet platform. Through this platform, companies can easily implement the F2C business model. As long as the manufacturer opens the flash purchase function on the product barcode, a direct dialog between the manufacturer and the consumer can be carried out. The internet of things allows everyone to become a market shareholder and a mobile phone shopper, bringing about a business model with buying and selling at any time. Flash purchases indicate that IoT shopping has entered a new historical development stage, and has become an effective catalyst for the establishment of the F2C model.

9. **Agricultural Products + Adoption (Internet Adoption Agriculture):** The concept of adoption is to initiate partnerships of all people to adopt one (head, piece, mu) agricultural product (plants, animals) and enjoy this solution according to the quantity or part of the subscription. An example can be seen below:

 > The Tianmu Fruit Professional Cooperative's 300-mu water-tight peach garden embraced the "adoption" model, in which 500 numbered peach trees are adopted for 480 yuan each. The peaches produced in the tree this year belong to the adopter. All the adopted peach trees are planted without chemical fertilizers. All of them are made of peaches and duck manure. In the annual picking period, each peach tree can produce approximately 40-60 kg, or 100-150 peaches. In April of each year, Tiantian Taoyuan will allow the adopters to go on an outing to see flowers. When the fruit is ripe in July, you can go pick and enjoy the harvest. On weekdays, the de-worming and fertilization of peach trees are handled by members of the cooperative.

10. **Agricultural products + crowdfunding:**[22] Selling agricultural products through crowdfunding platforms can solve problems such as slow sales and dissemination of agricultural products. Here is an example:

 > The Qinling No. 1 soil egg product crowdfunding project of Shaanxi Daqinji Agricultural Science and Technology Co., Ltd., was launched. This is the first case of Shangluo agricultural product crowdfunding. The company quickly shipped products to the table in a crowdfunding mode, using an "internet + agricultural products" approach, so that the original products with no added pesticides, hormones, or antibiotics, coming out of the Qinling hinterland, would reach the first-tier cities and the middle and upper-class people in the southern region. It is reported that the Qinling No. 1 soil egg product crowdfunding project was online for only 5 days and received support from 347 people, raising 29,201 yuan.

[22] LIN Xiaolan. Research on Accurate Marketing of Agricultural Products E-commerce in China [J]. Agricultural Economy, 2014(12):137-138.

5.2. New retail of agricultural products: a novel model of agricultural product marketing born of information technology

“New retail” is an activity that promotes, innovates, and integrates the traditional and online retail industry to serve consumers through new technologies and new ideas. It is based on omni-channels and advanced technologies, such as big data and cloud computing and constitutes a borderless, all-around service.

There are two main innovation modes of agricultural product marketing under the concept of “new retail”.

Online and offline development: deepening integration

The entry barrier of online retail is low and convenient. Establishing a unified online retail platform within the agricultural product industry will enable better network sales and development of offline channels. Offline sales have irreplaceable characteristics which can provide consumers with a good purchasing experiences and after-sales service. The offline sales of agricultural products has a traditional retail mode, namely, company + farmer, farmer + farmer, market + farmer, company + base. The basic form, in which the company + farmer, market + farmer, company + base form can be opened up as offline development channels, and set up offline experiences and direct offline marketing through the creation of branded specialty agricultural products, so that consumers can have an interactive agricultural product experience.

Offline retail and online platforms usually function simultaneously, and rarely exist independently. The "new retail" concept, as a simple experience method, needs some help from omni-channel sales. In the era of the Internet economy, online or offline retail alone cannot maximize benefits. Marketing must deepen online and offline integration and establish a more comprehensive marketing model.

Under the premise of continuous integration of various industries, the online and offline development of agricultural products can interact with other relatively complete platforms, such as the cooperation with mature network platforms and offline supermarkets, by relying on existing channels for agricultural products. To do this, one must synchronously develop and integrate the online and offline presence, completely open the online and offline channels, and comprehensively expand the integration of the virtual and physical outlets.

Consumer-centric, full-service marketing

First, one must improve the quality of food, and produce green and healthy agricultural products. Under the premise of ensuring the quality, it becomes vital to build distinctive agricultural products; establish a brand; transform traditional food marketing awareness; engage in marketing with services as the mainstay; seek to satisfy the multidimensional needs of consumers for shopping and entertainment; and include the introduction and promotion of featured agricultural products. Consumer experiences, such as tasting and site-seeing tours during the production process should be considered.

Second, a composite marketing model should be promoted. Related marketing, cultural marketing, word-of-mouth marketing, experience marketing, and other different marketing methods serve to stimulate the senses, thinking, and behavior of consumers. Experience marketing plays an important role in augmenting consumption. In the case of various landscaping methods and false advertisements in the internet age, consumers pay more attention to the actual experience. Products that are derived from personal experience are more reliable. Experience thereby becomes an important part of offline retailing. Word-of-mouth marketing refers to the promotion and sharing through the word of mouth of the internet, social media, and online platforms to achieve the purpose of promoting agricultural product brands to expand marketing.

5.3. Food safety

In recent years, with the background of the rapid development of the "Internet +" new economic form, internet food consumption, as a new way of consumption is quietly changing the traditional food production organization and management mode. Since 2009, the scale of food e-commerce has been increasing year by year, from 4.3 billion yuan in 2009 to 32.4 billion yuan in 2012. By 2018, it had reached 280 billion yuan, and the market scale has doubled nearly 70 times. Since 2013, the scale of new e-commerce has also increased year by year, from 12.67 billion yuan in 2013 to 1950 billion yuan in 2018. It is expected that the online food market will continue to maintain a rapid growth in the future. The consumption of online food is not only convenient for consumers, but also implies some risks, which pose a new task for the government to effectively supervise the safety of online food.

Food safety means that the food is nontoxic, harmless, meets nutritional requirements, and does not cause any acute, sub-acute, or chronic harm to human health. According to the definition from Bino Food Safety, food safety is a "public health problem affecting human health caused by toxic and hazardous substances in food." Food safety is also an interdisciplinary field that specializes in reducing disease hazards, preventing food poisoning, and ensuring food hygiene and food safety during food processing, storage, and sales. Therefore, food safety is very important.

Food safety management affects the survival and development of food companies. Especially in enterprise marketing, food safety management is closely related to purchasing behavior, sales performance, marketing channels, and crisis marketing. Food safety has a great impact on consumers' behavior and willingness to purchase. This is directly related to the smooth implementation of the corporate marketing strategy. Only by establishing a good food safety brand image can a company firmly strengthen consumers' beliefs and gain consumer recognition. Food safety directly affects the sales performance of companies. To ensure that consumers purchase a company's products over time, the company must appropriately lower the price and improve the competitive advantage for the same type of products to ensure food safety.

Food safety issues are related to the immediate interests of consumers and the long-term sustainable development of enterprises. To effectively prevent food safety incidents, enterprises must increase their emphasis on food safety management, strengthen internal controls, closely link management with marketing, and build a sound marketing model to continuously innovate in the market. Marketing means and methods enable enterprises to continuously expand marketing channels, improve sales performance, and enhance their market competitiveness by relying on food safety advantages.[23]

[23] Gao Wanmin. Food Safety Management and Marketing [J]. Science and Technology Pioneering Monthly, 2011(7):52-53.

6. Development

To learn from China's experience in the circulation of agricultural products, Brazil needs to construct a modern agricultural products circulation system, and apply advanced information and communication technologies to packaging, warehousing, transportation, distribution, and other circulation links. These ICT applications can efficiently connect agricultural production and sales, reduce transaction costs and risks, improve the efficiency of product circulation, and promote the modern transformation of Brazilian agriculture.

We believe that some digital technologies in Chinese agriculture can be applied to Brazilian food production, such as WSNs, an e-extension system, and eWarning. They can incentivize Brazilian farmers to more widely use precision agriculture and adopt wiser practices. With respect to new socialized services, the following should be practiced:

1. Vigorously develop agricultural socialization services, improve the agricultural production service system, eliminate the imbalance between supply and demand in the agricultural socialized service structure, and try to meet the needs of various types of farmers for productive services.
2. E-commerce for agricultural products in the digital era needs some new marketing methods to impress consumers. In the future, Brazil's agricultural product marketing planning is bound to combine the internet and market demands to generate new methods and models. As long as it can help farmers with agricultural product brand marketing or direct marketing, it is worth promoting. At the same time, the era of pure e-commerce has passed, and the next decade is the era of new retail. In the future, online, offline, and logistics must be combined. Relying on the internet, enterprises will upgrade and transform the production, circulation, and sales processes of commodities using big data, artificial intelligence, and other technical means, and will deeply integrate online service, offline experience, and modern logistics. However, all of these are based on the premise of agricultural product safety. Food safety has a domino effect from production to end use; once there is a problem in a certain link, it will affect the whole. To avoid the problem of a brand dilution, it is important for e-commerce

and agricultural product retailers to apply scientific and technological support elements, strengthen the control of the food production process, and realize transparent and bountiful production.

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Chapter 6

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The energy cane revolution in Brazil: delivering food, bioenergy, and biomaterials

1. Introduction

With a history dating back almost 500 years, the sugarcane industry plays a major role in the Brazilian economy. With around 380 mills, 70,000 cane growers, and 750,000 direct jobs (Mapa, 2019; MTPS, 2019), the sugarcane supply chain has annual net revenues close to USD 25 billion (Unica, 2019) and ranks as the fourth largest export sector in Brazil, having generated almost USD 7 billion in foreign exchange in 2018 (MDIC, 2019).

In the sugar market, Brazil is the world's largest producer and exporter of the commodity, with a share of around 25% of world production and about 40% of all the sugar traded worldwide (USDA, 2019).

In the energy sector, the sugarcane supply chain is the main renewable source in the Brazilian matrix, accounting for 17.4% of all domestic energy supply in 2018 (EPE, 2019), both for electricity and fuels.

In terms of the transportation matrix, Brazil has the largest program in the world to replace fossil fuels with biofuels. In 2018, for example, Brazil managed to replace 48% of all the gasoline in its transportation matrix with ethanol. Ethanol is used as fuel in two distinct ways. The first one is in a fleet of nearly 30 million light vehicles and more than 5 million motorcycles that can be fueled by any combination of gasoline and ethanol, referred to as flex-fuel cars and motorcycles. This decision depends solely on the relative pump price between the oil derivative and the renewable fuel and on consumer preferences. The second way fuel ethanol is used in Brazil is through mandatory biofuel blending in gasoline, currently set at the level of 27%.

Ethanol also provides undeniable environmental benefits: several studies show that, as compared to gasoline, Brazilian ethanol can reduce greenhouse gas (GHG) emissions by up to 90% (Seabra & Macedo, 2008). This attribute is even recognized by the US Environmental Protection Agency (EPA), which classifies Brazilian ethanol produced from sugarcane as an advanced fuel due to its better environmental performance compared to that produced from other feedstocks.

In fact, since the launch of flex-fuel vehicles in 2003, up until 2019, ethanol consumption in Brazil has reduced GHG emissions by about 600 million tons of CO2eq. For the same CO_2 savings to be achieved, it would be necessary to plant more than 4 billion native trees over the next 20 years (Unica, 2019).

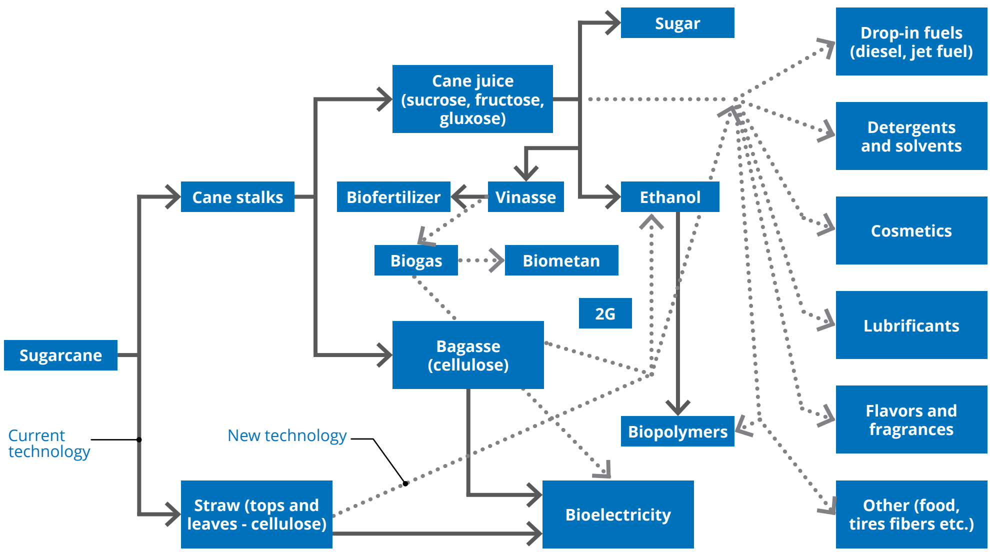
In addition to significantly reducing emissions compared to other fuels, sugarcane ethanol also provides an extremely favorable energy balance: it generates more than nine units of renewable energy for each unit of fossil energy consumed in the process (Seabra & Macedo, 2008b).

Additionally, the use of biofuel has yielded public health benefits by significantly reducing local pollutants and NOx and particulate matter emissions, alleviating one of the main problems in several global large cities around the world facing high pollution levels. According to the World Bank, 2016, car-generated pollution accounts for nearly 200,000 annual deaths and costs some USD 225 billion a year due to premature deaths from cardiovascular and lung diseases.

Still in the energy area, special mention should be made of the expansion of the supply of electricity generated from burning sugarcane bagasse and straw, the so-called bioelectricity. Currently, biomass accounts for 9% of the power generated in the Brazilian electricity matrix, and is the 3rd largest source of installed power, behind hydroelectric and wind power.

It is also worth stressing that, in addition to sugar, ethanol, and bioelectricity, there are a number of new products originating from sugarcane, such as biogas, jet fuel, bioplastics and others. Figure 1 schematically shows traditional sugarcane products and other products under development in Brazil and in the rest of the world.

Figure 1. Sugarcane products and uses



Source: Unica (2019).

The figures attest to the importance and potential of the Brazilian sugar-energy industry, while using just over 1% of the national territory for growing sugarcane (IBGE, 2019) managed to reach an impressive level in food and renewable energy supply on a sustainable and economically feasible basis.

Although the Brazilian example has characteristics of its own, the description presented here raises key elements for understanding the recent dynamics of the sugar-energy industry. This chapter details technological and productive transformations in this sector, as well as discussions about public policy instruments that have guided the development of this industry in Brazil over the last 5 decades.

In addition to this introduction, the chapter is made up of four other sections. The second one describes the evolution of the Brazilian sugar-energy industry, with emphasis on the role of public policies in fostering growth and sustainable development in sugar and ethanol production. The third section presents some of the other products produced – or under development – from sugarcane, such as bioelectricity, biogas, and renewable jet fuels. Section 4 presents the environmental legal framework for the sugarcane industry in Brazil. Section 5 reflects on the possibility of cooperation and interaction between China and Brazil in markets linked to the sugar and ethanol industry and, finally, the last section presents the chapter's conclusions.

2. History of the sugarcane industry

Introduced by the Portuguese in the 16th century, sugarcane in Brazil is a key element of the country's history and economy. That said, and considering that it is beyond the scope of this paper to provide details about the historical component associated with this industry, the description provided in this chapter portrays the evolution of the sugar-energy industry over the last five decades, starting from the first cycle of significant sugarcane increase fostered by the launch of the National Ethanol Program (Proalcool).

2.1. Proalcool and the first cycle of production growth

Ethanol began to be used as fuel in Brazil when it was first blended with gasoline at the rate of up to 5% in July 1931. However, fuel ethanol gained notoriety from 1975, when the National Ethanol Program (Proalcool) was established. In its first phase, the program encouraged the production of anhydrous ethanol to be blended with gasoline at a rate of 20% and, by the end of the 1970s, it also began to promote the use of pure use of hydrous ethanol as a fuel for vehicles.

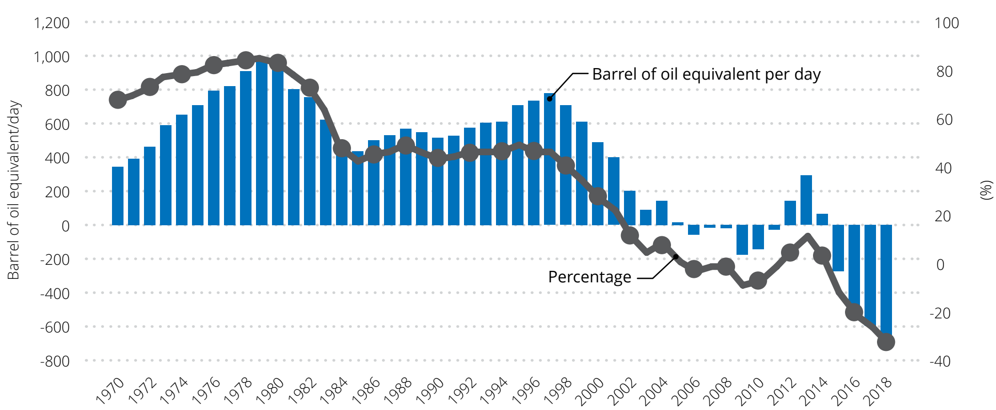
At that time, the environmental and social benefits afforded by the biofuel were secondary considerations. The incentive to using ethanol was therefore seen as an instrument to ensure energy security, whose main objectives were guaranteeing fuel supply and affordable prices.

In fact, the two oil shocks in the 70's brought greater energy supply insecurity and exposed how the Brazilian economy was vulnerable to changes in oil prices. In the first shock, world oil prices more than tripled from USD 2.9 to USD 11.65/barrel in just three months. At current values (2018 prices), this hike would represent an increase from UD 15/barrel to almost USD 60/ barrel (BP, 2019).

Brazilian expenditures on imports of oil and oil by-products increased by almost 450% between 1973 and 1974, from USD 750 million to USD 4.1 billion in the following year, even though the volume imported increased by only 15%.

The same upturn in oil prices in the world market was observed a few years later, in the late 1970s, when the market value of oil, at 2018 prices, soared from USD 54.00/barrel in 1978 to USD 112.24/barrel in 1980 – a shift known as the second oil shock (BP, 2019).

Figure 2. Brazil: evolution of its external dependence on oil



Source: EPE (2019).

It was in this scenario that the Proalcool program, combined with the other measures implemented by the Brazilian government to increase production and decrease the consumption of oil and its derivatives, made it possible for Brazil to gradually reduce its dependence on foreign fuel. Before the first shock, more than 80% of domestic consumption was supplied by imported oil; from 1979 onwards, the oil deficit in proportion to the country's domestic consumption took a downturn, reaching a level close to 45% in 1985 (Figure 2).

The launch of the Proalcool program and the measures taken to stimulate ethanol production incorporated biofuel into Brazil's transportation matrix for good not only as a supplement to gasoline (anhydrous ethanol as an additive), but mainly as a substitute for the fossil fuel (hydrous ethanol).

During the period of intense state intervention in the fuel industry, which began with the launch of the Proalcool program and lasted until the mid-1990s, the government had a considerable number of options and tools to address the complexity of the fuel sector and ensure the supply needed to meet domestic consumption demand.

In addition to controlling the domestic supply of oil by-products, especially gasoline, the Brazilian state also had instruments to address the evolution of ethanol supply. Besides subsidized credit provided by the government for the construction of ethanol distilleries, the control exercised by the government was applied, on the one hand, through an annual crop plan and, on the other, by setting prices to be received by producers for selling sugarcane (in the case of cane growers), ethanol (anhydrous and hydrous ethanol), and sugar.

An annual crop plan was published systematically and defined quotas for sugar and ethanol production for each production unit operating in Brazil. Sales prices received by producers were also set by the state and determined the profitability of the activity.

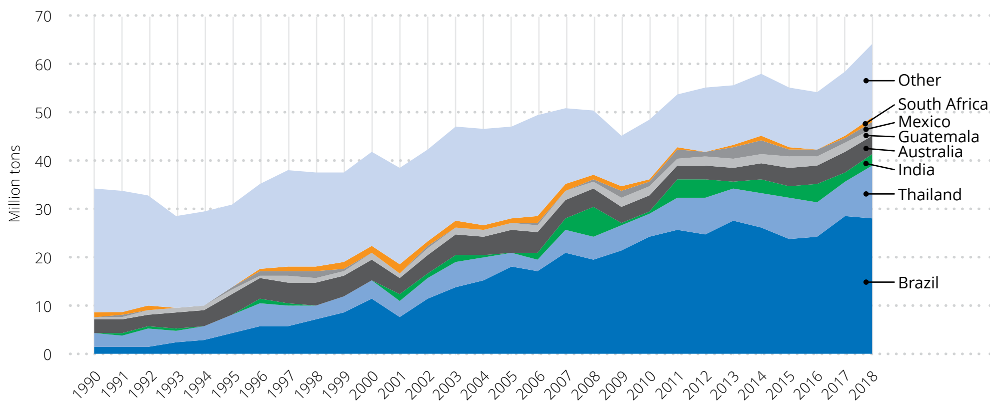
In this scenario, in which the government owned oil exploration and the production of oil by-products, controlled fuel pump prices, set the prices paid to ethanol producers, and set production quotas for biofuel industrial units, managing the supply of fuels and the interaction between the policy for the oil sector and the one applied to ethanol was less difficult, albeit often costly.

This dynamic, shaped by several political and economic policy aspects throughout the 1980s, began to change in the early 1990s, when oil prices took a downturn on the world market, the sugar and ethanol industry began to be deregulated, and fuel ethanol lost relevance in Brazil.

2.2. The process of deregulating the economy: Brazil becomes a global sugar-producing power

The process of deregulating the sugar-energy sector and the withdrawal of the state from this market was gradually implemented throughout the 1990s. Ethanol became less competitive and controls imposed on sugar production

Figure 3. Evolution of world sugar exports

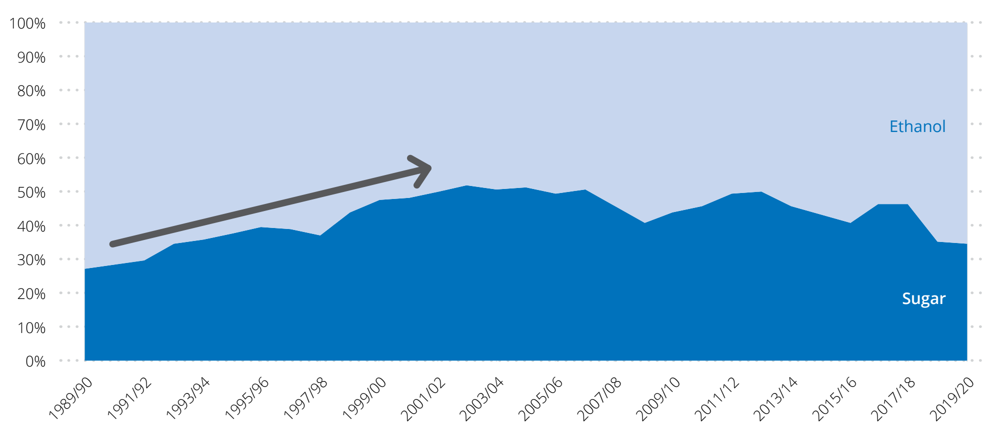


Source: USDA (2019).

and exports were eliminated, which made it possible for Brazilian producers to begin to competitively operate in the world sugar market.

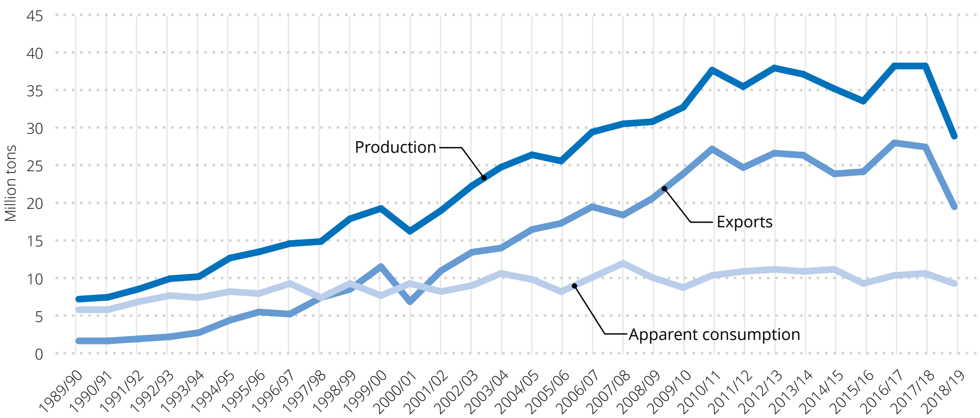
As can be seen in Figure 3, Brazil's share in the world sugar market, which was negligible in the early 1990s (around 4%), began to grow significantly, turning the country into the world's largest exporter of the commodity, with an average share exceeding 45% of the total traded in the last five years.

Figure 4. Proportion of sugarcane used to produce ethanol and sugar



Source: Mapa (2019) and Unica (2019).

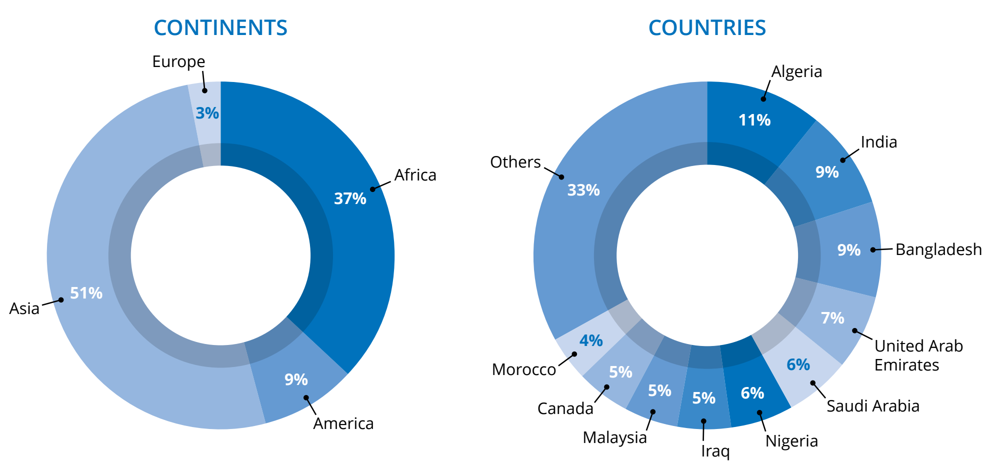
Figure 5. Brazil: sugar production, export and domestic consumption



Source: MDIC (2019) and Unica (2019).

As can be seen in Figure 4 and 5, Brazilian sugar production has been steadily increasing since the early 1990s, reaching an average annual growth rate of 6% per year. This dynamic is clearly supported by the higher volume of exported sugar, as the domestic sugar market grows only modestly, in line with the population increase recorded in the country.

Figure 6. Share of the main continents and countries to which Brazil exported sugar in 2018



Source: MDIC (2019).

In 2018, Brazil exported 21.2 million tons of sugar to 4 different continents and 120 different nations around the globe (Figure 6). The destinations of Brazilian sugar include particularly countries in Asia (51% of the total) and Africa (37%).

The deregulation of the sector, which began with authorization to access the world sugar market, was completed in the late 1990s through the liberalization of the prices of ethanol, sugar, and sugarcane.

During this period, Law 9,478 of August 6, 1997, known as the "Oil Law," was also passed, substantially changing how the state operated in the oil and oil by-products markets. With this law, private companies were granted permission to operate in all links of the oil supply chain under concession or upon authorization from the appropriate government authority. The role of the state, formerly of producer and provider, shifted to regulator and supervisor.

The same law established the National Energy Policy Council (CNPE) with the task of proposing policies for the energy industry and the National Petroleum, Natural Gas and Biofuel Agency (ANP) with the mission of regulating the fuel market in Brazil.

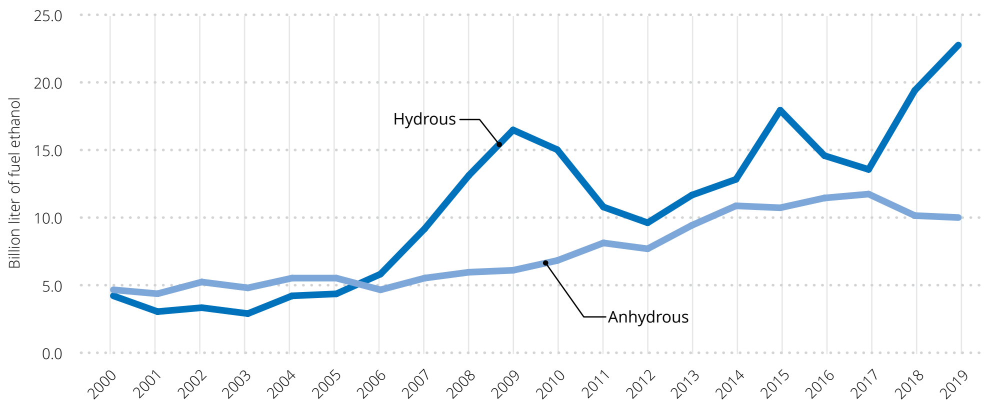
These changes led to profound transformation in the market structure and in the regulatory sphere associated with the Brazilian fuel industry.

2.3. The free market and the second cycle of ethanol expansion induced by flex-fuel vehicles

In the latter part of the 1990s, and early 2000s, hydrous ethanol consumption declined gradually due to the small number of ethanol-fueled cars sold and to the scrapping of the biofuel-powered vehicle fleet. As a result, the mills were prioritizing sugar rather than ethanol production.

However, from 2003 this downturn in ethanol consumption changed significantly due to the launch of flex vehicles (Figure 7). This initiative of the automobile industry, boosted by the competitiveness of ethanol against gasoline at that time, made it possible for flex-fuel vehicles to consolidate themselves in the domestic market. The wide acceptance of flex cars can be measured by the fact that, in four years, virtually 90% of all new cars sold in the country fell under that category.

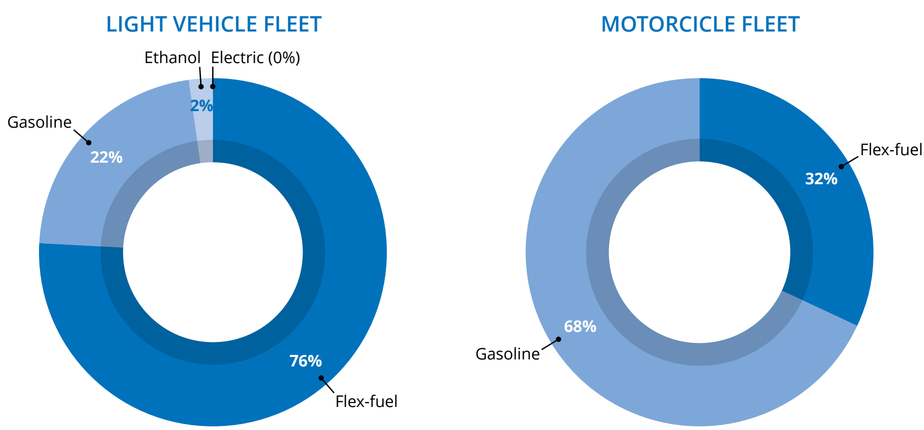
Figure 7. Consumption of anhydrous and hydrated fuel ethanol in Brazil



Source: Mapa (2019) and Unica (2019).

In 2018, out of the 38 million light vehicles circulating in Brazil, 76.4% were equipped with flex-fuel technology. In the case of motorcycles, the proportion of flex-fuel engines amounted to 32.5% of the circulating fleet (Figure 8).

Figure 8. Brazil: share of different technologies in the fleet of light vehicles and motorcycles



Source: Anfavea (2019), Abraciclo (2019), and Unica (2019).

Deregulation of the sugar-energy industry and the new configuration of the oil market coupled with the technological change of flex vehicles made it possible for consumers to decide on the type of fuel they wanted to use when filling their tanks. This required regulatory changes in the fuel industry and turned Brazil into a unique country in the world not only for its large-scale use of hydrous ethanol and availability of flex vehicles, but also for the possibility it afforded to consumers to use two substitute fuels – ethanol and gasoline – with a completely different production system and market structure coexisting in a free market environment.

Under this new configuration, the price relationship between hydrous ethanol and gasoline at the pump became a key factor in determining demand for these products, since the selection of fuel was no longer made when they bought a car, but rather when they filled their tanks.

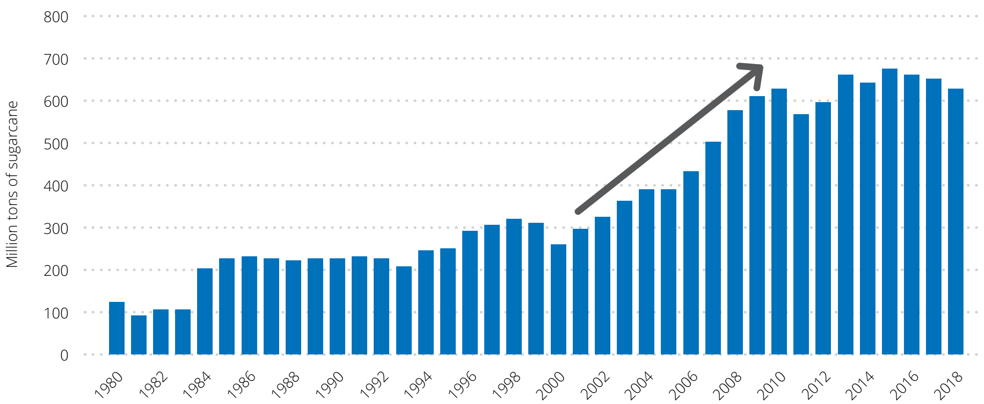
This led to a different dynamic in the fuels market than that observed in the past, when demand for ethanol and gasoline responded more slowly and less intensely to changes in relative fuel prices. In a deregulated environment with a significant presence of a flex fleet, demand for ethanol began to change rapidly in response to changes in relative fuel prices.

2.4. The new fuel market structure and the onset of the crisis in the sugar-energy industry

The business environment that emerged after the launch of flex-fuel vehicles offered great prospects for the sugar-energy industry. This was due to the introduction and consolidation of this technology in the domestic market, to the low cost involved in producing ethanol, to an upward trend in oil prices in the world market, to the tax differentiation applied to renewable fuels in relation to their fossil competitor domestically, and to a widespread global interest in renewable fuels, as particularly evinced by an ambitious program launched in the United States.

As a result, a new cycle of expansion of sugarcane and ethanol production was recorded in Brazil. Between 2002 and 2010, Brazilian sugarcane production virtually doubled, over 100 new production units were built, and significant investments were made to expand the existing industrial park (Figure 9).

Figure 9. Annual evolution of sugarcane processing for manufacturing sugar and ethanol in Brazil



Source: Mapa (2019) and Unica (2019).

However, the global financial crisis, and especially the elimination of the tax differential between ethanol and gasoline and use of fossil fuel prices for inflation control purposes completely changed this scenario.

The combination of global economic turmoil, credit crunch, and rising financial costs in an environment of low ethanol prices led some ethanol-producing companies to incur an unsustainable debt burden. Since 2009, this triggered a broad debt consolidation process involving about one third of all companies operating in this industry. Capitalized groups already in business and new players, including multinationals operating in different sectors such as the trading and oil industries, acquired existing assets to the detriment of building new production units.

In addition, since 2006 a structural change in how the energy policy was conducted has been observed, especially in the fossil fuel pricing dynamics in the domestic market. Since that year, gasoline sales prices in Brazilian refineries were artificially frozen, and federal oil taxes were sharply reduced.

This system of keeping gasoline prices artificially low, coupled with rising costs for producing ethanol, led to an unprecedented crisis in the sugarcane industry, reinforcing the importance of consistent and long-term public policies to ensure sustainable growth in the sector.

The mechanisms adopted for keeping gasoline prices under control in the domestic market caused losses to ethanol producers and Petrobras, the Brazilian public oil company. Thus, as of late 2017, the company began to adopt a new domestic pricing policy under which domestic prices reflected international oil prices converted into the Brazilian currency, reducing the uncertainties associated with how gasoline was being priced in the domestic market and leading government to adopt a new, long-term policy with clear rules that will likely usher a new phase of investment in the sector.

These measures have provided additional incentives for the ethanol industry to invest in an additional source of raw material, i.e., corn as a feedstock. In fact, since 2017, corn ethanol has gained relevance, and in the 2019/2020 harvest season, it should reach about 1.5 billion liters, representing almost 5% of total Brazilian ethanol production (Unica, 2019). Corn-based ethanol is mainly produced in Brazil's mid-west region in two different ways: in so-called "flex plants", which can process both sugarcane and corn – according to their different harvest periods – and in plants exclusively dedicated to processing corn. Corn ethanol production will likely increase in the coming years and complement the supply of ethanol to meet the decarbonization targets of the country, established by the new program, RenovaBio, described in the next session.

2.5. Looking ahead: The RenovaBio program

The need to address these challenges culminated in the approval of Law 13,576 of December 26, 2017, which established the National Biofuel Policy, also referred to as RenovaBio.

The program represents a major milestone in the Brazilian public policy, as it intended, in an unprecedented way, to establish a joint strategy between public and private agents. It aims at ensuring predictability and recognizes the role of all biofuels as instruments for decarbonization of the Brazilian transportation matrix, in line with the goals to reduce GHG emissions undertaken by Brazil under the Paris agreement.

In addition to the important environmental benefits it can afford, this program will also attract significant investments, with direct impacts on employment and income in more than 30% of all Brazilian municipalities.

Finally, it will also result in a reduction in dependence on imported oil and increase energy security in the country.

This national biofuel policy was completed in the end of 2019, and all the mechanisms to make it operational are effectively in place for the program to start in this harvest season of 2020.

The main objectives of the Program are: i) reducing greenhouse gas emissions, in line with the environmental commitments undertaken at COP21; and, ii) contributing to the security of fuel supply in Brazil, encouraging the expansion of biofuel production.

RenovaBio is based on market mechanisms and is in line with successful experiences in other countries, and it does not involve governmental subsidies, tax incentives, or new taxes.

The mechanisms of the Program incorporate the following measures:

- Government-defined greenhouse gas emission reduction targets – the national target will have a 10-year deadline and predictably induce a competitive and efficient reduction in carbon intensity in the fuel chain. There will also be an annual breakdown of the ten-year individual targets for fuel distributors.
- Issuance of Emission Reduction Certificates (CBios) – as an incentive tool for productive efficiency and a bond whose value corresponds to the carbon intensity of the biofuel produced in its life cycle. CBios will be issued by biofuel producers and purchased by fuel distributors on the stock exchange.
- Analysis of the life cycle of biofuels – each CBios issuing plant will have an efficient biofuel production certificate according to its productive efficiency. The greater the efficiency of an industrial plant, the greater its capacity will be to issue CBios.

The ten-year targets set by the federal government suggest that ethanol production is likely to grow significantly in the coming years to achieve the carbon intensity reduction proposed for the domestic energy matrix. The Program is expected to usher in a new cycle of investment domestically by ensuring greater predictability to the share of biofuels in the domestic matrix, incorporating a mechanism for recognizing the positive externalities of biofuels through carbon pricing via the market, and stimulating the pursuit of economic and environmental efficiency gains in ethanol production by differentiating production units according to the characteristics of their production process.

2.6. Important lessons learned from ethanol programs: the importance of clear and long-term rules

This brief description of the history of the sugarcane industry in Brazil points out the broad spectrum of public policies and regulation applied to sugar markets and especially to the domestic ethanol market over the last 5 decades.

The result of these policies evinces the need for predictability and clear and lasting rules to stimulate investment in a capital-intensive industry that takes a long time to mature. This is undoubtedly the key requirement for any program designed to boost biofuel production.

Another key element for consolidating renewable energy and particularly biofuels is recognizing the environmental benefits afforded by these products. Positive externalities require active state participation to incorporate this component into the pricing system.

This is a classic case where the proper functioning of markets alone is not sufficient to stimulate the investments needed to generate optimal consumption of the environmentally friendly product. The presence of positive externalities and the non-exclusion phenomenon prevent the market, by itself, from ensuring optimal conditions from the social point of view.

In the case of ethanol, consumers as a rule resist the idea of paying for air quality by not using the fuel that may be occasionally cheaper but is more polluting. Vehicle owners believe their contribution is limited and insufficient to change environmental conditions. In addition, if others pay for this clean fuel, they will not be excluded from the environmental benefits it provides. By not including environmental benefits in their decision, consumers' willingness to pay pushes the market price down, resulting in underinvestment in fuels that reduce CO_2 emissions.

Without any regulation, this rationale would be different only when the costs for producing clean and renewable fuels are higher than those for producing fossil fuels. From an environmental point of view, it may be too late.

This condition requires effective actions on the part of the state as regulator, establishing instruments that recognize the environmental advantages afforded by clean energy and allowing competition between fossil and renewable sources to incorporate all the social costs and benefits of this choice. The most widespread instruments for this purpose include carbon taxation and trade programs based on emission reduction targets.

In the Brazilian case, in recent years a tax on fossil fuels has been misused for inflation control, generating uncertainty and significant losses for the sugarcane industry and society. Despite imposing some transaction costs on the system, the mechanism proposed under the National Biofuel Policy – RenovaBio – will in turn ensure greater predictability for agents in the supply chain, based on decarbonization targets and recognition of the power of biofuels to reduce emissions through the CBios market. In addition, the mechanism proposed by RenovaBio will stimulate efficiency gains in biofuel production, as the number of CBios emitted by each producer will depend on the environmental efficiency of their production system.

3. Beyond sugar and ethanol

As mentioned in the introduction of this chapter, the sugar industry has the potential to go far beyond sugar and ethanol production. It can also generate, among others, bioelectricity (or energy generated from sugarcane biomass), biogas, and renewable bio-jet fuel. These three by-products and their benefits are described below.

3.1. Bioelectricity

Currently, biomass from the burning of the sugarcane accounts for almost 9% of all the electricity generated in Brazil and is the 3rd largest source in terms of installed capacity, behind only hydroelectric and fossil energy.

Bioelectricity (which is the power generated from the burning of the sugarcane bagasse in Brazil) is seen as a distributed, renewable, and clean form of power generation. Some of the benefits provided to civil society by the production and use of bioelectricity in Brazil will be highlighted below:

- Benefits from complementarity with hydroelectricity: sugarcane biomass (bagasse) is usually generated during the dry season, between April and November, when hydroelectric dams empty their reservoirs. Developing the potential of bioelectricity means adding new renewable and sustainable "virtual reservoirs" to the Brazilian electricity industry.
- Lower energy transportation losses and savings in transmission

investments: bioelectricity is predominantly generated close to large consumer centers and distributed in a way that reduces technical losses in the system and provides investment savings in transmission. In 2017, 84% of all the bioelectricity generated for the grid was concentrated in Brazil's mid-west region, which accounts for almost 60% of its domestic consumption.

- Bioelectricity avoids GHG emissions: in 2017, it was estimated that the bioelectricity made available to the Brazilian grid avoided the emission of about 10 million tons of CO_2 into the atmosphere, a volume equivalent to growing 67 million native trees over 20 years.
- It brings reliability to the system: bioelectricity generation for the grid is seen as quite stable and predictable throughout the year, mainly due to the predominance of sugarcane biomass as feedstock. Thus, bioelectricity is not seen as an intermittent source, such as solar and/or wind energy. Due to its greater predictability and reliability, it is regarded as a seasonal source, as is hydroelectricity, but not as intermittent as wind and photovoltaic sources. Adding bioelectricity to the system contributes to its reliability and mitigates the effects of the expansion of intermittent sources in the Brazilian electricity matrix.

3.2. Biogas

Biogas may be consolidated as a new product manufactured at scale in the coming years. Some plants have already made investments in producing biogas and others are considering this option.

It is a product made from the bio digestion of vinasse. Vinasse is an effluent produced from the distillation of an alcoholic solution called fermented wine at an approximate rate of 12 liters of vinasse for each liter of ethanol.

Although its composition varies according to the characteristics of its raw materials, inputs, and production process, it can be assumed that the average composition of vinasse is 93-97% water and 7-3% solids. Approximately 75% of the solids in its composition is biodegradable organic matter and 25% consists of minerals.

The presence of considerable levels of calcium, magnesium, phosphorus, nitrogen, and sulfur in vinasse makes it possible for it to be used in natura as a biofertilizer in soil where sugarcane is grown in a process referred to as fertirrigation, providing major agronomic and economic benefits. Vinasse is currently being used to meet a percentage of sugarcane fertirrigation varying from 30% to 40% of the total sugarcane harvesting area and it is applied by spraying the product on the crop soil.

Anaerobic biodigestion of vinasse with biogas production opens the possibility of using this effluent to produce energy, in addition to its agronomic use as described above.

Biogas obtained from this process can be used for generating thermal, electrical, and mechanical energy. It can also be purified into biomethane, ensuring its use as a fuel with the same characteristics as those of natural gas. This product can be traded in the natural gas market or even to fuel machinery and equipment run on sugarcane farms.

In the state of Sao Paulo alone, the main producer in Brazil, the theoretical potential for producing energy from vinasse and other by-products from ethanol production would make it possible to: i) replace 80% of the natural gas consumed in the state; or ii) replace 70% of all diesel oil consumed in Sao Paulo; or iii) meet 93% of the state's demand for residential electricity (Coelho et al., 2019).

3.3. Renewable bio-jet fuel

Accounting for about 2% of GHG emissions worldwide and with its demand likely to double over the next two decades, the aeronautics industry is already taking steps to develop sustainable fuels, targeting a 50% reduction in CO_2 emissions into the atmosphere by 2050 in relation to 2005 levels (International Air Transport Association, IATA, 2018). Several alternatives are already emerging, but so far biokerosene is the most concrete option.

Brazil is one of the pioneering countries in using sugarcane to produce aviation fuel. It is a cleaner compound than the aviation kerosene being used today, renewable, and requires virtually no adaptation in aircraft, engines, or even in the supply chain. This is because in order to be certified and approved for use in aircraft, renewable fuel must have the same characteristics as fossil fuel, without any need for major adaptations in aircraft or ground systems, regardless of the feedstock used for producing it. Studies show that sustainable aviation biofuels emit at least 70% less carbon over their life cycle than fossil aviation fuel (Klein et al., 2019). More than 1,600 commercial flights using aviation biofuel have been operated worldwide between 2011, when the use of this type of fuel was approved, and 2018, and biofuels may become a major source of renewable energy for aviation in the future, overcoming current technology and cost barriers (Aeromagazine, 2019).

4. The environmental regulatory framework in the sugarcane industry

Brazil has one of the most rigorous and advanced environmental legislations in the world. Created by Federal Law No. 12,651, of May 2012, the Brazilian Forest Code established an important regulatory framework in the country. The Code defines permanent protection areas (riverbanks, hill tops, etc.) and requires producers to maintain a portion of rural property with native vegetation (this proportion of native vegetation, called the legal reserve, varies from 20% to 80% between regions of the country).

Moraes, Zilberman and Rodrigues (2014) also highlight the Resolution No. 001/7,986-1986 of the Brazilian National Environmental Council (Conama, National Environmental Council) as a fundamental element of the Brazilian environmental framework. This Resolution establishes guidelines for the evaluation of environmental impacts for the industrial and for agro-industrial facilities.

In addition to these rules that are applied to the agricultural sector in Brazil, the sugarcane industry will also have to comply with specific rules from the National Biofuel Policy (RenovaBio), which impedes the suppression of native vegetation for the planting of sugarcane since 2018. According to this policy, rural properties with suppression of native vegetation are not permitted to participate in the Program.

This regulatory framework ensures that the production and expansion of sugarcane production in the country occurs in an orderly manner, without any type of degradation of forests or sensitive biomes.

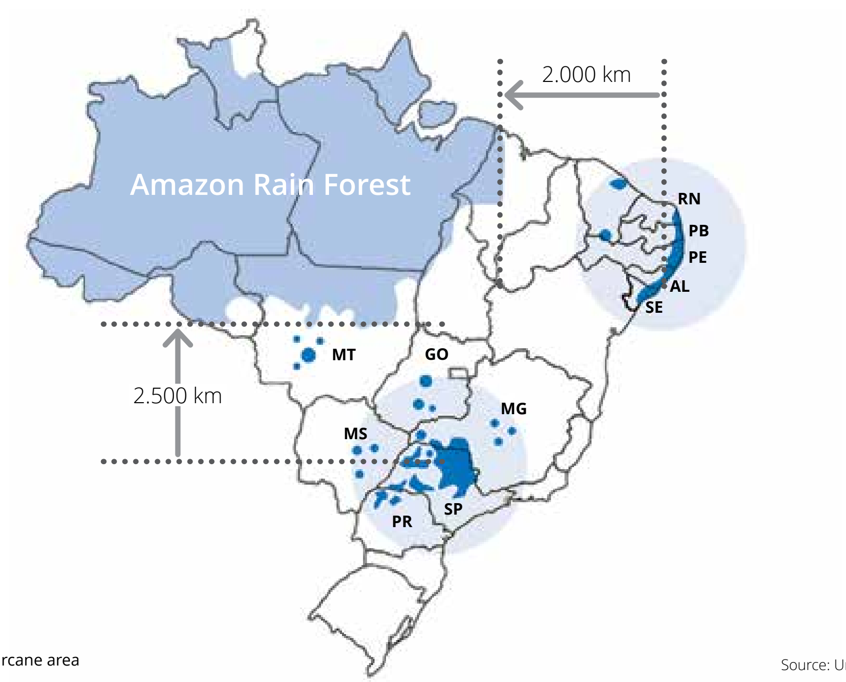
In fact, the most recent expansion of production has taken place primarily on degraded pasture land. Since the year 2000, for example, the increase in the amount of sugarcane planted and processed in Brazil has allowed ethanol production to triple, from 10.6 billion liters to more than 33 billion liters in the 2018 harvest/2019. In the same period, both sugar production and grain production (soy, corn, rice, wheat, cotton, among others), more than doubled (Mapa, 2019).

These numbers show that it is possible to increase the production of food, fiber, meat and bioenergy without deforestation, just by intensifying production on pastures and expanding the productivity gains observed historically in the agricultural sector of the country.

Today, only 1.2% of the Brazilian territory is used for the cultivation of sugarcane, of which 0.8% is used for the production of ethanol (IBGE, 2019; Mapa, 2019).

At this point, it is also worth mentioning that sugarcane production is located especially in the Midwest (more than 90%) and Northeast (about 10%) regions of the country, more than 2 thousand kilometers away from Amazon Rain Forest (Figure 10). In addition to the legal restrictions imposed

Figure 10. Location of sugarcane production in Brazil



Sugarcane area

Source: Unica (2019).

by the regulations presented, the planting of sugarcane in the Amazon is not economically effective because the region does not have adequate edaphoclimatic conditions for cultivation. Sugarcane needs a warm, rainy season to grow, alternating with a cold, dry season so that the plant can concentrate sugar in its stalks. The Amazon region does not have this cold and dry period, significantly reducing the activity yield.

In the last two decades, the environmental agenda has guided the sugar-energy sector. In Sao Paulo, a state responsible for more than 50% of national production, the elimination of fire for burning cane straw during harvesting operations was voluntarily anticipated by the productive sector. The Agro-Environmental Protocol, celebrated in 2007 by producers and the State government, guaranteed the elimination of sugarcane burning as early as 2014.

This agreement also involved other environmental actions, resulting in the preservation of more than 6,850 water springs existing in the sugarcane fields, in the recovery and preservation of 210,719 hectares of riparian forests, in the planting of about 38 million seedlings of native species and the reduction in water consumption in sugarcane plants by 37% (São Paulo, 2019).

In addition to complying with environmental legislation and establishing voluntary agreements with the government, the sugar-energy industry has long adopted environmental standards in order to meet the prerequisites established in the main certification schemes.

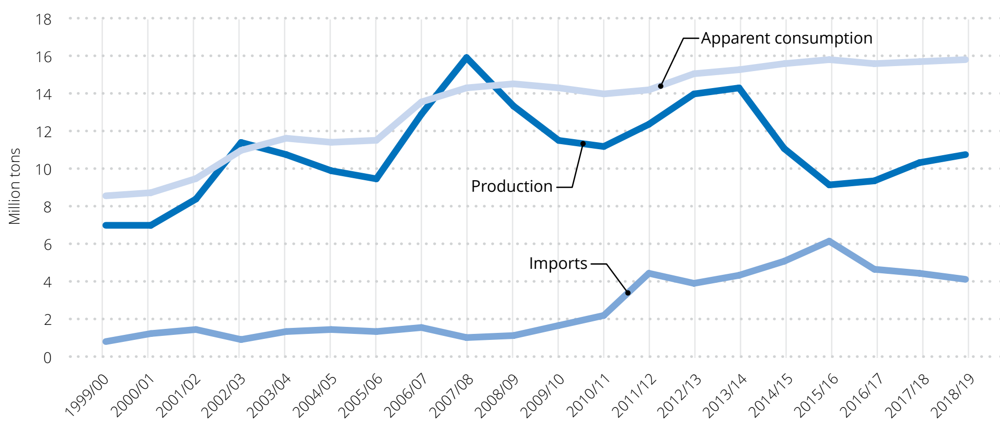
Sustainability standards and private certification initiatives, such as those developed by Bonsucro, have gained prominence in this industry in recent years. Namely, Brazil currently has 62 companies certified by Bonsucro, standing out as the country with the largest number of certified plants.

5. Cooperation opportunities with China

Brazil and China both claim potentially large consumer markets, and China, because of its large population and lower availability of arable land, will likely become more dependent on several imported commodities over the next few decades.

Sugar will surely be one of these products. Consuming around 15 million tons of sugar yearly, China produces only around 2/3 of this total, meaning that its annual dependence on imports is close to 5 million tons (Figure 11). As a result, China is the second largest sugar importer in the world, after Indonesia (USDA, 2019).

Figure 11. Evolution of sugar production, consumption and imports in China



Source: USDA (2019).

It is also noteworthy that for several recent years, China has been the major destination of Brazilian sugar, and Brazil, in turn, has been the largest supplier of this commodity to China. In fact, between 2011 and 2016 Brazil exported average volumes in the order of 2.5 million tons per year to China, which represented 10% of all Brazilian sugar exports and more than 60% of the total volume imported by the Asian country (MDIC, 2019; USDA, 2019).

It should also be noted that China is one of the countries with the highest potential for sugar demand growth in the world, as its annual per capita consumption of about 11 kg is still 50% lower than the annual average world consumption, which is in the order of 23 kg/inhabitant/year. In addition, the average sugar consumption growth rate in China has been increasing at three times the world average.

With the safeguard measure established by China in 2017 in the form of a higher import tariff on sugar, Brazil's share in Chinese imports decreased sharply. However, since the mechanism is scheduled to be lifted in 2020, trade between the two countries is expected to intensify once again. Actually, a more open trade flow will benefit both nations by ensuring the Chinese population access to a cheaper product of recognized global quality.

Another significant opportunity for cooperation is related to ethanol. With heavy reliance on imported gasoline and faced with the need to reduce greenhouse gas emissions and local pollutants, China has been signaling that it will strengthen its gasoline-ethanol blending program by 10% over the next few years across its territory.

A large-scale ethanol program would likely result in at least three major benefits: to the environmental, to public health, and to the Chinese economy.

From an environmental point of view, it should be emphasized that, according to an EU Report (2019), China is currently the largest emitter of greenhouse gas (GHG) in the world, accounting for 29.3% of global emissions. Its oil industry accounts for over 15% of those emissions and as a result China made a commitment at the United-Nations Climate Change Conference of Parties (COP) 21 in Paris to increase the share of non-fossil fuels in its matrix to 20% by 2030. It should be noted that China currently has a fleet of 240 million cars, a figure that is likely to double over the next 25 years, enhancing the problem.

The so-called "electrification" of vehicles (battery-powered cars) may be part of the solution, but it is being developed at a slow pace (battery-powered cars account for just over 1% of the fleet today) and is an expensive initiative due to the high costs of this technology and the need for investments in distribution infrastructure. Furthermore, this is not a complete solution at this moment, as much of the electricity to power these cars is generated by burning fossil fuels, particularly coal.

In this scenario, ethanol could be a complementary solution. Already tested in several countries and seen as economically feasible, it is a fuel that can reduce emissions by up to 90% compared to using gasoline. In addition to its use in combination with gasoline, biofuel can also be used in hybrid electric vehicles and especially to power fuel cell vehicles – a strategy with enormous potential for cooperation thanks to the Chinese technological expertise in the automotive industry.

In relation to public health, ethanol can also contribute to reducing local pollutants, which is still needed in most large Chinese cities. The

Organization for Economic Co-operation and Development (OECD) estimates that China spends USD 1.4 trillion a year due to health problems such as hospital admissions for cardiovascular and pulmonary diseases caused by air pollution (OECD, 2014). In fact, according to local pollution monitoring data produced by the World Health Organization (WHO, 2019), of the 100 most polluted cities in the world, 54 were Chinese cities in 2018.

According to Saldiva et al., (2014), the use of ethanol as fuel in eight major metropolitan regions in Brazil has been responsible for the reduction of around 1,400 deaths and almost 10,000 annual hospitalizations caused by health problems associated with the use of fossil fuels. This represents a savings of, at least, USD 430 million per year for the public and private health systems in Brazil, according to the authors.

Finally, on the economic side, large-scale biofuel use may contribute to reducing China's dependence on imported oil, which today supplies 65% of local demand, a figure that may rise to 80% by 2030 (Wang et al., 2018). In addition, increased ethanol consumption could provide an important income alternative for local rural producers and boost China's development in this area.

With an annual consumption in 2018 of about 4 billion liters, China is already blending biofuel with gasoline in 12 provinces (out of a total of 34), mainly biofuel produced from corn (at a rate of 70-80% of the production) and from cassava (at a rate of 10-20%), and it has been estimated that an increase in demand of about 15 billion liters of ethanol per year will be necessary for the 10% target to be achieved (USDA/FAS. Gain Report China Biofuels Annual, 2018).

Estimates suggest that part of this consumption will be met by domestic production, including as an interesting market diversification option for the sugarcane industry, and another part by imported ethanol, mainly from the United States and Brazil, the two largest ethanol producing and exporting countries. Until 2016, the ethanol import tariff stood at 5% and since 2017 it has risen to 30% and a reduction in this tariff is expected to contribute to reducing the cost of the imported product and to boost investments in producing it in both Brazil and the USA.

It should therefore be noted that there are clear opportunities for collaboration between Brazil and China either in the form of technical cooperation or of investment and trade. Specifically in the technical-scientific realm, relevant opportunities have been envisaged for exchanging experiences in the agricultural (sugarcane production and management), industrial (sugar and ethanol production, including second-generation ethanol), and automotive (improvements in vehicle technologies for electrification with biofuel in the future) areas, as well as in the area of regulation, given the experience of more than five decades of large-scale ethanol use in Brazil.

In addition to ethanol, cooperation arrangements may be developed around other products such as bioelectricity, biogas, jet-fuel, and even second-generation ethanol, as demand for energy in both countries is likely to continue to grow in the coming years.

Finally, it is worth mentioning that Chinese investments are already observed in the sugar-energy sector in Brazil. The COFCO International group, to cite one example, has been operating in the production of sugar and ethanol in the country since 2016 and today it ranks among the ten largest sugarcane producers in Brazil.

6. Final considerations

The Brazilian case of large-scale production and consumption of ethanol, sugar, and other energy sources, albeit designed for different purposes throughout its history, has become an illustrative and effective example worldwide of how fossil fuels can be replaced with renewables in conjunction with food production.

As in other countries, this shift in Brazil relied on the active participation of the state. Especially in the energy field, and more specifically in the case of ethanol, the presence of positive externalities associated with the production and use of biofuels requires public policies designed to induce their development, considering that the market cannot autonomously incorporate the value of these environmental benefits into the price system.

Although the Brazilian case provides an example with unique characteristics, this equation of the trade-off between energy security and climate change, including the instruments adopted to stimulate the use of biofuels, is not unique to Brazil. It actually began to permeate discussions on energy policy worldwide.

The way each nation will recognize this new component and address the energy security dilemma on a sustainable basis will likely shape the strategies adopted by states in the energy, political, and economic fields in the coming years.

In this scenario, stimulating the production and local consumption of ethanol by blending it with gasoline may be an efficient alternative for reducing pollution and greenhouse gas emissions in many countries around the globe. It is an economically feasible and readily available option that can be used in addition to other alternatives in the future that must be characterized by a multiplicity of clean and renewable energy sources.

China has already signaled its interest in expanding the share of biofuels in its energy matrix. It no doubt will need to rely on several sources of energy in the composition of its energy matrix. This is an unequivocal opportunity for technical and economic cooperation that can yield trade and investment gains for the two countries.

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Part 4

Cooperation in infrastructure and investments

Chapter 7

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Chengming Ji
Yu Li

The Chinese appetite for global agriculture investments: the role of Brazil

Abstract

This chapter briefly reviews the history of Chinese global agricultural investments. It begins by describing the ongoing process of Chinese agriculture "going global" within different subsectors, and discusses the current situation of this "going global" strategy in detail. The role of Brazilian global agricultural investments is analyzed, and agricultural trade and investments between China and Brazil are discussed. Finally, the conclusion and prospects for agricultural global investments are outlined.

1. Introduction: China's agriculture "goes global"

With the economic globalization and rapid population growth, agricultural global investment has been considered an effective way for China to ensure grain security, as well as alleviating domestic environmental and resource pressures caused by agricultural production. This movement gained strength in 2007 when the agricultural "going global" strategy was stated in No. 1 Central Document[1]. Since that time the Chinese government has implemented many measures to boost agricultural investment and cooperation. Brazil is centrally positioned within the Chinese "going global" strategy thanks to the potential of its agricultural resources and a beneficial environment for agricultural production. Agricultural investments in Brazil is not only necessary for China to meet increasing domestic food demand and optimize the allocation of domestic markets and resources. It offers an opportunity for Brazil to improve agricultural infrastructures and technologies. From the beginning of the 1950s to the present, China's agricultural foreign investment and cooperation policies can be roughly divided into three major stages.

The period dominated by foreign aid, from 1950 to 1970s: As a country with a long history of agricultural civilization, China has accumulated rich experience and technologies in agricultural production. After the founding of the People's Republic of China, with the launch of foreign aid work, China has engaged in agricultural foreign investment and cooperation with Asian and African countries, mainly involving the construction of farms for grain and poultry storage, as well as aquaculture, agricultural technology testing and diffusion stations, irrigation projects, agricultural machinery, and upgrading the technology of agricultural product processing. Improved varieties, fertilizers, pesticides and advanced agricultural technologies have also been disseminated. In the 1950s, China's agricultural foreign aid targets were mainly focused on Vietnam and Mongolia. After the 1960s, these expanded further to countries such as West Asia, African countries, and Eastern Europe, like Albania and Romania. In the 1970s, when China reclaimed its legal seat at the United Nations, the scale of agricultural foreign aid expanded dramatically. China has sent more than 600 agricultural technicians to 12 African countries, including Rwanda and Ghana, to replace the Taiwanese farming teams, and has been engaged in projects to boost agricultural production.

[1] No. 1 Central Document originally means the first document issued by the CPC Central Committee each year. It is October 1st of 1949 that the Central People's Government of the People's Republic of China began to issue No.1 Central Document. Now it has become the proper term for the CPC Central Committee to attach importance to rural issues.

Development from unilateral assistance to multiple forms of mutually beneficial cooperation, from the 1980s to 2001: the reform and opening led to an adjustment of China's foreign aid work; agricultural aid has developed into different forms of mutually beneficial cooperation, and agricultural foreign investment has gained momentum. In order to consolidate the results of the aid projects, China has carried out various forms of technical and management cooperation initiatives with other recipient countries such as escrow management, leasing operations, and joint ventures. Secondly, the scope of Chinese foreign aid has been further extended to Latin America and the South Pacific. Thirdly, Sino-foreign joint ventures and wholly-owned enterprises overseas have been established. In the 1980s, China's agricultural foreign investment mainly focused on the establishment of joint ventures and cooperative development of fisheries and forestry resources. According to public information, China's offshore fishing began in 1985. At that time, 13 fishing boats and 223 crew members of the CNFC Overseas Fisheries Co. Ltd. created China's first offshore fishing fleet. Since then, China has broken new ground in strategic development of the offshore resources. According to the 2015 30 year Chinese deep sea fishing symposium, total output reached 2.03 million tons in 2014, and there was an increase of nearly 800 times over the 2,600 tons caught in 1985. The total output value reached 18.5 billion yuan – 4,000 times more than that of the initial period. In the 1990s, China's large state-owned enterprises and joint-stock companies began to invest in agriculture in recipient countries by using their experience in building Chinese foreign aid projects. For example, in 1990, the China State Farm Agribusiness Group Co. Ltd (hereafter referred to as CSFA) invested in Zambia to establish the first farm, which enabled the country to obtain valuable experience in building and managing farms in Africa. By 1998, the CSFA Group had invested in three farms in Zambia to develop planting, aquaculture, and processing industries of agricultural and livestock products, and realized the integration of trade, industry, and agriculture. At this stage, China's foreign agricultural investment was still in its infancy, limited to small-scale investment by a small number of enterprises.

The initial development stage of agricultural foreign investment from 2001 to the present: After joining the WTO, China's opening up to the outside world shifted from only "bringing in" to "going global". In particular, the Ministry of Commerce, the Ministry of Agriculture, and the Ministry of Finance jointly issued the "Several Opinions on Accelerating the Implementation of the 'Going Global' Strategy for Agriculture" in 2006. At the same time, the Ministry of Agriculture also formulated and published the "Agricultural Going Global Development Plan". The “Guidance Policy for Overseas Investment Industries” and “Guidance Catalogue for Overseas Investment Industries” were published by the Ministry of Commerce, and it was clearly stated that five aspects of agricultural investment will be encouraged, which included crop farming of natural rubber, oil, cotton, vegetables, forest harvesting, transportation, cultivation, animal husbandry, and aquaculture. Since then, China has successively introduced a number of measures to support enterprises in carrying out overseas agricultural investment, and cooperation and agricultural foreign investment has entered a preliminary stage of development.

In recent years, China’s foreign agricultural investment development has shown a strong growth trend, where the scale and efficiency have been significantly improved, particularly in the “The Belt and Road” region. Although these investments have many advantages, such as focusing on the planting industry and the whole value chain layout, there are also problems in the low-end of the value chain, and the scattered geographical distribution of investments, especially in the context of the unstable international environment, and increasing uncertainties. There will be more challenges and risks in the development process in the future.

Nowadays, agricultural foreign investments continue to expand, covering crop cultivation, livestock and poultry breeding, agricultural product processing, warehousing and logistics system construction, development, and utilization of forest resources, aquatic product production and processing, rural energy, and biomass energy. Investments tend to be diversified. In addition to large state-owned agricultural enterprises, private enterprises and individual farmers have increased their overseas investments, which enjoy a strong momentum. In this chapter, descriptive and literature analysis are used to examine China’s agriculture “go global” strategy, identify the role of Brazil in China’s agricultural global investments, and discuss agricultural investments between China and Brazil. Finally, conclusions and prospects for agricultural global investments between the two countries are outlined.

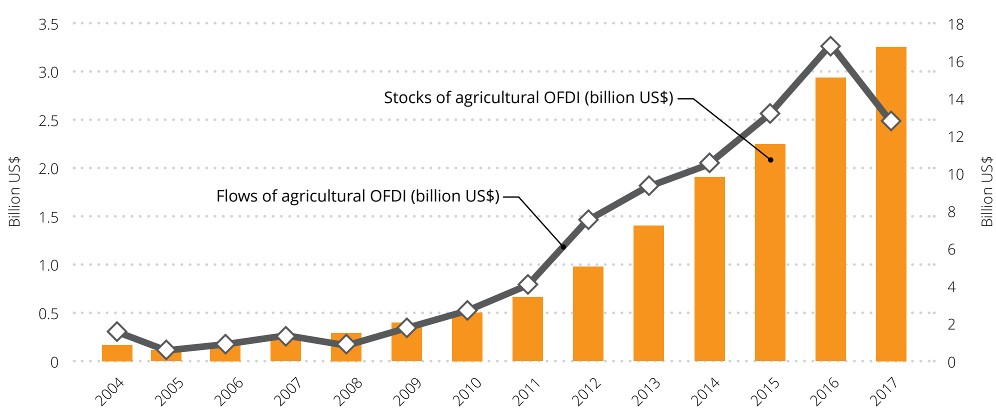
2. The current situation of China's agriculture "going global" strategy

In order to reduce the impacts of international market turbulence, maintain sources of agricultural imports, stabilize the domestic agricultural market and make full use of resources of host countries, China has been implementing the process of agricultural going global for many years. Here are the characteristics of Chinese agriculture "going global" strategy at this moment.

2.1. The scale of agricultural investments is increasing

In recent years, the scale of China's OFDI (Outward Foreign Direct Investment) is increasing in general, which can be seen from Figure 1. There has been a strong growth in the flows of agricultural OFDI, increasing from US$ 0.29 billion in 2004 to US$ 2.51 billion in 2017, with an average annual growth rate of 29% in spite of some yearly fluctuation . OFDI started growing quickly as of 2010. On the other hand, the stocks of agricultural OFDI increased from US$ 0.84 billion in 2004 to US$ 16.56 billion in 2017.

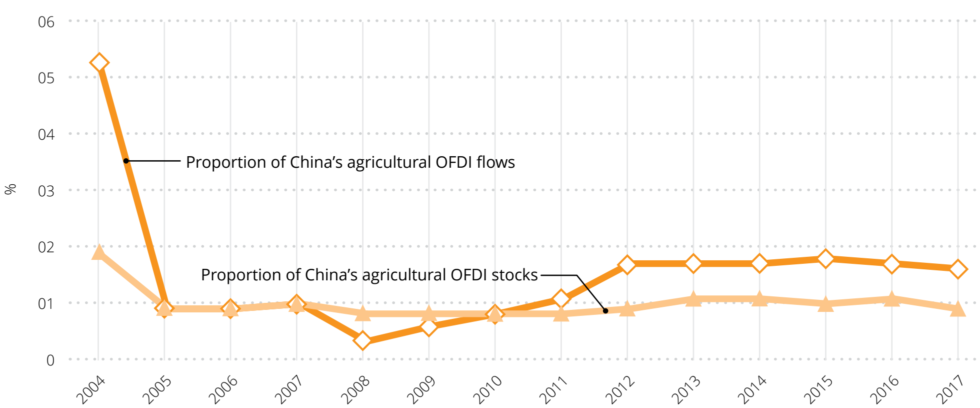
Figure 1. Stocks and flows of agricultural OFDI of China from 2004/2017



Data source: China Foreign Direct Investment Statistics Bulletin from 2004 to 2017.

Although the total amount of OFDI in agriculture is increasing, its proportion in China's OFDI has not increased significantly. With the expansion of China's OFDI from 2005 to 2008, Chinese companies' investment strategies have gradually been perfected and diversified, which has led to a decline in the proportion of OFDI in agriculture, which has stayed at about 1%. However, affected by the global financial crisis, this proportion fell to 0.31% in 2008. Although the proportion gradually recovered and exceeded 2% after nearly two years, it is still small when compared to other sectors of the economy as we can see from Figure 2. In most years from 2004 to 2017, the proportion of the stocks of agricultural OFDI in total OFDI of China are in the range from 0.8% to 1.1%.

Figure 2. Proportions of China's agricultural OFDI flows and stocks from 2004 and 2017



Data source: China Foreign Direct Investment Statistics Bulletin from 2004 to 2017.

2.2. Spatial distribution of agricultural OFDI is expanding

With both stocks and flows of China's OFDI in agriculture generally increasing, the spatial distribution of China's agricultural enterprises has reached over five continents. At first, these enterprises mainly focused on Russia, Southeast Asia, South Asia and other countries and regions which are close to China and have similar history and culture. Once having accumulated some level of investment experience, these enterprises began to gradually expand their business to Latin America, Africa, Europe and the United States so as to make full use of the environments and resources of these countries and to get better access to foreign markets. In 2017, the top three regions with the largest flows of China's agricultural OFDI were Asean, Hong Kong (China) and Russia, followed by Australia, the European Union and the United States, etc. The agricultural OFDI flows and stocks of these six countries and regions respectively accounted for 73% and 67% of China's total foreign direct investment in agriculture.

Table 1. China's agricultural OFDI in major countries and regions in the world (2017)

Country and region	Flow	Proportion (%)	Stock	Proportion (%)
Russia	2.90	11.55	27.02	16.31
Hong Kong	4.66	18.56	18.11	10.93
Asean	6.23	24.82	45.31	27.36
Australia	2.17	8.64	8.20	4.95
EU	1.41	4.54	9.12	5.51
United States	0.95	3.78	3.27	1.97
Total	18.33	73.03	111.04	67.05

Unit (100 million US dollars).
Data source: China Foreign Direct Investment Statistics Bulletin of 2017.

Southeast Asia and South Asia as well as Russia are in key positions for China's OFDI in agriculture. This can be explained by several factors: Firstly, there are long histories and frequent exchanges of China's trade with these neighboring countries. In terms of culture, adjacent countries have similar customs demand preferences. These similarities offer China comparative advantages which can reduce barriers to entry into these market. Secondly, taking the costs of raw materials into consideration, these regions have rich resources, lower labor costs and larger market potential which can provide a great opportunity for Chinese agricultural enterprises. For example, Russia is sparsely populated and nearly a quarter of arable lands are still idle. These fertile lands with lower rents are attractive for Chinese companies. Southeast Asian countries, especially Asean, have sufficient land and labor resources for agriculture. Indonesia has the largest amount of cultivated land, with 23,500,000 hectares, followed by Thailand and Myanmar, with 16,810,000 hectares and 10,772,000 hectares. The establishment of the China-Asean Free Trade Area and the maritime Silk Road aims to achieve policy communication, road connectivity, smooth trade, and currency circulation.

All these advantages offer convenient conditions and opportunities for China's agriculture "going global".

2.3. The number of enterprises that invest in agriculture overseas is increasing and the structure of domestic investors is diversifying

With stocks and flows of China's OFDI in agriculture increasing, both the numbers of overseas and domestic enterprises investing in agriculture shows a gradually increase visible in Table 2. From 2012 to 2017, the number of overseas enterprises investing in agriculture increased from 1012 to 1769, while the number of domestic investors increased from 594 to 986.

Table 2. Numbers of overseas enterprises as well as domestic investors investing in agriculture from 2012 to 2017

Year	Number of overseas enterprises invested in agriculture	Proportion (%)	Number of related domestic investors	Proportion (%)
2012	1012	4.6	594	3.7
2013	1157	4.5	551	3.6
2014	1356	4.6	607	3.3
2015	1421	4.6	764	3.8
2016	1737	4.7	985	4
2017	1769	4.5	986	6

Data source: China Foreign Direct Investment Statistics Bulletin from 2012 to 2017.

From the early 1960s to the mid-1980s, state-owned enterprises constituted the core element of China's agricultural internationalization. With the economic and social development, the strength of private enterprises has been continuously enhanced and gradually developed into a new force for the development of agricultural resources abroad. By the end of 2012, there were 1012 agricultural companies amongst China's overseas enterprises, accounting for 4.6% of the total number of Chinese overseas firms. These 1012 agricultural enterprises were funded by 594 domestic investors. Of the total number of firms, companies with limited liability accounted for 62.5%, state-owned enterprises for 9.1% and private-owned enterprises accounted for 8.3% (Ministry of Commerce, 2012). By the end of 2017, there were 1769 agricultural enterprises among China's companies abroad, representing 4.5% of the total number of China's overseas enterprises. There are 986 domestic investors committed to these overseas agricultural enterprises. Among all the domestic investors in China, limited liability companies occupied 41.4%, private enterprises 25.7%, and state-owned enterprises 5.6% (Ministry of Commerce, 2017). It can be inferred that the number of China's agricultural "going global" enterprises has been increasing, and the proportion of individual enterprises is growing.

On the other hand, the patterns of agricultural "going global" have been diversified and become more flexible because of the structural changes of the investors. As for the large scale state-owned agricultural enterprises, such as State Farm Agribusiness Group Corporation, China National Fisheries Corporation and Zhongmu Group, they all have played a major role in China's agricultural "going global" strategy. Their "going global" patterns are mainly based on foreign aid and technical cooperation. In recent years, with a rapid rise in foreign direct investment in agriculture, enterprises with agricultural "going global" have increasingly diversified, promoting a more flexible pattern of business. In addition to some large state-owned enterprises as well as agricultural research institutes, the strength of private enterprises has increased. Some non-agricultural corporations, such as ZTE Energy have also increasingly invested in foreign agriculture. Nowadays, the investment target of Chinese enterprises is mainly in grain, oilseed and plant oil and livestock product, which are the main components of Chinese agricultural imports. The typical investment cases are listed in Table 3.

Table 3. Typical cases of Chinese oversea agricultural investment

Company	Host country	Target
China Complete Engineering Corporation	Ukraine	Corn
COFCO	South America, Europe	Soybeans
Shandong Delisi Food Company	Australia	Beef
Shuanghui	US	Prok
Shanghai Pengxin	New Zealand	Dairy
Complant International	Jamaica	Sugar
ZTE Energy	Indonisia	Palm oil
Bright Foods	Italy	Olive oil

Data Source: Compiled from company's website and other news websites and opening documents.

2.4. Agricultural foreign aid based on technology demonstration plays a role in promoting agricultural "going global"

Agricultural foreign aid is an important means to promote the "going global" of Chinese agriculture, as China's aid funds have maintained rapid growth. In recent years, China has established agricultural cooperation committees and working groups with more than 50 countries and regions, the standardization, degree and efficiency of which have been significantly improved. Through the implementation of bilateral and regional food security cooperation strategies, agricultural technology demonstration, and personnel training systems have been improved. The five major technologies of hybrid cultivation, animal and plant protection, greenhouse horticulture, agricultural mechanization and rural energy have been promoted, effectively boosting local agriculture and rural economic development. Considering that the overall level of China's agricultural "going global" is still not high, the agricultural foreign aid projects not only plays an important role in promoting bilateral diplomatic relations, but also has a positive international influence, and has driven China's agricultural enterprises and agricultural technologies and equipments to "go global". Meanwhile, as support for the construction of agricultural infrastructure in overseas enterprises increases gradually, agricultural demonstration and investment cooperation have increasingly been organically combined, providing a role model for the development and exploitation of agricultural resources.

3. Brazil's position and role in global agricultural investment

In the past three decades, Brazil has been one of the countries in South America that attracts the most foreign direct investment, at an accelerating pace of growth. According to the United Nations Conference on Trade and Development, in 1990, Brazil absorbed foreign direct investment of US$ 990 million, accounting for only 19.6% of total foreign direct investments in South America. By 2017, this figure had risen to US$ 6.27 billion. Brazil's share of FDI in all of South America rose to 60.2% as the total foreign direct investment increased by 6242.3%, and the average annual FDI growth rate reached a level of 117.2%.

Brazil is predominantly located in the tropics, which bestows it with very favorable agricultural production conditions and natural resource endowments. It is worth noting that Brazil still has a considerable portion of undeveloped arable land. Brazil's uncultivated arable land is generally considered to be about 150 million hectares. This means that Brazil has huge potential for arable land development. In addition to planted crops, Brazil has abundant forests, pastures, and fishery resources. Although Brazil has tightened controls on foreign investments in Brazilian land since 2010, it has generally maintained an open attitude towards foreign capital investment in domestic agriculture.

Specifically, Brazil's foreign investment system is relatively mature, due to the country's early enactment of the Foreign Investment Law. To attract investment, the Brazilian government grants national treatment to foreign investors, and offers them a variety of preferential policies. If the products produced are exported to third countries, the government provides export credits and insurance. The Brazilian government also provides low-interest loans to foreign investors. In addition, to encourage the development of northern and northeastern Brazil, the Brazilian government and local governments have implemented tax breaks on foreign investment there. Brazil has enacted many laws and regulations on insurance, credit, and the quality of agricultural products, such as the Organic Agriculture Act, and the Pesticides Act. Brazil began implementing the new GM product labeling regulations on July 23, 2013, requiring GM products to be labeled. Brazil has also vigorously developed agricultural insurance. The government has adopted a series of policy measures that are compatible with agricultural insurance premium subsidies. Agricultural producers can select appropriate insurance items according to different years, production conditions, and crops. Brazil's agricultural openness is relatively high. At present, only the marine fishing industry in the agricultural sector is not open to the entry of foreign capital.

As a developing country, Brazil generally lacks agricultural capital and technology compared with developed countries, so Brazilian agriculture is an attractive investment target. This has attracted many multinational agricultural companies to invest in Brazilian agriculture. For example, Cargill, one of the world's four largest grain producers, invested R$ 520 million in the Brazilian market in 2018, for mergers and acquisitions, as well as factory facilities improvements.

Foreign capital plays an important role in Brazil's agricultural industry. Chinese scholars highly appreciate the Brazilian government's use of foreign capital to develop its agricultural resources, thereby enhancing its agribusiness' productivity and international competitiveness. It is generally believed that China can learn from Brazil's successful experience in benefitting from foreign investment in agriculture (Zhang, Zhai and Cao, 2013).

However, many Chinese are also of the opinion that foreign investment has had a somehow adverse impact on Brazilian agriculture. Firstly, since a considerable part of the agricultural land is controlled by foreign enterprises, and the export of agricultural products is incentivized, the agricultural production structure is relatively simple and causes great damage to biodiversity (Zhang, Zhai and Cao, 2013). Secondly, the value chain is subjected to control by foreign capital, and the host country's independent space for agricultural development is thereby restricted (Xu, 2011). Thirdly, the establishment of pesticides and fertilizer plants has caused serious pollution (Zhang, Zhai and Cao, 2013). Foreign direct investment in the agricultural sector has advantages and disadvantages for the development of Brazilian agriculture, but in general, it plays a positive role in promoting rural development. Brazil is expected to occupy an important position in global agricultural investment and to play a more important role in the future.

4. Analysis of agricultural investment between China and Brazil

According to the foreign investment briefing issued by the Brazilian Ministry of Economy, from 2003 to March 2019, China's total investment in Brazil reached US$ 71.3 billion, surpassing the United States' US$ 58.3 billion, and becoming the largest source of investment in Brazil (China becomes Brazil's largest source of investment, 2019). However, most of these projects focus on energy development, power supply, resources, and manufacturing, with relatively little investment in agriculture.

4.1. The current situation of Chinese agricultural investment in Brazil

The scale of investments and number of Chinese agricultural enterprises in Brazil are small. Chinese investments are concentrated in the industrial field. By contrast, Chinese companies have invested little in Brazilian agriculture. Secondly, the products and forms of Chinese enterprises' investment in Brazilian agriculture are relatively undiversified. Most enterprises focus on a few industries, such as soybeans (Lu, 2012). This is mainly determined by the trade structure of agricultural products between the two countries. More than 80% of this trade is concentrated in soybean and soybean oil. Therefore, the most common investment modality is that Chinese enterprises grow soybeans in Brazil, and ship them back to China, or build refineries in Brazil to transport soybean oil back to China. Finally, China's investment in Brazilian agriculture tends to overlook the latter's dominant industries. The concentrated bilateral trade structure between China and Brazil affects Chinese investment decisions, spurring interest mainly in investing in soybean, soybean oil, and other products, ignoring other advantages of Brazil's industries.

4.2. Prospects for agricultural investment between China and Brazil

China and Brazil have different endowments of agricultural resources, and the bilateral trade is highly complementary. They have the conditions and motivation to further expand agricultural investment. In the future, China will continue to import land intensive commodities from Brazil, and products such as beef, corn and feed additives may become new potential points for bilateral trade. Therefore, from the perspective of investment prospects, Brazil and China should strengthen agricultural cooperation. On the one hand, Chinese enterprises with investment needs should follow the direction of Brazilian agricultural policy adjustment, focusing on the industries that the Brazilian government supports financially. Brazilian needs should also be taken into consideration. For example, the Brazilian government especially welcomes foreign investment in agricultural infrastructure, and the promotion of the internationalization of public and private companies.

1. China and Brazil may consider establishing free trade zones or signing investment agreements to create convenient conditions for further expanding bilateral agricultural trade and investment. In terms of trade, Brazil can further promote its economic development through exports, while China can use Brazil's rich natural resources to support agricultural and industrial development. Due to the limitation of agricultural resources, the continuous promotion of industrialization and urbanization, as well as the improvement of people's living standards and consumption upgrading, China basically does not have a comparative advantage in the production of bulk agricultural products, while Brazil benefits from its natural resources, with a strong comparative advantage in cotton, tobacco, sugar, oil, vegetable oil and other bulk commodities. In terms of investment, Brazil can benefit from China's capital and technology to improve its weak links, such as fishery, biomass energy and agricultural infrastructure industry, while Chinese enterprises can improve their international competitiveness by "going abroad" (Ma and Tian, 2015). For example, Chinese enterprises can establish themselves in Brazil with the aims of building farms, and jointly developing new agricultural or export industries.
2. Chinese enterprises should explore the potential areas for agricultural investment and technical cooperation. Chinese capabilities complement Brazilian capacities in many ways. There is much room for investment and cooperation between the two sides. For example, Brazil has resource advantages in many fields such as fisheries, bamboo forests, and bamboo products, the silkworm industry, and fungus production, but it does not possess advanced production technology. In addition to this, low-carbon agriculture is a mode of production which has been strongly encouraged by Brazil in recent years. The low-carbon agriculture plan covers Brazil, with a total investment of about R$ 197 billion (about US$ 44.9 billion) and implementation time from 2010 to 2020. Brazil has made significant achievements in this respect, such as transforming a large number of poor and acid soils into fertile fields, planting original non-tropical plants in tropical areas, and implementing ecological planting methods. Strengthening bilateral cooperation in the above areas is not only conducive to deepening agricultural and energy cooperation between the two countries, but

also helps to effectively reduce China's energy pressure and building a resource-efficient and environmentally friendly society in China.

3. China and Brazil have broad prospects for investment and cooperation in the field of bioenergy. Brazil is the world's largest producer of ethanol from sugarcane, and the world's second largest producer of bioethanol. The Brazilian government is now raising the requirement for ethanol content in commercial gasoline from 20% to 25%. This means that ethanol demand is increasing by nearly 2 billion liters per year, significantly stimulating Brazil's demand for biofuel ethanol. In addition, Brazil's biofuel market is open and demands high levels of foreign investment. Brazil can induce Chinese investors to inject funds, which is a good opportunity for both sides. On the one hand, Brazil can use the funds of Chinese investors to cooperate in the research and development of the second generation ethanol project; on the other hand, China can learn from Brazil's experience and technology to develop the country's biomass fuel industry (Liu and Yuan, 2014).
4. Chinese enterprises should focus on strengthening investment in Brazilian agricultural infrastructure. Brazil's weak agricultural infrastructure and lack of investment are areas in which the government most welcomes foreign investment. The Brazilian government plans to attract R$ 56 billion (about $ 12.8 billion) in construction investment within five years, and to provide a range of preferential policies, such as lending at lower interest rates. This gives Chinese enterprises new investment opportunities, especially in the fields of agricultural and animal husbandry products, storage, and international transportation, such as canals, highways, airports, wharfs, and ports.

5. Conclusion

From the beginning of the 1950s to the present, China's agricultural "going global" strategy can be roughly divided into three periods; the period from 1950s to 1970s, which was dominated by foreign aid; the period from 1980s to 2001, when China's agricultural investments were developed from unilateral assistance to multiple forms of mutually beneficial cooperation; and the period from 2001 to the present, when agricultural investments reached a new stage. Considering the current situation of China's agricultural "going global", it becomes evident that agricultural investments tend toward diversification. The amount of agricultural foreign investment has increased year by year, and the Chinese agricultural internationalization is expanding more than ever before, displaying increasingly flexible investment patterns. Brazil possesses extensive land and natural resources, but is held back by a lack of capital and technology. This has attracted investments in Brazilian agriculture by a host of multinational agricultural companies, implying both advantages and disadvantages for the development of Brazil's agriculture. The investment scale and the number of Chinese enterprises within the field of agriculture is small, and their investments are undiversified. In the future there may be more room for investment and cooperation between China and Brazil.

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Chapter 8

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Thiago Guilherme Péra

Transport infrastructure: opportunities for a close partnership with China

1. Introduction

Transportation infrastructure can determine the competitive success of agricultural enterprises or even the entire agricultural sector. The Brazilian Government has proposed investment in large projects to improve the transportation infrastructure of the country's Center-West and North regions. These projects aim to develop the commodity delivery system in both regions, which should stimulate the expansion of soybean cultivation into northern areas. The highway freight market is not under government control, meaning that freight prices are formed through free negotiation determined by supply and demand for the transport service. Carriers have to stay up-to-date on shipping cost variables to negotiate efficiently with shippers. These have the negotiation power to exert strong pressure on carriers to obtain freight transport discounts (except under very specific circumstances). The current deregulated railway system shows potential, especially for the shipment of grains. Transportation using waterway systems, considered to be the most economical one for bulk volumes, has generated high expectations due to projects such as the Madeira and the Tapajós waterway systems. It is hoped that these waterway systems – together with the advance of coast traffic operations ("cabotage") – will efficiently reduce the transportation costs for grains produced in Brazil's Center-West region. The ports of Santos and Paranaguá are still the preferred embarkation points, but the ports of Itaqui, Barcarena, Vitória, Ilhéus, Sao Francisco do Sul, and Rio Grande (among others) can be considered very good alternatives. The present and future Brazilian transportation system, in particular, the location of and access to efficient transportation corridors, has been a crucial variable in the determination of processing plant location by private investors. Investments of this sort can bring opportunities for a close partnership with China, a country which has achieved steady economic growth in part through investment in logistic infrastructure.

In order to consolidate cooperation in infrastructure and investments by both countries, regional transportation indicators will be described in this chapter, focusing on the movements of agricultural cargoes. The magnitude of such indicators means that they are involved in a multitude of different areas, which may include:

- rationalization in the planning and operation of physical, information and management systems;
- the necessary investments, which will be defined according to volumes transported, stored and shipped;
- the mass expansion of the use of applied mathematical models – seeking to increase logistic efficiency;
- increase in the quality of the existing transportation system (highways, railways, waterways, pipelines, and airways);
- improving the conditions of the roads connecting farms to the warehouses;
- implementation of definitive (and not merely palliative) solutions for the adequate maintenance of roads;
- implementation of measures to consolidate the modernization of seaports and increase their capacity and efficiency;
- implementation of strategies to optimize the logistics of arrival and departure of products;
- clear definition of the role to be exerted by a transport coordinating agent;
- definition and implementation of "legal and/or regulatory frameworks" for Public-Private Partnerships (PPP), based on concentrated efforts

in the two houses of the Brazilian National Congress, ideally with the support of the Executive Branch of government;

- availability of specific resources so that the Brazilian states effectively increase their logistics for the proper movement of agricultural cargoes, during an initial period of ten years;
- definition and application of key logistics indicators, which should serve both as a measure of the efficiency of logistics systems and as a parameter for the allocation of new resources in investments.

2. Brazil and China logistic indicators

Brazilian agribusiness has increased production in recent years due to greater productivity, planted area and number of crops, among other factors. About 2 billion tons are produced and handled annually involving inputs, agricultural and livestock products, as well as processing, demanding a very integrated and synergistic logistics system to reach the final consumers with quality and competitiveness. Since the 1970s, the country has gradually expanded agricultural production into remote regions, but these areas do not have a sufficient road network to meet the growing transport demand for production flow. That is, production development takes place before transportation infrastructure development. The Brazilian Ministry of Livestock, Agriculture and Supply estimates that for the coming years agricultural production will increase by around 25%, placing still more pressure on the Brazilian logistics system, including highways, railways, pipelines, rail terminals, port terminals, warehouses, and distribution centers.

Brazil has a modal share that is highly dependent on the road mode for cargo handling, especially involving long distances. Officially, the freight transportation matrix in Brazil has a dependence on road mode in the order of 61.1%, 20.7% for rail, 13.6% waterway, 4.2% pipelines, and 0.4% by air (Brazilian National Transportation Confederation – CNT, 2019).

Table 1 presents the comparison of the main logistics infrastructure indicators for China and Brazil.

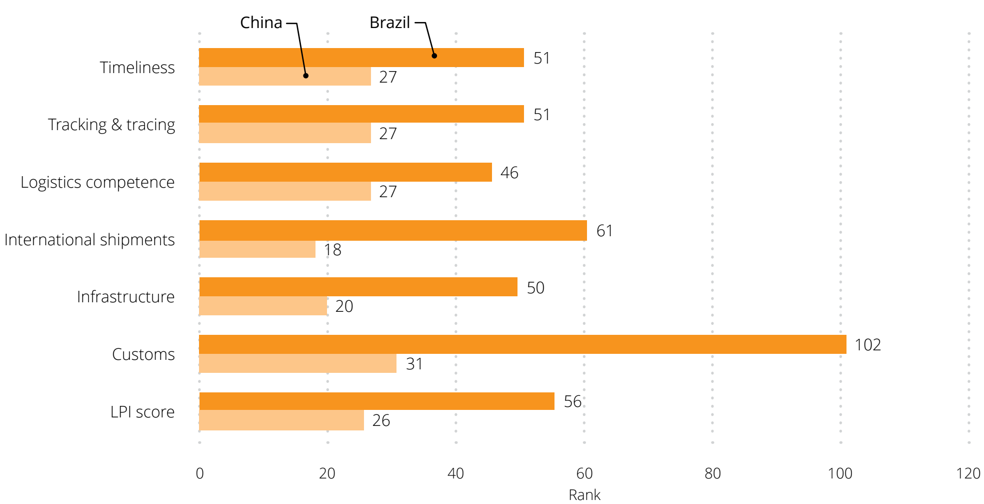
The World Bank calculates what has been known as LPI, a Logistic Performance Index. Figure 1 presents a comparison between the two countries. China ranks 26th while Brazil ranks 56th, among all countries

Table 1. Transport infrastructure indicators

	Indicators	Unit	China	Brazil
Length	Length of railway in operations	km	127,000	30,485
	Length of highways	km	4,773,500	213,208
	Length of navigable waterways	km	127,000	19,464
Density	Railway density	km/1,000 km²	13.23	3.59
	Highway density	km/1,000 km²	497.24	25.08
	Waterway density	km/1,000 km²	13.23	2.29
Mode share (freight transportation)	Railways	%	13.7%	20.7%
	Highways	%	33.8%	61.1%
	Waterways	%	50.0%	13.6%
	Air	%	0.1%	4.0%
	Pipelines	%	2.4%	4.2%
Number of Trucks		1,000 units	14,784.0	2,766.1

Source: CNT (2019) and the National Bureau of Statistics of China (2018).

Figure 1. LPI and sub-indicators between Brazil and China

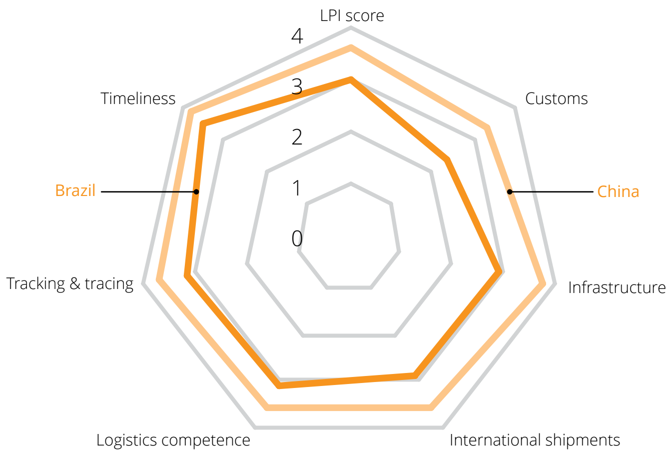


Source: The World Bank (2018).

evaluated. In terms of sub-indicators[1], China surpasses Brazil in all of them, involving: timeliness, tracking & tracing, logistics competence, international shipments, infrastructure, and costs.

Figure 2 shows the score between China and Brazil using the World Bank to gauge the logistical competitiveness of countries.

Figure 2. Score by each LPI sub-indicator between China and Brazil



Source: The World Bank (2018).

The biggest difference between Brazil and China extends beyond the Customs sub-indicator. Improvement of the Brazilian logistics system does not only depend on investments in infrastructure and logistics, but primarily on improvements in the existing bureaucracy. These must extend far beyond the "Custom" indicator. For example, the transportation of cargo by road requires a complex set of documentation.

[1] According to World Bank definition:
Customs: efficiency of the customs clearance process;
Infrastructure: quality of trade and transport-related infrastructure;
International Shipments: ease of arranging competitively priced shipments;
Logistics Quality: competence and quality of logistics services;
Tracking & Tracing: ability to track and trace consignments; and,
Timeliness: frequency with which shipments reach the consignee within the scheduled or expected time.

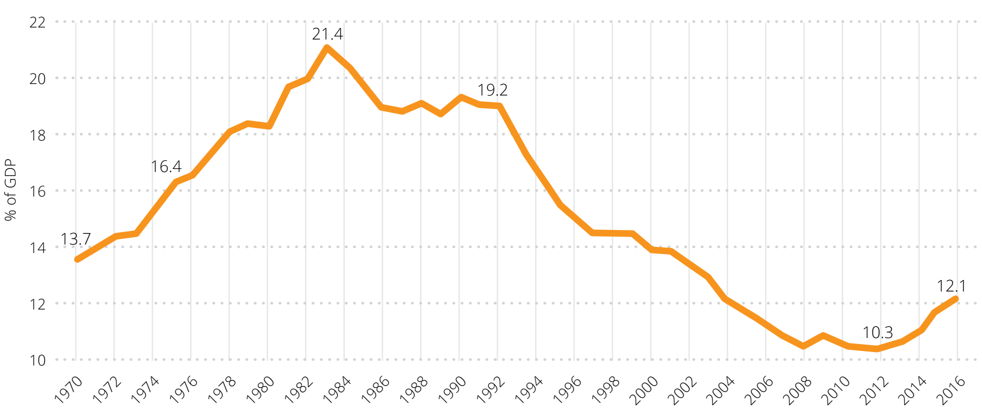
This discussion of bureaucracy extends to another important concept called "Brazil Cost", which reflects the set of structural, bureaucratic and economic difficulties that make companies more expensive and compromise investments. In 2019, the Brazilian Government announced that "Brazil Cost" consumes around US$ 375 billion per year – equivalent to 22% of the national GDP (Brazilian Ministry of Economy, 2019).

3. Historical overview of transportation in Brazil

Historically, Brazil has had a significant dependence on road transport for cargo handling, due mainly to the strong investments made in the past to create a vector for regional integration.

Figure 3 shows the capital stock of transport infrastructure[2] in Brazil as a parcel of GDP. There was a strong expansion of the stock in the 1970s, stability in the 1980s, and a continuous retraction until the year of 2013.

Figure 3. Capital stock in Brazil transport infrastructure



Source: Frischtak and Mourão (2017).

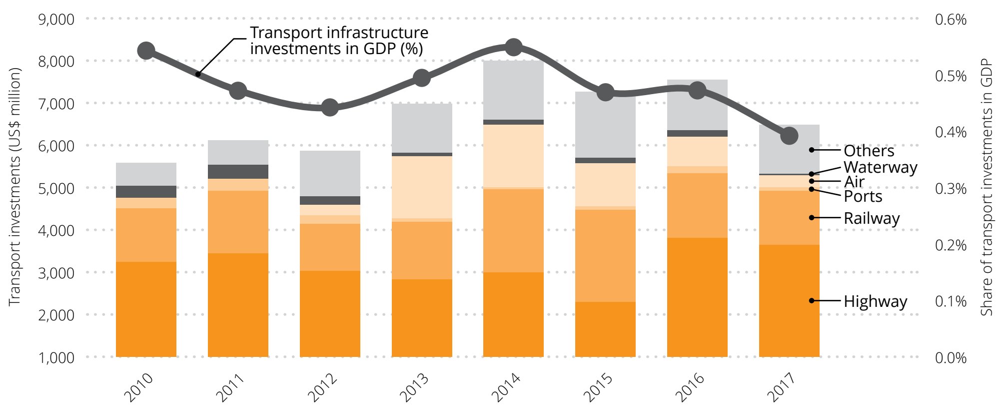
[2] Frischtak and Mourão estimated the capital stock in transportation infrastructure in Brazil as being:
$S_t = S_o (1 - d)^t + \sum I_i (1 - d)^{t-i}$ where:
S_t: is the infrastructure stock in period t
d: is the depreciation rate in effect in the period
I_t: is the investment made in the period t
t: is the year of reference

After 2013, the increase in the capital stock was not the result of an increase in investment, but much more related to a reduction in the Brazilian GDP (Frischtak and Mourão, 2017).

The 1970s period in Brazil was marked by the Brazilian economic "miracle", with strong investments in infrastructure. In the 1980s, the country experienced a severe crisis, with high levels of inflation and increased debt. Also, at the end of the 1980s, the country went through the process of re-democratization, with a new change in government, which enabled the country's economic opening in the 1990s. The peak of investments in transport infrastructure occurred in the 1980s, reaching average levels of 2.36% of GDP (Frischtak and Mourão, 2017).

Federal and private-public investments in the country in a most recent period (2010/2017) presented high levels for the year 2014. More specifically in 2017, the level of investment in transport infrastructure was 0.4% of GDP, as presented in Figure 4. The data shows that we need to significantly increase investments in infrastructure and generate more infrastructure capital for the country, providing economic and social development.

Figure 4. Federal and private public investments in Brazilian transport infrastructure



Sources: Based on Ministry of Infrastructure (2018) and IBGE (2019).

The development of the Brazilian railway system began in 1847, with the first 14.5 km of railways in the region of Rio de Janeiro. At the end of the

Brazil Empire period in 1889, the railway system was 9,228 kilometers long. In the state of Sao Paulo, the main railway axes were financed and built by coffee farmers, aiming to gain competitiveness in exports. In 1954, the 37,190 km railway system was consolidated under state management through state-owned companies, creating the “Rede Ferroviária Federal Sociedade Anônima” (RFFSA), unifying the 18 railroads. In 1971, the Government of the state of Sao Paulo unified its railroads, creating “Ferrovia Paulista S.A.” (Fepasa), reaching the peak extension of the railway network, on the order of 38,200 kilometers (IBGE, 1990). From the 1990s onwards, the Brazilian Government began the process of privatizing Brazilian railways through Law No. 8031/1990, (which opened opportunities for concessions), segregating railway companies into railway networks.

The 1990s in Brazil were marked by a significant economic opening, associated with wide privatization in different sectors, mostly involving the logistics infrastructure. In this process of concession of railroads, the National Land Transportation Agency (ANTT) was created in 2001 to regulate and to inspect railroad and road concessions.

The concessions of the Brazilian public railway networks improved logistics. There was a 125% increase in transported volume, a productivity gain of around 19% in terms of tons per useful kilometer movement, an increase in private investments in the concession network, growth of railway rolling stock on the order of 159%, a reduction of the accident rate of approximately 86%, all of these according to information from the National Association of Railway Transporters – ANTF (2018).

With the privatization process, approximately one-third of the railway network is operated commercially (approximately 10,000 kilometers), while the remainder has deteriorated due to lack of interest by the concessionaires in operating in function either of the low demand or the high investment for restructuring.

The predominant railway concession model in Brazil is the vertical one, that is, the concessionaire company is responsible for the service of rail freight transportation, for the investment and expansion of the railroad infrastructure, as well as for the rail transport operations. In other words, the railway company is responsible for both infrastructure management and service provision.

In a recent railroad concession process (2019), involving the North-South Railroad stretch between Palmas and Estrela D’Oeste, the auction took place for the economic proposal, defining metrics for verifying the quality of the railway service provision: 1. Serious Railway Accidents Index; 2. Average travel speed, and 3. Average Age of the Locomotive Fleet.

However, several challenges in the railway sector have yet to be overcome. The oligopoly structure often does not generate an economic gain for the shipper. Sometimes the rail freight charged by the railway concessionaires is priced as a discount on the corresponding road route freight. Due to the lack of a competitive structure and the high pent-up demand for railroads in the country, railway concessionaires have a greater power of discrimination against users, preferring customers who operate with high volume in a medium and long time horizon, making its access difficult for small and medium-sized shippers.

Railroad investments in the country can be advantageous. There is high pent-up demand for rail transport in the country since there is already productive and economic development in many regions, mainly in the agribusiness segment. As was pointed out earlier, the development of production systems started before the logistics infrastructure (see the example in new Brazilian agricultural frontier involving the states of Maranhao, Piauí, Tocantins, and Bahia). A very interesting opportunity for the railway sector is the movement of general cargo and containers, which is still relatively low in Brazil when compared to other countries. However, the railway companies still need to improve reliability, in terms of length of time and safety, as well as to reduce the prices of freight to further extend their market reach. Also, the terms of contracts concluded in the 1990s end between 2025 and 2030 (there are still no guarantees to anticipate renewals).

In any case, a very important attribute to attract foreign capital for investment in railway infrastructure in the country involves better regulation of the so-called tracking rights and mutual traffic. The tracking right is an operation in which a railway concessionaire allows another to travel on its network to complement a cargo transport service, while mutual traffic is the operation in which a concessionaire uses the network of another on the rail transport, sharing resources with each other.

Other risks posed by Pompermayer, Campos Neto, and Souza (2012) in rail investments by the private sector involve:

- Despite the rules of the railway concession obliging the provision of the transport service to all users by paying an appropriate tariff, without discrimination, the potential investors in the new lines fear the dependence on access to the network already granted, under unfavorable negotiation conditions;

- Investors in new railroads fear the dependence on access to the network already connected in unfavorable trading conditions, despite the concession rules obliging the provision of service to all users;
- Part of the existing lines that can be used by loads of the new railways do not have high idle capacity, resulting in risk.

The railway sector in Brazil is very concentrated. In 2019, Brazil submitted eleven railway concessions, described in Table 2.

Table 2. Railway companies in Brazil

Railway company	Railway extension (km)	% of the brazilian railway network
Estrada de Ferro Paraná Oeste S.A.	248	0.7%
Ferrovia Centro-Atlântica S.A.	7,223	21.7%
Ferrovia Norte Sul (FNSTN e FNSTC) - Valec S.A	1,638	4.9%
Ferrovia Tereza Cristina S.A.	163	0.5%
Ferrovia Transnordestina Logística S.A.	4,295	12.9%
MRS Logística S.A.	1,686	5.1%
Rumo Malha Central S.A.	1,537	4.6%
Rumo Malha Norte S.A.	5,228	15.7%
Rumo Malha Oeste S.A.	1,973	5.9%
Rumo Malha Paulista S.A.	2,055	6.2%
Rumo Malha Sul S.A.	7,230	21.7%

Source: ANTT (2020).

As in the railway sector, the road sector at the end of the 19th century underwent a process of deterioration in the network, due to the low investment capacity of the Brazilian Government to guarantee the replacement of the depreciated infrastructure. In this context, the government chose to follow the road infrastructure concession process.

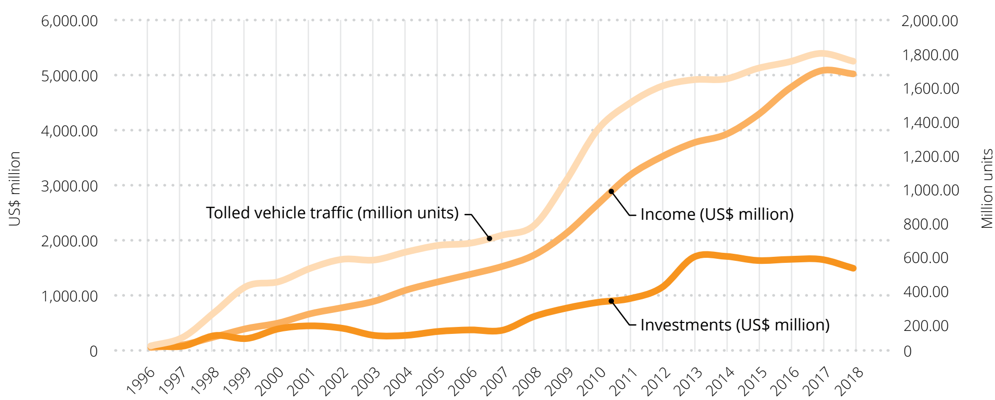
According to Campos Neto, Moreira, and Motta (2018), typical road concession contracts in the country involve the specification of the concessioned road sections, the investments required and the schedule, location, and toll plazas, performance target metrics operating and concession terms. Normally, the company that has the lowest toll rate wins the concession; usually, the government sets the ceiling toll rate. The concessionaire's remuneration is the toll collection. Also, the contract provides for an economic-financial rebalancing mechanism to maintain the rate of return during the concession contract.

More specifically, the main risks involving road concessions involve changes in the macroeconomic scenario, government disruptions, environmental licenses for investments in construction, and changes in the traffic profile on the roads planned in the concession model.

The growth potential of the sector is significant, since part of the Brazilian highways run below capacity, and the country had a fleet of light vehicles, trucks and buses of 45 million units in 2018 (Sindipeças/Abipeças, 2019).

Brazil has 37 highway concessions, totaling 15 thousand concession kilometers, with investments of US$ 1.5 billion made in the last years and total revenue on the order of US$ 5 billion, with an additional of 1.6 billion vehicles (light vehicles, trucks, and motorcycles) being operated in 2018, with an average toll amount of US$ 2.83 per vehicle (ABCR, 2019). See Figure 5 for more details.

Figure 5. Revenue and investments from road concessions in Brazil and number of toll-paying vehicles



Source: ABCR (2019).

The road freight transport sector in the country has changed the regulatory and legislative scenario, especially in the last decade. In 2007, Law No. 11,442/2007 was established, which provides for the Road Freight Transport carried out on public roads in the national territory on behalf of third parties and for remuneration, the mechanisms of its operation and the responsibilities of the transporter. Subsequently, a series of resolutions were published involving the anticipation of the toll (ANTT Resolution number 2,885/08), the electronic freight payment and the transport operation identification code – CIOT (ANTT Resolution number 3,658/11). In 2012, a new Law was established (12,619/12) that regulated professional truck drivers, mainly in terms of working hours.

In 2015, the country experienced a major strike of drivers who demanded a relaxation in Law number 12,619/2012 on working hours and improvement in diesel oil price levels. The direct and indirect consequences of this stoppage were: establishment of a new Law (13,103/2015), which provides for the exercise of the profession of drivers, making Law number 12,619/2012 more flexible and establishing a single value for all loads and conditions of stay; structuring of the Law Project (PL 528/2015), aiming to create a minimum price policy for road cargo transportation.

In 2017, Petrobras (semi-public Brazilian corporation in the petroleum industry) changed the fuel pricing policy in Brazil, increasing the frequency of adjustments and trying to seek greater proximity to prices charged with the international rates. In May 2018, the truckers' strike in Brazil peaked with a stoppage of autonomous truckers throughout the country. As a consequence, the Federal Government created Law No. 13.703/2019 which institutes the national policy for a minimum price for road freight transport. In this context, all road freight transport in Brazil is subject to a minimum price that covers the truck's operating costs (the Brazilian Supreme Federal Court plans to judge the constitutionality of this law in 2020).

4. The context of logistics in Brazilian agribusiness

Brazilian agribusiness involves the entire supply chain, from fertilizers, agricultural production, and final products (food and feed), moves more than one billion tons annually, demanding a very high level of logistics, especially transportation. The expectation of an increase in production for the next ten years is on the order of an increase of almost a quarter in the Brazilian agricultural system, putting further pressure on the Brazilian logistics system. In 2019, Brazilian agribusiness generated more than US$ 50 billion in logistics services, including transportation and storage.

The great flagship of the Brazil-China relationship in Brazilian agribusiness is soybean, which moves a very robust and complex logistics, involving practically all the available infrastructure in the country. Figure 6 shows the soybean handling network for exports to China.

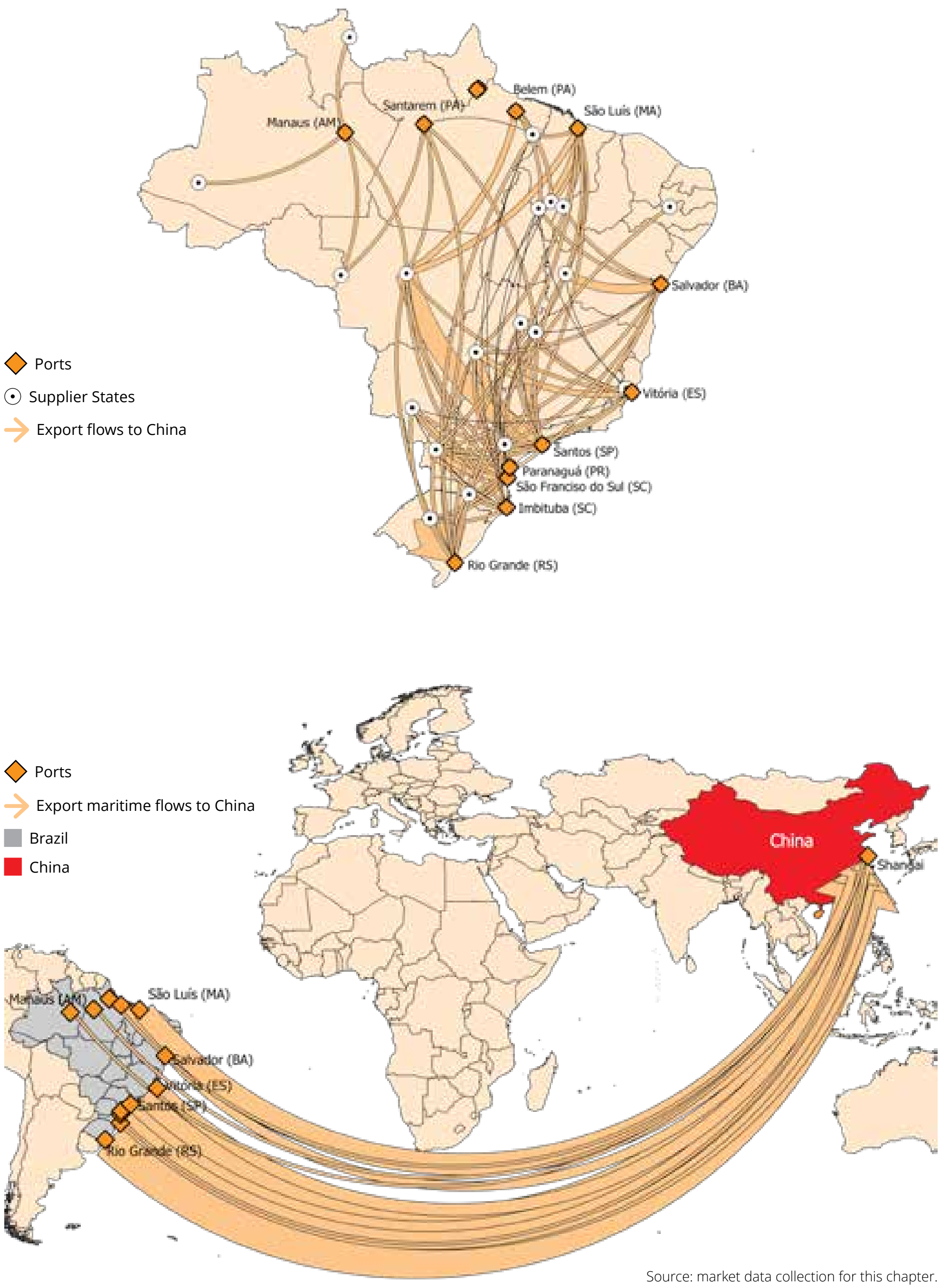
Figure 7 shows the configuration of the Brazilian soybean supply chain to China in 2019. The largest soybean supply states to China are Mato Grosso, Rio Grande do Sul and Paraná, the largest soybean-producing states in the world. Brazil. The largest export ports are Rio Grande (RS), Santos (SP), Paranaguá (PR), and São Luís (MA).

The so-called Brazilian Northern Arc has been highlighted, involving a system of highways, waterways, and ports covering the region of the North ports (Itacoatiara/Manaus, Santarem and Barcarena/Belem) and the Northeast region (São Luís and Salvador). Specifically, there is a waterway integration of the Tapajós river from Itaituba (PA) to Santarem (PA) or Barcarena (PA), which passes through the Amazon river; as well as a waterway integration of the Madeira River from Porto Velho (RO) to Itacoatiara/Manaus (AM), Santarem (PA) or Barcarena/Belem (PA), which also passes through the Amazon River. Also, the share of grain exports through the ports of the Northern Arc increased from 15.1% in 2010 to more than 30% in 2019. Figure 8 shows the main export corridors for Brazilian soy, involving the main available infrastructure.

Brazil has significantly increased soybean production in recent years, mainly due to increased productivity and also because of the expansion in agricultural frontier areas. In 2018, for example, production was 119 MTT, with total exports of 83.2 MMT. China accounts for almost 70% of Brazilian exports, importing 57.4% of Brazilian production. Figure 9 shows the evolution of production, exports to China and other countries and the average distance travelled by Brazilian soybean exports.

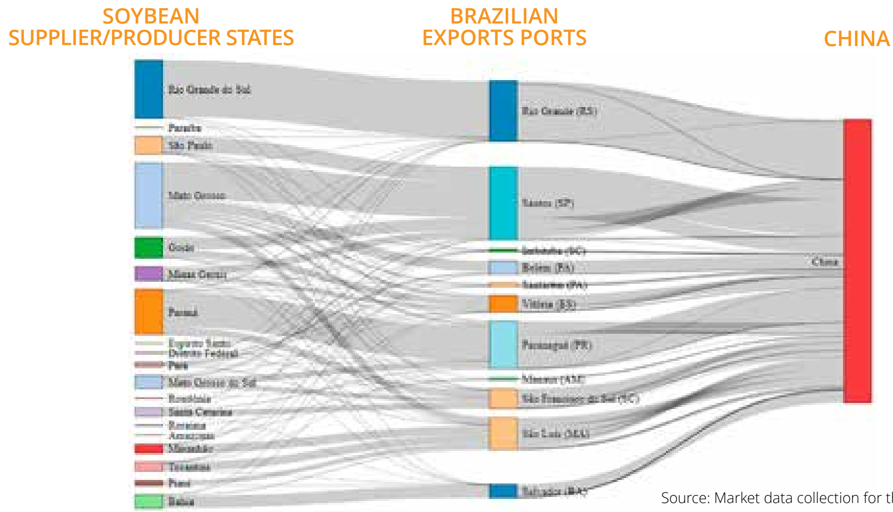
In the last ten years (the period from 2010 to 2019), soybean production increased by 67.5%, exports to China increased by 204%, and Brazil's average export radius of soybean increased by 31.7%, as shown in Figure 6.

Figure 6. Logistics network for supplying Brazilian soybean from Brazil to China



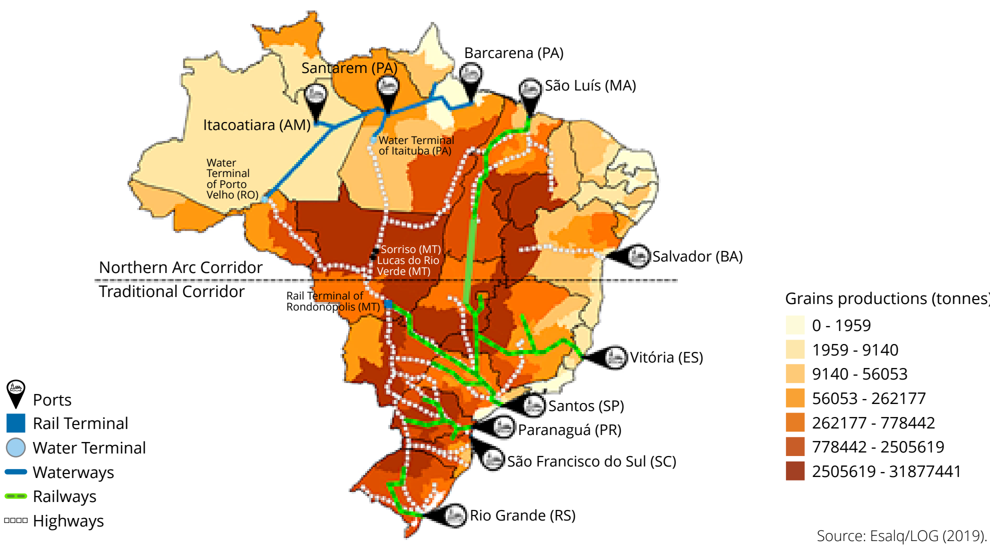
Source: market data collection for this chapter.

Figure 7. Brazilian network soybean supply chain to China



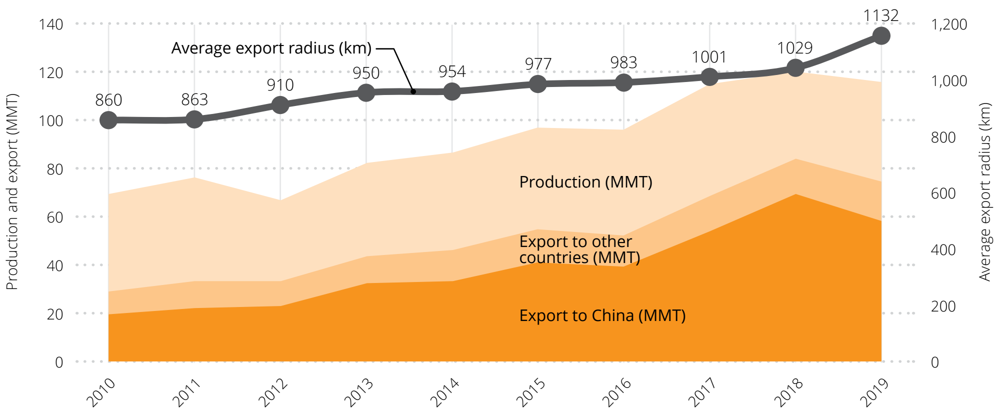
Source: Market data collection for this chapter.

Figure 8. Main transport infrastructure for soybean exportation



Source: Esalq/LOG (2019).

Figure 9. Evolution of production, exports to China and other countries and the average distance travelled by Brazilian soybean exports



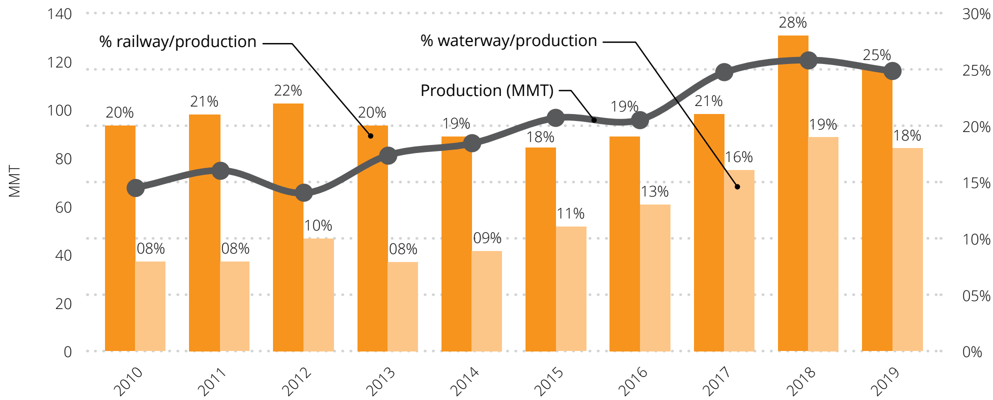
Sources: Based on Conab (2019) and Secex (2019).

In other words, Brazil increased the production of soybeans as a result of the increase mainly of Chinese consumption, moving into increasingly distant regions by road.

Figure 10 shows the evolution of soybean production in the last ten years and the movements of soybean on railways and waterways. It is interesting to note that to diversify the transport matrix, the growth in infrastructure is expected to be higher than the growth in production, in relative terms. In the case of railways, this was true for the 2017 railroad movement. In waterway transport, the growth was quite relevant, more than doubling in the period analyzed, mainly due to the strong waterway and port investments in the northern region of the country. Also, in Brazil, when rail or waterway is used, multimodal transport predominates, that is, there is still a dependence on road transport from the origin to the rail or waterway terminal to make the change of mode. As the country has a low density for both rail and waterway, the road distance to make the transfer is relatively high, up to 1,000 km in some situations.

In terms of volume, there is a very strong predominance of road transport, over long distances – more than a thousand kilometers on average to export to China. And what is the impact of that?

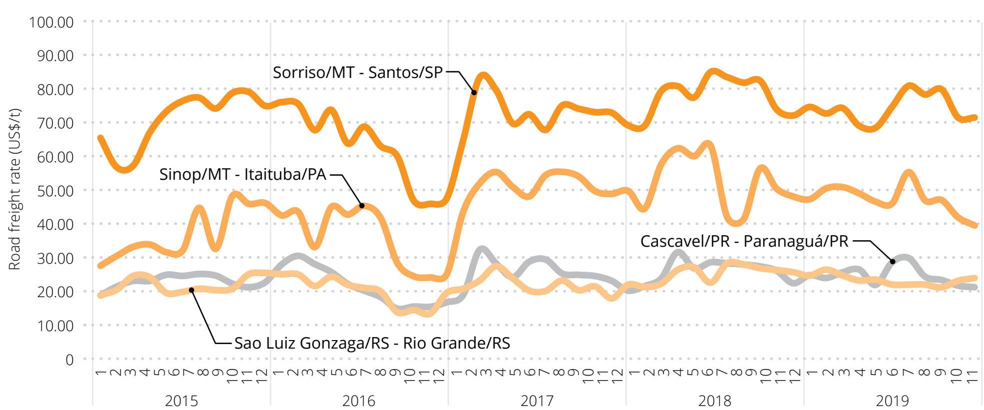
Figure 10. Evolution of soybean production and the proportions between rail and waterway movements about production



Sources: Based on Antaq (2019), ANTT (2019) and Conab (2019).

The high dependence on road transport, associated with a highly competitive freight market, has significant consequences for freight prices. Figure 11 shows road freight prices for the main soybean export routes in Brazil (it is interesting to note the high volatility of the freight price).

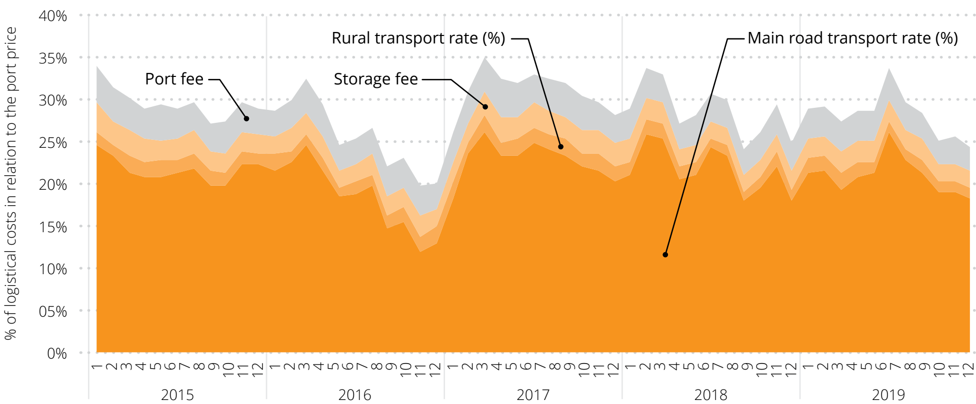
Figure 11. Historical series of soybean export road prices in different Brazilian corridors



Source: Esalq/LOG (2020).

Figure 12 shows the share of each component of the logistical cost of exporting Brazilian soybean on the price of soybean in the port of an important logistical corridor involving Sorriso (MT) to the port of Paranaguá (PR), in the period from 2015 to 2019. The variations that occurred from such impacts were from 15% to 35%. In the 2019 average, for example, the rural producer was discounted by 22% in the main road transport, 1.3% in rural transport between farm and warehouse, 2.6% in the storage fee and 3.5% in the port fee, totaling a logistical discount of 29.4% of the port price.

Figure 12. Participation of logistics costs in the price of soybean at the port of Paranaguá originating in Sorriso/MT region

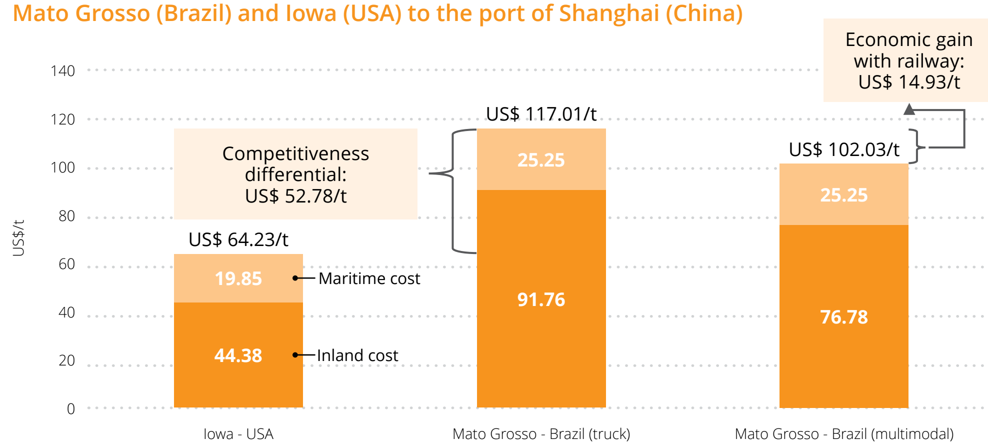


Sources: Esalq/LOG (2020) and Cepea (2020).

Cost comparison of Brazilian soybean export logistics compared to another important player in the sector, the USA?

As shown in Figure 13 – in 2018 – the cost of transporting soybeans to supply China at the port of Shanghai, from the main Brazilian producing state – Mato Grosso – by road was US$ 117 per ton. US soybeans originated from the state of Iowa to supply Shanghai cost 82% less. In this specific situation, the North American producer in Iowa presented a competitive differential on the order of US$ 52.78 per ton, with almost 90% of the difference resulting from the cost of internal handling (and the rest of maritime transport). Comparing specifically the multimodal movement (integration between highway and railroad) from the state of Mato Grosso to Shanghai with the movement of the same route, the economic gain with the railway option is US$ 14.93 per ton, illustrating the importance of the railroad. So, this can be understood as an opportunity cost of the lack of railway infrastructure in Mato Grosso.

Figure 13. Comparison of the logistical costs of exporting soybean from Mato Grosso (Brazil) and Iowa (USA) to the port of Shanghai (China)



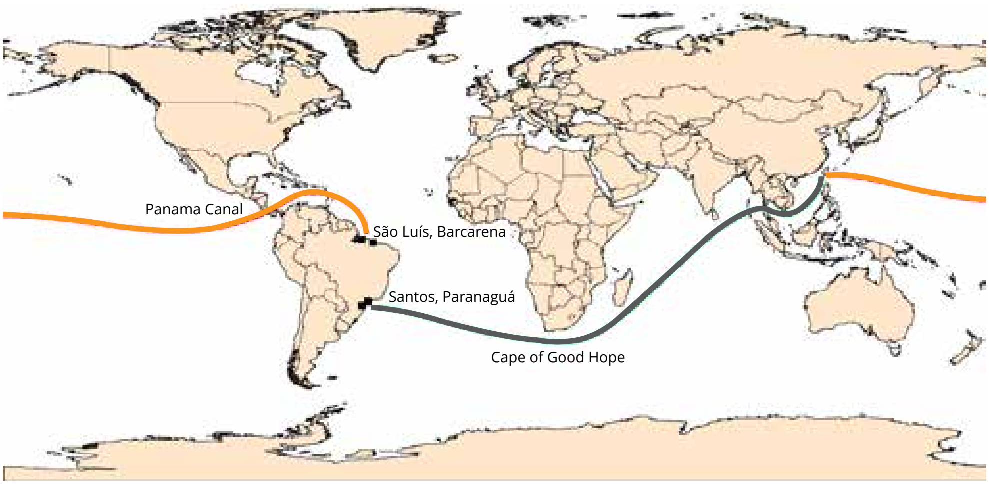
Sources: Esalq/LOG (2019) and USDA (2019).

In 2016, the USA exported 39% of soybeans on railroads, 48% on waterways, and 13% on highways (USDA, 2019). Brazil exported, in the same period, 34% by rail, 24% by waterway and 42% by road (Esalq/LOG, 2020).

There is great concern in Brazilian agri-business logistics with the post-harvest losses of agricultural products and losses/waste of food in the supply chains. Logistics has an important role in stabilizing what was produced along the entire chain until reaching the consumer. In this context, a series of new technologies associated with industry 4.0, big data, and digital twins can be applied to seek solutions that strengthen food security. In a recent study we have conducted, losses in soybean and corn logistics in Brazil in 2015 reached the level of 2.3 million tons, generating an economic loss of US$ 650 million and externalizing emissions of 39 thousand tons of CO_2 in the transportation system.

What is more worthwhile in maritime logistics from Brazil to China: The Cape of Good Hope (South Africa) or the Panama Canal?

Figure 14. Possibilities of maritime routes for supplying Brazilian soybean to China



Source: Authors.

The choice of maritime logistics is important to increase the productivity of maritime transport and to reduce the logistical costs of supplying soybean to China. Here are two possibilities of sea routes to Shanghai from Brazilian ports: using the Panama Canal or passing through the Cape of Good Hope (South Africa).

Table 3 shows the comparisons of distance and maritime costs using both possibilities. In terms of distance and sea freight, it is advantageous for the ports in the northern region of the country (Barcarena and Manaus) to sail through the Panama Canal, due to the greater proximity. However, this comparative advantage is lost due to the high toll for using the Panama Canal. Improvements in such routes may strengthen the Brazil-China trade by reducing logistical costs.

A sea trip from Santos to Shangai through the Cape of Good Hope takes around 30 to 40 days, depending on the speed of the vessel.

One of the major logistical bottlenecks in the Brazilian soybean supply chain to China concerns maritime logistics, especially the sizes of Brazilian vessels.

Due to the low depth of the channels and berths of Brazilian terminals and ports, the soybean ships in the country are still considered medium-sized,

Table 3. Distance and costs of maritime routes from Brazil to China

Origin port	Distances (km)		Maritime freight (US$/t)		Panama Toll (US$/t)
	Panama Canal	Cape of Good Hope	Panama Canal	Cape of Good Hope	
Santos (SP)	24,156	20,476	26.98	24.54	3.10
São Luís (MA)	21,683	20,533	25.39	24.58	3.10
Barcarena (PA)	20,337	22,409	24.44	25.87	3.10
Manaus (AM)	21,468	23,854	25.24	26.79	3.10

Source: Esalq/LOG (2018).

usually Panamax type vessels, with an average capacity of around sixty thousand tons per voyage. Table 4 shows the depth of Brazilian soybean vessels and the size of the vessel.

Table 4. Soybean average ship size and ship draft in main Brazilian ports

Port	Average ship size (dwt)	Ship draft (meters)	
		Max	Min
Santos	66,389.49	14.5	1.1
Paranaguá	59,080.43	12.5	2.6
Rio Grande	62,489.42	13.0	2.6
Vitória	36,415.70	12.0	3.8
Itaqui	59,881.95	14.5	2.6
Santarem	54,706.00	12.8	3.1
Belem	47,969.94	13.0	4.0
Itacoatiara	54,847.67	11.5	4.6
Sao Francisco do Sul	57,095.48	13.0	3.8
Average Brazil	**55,430.67**	**12.98**	**3.12**

Source: Antaq (2019).

According to Péra et al., (2019), improvements in the redesign of the Brazilian logistics network for supplying soybean in China – involving railways, waterways, and ports in Brazil – may bring economic gains of up to US$ 6.54 per ton (15% reduction in logistics costs) and a reduction of 43.07 kg of CO_2 per ton transported (32% reduction). In this context, the optimal investment recommendation is the expansion of rail terminals in the regions of Mato Grosso and Minas Gerais, expansion of ports, and strong investments for the use of Capesize-type ships through investments to increase the depth of terminals and channels.

5. Demand for infrastructure development in Brazil and Chinese investments

Investing in infrastructure includes improving existing structures as well as operating them. This section will discuss the risks related to investing in different types of infrastructure and present the major projects in Brazil. Table 5 shows the transport infrastructure and operations organization.

Table 5. Transport infrastructure and operations organization

Sector	Infrastructure	Operations	Operations concerning infrastructure
Roads	Roads, bridges, signaling/traffic control equipment	Freight/passenger road vehicles	Liberalized and separate from infrastructure management
Rail	Track, switches, bridges, signaling/traffic control equipment	Freight/passenger railway cars, locomotives, motor-rail cars	Diverse organization models (integrated liberalized, separate from infrastructure and liberalized, competition for the contract for passenger transport, integrated)
Air	Airport building, runways, parking lots, signaling/traffic control equipment	Air carriers/planes	Liberalized and separate from infrastructure management
Port	Pier substructure, breakwaters, basin etc.	Port superstructure: terminal operations (ship-to-shore cranes, straddle carriers, warehouse etc.) Shipping	Mostly separated (Farrel, 2012) competition for the contract Shipping is fully liberalized

Source: International Transport Forum (ITF) by Makovsek (2019).

In recent years, the largest share of private investment in transport infrastructure in Brazil has intensified due to the deceleration of investments by the public sector. In 2010, investments reached the level of R$ 30.1 billion, with public sector participation of 88%. Infrastructure investments peaked in 2014 (the year in which private investment surpassed public), at a total of R$ 46 billion. Specifically, in 2017, there was a large deceleration of investments due to the Brazilian economic crisis, which reduced infrastructure investments to approximately R$ 23 billion – even with greater participation of the private sector (53.6%), according to Brazilian Planning & Logistics Company (EPL, 2019).

Continuous, progressive, and long-term investments in infrastructure are necessary conditions to guarantee the country's economic development, and generate gains in competitiveness (Frischtak, 2008).

However, investments in Brazil are below the minimum needed (mainly due to government budget constraints) to progressively expand the country's highways, railways, and waterways. Specifically, for public expenditure control purposes, federal public accounts are subject to a spending cap, which makes it difficult for investments to rise above inflation in the country. In this scenario solutions for infrastructure growth in Brazil depend on private initiatives.

There are several private infrastructure investment mechanisms, including concessions, project investments, public-private partnerships, among other models.

Chinese investments made in Brazil during the period from 2007 to 2018 reached US$ 58 billion. In addition, there are US$ 44.5 billion that were committed in this period but not yet carried out, according to Brazil China Business Council (CEBC, 2019).

During this period, 31 investments/projects were made in addition to the existing 12. It is interesting to highlight that the main interest of Chinese investment projects in Brazil has been in the area of electricity, with 13 projects being carried out.

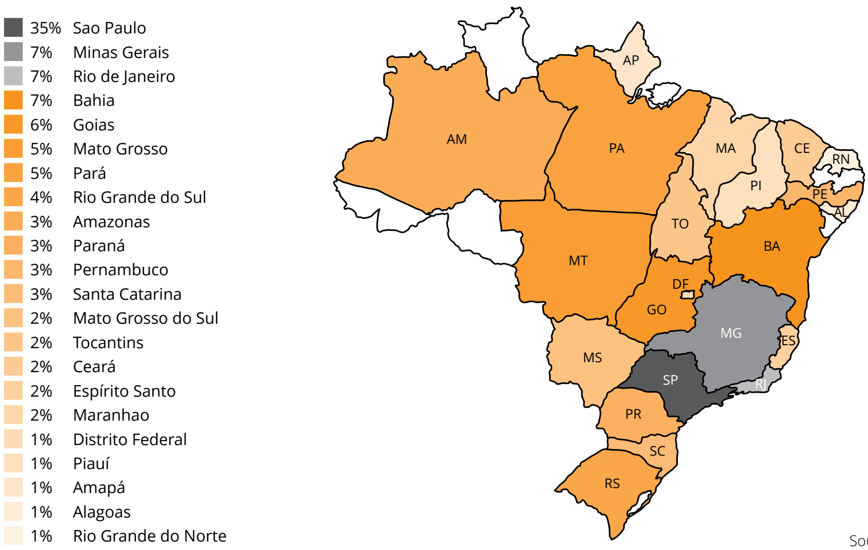
There were three Chinese investments in logistics made in Brazil in the same period, in addition to the announcement of two others, involving the following sub-areas:

- Warehousing and transportation ancillary activities (two projects confirmed and one announced);
- Ground Transportation (one project announced);
- Production and distribution of gaseous fuels by urban networks (one project announced).

The entry of Chinese capital into the country in 2007/2018 was predominantly through Greenfields (50% of the total number of projects). Mergers and acquisitions (36.5%) and joint ventures (13.5%) complement the remainder. Particularly in the logistics area, there has been a predominance of capital inflows via mergers and acquisitions (Ministry of Economy – Brazil, 2018).

Figure 15 shows the main states with Chinese investment contributions.

Figure 15. Brazilian states with the largest contributions of Chinese investments



Source: CEBC (2019).

6. Brazilian transport infrastructure projects

The Brazilian Ministry of Infrastructure has developed the Investment Partnerships Program (PPI) which includes a series of highway, rail, airport, and other concession projects.

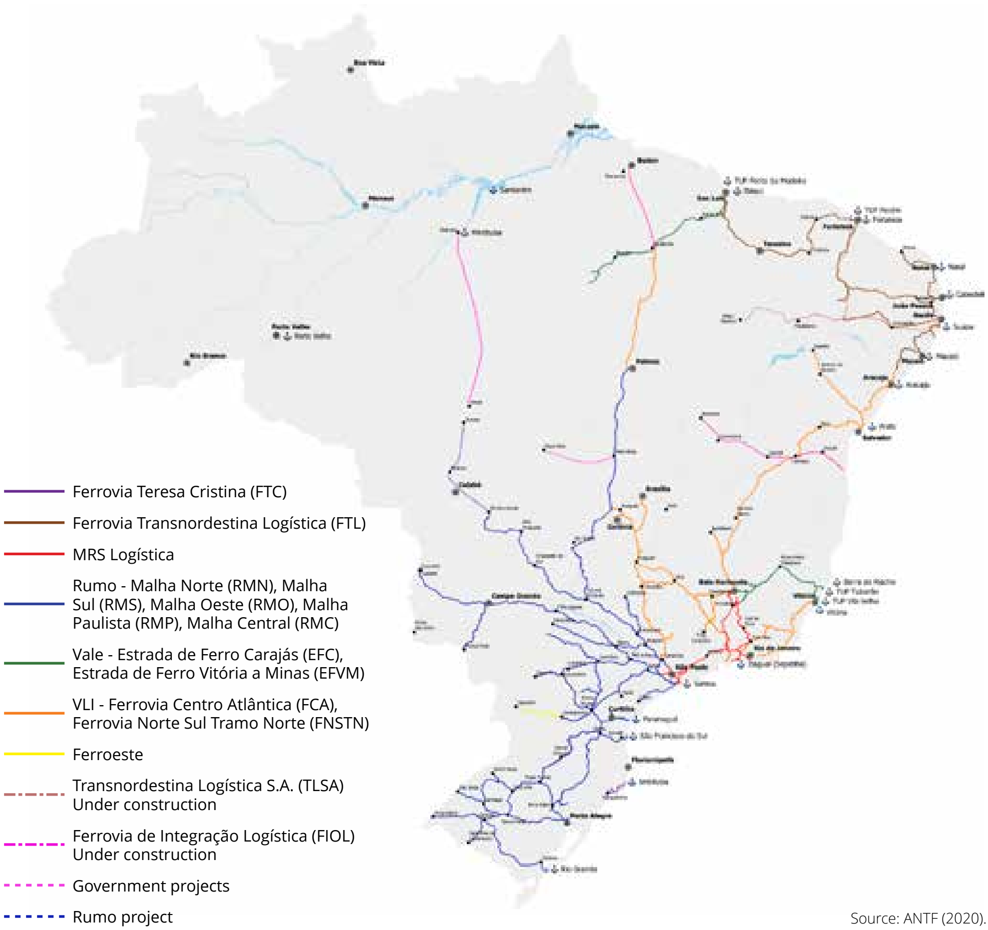
According to the Brazilian Infrastructure Ministry, the objectives of the PPI are:

- Expand investment and employment opportunities and stimulate technological and industrial development, in harmony with the country's social and economic development goals;
- Ensure the expansion of high quality public infrastructure, with appropriate tariffs for the users;
- Promote fair competition in the celebration of partnerships and the provision of services;
- Ensure legal stability and security of contracts, with the guarantee of minimal intervention in business and investment;

- Strengthen the regulatory role of the state and the autonomy of state regulatory entities.

Figure 16 shows the current situation of the railway infrastructure in the country.

Figure 16. Railways in Brazil: existing, under construction and projected

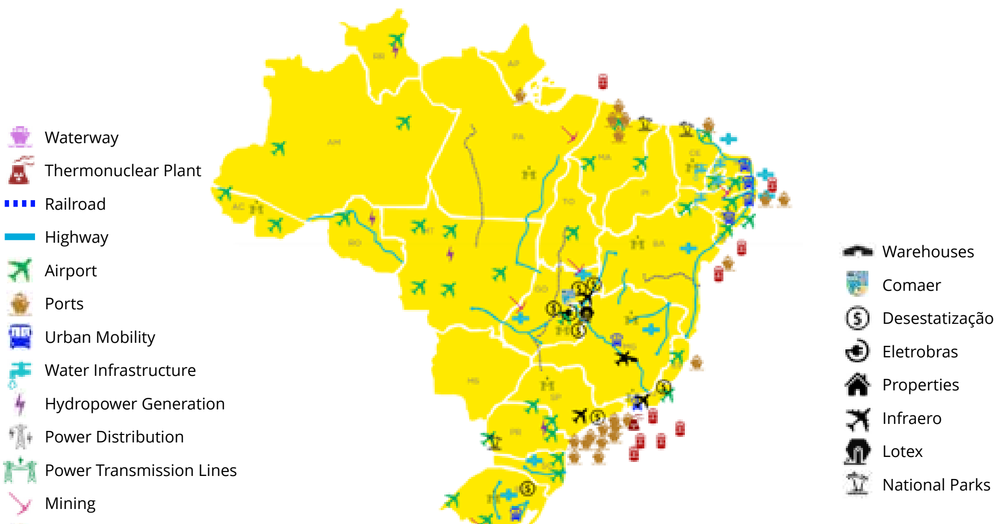


Source: ANTF (2020).

The federal government, with the PPI concessions program, has shown a very clear interest in expanding the Brazilian logistics system with the integrated projects illustrated in Figure 17.

Table 6 presents the main PPI federal government concession projects.

Figure 17. Spatial distribution of infrastructure projects



Source: Brazilian Ministry of Infrastructure (2019).

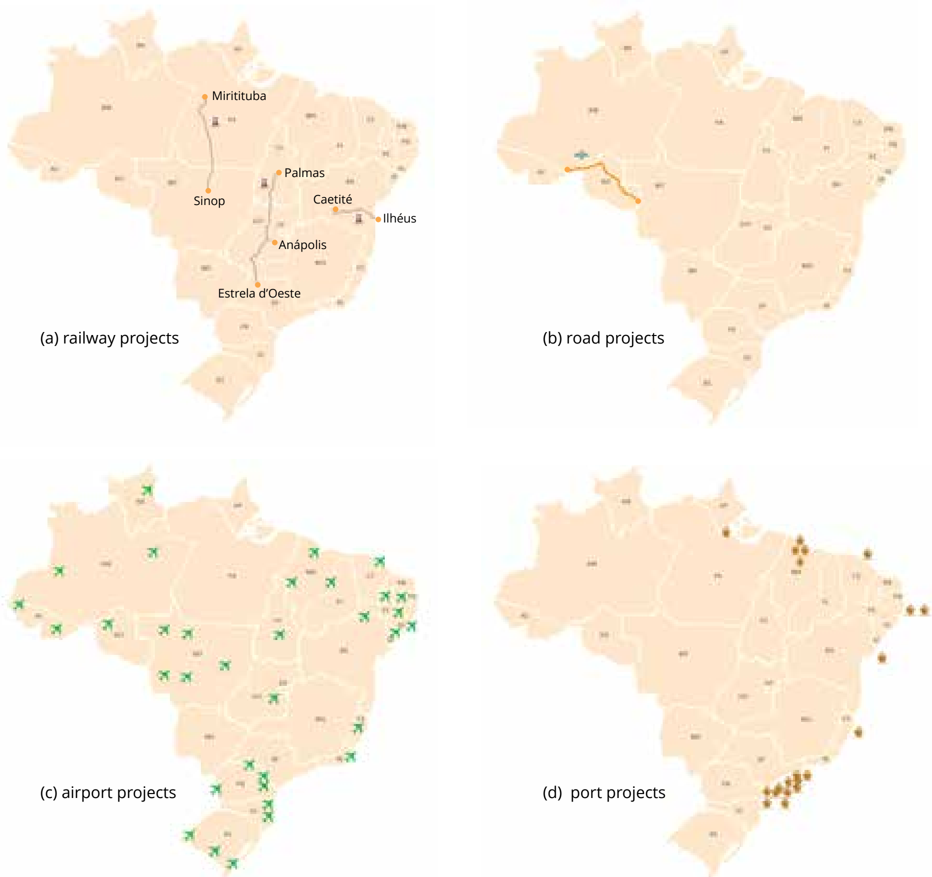
Table 6. Main PPI federal concession projects

Project	Sector	Model
Concession of EF-354 - Central-West Integration Railway	Railroad	Common concession
Concession of the North Railroad Section of Sao Paulo	Railroad	
EF 151 - SP/MG/GP/TO - North-South Railroad	Railroad	Subconcession
EF 170 - MT/PA - Ferrogrão Railroad	Railroad	Common concession
EF 334/BA - FIOL Railroad	Railroad	Subconcession
Highway BR 364/RO - Porto Velho to Comodoro	Highway	Common concession
6th Round of Airport Concessions - Blocks South, North, and Central	Airport	Common concession
Airports in the Northeast, Midwest, and Southeast (12 Airports)	Airport	Common concession
ATU 12 - Leasing of solid bulk in port of Aratu (BA)	Ports	For rent/lease
Cabling stimulation policy, named "BR do mar"	Ports	Política de fomento
Cellulose Terminal at the Port of Paranaguá (PR) - (PAR01)	Ports	For rent/lease
Grain Terminals in the Port of Paranaguá (PR) - (PAR 07, PAR 08, and PAR XX)	Ports	For rent/lease
IQI 03 - Liquid Bulk Terminal in the Port of Itaqui (MA) - São Luís, Maranhão	Ports	For rent/lease
IQI 11 - Liquid Bulk Terminal in the Port of Itaqui (MA) - São Luís, Maranhão	Ports	For rent/lease
IQI 12 - Liquid Bulk Terminal in the Port of Itaqui (MA) - São Luís, Maranhão	Ports	For rent/lease
IQI 13 - Liquid Bulk Terminal in the Port of Itaqui (MA) - São Luís, Maranhão	Ports	For rent/lease
Privatization - Companhia Docas do Espírito Santo - Codesa	Ports	Privatization
Privatization of the Organized Port of São Sebastião (SP)	Ports	Privatization

Source: Brazilian Ministry of Infrastructure (2019).

Figure 18 shows the location of major infrastructure concession projects.

Figure 18. Spatial distribution of infrastructure projects by modality



Source: Brazilian Ministry of Infrastructure (2019).

7. Risks of investments in logistics projects in Brazil

Transportation infrastructure investors in Brazil typically have a greater preference for projects being executed and with a minimum of infrastructure built by the public sector due to the lower project risk. Generally, transportation infrastructure projects have a very long maturation, and thus a series of events can occur in the legal, regulatory, political, and economic environment in the country, increasing investor risk.

In 2016, Esalq/LOG Group, together with the World Bank, mapped and built a series of risk and limitation matrices associated with the agro-logistics of various agribusiness production chains (see Figure 19). Thus, for example, the events with the highest probability and which cause a considerable increase in logistics costs are those that require more priority management, involving, for example, queues at port and rail terminals, jams, and lack of rail cars.

Figure 19. Risk matrix of agro logistics in Brazil

Risk matrix		Impact severity				
		Negligible	Moderate	Considerable	Critical	Catastrophic
Event probability	Highly probable		• Stoppage of the movements (rains) • Fuel price changes	• Queues at the port terminal		• Lack of rail cars
	Probable	• Reduction of truck supply (rain)		• Quagmire		• Queues at the railway terminals
	Occasional		• Correction of back roads (rain)	• Increased product humidity	• System unavailability (lack of infrastructure)	
	Remote		• Sudden storage unavailability	• System unavailability (lack of infrastructure)	• Regulation of road transport	• Port strike
	Improbable					

High priority management
Moderate priority management

Sources: Esalq/LOG and The World Bank (2016).

8. Close partnership with China

As we discussed in the previous sections, Brazil is highly dependent on road transport for cargo handling and especially over long distances, with high logistical costs for the agribusiness segment. As was explained at the beginning of the chapter, Brazilian logistics tend to be inefficient, in large part, mainly related to the existing bureaucracies in the various logistical activities, which ends up making the so-called "Brazil Cost" even more expensive.

Brazil, over the past decades, has presented good planning, but as a result of low levels of investment, it has not been carried out. More specifically, unlike developed countries, the country's logistical planning is not carried out to induce economic and social growth in a region, but to solve the already established infrastructure problems in a region that already has an established production system, as is the case along the agricultural frontier region of the states of Maranhao, Piauí, Tocantins and Bahia.

The biggest challenge involved in building a strong relationship with China in transport infrastructure is to strengthen Brazilian institutions to make them capable of providing a safe and predictable investment environment.

In Brazil, the policies designed for transportation often coincide with the term of office of the political positions of the Executive, and we know that infrastructure projects have a medium and long term development time. To strengthen the investment environment in the country, it is necessary to create a national state policy so that infrastructure projects can be carried out in a more permanent manner.

Another very important aspect of attracting Chinese interest in infrastructure concerns the degree of understanding of the projects. Brazil is a country with a high degree of complexity in different spheres: market, political, regulatory, legal, tax, etc. Very often, the description of infrastructure concession projects in the country has a low level of detail.

Understanding the fiscal dysfunction that exists between the different regions of the country is essential for investments in infrastructure and logistics projects. States often seek to attract investment with tax benefits. It is not uncommon to see the existence of uneconomic logistical flows, resulting in the use of more expensive distribution channels offset by cheaper taxation because each Brazilian state has different rules and taxation.

In the railway sector, there are several challenges that need to be overcome to foster foreign investment. First, the railway sector in Brazil is very concentrated and national companies predominate. The concession format adopted in slicing the length of the country's rail network into meshes caused a major problem with respect to the trackage rights of a railway company on a stretch maintained by a different company. For the investor interested in a railroad concession, it is essential to know the capacities per period and costs of accessing the network of other railroads. There is a high risk of a lower rate of transport than that which was originally planned.

Besides, in the rail sector, it is necessary to create a system that can reduce the degree of monopoly in some sections of the railway companies, so that medium and small shippers can have access to rail transport (the formation of the price of rail freight is often based on the top tier price of road transportation).

A solution that has been discussed in the legislative sphere is the creation of private railroads under private law, built and operated by the private initiative and organized under private self-regulation, fostering investments and the development of the railway sector.

Recently, Brazil presented an example of attracting investments from the structuring of a new regulatory framework in the port sector, called Law No. 12.815/2013. Such a Law provides for the direct and indirect exploration by the Union of ports and port facilities and the activities performed by logistics operators. This milestone allowed for the creation of infrastructure by private agents in terminals (TUP), organizing and still permitting the movement of third party cargoes (before the regulatory framework, the terminals were restricted by their own cargo quotas). There was an expansion of private terminals after this change, from 120 in 2010 to the current 173 terminals (EPL, 2019). China has invested in one of them in Santa Catarina state – the Babilonga Bulk Terminal[3]. Revenues from terminals come from warehousing and freight forwarding services (Pierdomenico & Azevedo Neto, 2015).

Cabotage in Brazil presents a high possibility of growth and interesting comparative advantages, mainly due to the country's extensive sea coast. However, there are some obstacles to its expansion. Currently, only nationalized or Brazilian ships can operate in cabotage, with Brazilian shipping companies and Brazilian crew. Also, coastal shipping is often made more expensive by the high tax burden paid for fuel oil and also in the nationalization of ships, reducing the advantage in terms of economic gains. Therefore, allowing international shipping companies to operate with cabotage and also ensuring equality in the treatment of tax exemptions in the fuel oil of coastal shipping with long-distance shipping, will generate a significant opportunity for the expansion of this segment.

The country can exploit Public-Private Partnership Programs (PPPs) very well. Many countries have been using PPPs, but in Brazil, progress is still

[3] Terminal acquired by China Communications Construction Company (ACC) in Sao Francisco do Sul (Santa Catarina), a company that also purchased the project of São Luís Port (Maranhao).

slow, mainly due to the dependence on the public sector for the effective execution of infrastructure works, as well as the Law No. 8.666/1993, which deals with a bidding system in which the lowest price wins, which does not mean that there is a quality assurance or that the best solution is reached.

An area of great interest in Brazil, which may strengthen the relationship with China, concerns the applicability of technology for gains of scale in the logistics system from the so-called logistics 4.0 or digital logistics. Based on Chinese experiences and with the advancement of 5G technology, China could bring innovations to this Brazilian segment.

Here is a summary of the principal opportunities for Chinese investments in logistics in Brazil, particularly with respect to agribusiness.

In the road sector:

- Increased road density in more remote regions;
- Improvement of road quality – duplication, traffic signalling, and paving;
- Improvement of the quality of rural roads that connect large production centers to runoff roads;
- Modernization of the Brazilian transport vehicle fleet with the effective retirement of old vehicles;
- Brazil's fleet is aging. There is no policy to remove old vehicles from the market to increase productivity and service level of the sector;
- Increased productivity in road transport, especially at loading and unloading points, through new technologies (much time is lost in queues, which generates idle fixed cost and reduces annual carrier revenues).

Specifically in rail:

- Modernization of the mesh, rolling stock, equipment and terminals for productivity and efficiency gains;
- Expansion of transport capacity in existing meshes;
- Expansion of terminal handling capacity;
- Creation of new competitive multimodal rail corridors;
- Expansion of container handling on the rail system – Brazil has a huge market to be explored for the still incipient railroad that moves containers;

- Increased productivity in rail transport (average speed, number of formed trains, number of wagons per trip, loading time, unloading time etc.).

In waterway transport:

- Expansion of storage capacity at terminals;
- Expansion of terminal handling capacity;
- Equipment modernization for productivity and efficiency gains;
- Investment to expand navigability of strategic waterways – especially those that can promote economic and social development.

In maritime logistics:

- Modernization of equipment and port terminals to increase productivity, to generate efficiency and to increase cargo capture;
- Expansion of storage capacity in port terminals;
- Expansion of retro areas for container movement;
- Expansion of operational capacity of port terminals;
- Promotion of the creation and expansion of private terminals in strategic regions;
- Expansion of rail and/or waterway access capacity at port terminals.

Finally, in the Brazilian storage system:

- Expansion of static storage capacity; extension of the storage coverage radius in the country;
- Expansion of storage capacity in rural properties; expansion of fuel export and import tanking in the country;
- Equipment modernization, including investments related to logistics operations, involving the provision of services to transportation and storage activities.

Invariably, the growth of agricultural production increases the pressure on transport infrastructure in the country, especially because transport is a derived demand from production.

Closer relations between Brazil and China can bring significant changes in Brazil's economic and social development. Brazil is a major trading partner and supplier to China. A close partnership between the countries is a way to ensure cheaper and more competitive delivered products, constructing a win-win relationship for both.

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Part 5

Bilateral trade perspectives

Chapter 9

Honghua Chen
Yixing Tian

Opportunities and challenges to strengthen bilateral agri-food trade: the Chinese perspective

Abstract

In recent decades, a spike in Chinese economic and population growth has spurred a large demand for agricultural commodities and foodstuffs. In spite of the extensive Chinese land resources and large amounts of rural workers, which bestows the country with a competitive advantage in labor intensive products, its agri-trade relations with Brazil have intensified, and largely been based on imports of a long range of foodstuffs. Yet, a the high degree of potential complementarities in the agricultural resource arrays of these two countries have also become evident. These complementarities are treated in the following chapter, which through an analysis of production and commercial data highlights the potential for further strengthening Sino-Brazilian economic ties, as well as the opportunities and challenges with which this partnership is faced.

1. Introduction

Due to the differences in resource endowments and the complementarities of agricultural production, China and Brazil show real potential for further expanding bilateral agri-food trade and investment. For China, expanding imports of agricultural products from Brazil would help to improve Chinese domestic market supply at a lower cost. Investment in agri-food production in Brazil is becoming a more attractive option than expanding China's agricultural exports. Agricultural products defined in the WTO Agricultural Products Agreement can mainly be encountered within the first 24 chapters of HS classification, so the definition and scope of agricultural food applied in this chapter are all products in the first 24 chapters, and in chapter 51 and 52 of the HS coding.[1] The relevant data in these chapters are derived from UN Comtrade, and specific data are calculated by the authors.

This chapter attempts to describe the development of agricultural trade between China and Brazil, and clarify the complementarity and key products of agricultural trade between the two countries. We aim to analyze the comparative advantages of China's agricultural trade by using trade statistics, and to identify the structural characteristics of bilateral trade. Finally, through SWOT analysis, this chapter evaluates the strengths, weaknesses, opportunities, and threats to bilateral trade, and explores the possibilities for future agricultural cooperation.

1.1. Background

Brazil is the largest country in South America. It has abundant arable land resources and crops such as soybean, sugarcane, and maize. China faces a huge demand for agricultural products, and cannot completely rely on domestic production to meet its food needs in the long run. How to make full use of the advantages of both sides, and strengthen agricultural

[1] Note that the definition of agricultural products in this chapter is classified by the HS Code, an international standard from the United Nations Commodity Trade Statistics Database (UN Comtrade). We will use the code instead of name of products in the following.

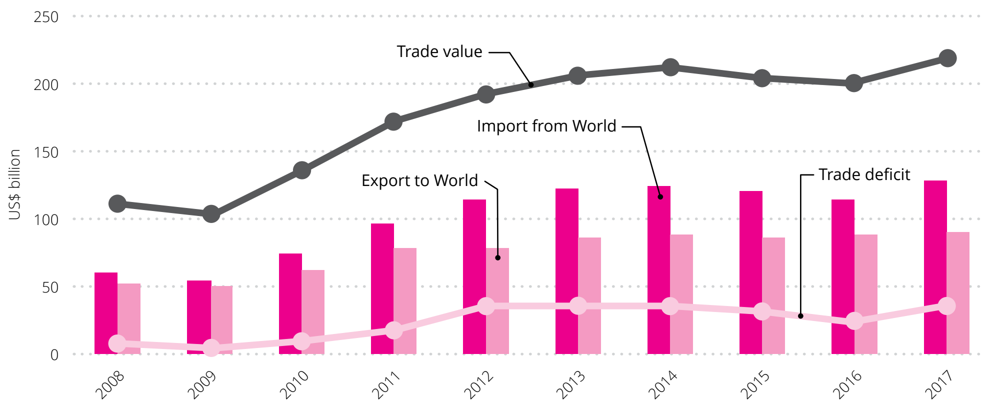
cooperation between China and Brazil is of great strategic significance to China's economic development and food security. In recent years, China and Brazil have established good business ties and mutual trust in the field of agricultural trade. There are many differences in comparative advantages between the two countries, allowing for the further expansion of trade in agricultural products. For example, China's dominant products are mainly labour-intensive and often processed foods, such as vegetables and fruits. In addition to its comparative advantages in land-intensive products such as grain, Brazil also has many special agricultural products with production advantages, such as coffee and cocoa. The export products of both China and Brazil are more complementary than competitive in general, suggesting that bilateral trade between two countries has great potential for development.

According to the Agricultural Trade Promotion Center of the Chinese Ministry of Agriculture and Rural Areas, at present, Brazil is the world's largest exporter of sugar, coffee, and soybeans, and the world's second largest exporter of corn and beef. In 2017, Brazil exported 28.5 million tons of sugar, accounting for 48.3% of the world's total exports. Soybean exports amounted to 70.5 million tons, accounting for 46.8% of the world's total export volume, while 45.1% of the total output was exported to China, which occupied 72.2% of total export volume. Corn exports amounted to 35 million tons, accounting for 22.4% of the world's total corn exports. Beef is the main export amongst livestock products. In 2017, 1.76 million tons of beef were exported, an increase of 3.7%, of which 198 thousand tons were exported to China. China and Brazil have their respective areas of expertise and advantages. It is a win-win situation for both countries to expand trade and investment in agriculture, forestry, animal husbandry, and fisheries. We believe that Sino-Brazilian agricultural cooperation has a bright future, but also that it contains both opportunities and challenges.

2. Chinese agricultural import and export

Over the past decades, as China gradually has become more integrated into the world economy, its foreign trade in agricultural products has also expanded rapidly. Exports grew from US$ 51.6 billion in 2008, to US$ 90.7 billion in 2017, while imports grow from US$ 60.5 billion to US$ 127.5 billion in the same period (Figure 1). The total value increased from US$ 112.1 billion to US$ 218.2 billion, rising by 94.7%.

Figure 1. Trade value of agricultural products between China and World, 2008/2017



Source: UN Comtrade.

Table 1 and Table 3 present information on China's agricultural imports and exports according to the main product categories. Oilseed (especially soybean), fruit, cereals, and wool were the main import items over a recent five year period. China is also a significant importer of cotton. However, it is difficult to observe domestic policy-induced changes in trade patterns due to price fluctuations in the international market (Jales et al., 2006). Imports of wheat, rice, and other cereals that are considered strategic and thus subject to self-sufficiency requirements, represented only a small part of total imports in recent years. The imports of sorghum and maize products have dropped, while the imports of barley products have grown. The increase in barley imports resulted from two different factors. First, it is used in beer. There is a brewing demand of about 3 million tons every year in China. Second, barley can replace corn and sorghum to meet the rising demand for domestic feed. Influenced by the policies of structural adjustment of the domestic corn industry and de-stocking, the price of domestic corn has continued to fall since 2016, further narrowing the price gap with that of internationally traded corn.

Influenced by the reduction of production in the major producing countries in 2016, the global sugar market is in a tight supply, and the international sugar price has reached levels as high as 5544 yuan/ton. By the first half of 2017, Brazil and other major producers had sustained high production levels, greatly easing the tension of international production reduction for two consecutive years. In order to protect the development of a domestic sugar industry, China has made a series of policy adjustments: on the one hand, in 2017, the government reduced the extra-quota for sugar from 1.9 million tons to 1 million tons, and the amount of sugar imports within the quota was reduced by nearly half. On the other hand, the Tariff Commission of the State Council has decided to implement the highest safeguard measures for imported sugar products, and levy a 45% tariff as of May 22, 2017. This tariff has cancelled the advantages of importing sugar (Yijun & Xiaoyan, 2017). While overall grain exports have not changed significantly, exports of rice, sorghum, and wheat have increased considerably. According to UN Comtrade data, wheat imports in 2018 were 10 times higher than in 2014. As expected, horticultural exports have been amongst the main export items, growing at a stable pace, and suggesting great export potential for China.

Table 1. Chinese agricultural imports by product category

Product category	2018	2017	2016	2015	2014
Livestock	0.41	0.36	0.39	0.55	0.84
Vegetables	2.04	2.02	1.86	2.62	2.58
Fruit and nuts	8.68	6.40	5.86	6.02	5.14
Cereals	5.79	6.40	5.66	9.35	6.17
Wheat	0.78	1.03	0.8	0.89	0.96
Barley	1.69	1.82	1.14	2.86	1.57
Maize (corn)	0.79	0.60	0.64	1.11	0.73
Rice	1.60	1.83	1.59	1.47	1.23
Grain sorghum	0.86	1.03	1.43	2.97	1.64
Oil seeds	43.37	44.51	38.3	39.71	45.89
Soybeans	38.08	39.64	33.98	34.79	40.26
Sugars	1.42	1.41	1.46	2.08	1.79
Tobacco	1.76	1.76	1.73	1.86	2.09
Wool	4.20	3.63	3.15	3.42	3.38
Cotton	9.89	8.61	7.74	10.25	12.76

(US$ billion).
Source: UN Comtrade.

3. Characteristics and opportunities of China-Brazil bilateral trade in agriculture

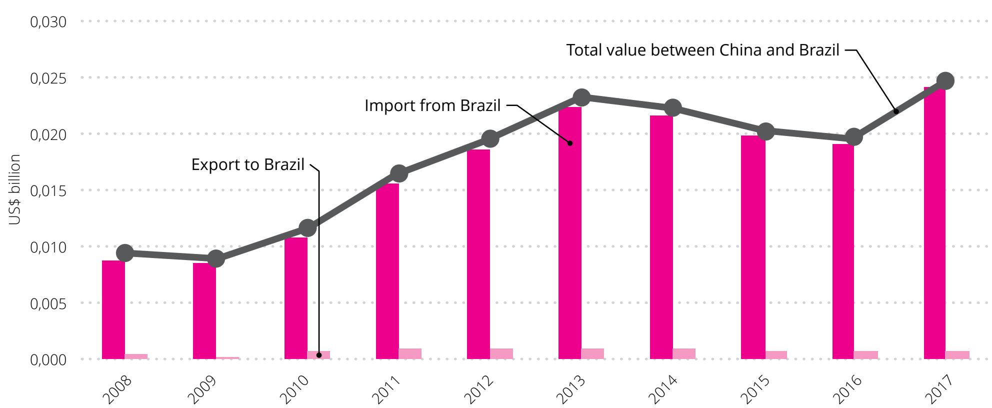
After the establishment of a strategic partnership in 1993, the economic and trade relations between China and Brazil have shown sustained and stable growth. Since 2001, trading of agricultural products has reached a stage of rapid development. In recent years, trade agreements and cooperation projects between the two countries have also been signed. Chinese imports of Brazilian agricultural products increased, and created an open, inclusive and win-win development environment for agri-food trade. Long-term agricultural cooperation plans have been signed under the BRICS cooperation mechanism, such as the BRICS Agricultural Cooperation Action Plan (2012/2016), and the BRICS Agricultural Cooperation Action Plan (2017/2020), which have been actively promoting the development of and opened more opportunities for agricultural trade between China and Brazil.

3.1. Agri-food trade has scaled

Since the 21st century, the scale and speed of agricultural trade between China and Brazil have gradually expanded. China's accession to the World Trade Organization in 2001 increased its openness to the outside world. Under the active promotion of the World Trade Organization and the two countries, the bilateral trade quickly developed from 2001 to 2008. The trade volume of agricultural products between China and Brazil increased from US$ 801 million in 2001 to US$ 9.253 million in 2008. As a result of the global economic crisis in 2008, this level declined in 2009, from US$ 9.253 billion in 2008 to US$ 8.729 billion in 2009. In 2009, the global economy began to recover gradually, and the BRICS cooperation mechanism was launched. China and Brazil utilized the BRICS cooperation mechanism to benefit from resource complementarities on both sides, and actively expanded cooperation in the field of agriculture.

From 2009 to 2013, the agricultural trade between the two countries entered a stage of rapid development, increasing from US$ 8.729 billion in 2009 to US$ 23.549 billion in 2013, with an average annual growth rate of 28.57%. The value of trade declined for three consecutive years in 2014, 2015 and 2016, with $ 22.342 billion in 2014, and $ 21.943 billion and $ 21.487 billion respectively in the next two years. On the other hand, the proportion of Brazilian agricultural exports to China and the world still shows a small increase, from 26.13% in 2013, 26.19% in 2014, 24.1% in 2015, to 27.80% in 2016. The trade volume of agricultural products between China and Brazil accounts for an increasing proportion of the total trade volume of agricultural products in Brazil, and the trade relations between the two countries continue to deepen. In 2017, the value of agricultural products traded between the two countries increased again, from $ 19.737 billion in 2016, to $ 24.730 billion in 2017, which shows that the agri-food trade offers good prospects for further development (Figure 2).

Figure 2. Trade value of agricultural products between China and Brazil, 2008/2017



Source: UN Comtrade.

In the long run, the bilateral agricultural trade will continue to be dominated by China's imports (Ma & Tian, 2015). Due to the limited availability of agricultural resources, the continuous advancement of industrialization and urbanization, the improvement of people's living standards, and changing consumption patterns, China's comparative advantage in the production of bulk-stock agricultural products has gradually decreased (Jie Fan, 2010). Brazil, on the other hand, benefits from abundant natural resources, and has a strong comparative advantage in commodities such as cotton, tobacco, sugar, oil, and vegetable oil. The demand for these products has a high income elasticity, which will increase with the growth of the income level of the Chinese population. Although Brazil's economic growth also will stimulate the demand for Chinese agricultural products, the distance between the two countries will restrict the export of fresh produce. Brazil is fully capable of producing agri-food, such as fruits, aquatic products and vegetables, under the appropriate market environment. Therefore, China will maintain its net import status within bilateral agricultural trade for many years to come.

China's strong demand for Brazilian agricultural products, especially soybeans, soybean oil, and sucrose has gradually strengthened its position in the agricultural products market. The export of agricultural products from Brazil to China has gradually increased, and there is potential for further expansion. After the financial crisis, China's position in Brazil's agricultural export market has improved significantly, as the country became the largest export destination of Brazilian agricultural products (Wilkinson et al., 2013). Similarly, Brazil has become the second largest source of agricultural imports in China, closely following the United States.

3.2. Trade in agri-food is less competitive

China and Brazil have very different resource endowments in relation to agricultural production. Table 2 summarizes both Chinese and Brazilian agricultural exports by country of destination. Brazilian agricultural products were mainly exported to China, the United States, the Netherlands, Russia, Japan, Saudi Arabia, Germany, Spain, South Korea, and Belgium in 2017. China is Brazil's largest agricultural export market, accounting for 29.15% of total exports. The main markets for China's agricultural exports are Japan, the United States, Vietnam, Korea, Thailand, the Philippines, Malaysia, Bangladesh, Indonesia, and Germany. Japan was the most important foreign market for China's agriculture in 2017. It purchased US$ 10.42 billion worth of Chinese agri-food, or 11.49% of China's total agricultural foreign sales.

There are several common markets for agricultural exports from China and Brazil, such as the United States, Japan, South Korea, and Germany. However, the types of products exported by the two countries differ.

Table 2. China's and Brazilian agricultural exports by country of destination, 2017

China			Brazil		
Country	US$ billion	% of total	Country	US$ billion	% of total
Japan	104.21	11.49	China	235.51	29.15
United States	78.75	8.68	United States	36.65	4.54
Vietnam	74.73	8.24	Netherlands	35.54	4.40
South Korea	50.73	5.60	Russia	23.77	2.94
Philippines	38.70	4.27	Japan	23.02	2.85
Thailand	33.52	3.70	Saudi Arabia	20.60	2.55
Indonesia	28.09	3.10	Germany	17.33	2.15
Bangladesh	27.05	2.98	Spain	17.17	2.13
Malaysia	25.69	2.83	South Korea	15.68	1.94
Germany	20.22	2.23	Belgium	15.32	1.90

Source: UN Comtrade.

For example, on the US market, China mainly exports agricultural products in chapters 3, 16, and 20. Brazil mainly exports agricultural products included in chapters 9, 20, and 22. Only fruits, vegetables and nuts are exported by the two countries to the US market. On the Japanese market, the main agricultural products exported by China are chapter 3, 7, 16, and 20, while Brazil's main exports are chapter 2, 12, and 20. The two countries export the same products under chapter 20 to the Japanese market, but China's exports of such products are much higher than Brazil's. In the Korean market, the main categories of China's exports include chapters 3, 7, and 20. Brazil's exports include chapters 10, 12, and 23. The competitive export advantages of the two countries are very different. China focuses on fish and vegetables, while Brazil concentrates on oil seeds, food industry residues, etc.

China and Brazil have less competitive export products, which are summarized in Table 3 and Table 4. Agricultural products exported by China mainly include chapter 3, 7, 16, 20, and 52 in a recent three year period. These categories of agricultural products account for more than 68% of total exports. Brazil's agricultural exports are mainly concentrated in chapters 2, 9, 10, 12, 17, 20, 23, and 24. These agri-foods account for more than 80% of the total worldwide exports in value.

Table 3. Chinese agricultural exports by product category

HS Code	Commodities	2015	%	2016	%	2017	%
1	Live animals; animal products	0,598	0.69	0,647	0.73	0,562	0.62
2	Meat and edible meat offal	1,057	1.23	0,902	1.02	0,916	1.01
3	Fish and crustaceans, molluscs and other acquatic invertebrates	13,324	15.45	13,705	15.53	13,253	14.61
4	Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included	0,606	0.70	0,59	0.67	0,588	0.65
5	Products of animal origin, not elsewhere specified or included	1,772	2.05	1,772	2.01	2,309	2.55
6	Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage	0,300	0.35	0,33	0.37	0,338	0.37
7	Edible vegetables and certain roots and tubers	9,024	10.46	10,546	11.95	11,164	12.31
8	Edible fruit and nuts; peel of citrus fruit or melons	5,161	5.98	5,485	6.22	5,337	5.88
9	Coffee, tea, mati and spices	2,535	2.94	2,981	3.38	2,931	3.23
10	Cereals	0,322	0.37	0,429	0.49	0,67	0.74
11	Products of the milling industry; malt; starches; insulin; wheat gluten	0,59	0.68	0,565	0.64	0,575	0.63
12	Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit; industrial or medicinal plants; straw and fodder	2,903	3.37	2,674	3.03	2,646	2.92
13	Lac; gums, resins and other vegetable saps and extracts	1,272	1.48	1,258	1.43	1,348	1.49
14	Vegetable plaiting materials; vegetable products not elsewhere specified or included	0,125	0.14	0,121	0.14	0,131	0.14
15	Animal or vegetable fats and oils and their cleavage products; prepared edible fats; animal or vegetable waxes	0,667	0.77	0,584	0.66	0,839	0.93
16	Preparations of meat, of fish or of crustaceans, molluscs or other aquatic invertebrates	8,005	9.28	7,942	9	9,024	9.95
17	Sugars and sugar confectionery	1,562	1.81	1,707	1.93	1,759	1.94
18	Cocoa and cocoa preparations	0,442	0.51	0,426	0.48	0,376	0.41
19	Preparations of cereals, flour, starch or milk; pastry cooks' products	1,528	1.77	1,579	1.79	1,65	1.82
20	Preparations of vegetables, fruit, nuts or other parts of plants	7,386	8.56	7,338	8.32	7,694	8.48
21	Miscellaneous edible preparations	2,977	3.45	3,205	3.63	3,26	3.59
22	Beverages, spirits and vinegar	1,994	2.31	2,203	2.50	2,227	2.46
23	Residues and waste from the food industries; prepared animal fodder	2,665	3.09	2,768	3.14	2,659	2.93
24	Tobacco and manufactured tobacco substitutes	1,351	1.57	1,377	1.56	1,327	1.46
51	Wool, fine or coarse animal hair; horsehair yarn and woven fabric	2,281	2.65	2,141	2.43	1,999	2.20
52	Cotton	15,799	18.32	14,966	16.96	15,127	16.68

(US$ billion, %).
Source: UN Comtrade.

Table 4. Brazilian agricultural exports by product category

HS Code	Commodities	2015	%	2016	%	2017	%
1	Live animals; animal products	0,278	0.38	0,284	0.4	0,358	0.44
2	Meat and edible meat offal	13,078	17.66	12,656	17.83	13,953	17.27
3	Fish and crustaceans, molluscs and other acquatic invertebrates	0,208	0.28	0,226	0.32	0,234	0.29
4	Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included	0,472	0.64	0,312	0.44	0,284	0.35
5	Products of animal origin, not elsewhere specified or included	0,447	0.6	0,418	0.59	0,551	0.68
6	Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage	0,017	0.02	0,013	0.02	0,013	0.02
7	Edible vegetables and certain roots and tubers	0,092	0.12	0,059	0.08	0,101	0.12
8	Edible fruit and nuts; peel of citrus fruit or melons	0,827	1.12	0,801	1.13	0,876	1.08
9	Coffee, tea, mati and spices	6,046	8.17	5,228	7.36	5,01	6.2
10	Cereals	5,725	7.73	4,11	5.79	4,981	6.17
11	Products of the milling industry; malt; starches; insulin; wheat gluten	0,087	0.12	0,086	0.12	0,116	0.14
12	Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit; industrial or medicinal plants; straw and fodder	21,208	28.64	19,558	27.55	26,008	32.19
13	Lac; gums, resins and other vegetable saps and extracts	0,09	0.12	0,123	0.17	0,133	0.16
14	Vegetable plaiting materials; vegetable products not elsewhere specified or included	0,007	0.01	0,014	0.02	0,019	0.02
15	Animal or vegetable fats and oils and their cleavage products; prepared edible fats; animal or vegetable waxes	1,626	2.2	1,251	1.76	1,441	1.78
16	Preparations of meat, of fish or of crustaceans, molluscs or other aquatic invertebrates	1,351	1.82	1,301	1.83	1,178	1.46
17	Sugars and sugar confectionery	7,781	10.51	10,586	14.91	11,566	14.32
18	Cocoa and cocoa preparations	0,375	0.51	0,39	0.55	0,364	0.45
19	Preparations of cereals, flour, starch or milk; pastry cooks' products	0,166	0.22	0,172	0.24	0,203	0.25
20	Preparations of vegetables, fruit, nuts or other parts of plants	2,15	2.9	2,209	3.11	2,273	2.81
21	Miscellaneous edible preparations	1,135	1.53	1,083	1.53	1,141	1.41
22	Beverages, spirits and vinegar	1,024	1.38	1,03	1.45	0,973	1.2
23	Residues and waste from the food industries; prepared animal fodder	6,172	8.34	5,539	7.8	5,395	6.68
24	Tobacco and manufactured tobacco substitutes	2,186	2.95	2,123	2.99	2,092	2.59
51	Wool, fine or coarse animal hair; horsehair yarn and woven fabric	0,04	0.05	0,03	0.04	0,029	0.04
52	Cotton	1,45	1.96	1,388	1.95	1,497	1.85

(US$ billion, %).
Source: UN Comtrade.

3.3. Agricultural trade is highly complementary

Agricultural resources are highly complementary between China and Brazil (Julimar, et al., 2016). Brazil is the largest country in Latin America. It has abundant land resources, and a land area of more than 8 million square kilometers. Its arable land area is 153 million hectares, accounting for 18% of the total land area, of which 6 million hectares are cultivated for crops. Brazil has a favorable climate, with annual precipitation exceeding 1200 millimeters in most regions, and even in some regions without irrigation conditions, crops can be planted in two seasons. Brazil has relatively abundant land and natural resources for agricultural production compared with China. The per capita cultivated land area is less than 1.35 mu in China, and the arable land area is still decreasing. China has 1.395 billion inhabitants, 900 million rural dwellers, and 200 million workers engaged in agricultural production, and its agricultural labor resources are relatively abundant compared with Brazil. China is on a positive development trajectory, both in relation to economics and technological strength. Compared with Brazil, China has greater advantages in the development of agricultural science and technology. Therefore, China and Brazil have strong complementarity from the perspective of agricultural production resources.

The Revealed Comparative Advantage Index (RCA) can measure the competitive advantage of a product in an exporting country. It refers to the ratio of a country's exports of a specific product to its total exports and that of the world's exports to its total exports in the same period.

$$RCA_{ki} = \frac{\frac{X_{iw}^{k}}{X_{iw}^{t}}}{\frac{X_{ww}^{k}}{X_{ww}^{t}}}$$

X_{iw}^{k} represents country i exports the value of product k to the world. X_{iw}^{t} represents country i's total export value to the world. X_{ww}^{k} is the total export value of product k of the world. X_{ww}^{t} is the total export value from the world. When the value of RCA is greater than 1, it shows that country i has a comparative advantage in the export of k products. When RCA is greater than 2.5, it shows that this kind of product has a strong comparative advantage.

A RCA value between 0.8 and 2.5 represents a strong comparative advantage. When the RCA value is less than 0.8, this kind of product has no comparative advantage. The RCA index of agricultural trade of China and Brazil from 2013 to 2017 is summarized in Table 5.

Table 5. The RCA index of agricultural trade of China and Brazil, 2013/2017

	RCA index of China's agricultural products export					RCA index of Brazil's agricultural products export				
HS Code	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017
1	0.224	0.202	0.204	0.244	0.181	2.757	2.659	1.132	1.212	1.201
2	0.067	0.071	0.064	0.059	0.052	9.127	9.651	9.385	9.432	8.223
3	1.055	1.024	1.030	0.963	0.891	0.154	0.135	0.192	0.180	0.163
4	0.049	0.048	0.056	0.060	0.051	0.182	0.447	0.519	0.363	0.254
5	1.795	1.710	1.379	1.560	1.648	4.754	5.024	4.153	4.174	4.088
6	0.105	0.150	0.110	0.129	0.113	0.083	0.091	0.073	0.058	0.044
7	1.025	1.008	0.984	1.146	1.151	0.044	0.078	0.120	0.073	0.108
8	0.366	0.342	0.374	0.386	0.368	0.670	0.652	0.710	0.638	0.629
9	0.438	0.408	0.451	0.484	0.463	8.809	11.325	12.844	9.611	8.220
10	0.035	0.029	0.022	0.033	0.049	4.432	3.054	4.659	3.594	3.753
11	0.273	0.254	0.244	0.240	0.255	0.277	0.352	0.429	0.413	0.536
12	0.246	0.247	0.229	0.225	0.188	17.676	19.369	19.963	18.647	19.208
13	1.174	1.352	1.376	1.388	1.389	0.842	1.028	1.164	1.537	1.423
14	0.935	0.949	1.152	1.072	0.943	0.656	0.746	0.758	1.394	1.397
15	0.052	0.053	0.069	0.050	0.060	1.442	1.360	2.017	1.223	1.079
16	1.525	1.419	1.337	1.336	1.656	2.374	2.535	2.693	2.478	2.248
17	0.247	0.273	0.283	0.290	0.295	18.626	17.708	16.794	20.337	20.174
18	0.075	0.081	0.072	0.076	0.061	0.546	0.597	0.726	0.787	0.616
19	0.200	0.183	0.170	0.179	0.171	0.245	0.252	0.221	0.222	0.218
20	1.090	0.995	0.901	0.935	0.938	3.222	3.061	3.131	3.190	2.882
21	0.330	0.326	0.339	0.368	0.353	1.522	1.419	1.542	1.407	1.287
22	0.100	0.117	0.132	0.155	0.142	1.377	0.785	0.812	0.822	0.643
23	0.285	0.313	0.260	0.302	0.275	6.796	7.352	7.198	6.846	5.801
24	0.251	0.228	0.249	0.260	0.240	5.658	4.632	4.800	4.535	3.932
51	1.533	1.395	1.200	1.270	1.081	0.241	0.226	0.249	0.200	0.162
52	2.139	2.081	2.095	2.192	2.079	1.407	2.003	2.294	2.302	2.138

Source: Original data is from UN Comtrade, indexes are calculated by the author.
Note: The HS Code of each Chapter refers to the Appendix.

According to the data in the table, the agri-foods with comparative advantages of China's agricultural exports are: chapter 3, 5, 7, 13, 14, 16, 20, 51, and 52. The RCA of agricultural products in chapter 5, 7, 13, and 16 increase gradually, while other agricultural products decrease, indicating that the favorable position of primary raw materials related to agri-food in China is decreasing gradually. The comparative advantages of Brazil's export agricultural products are: chapter 1, 2, 5, 9, 10, 12, 13, 14, 15, 16, 17, 20, 21, 22, 23, 24, and 52.

Comparing the export advantages, we find that the comparative advantage of agricultural products between the two countries is determined by their resource endowments. With the exception of chapter 5, 13, 14, 16, 20, and 52, Brazil is at a comparative disadvantage in the export of other agricultural products with very strong or relatively strong comparative advantages in China.

4. Major challenges in agricultural trade between China and Brazil

China and Brazil have strong complementarities and many opportunities for cooperation. Agriculture, as the main area of cooperation between the two countries, plays an important role in promoting social development and economic growth. As we discussed above, the two governments have introduced relevant agricultural policies to further promote the deepening of relations in recent years.

At the same time, however, Sino-Brazilian agricultural cooperation still faces a series of problems and challenges. Generally, commercial relations within this field are relatively homogeneous – China imports primary agricultural products from Brazil and invests in Brazilian agriculture. In addition, the engagement of state-owned enterprises is more intense than that of private enterprises, and private capital needs more opportunities to further enter the Brazilian market. Although policies in the two countries have been somewhat supportive of agricultural cooperation, there are still some restrictions on its implementation, and its further development is still facing difficulties.

4.1. The trade balance of agri-food is large

There has been a serious trade deficit between China and Brazil in agricultural products trade. Table 6 shows commercial data from 2008/2017.

Table 6. Agri-food trade between China and Brazil, 2008/2017

	Import from Brazil	Export to Brazil	Total value	Trade deficit
2008	8,788	0,465	9,253	8,323
2009	8,437	0,291	8,728	8,146
2010	10,724	0,765	11,489	9,959
2011	15,584	0,990	16,574	14,594
2012	18,678	0,861	19,539	17,817
2013	22,521	1,028	23,549	21,493
2014	21,534	0,809	22,343	20,725
2015	19,836	0,662	20,498	19,174
2016	19,038	0,699	19,737	18,339
2017	24,082	0,647	24,730	23,435

(US$ billion).
Source: UN Comtrade.

The trade deficit of agricultural products in China is close to the total trade value. Due to the impact of the global financial crisis in 2008, the total agricultural trade volume and trade deficit declined in 2009, dropping to US$ 8.146 billion. Since 2009, agricultural trade between the two countries has developed rapidly, and the trade deficit has also increased, from US$ 8.146 billion in 2009, to US$ 21.493 billion in 2013. From 2014 to 2016, the total trade volume and trade deficit declined. The trade deficit decreased from US$ 20.724 billion in 2014 to US$ 18.339 billion in 2016. With the increase of the total trade volume of agricultural products between Brazil and China in 2017, the trade balance between the two countries increased to $ 23.435 billion. The trade balance of agricultural products between the two countries displays a fluctuating growth.

4.2. The trade of agricultural products is relatively homogeneous

China's imports of certain types of products from Brazil account for a large proportion of total imports. The same is the case for exports, which also are highly concentrated. At present, the agricultural cooperation between the two countries is more confined to importing Brazilian primary agricultural products and investments in Brazil by Chinese-funded enterprises. Yet, this form of cooperation is not conducive to comprehensive and in-depth development of agricultural cooperation between the two sides, nor can it promote the realization of industrial harmony between them.

Table 7. Product structure of agricultural trade between China and Brazil, 2014/2017

		2014		2015		2016		2017	
	HS Code	Value	%	Value	%	Value	%	Value	%
Import from Brazil	12	18,724	86.96	16,89	84.8	15,552	81.69	20,31	87.73
	11	0,001	0.00	0,001	0.00	0,001	0.00	0,00	8.64
	2	0,55	2.55	0,992	4.98	2,005	10.53	1,79	7.73
	15	0,54	2.51	0,269	1.35	0,31	1.63	0,343	1.48
	24	0,434	2.01	0,284	1.43	0,172	0.90	0,276	1.19
	17	0,862	4.00	0,945	4.75	0,705	3.70	0,135	0.58
	52	0,276	1.28	0,225	1.13	0,126	0.66	0,133	0.57
	20	0,092	0.43	0,093	0.47	0,101	0.53	0,065	0.28
	23	0,001	0.01	0,008	0.04	0,014	0.07	0,037	0.16
	14	0,004	0.02	0,002	0.01	0,004	0.02	0,029	0.12
	13	0,013	0.06	0,005	0.03	0,015	0.08	0,02	0.09
Export to Brazil	3	0,237	31.44	0,167	25.18	0,134	19.14	0,164	26.28
	7	0,373	18.54	0,189	28.45	0,302	43.27	0,162	25.96
	5	0,065	8.83	0,064	9.63	0,061	8.79	0,08	12.82
	52	0,187	20.36	0,089	13.35	0,054	7.77	0,061	9.78
	23	0,041	4.55	0,029	4.34	0,029	4.17	0,057	9.20
	21	0,022	3.26	0,026	3.96	0,025	3.56	0,027	4.39
	12	0,003	0.90	0,006	0.89	0,004	0.52	0,017	2.77
	13	0,01	1.27	0,014	2.06	0,011	1.53	0,011	1.73
	17	0,012	1.19	0,006	0.83	0,005	0.71	0,008	1.27
	20	0,048	5.70	0,048	7.27	0,037	5.31	0,008	1.27
	8	0,004	0.67	0,002	0.36	0,005	0.77	0,008	1.23
	9	0,001	0.22	0,002	0.23	0,004	0.61	0,004	0.71
	11	0,004	0.50	0,006	0.83	0,01	1.50	0,003	0.53
	16	0,002	0.33	0,003	0.45	0,004	0.61	0,003	0.53

(US$ billion, %).
Source: UN Comtrade. Note: The HS Code of each chapter refers to the Appendix.

In terms of the amount and the proportion of agricultural products imported from Brazil by China from 2014 to 2017 (Table 7), a concentration can be observed in relation to chapter 2, 11, 12 15, and 24, especially chapter 12. In general, the main types of agricultural products imported from Brazil are soybeans and soybean products, chicken, beef, pork, coffee and sugar. In 2017, China imported around 50,000,000 tons of soybean, amounting to US$ 20 billion 300 million, accounting for nearly 79% of the total export volume. Food derived from soybean is traditionally popular among the Chinese population. As the Chinese get wealthier, we tend to consume more protein and quality cooking oil. Those are the driving forces behind the rising soybean import to China in recent years. Therefore, soybean import is expected to continue to grow in the near future, extending a great commercial opportunity for both sides. Imports of tobacco, sugar and cotton in Brazil have gradually decreased.

4.3. Trade is focused on low added value products

Most of agri-foods traded between China and Brazil are primary agricultural products. The proportion of deep-processing, branded, and organic agricultural products is relatively small, resulting in a low added value of agricultural products trade between the two countries. Most of Brazil's agri-food exports to China are land intensive products, based on unprocessed raw materials. China's agricultural exports mainly include aquatic products, fruits, vegetables and some animal products. These exports are marked by the Chinese resource endowments, and are basically labor-intensive. Exports of processed and raw materials-based agricultural products exeed 80%, while those that are highly processed account for less than 20%.

4.4. Weak Policy Guidance

Policy guidance of the two countries needs to be further strengthened. At present, many agricultural enterprises in China do not have a clear and deep understanding of the relevant cooperation policies between China and Brazil, which leads to a lack of confidence. Most of the enterprises engaged in agricultural cooperation between the two countries are state-owned (Mi & Tong, 2017). Private capital faces difficulties regarding market entry due to the lack of effective policy guidance and incentives for agricultural cooperation between China and Brazil.

The intra-industry communication platform is an important way to enhance information sharing and cooperation opportunities between the two countries. It can help enterprises to identify relevant agricultural policies, cooperation needs, and bench mark cases. At present, there is no effective communication platform between Chinese and Brazilian enterprises, which makes Chinese enterprises unable to learn from experiences and lessons, resulting in repeated setbacks on the same issue. On the other hand, the two countries are not familiar with each other's real needs in agricultural cooperation. This cooperation relation is not sufficiently intense to make it possible for both sides to benefit from their respective advantages, and thus, the development of agricultural cooperation is slow. At the national level, the WTO still constitutes an important opportunity to improve conditions for the international trade of agricultural products. It is at the multilateral level that these two developing countries can find space to address systemic issues, such as domestic support and export competition. Those subjects have often been excluded from regional and bilateral trade agreements. We believe that the BRICS conference platform may end up being accepted as a good way to strengthen communication.

For Brazilian and Chinese agribusiness sectors, it is urgent to speed up the construction of an information network on agricultural production and consumption. Agricultural enterprises in both countries need to know the agricultural production and consumption information of both sides accurately and quickly. Accelerating the construction of such a network would significantly help Chinese enterprises to obtain the agricultural product policies, technologies, and environmental health indicators.

5. Summary

Based on the considerations above, we made a summary by applying SWOT analysis of China's agricultural trade with Brazil. SWOT analysis is based on internal and external situation analysis of the competitive environment. It enumerates all kinds of main internal advantages, disadvantages, and external opportunities and threats that are closely related to the research object. Then it uses the thought of system analysis to match all kinds of factors, while drawing a series of corresponding conclusions, which can be useful in supporting decision-making. Through SWOT, it becomes possible to conduct comprehensive, systematic, and accurate research on specific objects, and to define a corresponding development strategy, plan, and countermeasures according to the results obtained. SWOT analysis divides the environmental analysis into "opportunities and threats". The purpose of opportunity and threat analysis is to try to understand the factors that influence the marketing strategy of an enterprise. Here we want to assess the opportunities and challenges of bilateral trade, and whether the advantages of Chinese products may hold.

5.1. Strength

With the gradual improvement of the rural management system, China's agricultural development has displayed a sustained and steadily growing momentum in recent years. China's agricultural output plays an increasingly important role in the total global agricultural output. Labor-intensive products are China's comparative advantage. Horticulture accounts for the most dominant agricultural products, with more than 30% of the total export of agricultural products every year. Vegetables and fruits represent about 50% of the export of horticultural products. In particular, vegetables are difficult to produce by mechanized cultivation and harvest, as it is evident with yam and asparagus. China is the world's largest producer of fish products, and its output is equivalent to 61.5% of the world's total. The Food and Agriculture Organization highlights that the global demand for fish products is more than one hundred million tons per year. Brazil has the potential to become the largest global producer of fish products, but lacks fish farming technology and development experience.

5.2. Weaknesses

Compared with the export scale and potential of Brazil, China does not have many advantages in terms of agricultural exports. The trade deficit between China and Brazil continues to expand. China's exports to Brazil are relatively limited. In the long run, China will maintain the advantages of a few labour-intensive horticultural products, such as export vegetables, but its potential is very limited. Due to the restriction of farmland conditions, China's agricultural production has become very concentrated. Excessive use of pesticides and fertilizers, pesticide residues, food additives, and poor production hygiene conditions are frequent problems. The agricultural products exported by China are often rejected and returned due to factors concerning quality and safety. However, Brazil has some of the strictest food safety regulations in the world. The quality and safety of agricultural products greatly restrict the sustainable development of China's agri-foods' trade.

Generally, the production costs of wheat, corn, soybean, rape, and cotton in China are relatively high, and could rise even further (Li Deng, 2003). Therefore, the final consumer price of agricultural products in China is relative high. Taking grain as an example, the prices of major grain varieties in China, such as rice, corn and wheat, are generally higher than those on the international market. The low efficiency of circulation and transportation is also an important reason for the high price of agricultural products.

5.3. Opportunities

China and Brazil have implemented positive policies in bilateral agri-food trade, which provide support for the development of trade between the two countries, and will continue promoting cooperation. China's import demand and export supply capabilities are strong. The scale of Brazil's economy is also increasing, and the export capacity of agricultural products has been enhanced. With the expansion of bilateral ties, trade volumes of agricultural products will also increase. Demand for these products will rise with the sustained expansion of the scale of the economy. Increased economies of scale are thereby likely to have a positive impact on bilateral agricultural trade. In fact, China's rising income level, mounting urbanization, and great changes in consumption patterns provide a widening array of export opportunities for Brazil. The Chinese urban middle-class has increasing demands for meats, milk, oils, and high-valued processed foods. Brazil could benefit from increased Chinese imports of these products. Prospects also seem encouraging for cotton growers. Although China is the world's greatest producer of cotton, Brazil's emerging cotton production could play an important role in supplying China.

5.4. Threats

The distance between China and Brazil is great, and the cost of transportation, information acquisition, and communication are relatively large. Cultural differences and consumer preferences also vary greatly. Therefore, the distance between the two countries has a negative impact on bilateral trade, and will likely lead to more challenges. In recent years, China's exchange rate has remained relatively stable. The exchange rate risk is therefore relatively small. Appreciation of the Yuan could favor the export of Brazilian agricultural products to China, but is not conducive to China's export of agricultural products.

6. Suggestions and expectations

A positive bilateral political and economic environment creates conditions for trade growth, and bilateral agricultural trade has great potential for development. We believe that the agricultural trade between China and Brazil will be dominated by unilateral flows towards China for many years into the future. First, due to the limitation of agricultural resources, rising income levels, mounting urbanization, and significant changes in consumption patterns, China's comparative advantage in the production of bulk agricultural products will gradually weaken (Zhao, 2017). Brazil has benefited from its wide array of natural resources, and with its obvious advantages in agricultural production and exports, it is expected to remain competitive in these products for a long time. The Chinese urban middle-class is increasingly demanding more meat, milk, oils, and processed foods. The demand for these products has a high income elasticity, which will rise significantly with the increase of average income levels. Brazil could benefit from increased Chinese imports of these products. Secondly, although economic growth also stimulates the demand for Chinese agri-food products, the transportation distance is restricted to the export of fresh products. Under the appropriate market environment, Brazil is fully capable of producing such foods on its own. We believe that from the Chinese perspective, expanding imports of agricultural products from Brazil and other developing countries will help to ensure food security and improve domestic market supply, at a lower cost. The expansion of trade and economic cooperation between China and Brazil has a good foundation so far. Exporting agricultural technology and engaging in agricultural production in Brazil is a more attractive option than expanding the import of agricultural products.

For China, the following points should be noted. First, it would be better to develop deep processing and high value-added production of agricultural products to increase exports. Compared with Brazil, China has no comparative advantage in primary raw materials and has more competitive advantages in processing agricultural products. Therefore, China should pay more attention to upgrading its agricultural industrial structure and develop more efficient processing and export of high value-added agricultural products. In the long run, with the improvement of processing capacity, the demand for raw materials will increase. Expanding the import of raw materials will help enrich the varieties of processed agri-foods, and maintain the competitiveness of processed agricultural products. In addition, China could strengthen the labour intensive products, such as fruits that grow in temperate or frigid zones, since they are not suitable for growing in Brazil.

Second, encouraging China's agricultural enterprises to internationalize and strengthen investment in Brazil's agriculture is another way to improve the bilateral agri-food trade. In recent years, Brazilian governments have made some openings for foreign capital to enter the agricultural sector. This is an opportunity for Chinese agricultural enterprises. In particular, the government may allow foreign investors to lease agricultural land. Through the establishment of Chinese and Brazilian agricultural products trade cooperation demonstration zones, governments can encourage domestic enterprises to use their capital and technological advantages to engage in cooperation initiatives.

Third, we need to explore bilateral cooperation in agricultural science and technology, environmental protection, and other fields to create conditions and explore potential opportunities for the expansion of bilateral agricultural trade. China and Brazil are developing countries, but have their own specialties and advantages. Brazil has much experience in environmental protection, biodiversity conservation, water resources utilization, and other sustainable agricultural development initiatives. China has an advantage in infrastructure construction and transportation of agricultural products. It is necessary for the two sides to further strengthen information exchanges and cooperation in the above areas. For example, we can make use of the advantages of capital and technology to invest in the railway and highway systems that provide access to all major ports in Brazil. This would improve the backward transportation infrastructure and result in greater efficiency, reducing the transportation costs of agricultural trade between the two countries.

Fourth, the promotion of product quality can effectively enhance the competitive advantage of Chinese products on the international market. If China wants to improve the market share of agricultural products in Brazil, it must enhance the quality of agricultural products, and ensure that exports meet requirements related to quality, safety, and hygiene. We must speed up the construction of comprehensive series of standards for the quality, inspection, and testing system on the basis of international principles and internationally prevailing standards. At the same time, domestic agricultural enterprises should actively pursue international certification, such as ISO900, ISO1400, Good Agricultural Practices (GAP), Hazard Analysis and Critical Control Point (HACCP), and organic products, to upgrade and improve the quality of agricultural products in China.

7. Conclusion

This chapter has outlined the current situation of China's agri-food trade, and described the development of agricultural trade relations between China and Brazil. We have also sought to clarify the complementarities and identify the key products of agricultural trade between the two countries. This chapter also analyzed the comparative advantages of China's agricultural trade by using trade statistics, and identified the structural characteristics of bilateral trade. The main conclusions from the statistical analysis are listed in the following. First, China and Brazil have different types of agricultural products with comparative advantages. China mainly produces horticulture and processed foodstuffs, while Brazil is more focused on land intensive agricultural products. Second, the trade complementarity between China's agricultural exports and Brazil's agricultural imports is weak, but it shows a certain upwards trend, while the trade complementarity between Brazil's agricultural exports and China's agricultural imports is strong, and displays an upwards trend. The complementarities of agri-trade between the two countries are largely based on agricultural products with comparative advantage in exports. Third, the overall competitive advantage of China's agricultural products is weaker than Brazil's, but horticultural products still score very well. The international export markets of the two countries are similar to some extent, but their export products are somewhat different. Fourth, the trade in agricultural products between the two countries still has a certain growth potential. Finally, through SWOT analysis, we summarized the strengths, weaknesses, opportunities, and threats to bilateral trade, exploring both opportunities and challenges for expanding bilateral economic and trade cooperation in the future.

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Appendix

HS Code	Description
1	Live animals; animal products
2	Meat and edible meat offal
3	Fish and crustaceans, molluscs and other acquatic invertebrates
4	Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included
5	Products of animal origin, not elsewhere specified or included
6	Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage
7	Edible vegetables and certain roots and tubers
8	Edible fruit and nuts; peel of citrus fruit or melons
9	Coffee, tea, mati and spices
10	Cereals
11	Products of the milling industry; malt; starches; insulin; wheat gluten
12	Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit; industrial or medicinal plants; straw and fodder
13	Lac; gums, resins and other vegetable saps and extracts
14	Vegetable plaiting materials; vegetable products not elsewhere specified or included
15	Animal or vegetable fats and oils and their cleavage products; prepared edible fats; animal or vegetable waxes
16	Preparations of meat, of fish or of crustaceans, molluscs or other aquatic invertebrates
17	Sugars and sugar confectionery
18	Cocoa and cocoa preparations
19	Preparations of cereals, flour, starch or milk; pastry cooks' products
20	Preparations of vegetables, fruit, nuts or other parts of plants
21	Miscellaneous edible preparations
22	Beverages, spirits and vinegar
23	Residues and waste from the food industries; prepared animal fodder
24	Tobacco and manufactured tobacco substitutes
51	Wool, fine or coarse animal hair; horsehair yarn and woven fabric
52	Cotton

Chapter 10

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Opportunities and challenges to strengthen bilateral agri-food trade: the Brazilian perspective

Chapter proposal

In recent decades, both China and Brazil have assumed roles as global agri-food players. China has been very active in proposing different partnership modalities and trade agreements with various countries. In the following chapter, we conduct an analysis of a series of determinant factors for the agricultural trade between Brazil and China, which, briefly summarized, contains:

1) An assessment of the evolution of bilateral trade, and a description of products traded, underlining strategic points related to the kinds of goods exchanged today and possibilities for the future.
2) A description and critical examination of the trade policy regarding the agri-food sector bilateral trade flows, and a broader overview in terms of international relations and trade policy.
3) A discussion of the trade and cooperation agreements signed by both countries, as well as others that are currently under negotiation with third countries, particularly the Economic and Trade Agreement between

the United States and China (Phase One) signed on January 15th 2020, and its potential impacts on Brazilian agri-food exports to China.

4) A description and critical discussion of trade barriers and other policies affecting Brazilian agribusiness' market access in China, such as tariffs and sanitary, technical, and other non-tariff measures. We also highlight recent developments in terms of labor and environmental regulation in China and in Brazil, which might be decisive for future market access.

Finally, this chapter highlights issues of increasing importance within international trade policy concerning supply and value chains, and discusses potential threats to Brazilian exports to China, as well as tools that might be promoted to guarantee a successful and sustainable trade partnership.

1. Introduction

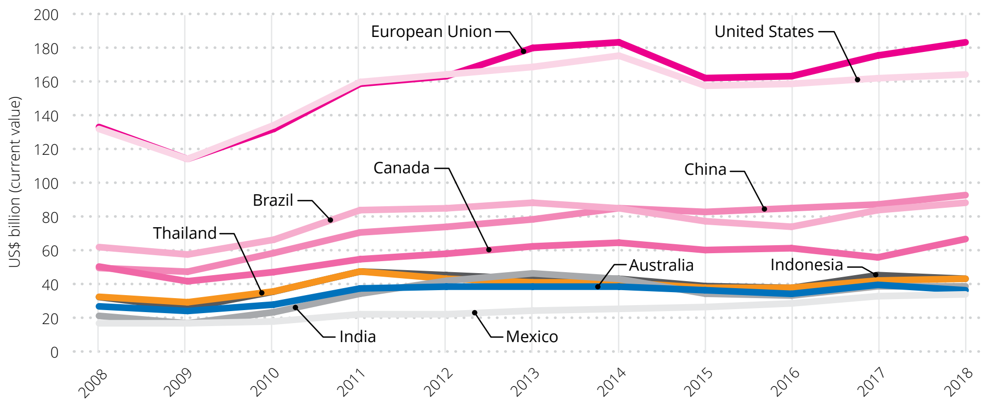
In recent decades, both China and Brazil have become important global agricultural players. China has proposed various partnership modalities (such as the Belt and Road Initiative – BRI) and trade agreements with many different countries, as trade and food security policies are major Chinese concerns. International trade is central to the Chinese development strategy, and due to its huge population and extensive rural migration, food security is a strong social priority. In this sense, trade is strategic to guarantee food supply in China.

On the other hand, since the mid-1990s, Brazilian exports of agricultural commodities have surged, due to the country's comparative advantages in land and natural resource endowments, and its technological advancement within the field. For historical reasons, Brazilian exports are highly concentrated in primary commodities, and distributed to a relatively small number of trading partners.

Until the 1980s, Brazil had mainly been an exporter of sugar and coffee, but from that point onwards, it gradually became one of the largest global suppliers of soybeans and soy products, animal protein (mainly beef and poultry), wood pulp, sugar, ethanol, and orange juice. More recently, the country has also become an important exporter of maize, cotton, and pork, which just 30 years ago were destined for domestic consumption only.

According to the USDA (2019), Brazil ranked as the 4th largest exporter of agricultural and related products in 2018, following the European Union (EU), the United States (USA), and China (Figure 1).

Figure 1. Top ten world exporters of agricultural products, 2008/2018

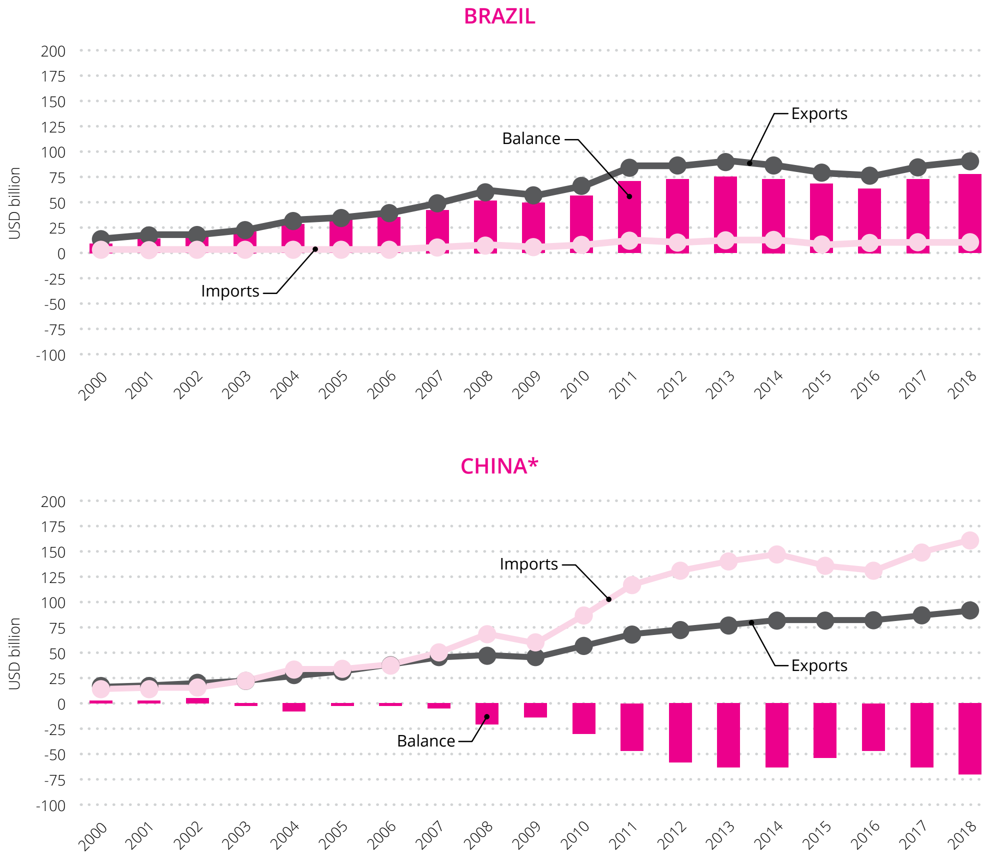


Source: USDA (2019).
Note: Information for some countries is unavailable for 2018 until this study's end date.

China also enjoys a distinguished position as the third largest global exporter of agricultural products, surpassed only by the EU (considering only extra-bloc trade). The Chinese entry into the World Trade Organization (WTO), in 2001, led to a drastic surge in global demand for raw materials, and the country became the world's largest importer of a wide range of agricultural products. China has also become the main trading partner of many countries in South America, Southeast Asia, the USA, EU, and Africa.

The comparison of the trade balances of the Brazilian and Chinese agri-food sectors in Figure 2 illustrates the substantial volume of Chinese trade, as well as its clear dependence on agri-food products, which has risen rapidly during the last 10 years. Notwithstanding the spike in Chinese production and export of agricultural products, the country is increasingly dependent on international supply. With its growth in GDP per capita, China will likely continue to be highly dependent on the external market to meet its food security needs.

Figure 2. Trade balance of agri-food products, Brazil and China, 2000/2018

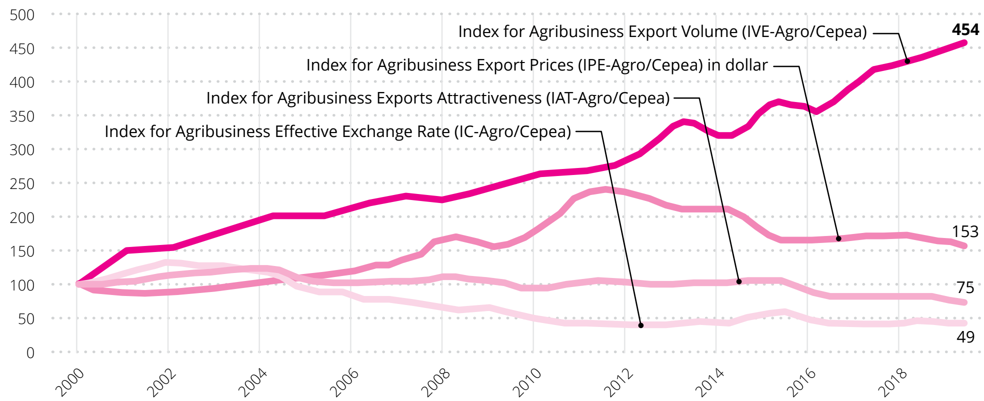


Source: USDA (2019).
*Note: Data from 2018 are estimates (unavailable within the USDA database until this study's end date).

Figure 2 illustrates the clear correlation between Brazilian agricultural exports and the Chinese imports, which shows how the export boom in Brazil during the 2000s was closely linked to a rise in demand within this Asian country. In the following sections, we will discuss these recent trends in light of the historical concentration of the Brazilian exports on primary commodities, centered on a limited range of products and consumer markets. This export profile should be seriously considered within the official economic planning and the definition of macroeconomic and industrial policies, especially regarding foreign trade.

Contrary to manufacturing, which was significantly impacted by the 2008 crisis and by a long period of appreciation of the Real in relation to the Dollar, the Brazilian agro-exports have maintained their competitiveness. As can be noted in Figure 3, the index for the agribusiness' effective exchange rate (IC), calculated by Cepea in relation to a group of imports, fell from a level of 100 to 49, between 2000 and 2019. In spite of this unfavorable effect, and of the reduced value of exports measured in R$ (IAT), export volumes increased more than 4,5 times.

Figure 3. Index of Brazilian agri-food exports, 2000/2019 (until September)



Source: Based on MDIC data, elaborated by Cepea/Esalq/USP (2019)[1].
Annual data. 2000 – Average of Jan-Sept/2019.

At present, more than a fourth of the total Brazilian global shipments are destined for China. If we consider agri-food products, this proportion rises to around 35%[2]. Further contributing to the commercial risk faced by Brazil (due to the high trade concentration) is the fact that it has signed very few trade agreements, which otherwise could help boost food exports.

[1] Available at: https://www.cepea.esalq.usp.br/upload/kceditor/files/Cepea_ExportAgro_3trimestre2019_(2).pdf.

[2] Considering exports of agri-food products to China and Hong Kong in 2019 (Mapa, 2019).

The increase in the United States' tariffs on many imports from China since 2017 led to retaliation against North American agricultural products. This situation, which became known as the "trade war", generated high expectations that Brazil could substitute the USA as a supplier of soy and other products to China, which in large measure did in fact materialize (see more details in Box 1). Yet, in late 2019, China and the United States negotiated an agreement which changed Brazilian expectations. The volumes of the trade flows it involves are sufficient to indirectly impact the trade revenues of many third countries, and poses new challenges that might affect Brazilian exports and trade policies.

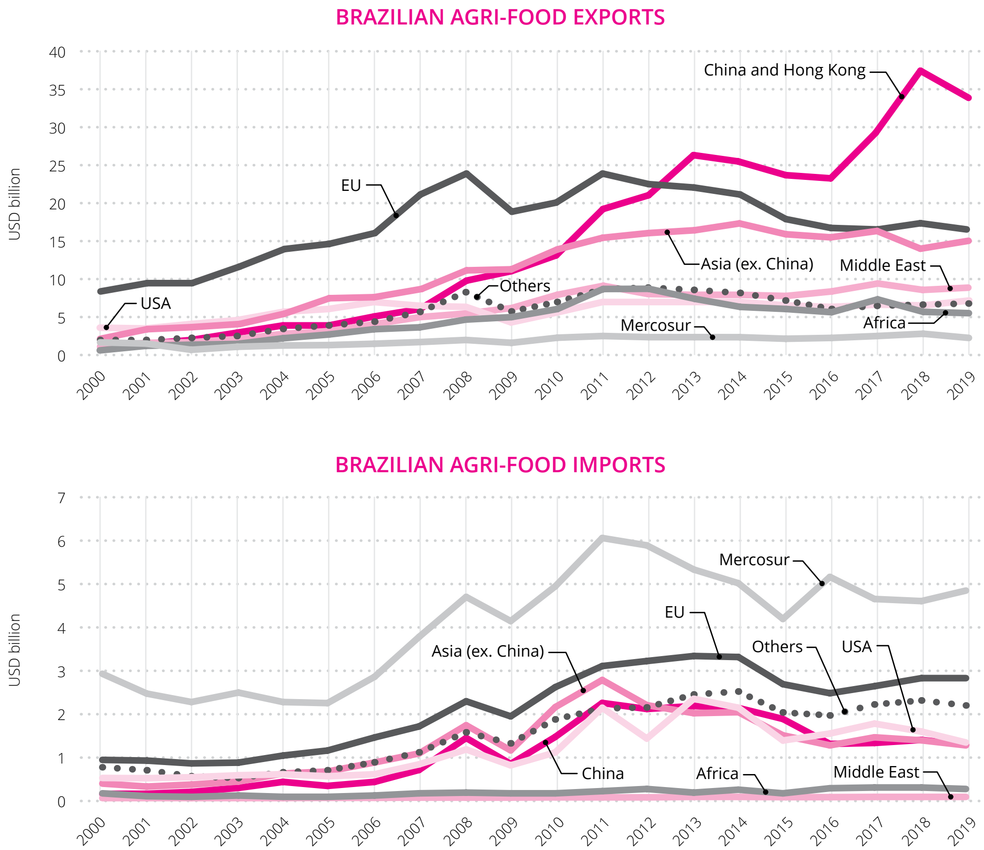
Considering the approximation between Brazil and China through both the BRICS and other institutional initiatives, it becomes a strategic imperative for both parties to establish trade and cooperation agreements. These agreements would reduce the impacts of the trade war and other exogenous factors, and also provide a more sustainable trade relation in the future.

2. Brazil within agricultural trade and the rise of China as a trading partner

Historically, Brazil's global trade has been strongly concentrated in terms of products, exporting companies, and final destinations. Despite trading with many different countries, until the early 21st century, Brazil's dependence on the European and US markets meant that it invested much in the conclusion of trade agreements with developed countries, and multilateral negotiations aimed at liberalization of agricultural markets, such as the General Agreement on Tariff and Trade (GATT), and as of 1995, the World Trade Organization. In 1997, the EU and USA accounted for half of Brazil's agricultural exports and imports.

Twenty years on, a highly concentrated export composition continues to characterize Brazil, in spite of the changes of its export markets and in the relative importance of its trading partners. With the acceleration of the Chinese commercial opening in the 2000s, and the increasing supply of Brazilian soy grains and ores, trade flows between Brazil and China changed. In only a few years, China became the main destination for Brazilian foreign sales of agri-food products, accounting for 32.4% of the country's exports, and 7.6% of its imports in 2019 (see Figure 4).

Figure 4. Main Brazilian trade partners in exports and imports of the agri-food sector, 2000/2019



Source: Mapa (Agrostat) (2019).

The ranking of Brazil's trade partners has changed, and the trade balance has similarly diversified, but the concentration of export destinations remains. Trade diversification has been sought since the first mandate of President Fernando Henrique Cardoso, in 1995, but advances have been few. In addition, Brazilian exports are concentrated on low value-added products, which entails a high commercial and economic risk, due to the dependency on a few countries which import a large volume of commodities. Hence, the new geography of the agricultural trade and the increasing importance of emerging countries in Asia presents challenges for Brazil and other exporters, and the need to establish new bilateral and regional agreements.

The difficulties of promoting multilateral trade liberalization – which for many years was a Brazilian foreign policy priority –, and the lack of an "export culture" contributed to the country's hesitance in establishing new trade agreements, and to its timid participation within proposed initiatives. The rigidness of the customs union agreement, which led to the Mercosur's Common External Tariff (CET) definition further complicates this picture, as it requires all member states to agree upon a common trade policy.

Considering the course of recent negotiations, there is reason to believe that access to consolidated markets, such as the USA, EU, and Japan will remain highly disputed. The ratification of the bi-regional EU-Mercosur agreement and the potential for strengthening relations with the UK after Brexit might yield some commercial benefits for Brazil. Yet, there is still much uncertainty regarding the materialization of these agreements.

Beyond this, companies confront new and growing technical and phytosanitary requirements for European market access, which demand constant and costly adjustment on behalf of exporters. These comprise of maximum limits for restrictive residues, the prohibition of certain pesticides, certification demands etc. In recent years, a discourse favoring local produce instead of imports has spread within the European market, which further exacerbates competition.

Thorstensen and Nogueira (2017) emphasize how Brazil has prioritized the multilateral forum (WTO), and alignments with Southern emerging countries (South America and Africa), leading to commercial isolation. Considering the current global rush to establish preferential trade agreements, the Brazilian trade policy faces a serious challenge: that of quickly identifying strategic partners and accelerating trade and investment agreements, especially with China. It is important to extend agreements and to improve sustainability in trade relations with this partner. Not least also taking into account, that strengthening this cooperation would facilitate market access in Southeast Asia.

Despite Brazil's timid stance on trade agreements, its bilateral trade with China has risen significantly since 2002, when commercial interactions intensified. The two countries have traded informally via Hong Kong since the creation of the Republic of China, in 1949 (Mortatti et al., 2011), but trade volumes only gained real importance during the 1990s. In 2002, China reached 3rd place in the ranking of trade destinations of Brazilian exports, surpassed only by the USA and Argentina. In 2008, China surpassed Argentina, and in 2009 it became the main destination for Brazilian exports, according to Secex trade statistics (MDIC, 2019).

Even during the Cold War, which was marked by polarization between East and West, Brazil and China maintained diplomatic relations and signed different cooperation agreements. During the military regime of President Ernesto Geisel in 1974, Brazil established diplomatic relations with the People's Republic of China (Vizentini, 2003).

In the early 1980s, new agreements and partnerships were sought through the foreign policy known as "Universalism", mainly with the so-called "non-aligned world", in partnership with China, Argentina, India, the USSR, and Arab countries. The relationship with China eventually substituted the historical cooperation with Japan, even within agriculture. This occurred through growth in bilateral trade, as well as cooperation around nuclear energy, satellites, and cutting-edge technology (Vizentini, 2003).

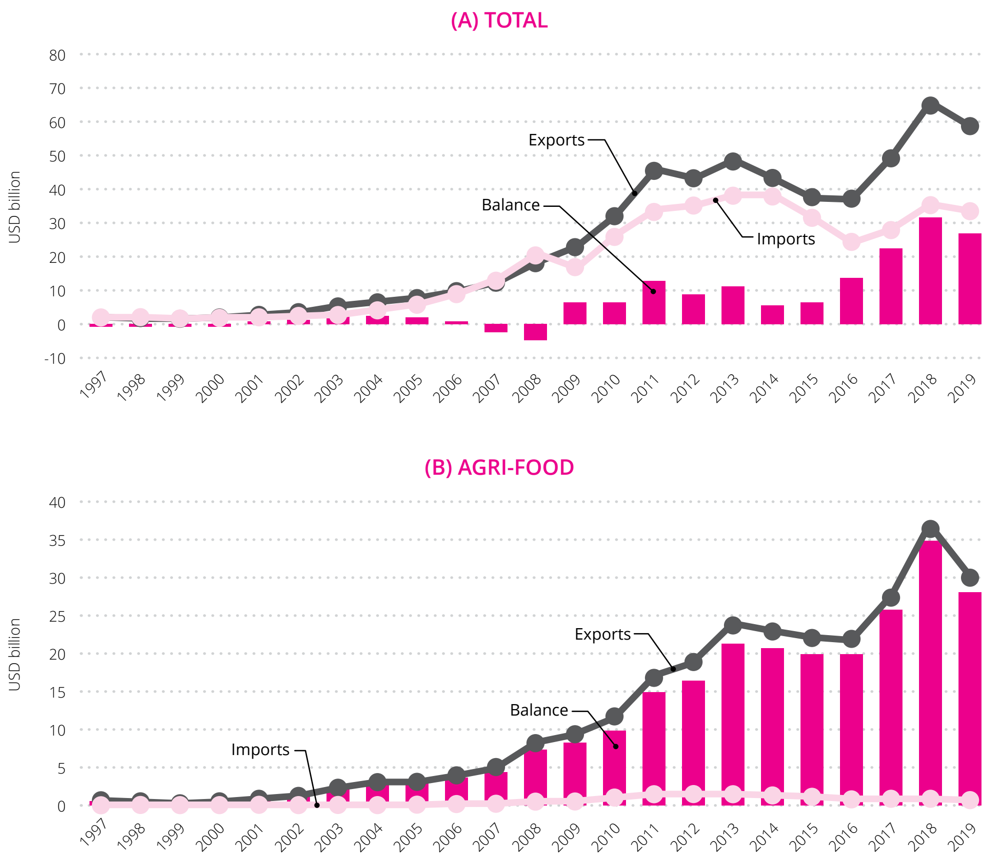
Between 1984 and 2008, Brazilian imports from China increased at an average annual rate of 16.6%, while its exports to this country grew at 15.4% (Mortatti et al., 2011). Contributing to this performance was the change in the Brazilian exchange rate regime in 1999, with the adoption of a flexible exchange rate, and the Chinese entry into the WTO in 2001.

Figure 5A shows the evolution of bilateral trade between Brazil-China from 1997 to the accumulated level in 2019. The bilateral trade balance presents a surplus, although the value of Brazilian imports surpassed exports in 2007 and 2008. Figure 5B demonstrates that, within the agri-food sector, the trade balance has been consistently positive for Brazil. Comparing the two graphs, it is clear the sector's performance has led to a positive total bilateral trade balance for Brazil.

Analysis of the agri-food trade balance during the 2000s points to a drastic surge in trade flows from Brazil to China within this specific product category. In the opposite direction, the most pronounced growth was that of industrial products, textiles, machines, equipment, and other manufactured goods. As displayed in Figure 5, trade between these two countries grew in 2017, which likely is associated with market gains due to the US-China trade war.

Despite the surprising increase in Chinese imports from Brazil, and of China's rise to become the country's main trading partner, calculations based on USDA data indicate that the Brazilian share of the Chinese agricultural product market has stabilized at around 13%. From 2016, there was a 6% increase, and in 2018, Brazil reached the level of 19% of Chinese agricultural imports. Yet, this share is excessively concentrated on low value-added products. Furthermore, in this period, the Chinese share of the global imports from this sector grew from 10% to 12%. These numbers point to other potential impacts of the trade war between the USA and China (see Box 1).

Figure 5. Bilateral trade balance (A) and agri-food trade balance (B), Brazil and China, 1997/2019

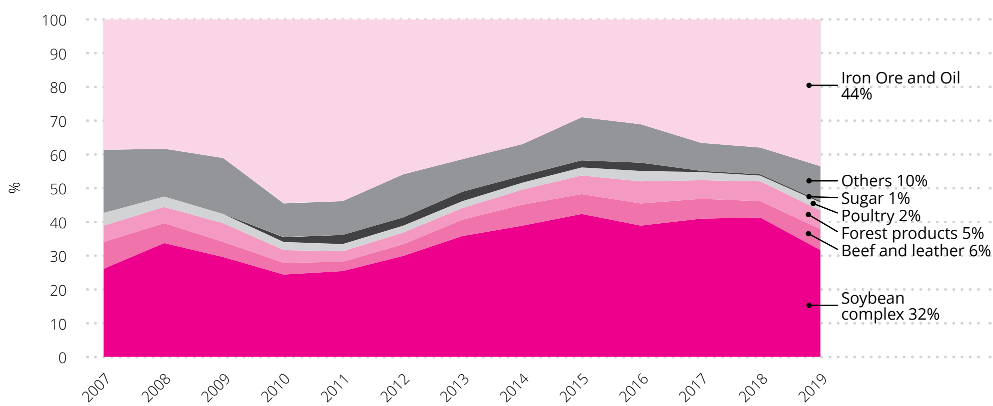


Source: Data from MDIC (2019) e Agrostat/Mapa (2019).

Analysis of the product profile of trade between Brazil and China reveals that in the 1980s and 1990s, Brazil mainly exported manufactured goods, which in the 2000s gradually were substituted by metals, minerals, and food products (Mortatti et al., 2011). These changes reflect the Chinese industrialization and elevated growth rates. Brazilian imports from China also underwent a shift: although manufactured goods already constituted more than 90% in the 1990s, in the mid-2000s, this share surpassed 98% of imports.

Brazilian imports from China are composed of high value-added products, such as machinery, electronics, textiles, chemicals, and other manufactured goods, while trade from Brazil to China is concentrated on iron ore and soybeans (Figure 6).

Figure 6. Composition of Brazilian exports to China. Main categories of products, 2007/2019



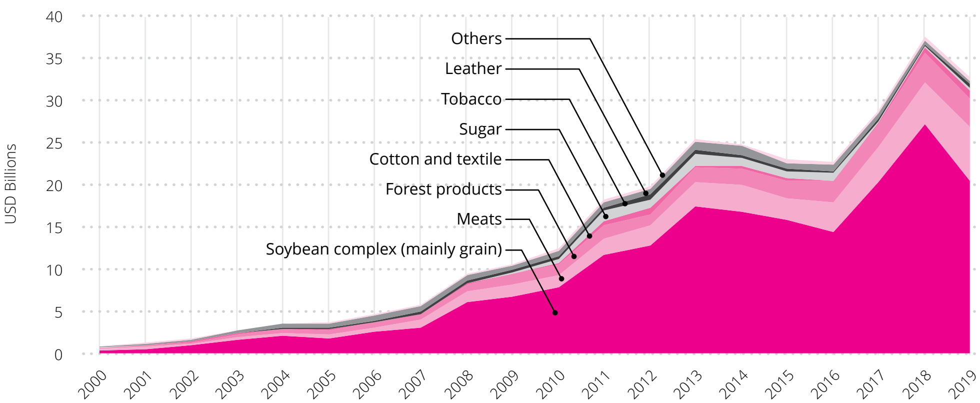
Source: MDIC (2019) and Agrostat/Mapa (2019).

Apart from being Brazil's main trading partner, China is now also the primary foreign destination for the Brazilian agri-food exports (Figure 6). Thus, in 2013, China and Hong Kong, together, surpassed the value of agricultural products imported by the EU, historically Brazil's main buyer within this sector.

Brazilian agri-food exports to Southeast Asia and the Middle East have also undergone a strong increase. In 2018, China and Hong Kong purchased around 37% of Brazilian agricultural exports, which added to the 15% share of the rest of Asia makes this single continent account for more than 50%.

A stratification of the main groups of Brazilian agricultural products exported to China highlights the dependency (and risk) which the reliance on oilseed sales, – and hereunder predominantly soy – constitutes for Brazil. A dramatic growth in soy exports as of 2007 can hereby be observed. In 2019, the soy complex represented 62% of the sector's exports to China, followed by the meat complex, with 19.2%; forest products with 10.7%; cotton with 2.6%; sugar and ethanol with 1.2%; and mixed products, including 3.8% of agricultural origin. Figure 7 shows these exports' evolution by product categories:

Figure 7. Brazilian exports of agricultural and food products to China, 2000/2019



Source: Mapa (2019).

3. Protectionism, trade barriers and agricultural policies

3.1. Tariff barriers

Trade protectionism is widespread globally, affecting agricultural products, minerals, and manufactured items, as well as the service sector. Reasons for this vary: Brazil maintains an elevated tariff structure on manufactured products, while EU countries protect their agricultural markets and foodstuffs. China also applies protectionist measures with food security in mind.

China has drawn much attention for its use of different trade policy instruments, such as tariff quotas, or measures of macroeconomic character. Amongst these are the state's active participation in foreign trade negotiations, through the State Trade Enterprises (STE) and the administered fixed exchange rate policy. The latter implies exchange rate controls, and provides a tool to maintain a depreciated currency (Dadush et al., 2011), which increases the country's competetiveness.

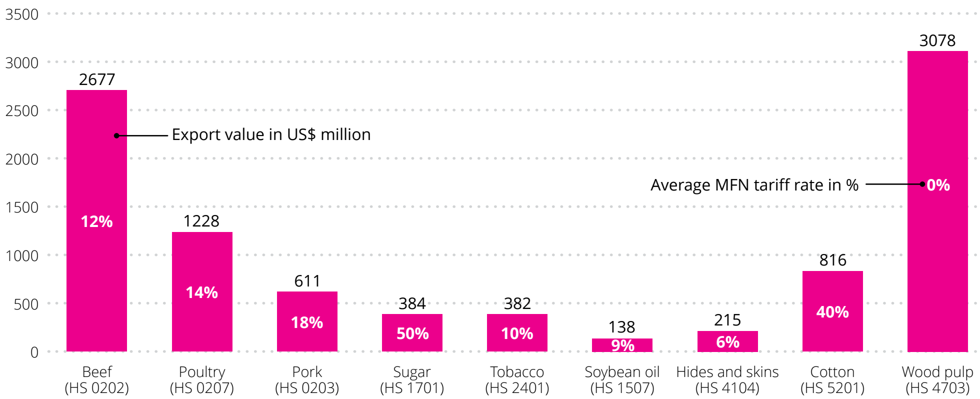
On the bilateral level, Chinese manufactured exports have also faced significant trade barriers in Brazil, mainly in form of elevated tariffs. In relation to China, Latin American countries generally apply technical barriers, customs restrictions, non-automatic import licenses, anti-dumping measures, special safeguards etc. (Moreira et al., 2016, p.3). China has also imposed restrictions on agricultural products from Latin America and the Caribbean; the countries of these regions question the Chinese non-tariff measures, such as tariff quotas, price controls, sanitary and phytosanitary requirements, and the role of state enterprises. Chinese protectionism tends to grow along with the degree of value addition to products (Moreira et al., 2016).

This pattern is illustrated by the tariff escalation on soy products imported by China from Brazil, with rates of 3% for soybeans, 5% for soy meal, and 9% for soy oil, thus clearly discouraging the import of higher value-added products. China has also drawn attention through its imposition of technical requirements on imported products, and due to its growing adoption of agricultural subsidy policies which, due to their potential impact on trade flows, could fall within the amber box.

Apart from soybeans, which at a total value of US$ 20,5 billion in 2019 constituted by far the largest Brazilian agricultural export commodity to China, other products are worthy of consideration. Brazilian animal proteins, wood pulp, and cotton have performed particularly well on the Chinese market. Tariff rates on the main Brazilian agricultural exports vary significantly, from 0% in the case of wood pulp, to as much as 50% on sugar. Yet, as is illustrated in Figure 8 below, average MFN tariff rates for the most relevant products categories can be found in the range of 10-20%.

Moreira et al., (2016) find that tariffs on agricultural products are higher, both in relation to their simple or weighted averages, than those on products

Figure 8. Value and tariff rates on the main Brazilian agricultural export products to China in 2019 (excluding soybeans)



Sources: Authors' elaboration based on data from WTO (2020) and ITC (2020).

from other sectors, reaching tariff peaks of 65%. Furthermore, although the tariffs on manufactured products are relatively low, they do impact trade flows, thus contradicting the logic of Chinese comparative and competitive advantages within this product category. By comparison, medium (simple) tariffs in Latin American and Caribbean countries are more than double those of the OECD countries of 3.6%, with peaks reaching 45%.

The degree of Chinese protection varies depending on whether imports are intermediates, capital or consumer goods, as well as their final destinations. Inputs meant for processing and re-export benefit from duty exemptions, which in 2010 were estimated to amount to some US$ 447 billion (Moreira et al., 2016).

According to Moreira et al., (2016), average applied tariffs on exports destined for the Chinese domestic market are underestimated. In 2014, the Chinese average MFN tariff on consumer goods was 11.1%, double the 4.9%, medium rate on intermediates, and 10 times higher than the 1.1% rate on raw materials.

Production chains of strategic interest to Brazil, like soy and coffee, and to a lesser degree, wood pulp, are negatively affected by the Chinese tariff escalation, as tariff rates on imports gradually increase according to their level of processing, independently of their final use. It is not only agricultural products that face this policy, but also minerals, and particularly iron ore.

Beyond tariff escalation, maize is also impacted by the Chinese tariff quota system (Moreira et al., 2016).

Tariff policies are also affected by preferential and regional trade agreements. Due to the ease of treating tariffs within bilateral or regional negotiations, these are generally the first to be reduced or eliminated when trade agreements are made. In this regard, Brazil stands in an unfavorable situation compared to other developing countries, such as Chile, Mexico, and South Africa, which also export food products.

Brazil has seen only slow progress in the negotiation of bilateral and regional trade agreements, either due to the lack of export culture, or because of the obstacles provided by the Mercosur Common External Tariff (CET). According to this tariff policy, Argentina, Brazil, Paraguay, and Uruguay need to adopt the same trade policy in relation to third countries. China, on the other hand, continues to rapidly expand its extensive network of trade agreements (Box 2).

This situation strongly highlights the importance of measures to formally strengthen the trade and investment relations between Brazil and China, in the direction of a more sustainable future partnership. Comparisons of tariffs for different product categories show that average rates imposed by China on imports from members of trade agreements are lower than those on other countries (Moreira et al., 2016).

Though less important regarding Brazil, China also uses export taxes as a tariff instrument for agricultural market intervention. In 2008, China imposed a 5% tax on exports of maize, rice, soybeans, and a 20% tax on wheat, barley, and oatmeal, although in its agreement of adherence to the WTO in 2001, China had committed itself to the elimination of all fees and taxes on exports (Watson, 2016).

3.2. Non-tariff barriers

Beyond tariffs, agricultural exporters such as Brazil also face non-tariff barriers to the Chinese market. These barriers are both technical, such as those treated within the WTO agreements – the Technical Barriers to Trade (TBT) Agreement and the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS) – but also include other non-tariff obstacles.

Instruments vary from managed trade by the State Trading Enterprises (STE), to systems of price control, or Tariff Rate Quotas (TRQ). Many agricultural products of present and future strategic importance to Brazil are controlled by the STEs. This is the case with grains (wheat, rice, maize), sugar, fertilizers, cotton, and tobacco. Some products are also subjected to tariff quotas. Here, we again find grains (wheat, rice, and maize), sugar, fertilizers, cotton, and wool (Moreira et al., 2016).

The impacts of tariff quotas vary according to how they are administered, mainly with regards to the model for distribution of import licenses. State-owned enterprises generally control some quotas and leave the rest for the non-state companies (Moreira et al., 2016). A problem with this system is the lack of transparent criteria for distribution of import licenses.

In China, as in the rest of the world, the TRQs are not fully allocated. Analyses of the number of tariff quotas applied by the WTO countries in 2002 thereby conclude that 63% were not fully allocated (Cunha Filho, 2003). Amongst the main reasons for this – which also are evident with regards to China, – are difficulties in administering the quota system and a lack of transparency concerning its function. Table 1 highlights Brazilian products exported to China which are affected by TRQs, according to official documents (Mapa, 2017).

In spite of attempts to liberalize the Chinese agricultural support policies, a series of interventionist measures do nonetheless persist. These include price support schemes, comprising of governmental purchases of certain

Table 1. Tariff regime for agricultural products exported by Brazil and subjected to tariff quotas, price controls and participation of STEs

Product	Quantity (tonnes)	Intra quota tariff – applied to Brazil (%)	Extra quota tariff – applied to Brazil (%)	Administration: STE and price control*
Wheat	9.636.000	1	65	90% of quota allocated to STE (COFCO) in 2014 and minimum procurement scheme
Maize	7.200.000	1	65	60% allocated to COFCO and reserves set at market prices
Sugar (raw and white)	1.945.000	15	50	70% allocated to COFCO and other STEs; temporary price program
Cotton	894.000	1	40	33% allocated to STEs and temporary price program

Source: WTO (2015), apud Mapa (2017).
*Data for 2014, according to Moreira et al. (2016).

products when market prices fall below a certain price band. The government can also discourage imports by keeping domestic prices below international ones. Price controls are maintained not only through direct governmental intervention, but also by local governments (Moreira et al., 2016).

While these programs are intended to provide security for farmers by stabilizing prices of certain crops, they might also wield indirect effects on potential foreign suppliers. Analyses of the effects of these price support programs on rice and corn indicate that they do have a stabilizing effect on rice, but also highlight a price enhancing impact on corn, without this same stabilizing effect, suggesting some distortive outcomes (Li & Chavas, 2018).

Food security concerns have also made China adopt price support policies in relation to soybean production. Recent estimates of these policies point to a stabilizing effect on both domestic and world market soy prices, obtained at the cost of a welfare loss amongst Chinese consumers and increased domestic budgetary expenses. A net welfare gain is nonetheless detected amongst global soybean exporters, as support policies raise domestic prices and spur imports (Wang & Wei, 2019). Thus, while this specific interventionist policy measure does not appear to harm Brazilian soy exporters, the fiscal burden which it constitutes might lead future Chinese policy makers to reconsider it.

Cotton is one of the sectors that have been most impacted by price controls. The establishment of a program for minimum purchase prices in 2011 led to a surge in imports and reduced domestic prices, thus widening the gap in relation to higher world market prices. This program benefitted some exporters, such as Brazil and Mexico, until the government began to auction its cotton stocks in 2014, which reversed this trend.

Apart from tariff quotas, and from control by STEs, sugar is also subjected to price intervention. Local utility plants acquire sugarcane at a centrally determined price, although the specific level varies between provinces. Since 2011, the domestic sugar prices have been kept above the international level. Despite the punitive extra tariff quotas, a growth in demand and a price gap have elevated imports. In response, the government released stocks and adopted a policy of directly subsidizing cane producers, instead of pursuing price intervention.

Beyond the importance of these policies of sectoral protectionism through non-tariff barriers, the future trend appears to be that non-tariff barriers will gain relevance relative to other protectionist instruments, as is already the case in Europe and other developed countries.

Technical, sanitary, phytosanitary, and more recently, environmental standards are increasingly shaping trade negotiations and agricultural commerce. These standards relate to requirements regarding production systems, and the intrinsic and extrinsic characteristics of products and their packing. Issues concerning product processing, crop management, disease and pest transmission risks, pesticide contamination, labeling, types of packing, environmental and social standards, the intensity of inputs use, and pollution generated in production and consumption may thereby constitute potential barriers to market access.

Thus, this type of trade barrier tends to be more complex than tariff barriers and other non-tariff barriers, such as quotas and price controls, as it relates to sensible issues for consumers, like their health, animal welfare, or the environment. The complexity of these measures also extends to their scientific basis, discussions about their legitimacy, and the assessment of their impacts (Miranda and Barros, 2009). Even when countries are strongly engaged in the negotiation of free trade areas, the technical, technological, and cultural challenges might prove to be so great that they result in a significant slowdown of market access beyond the period agreed upon for the reduction of tariff barriers.

Although complaints about technical and sanitary barriers on behalf of agricultural exporters from Brazil and other countries have most frequently been directed towards importers in the EU, USA, Japan, and other developed countries, such restrictions have also become evident in relation to developing countries. Yet, the dissemination of this type of trade obstacle should be expected, considering that a significant share of global food trade currently occurs between subsidiaries and headquarters of large transnational retailers, which in general are at the forefront in demanding technical standards of the products which they distribute.

Technical and sanitary issues, mainly concerning food products, have already led to disputes between Brazil and China. In April 2004[3], China blocked a shipment of Brazilian soy because it contained grains treated with fungicides,

[3] Available at: https://jornalcana.com.br/ministro-considera-possivel-reverter-decisao-da-china-sobre-soja/.

which again occurred in 2008[4]. In 2007, China prohibited the entry of Brazilian beef, as it did not, at that time, recognize the differentiated status of Brazilian states concerning foot-and-mouth disease (Moreira et al., 2008)[5]. In 2012, China once again imposed an embargo on Brazilian beef, alleging suspicions of Bovine Spongiform Encephalopathy (BSE) in the state of Paraná, which eventually was identified as an atypical case. Beef products have also been targeted for additional inspections by China, due to the United States' ban on Brazilian products, because of the detection of abscess (Estadão, 2017)[6].

The beef and pork sectors have been most heavily affected by sanitary, and more recently, environmental requirements. Just like other countries, – with special emphasis on those that enjoy the status of being considered as free from foot-and-mouth disease without vaccine (USA, Canada, Australia, New Zealand, Japan, South Korea, Chile) – China also imposes restrictions on the purchase of beef and pork, under allegations related to the status of the disease. Figure 9 shows the significance of a differentiated sanitary status for gaining market access within major meat importers.

In recent years, technical, sanitary, and bureaucratic questions have meant that sales to China have been interrupted due to sanitary disputes, in spite of the approval of slaughterhouses for exports of pork and beef. Based on interviews with Latin American exporters, Moreira et al., (2016) identify how most of the technical difficulties concerning market access in China relate to SPS rules, due to the lack of clarity and protracted periods for producers to obtain certification. A regulatory milestone highlighted by the authors is the Law on the Entry and Exit of Animals and Plant Quarantine. The law determines the mode of official inspections and approves imports, including the farms and industrial facilities from which they originate. This regulatory tool also establishes the quarantines and restrictions in case of diseases, and is enforced by the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ).

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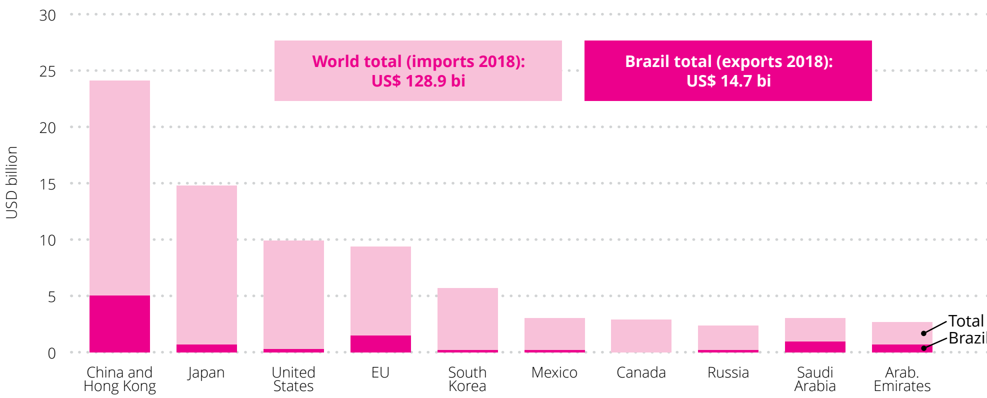
[4] Available at: https://exame.abril.com.br/economia/china-rejeita-novo-carregamento-de-soja-brasileiro-m0065341/.

[5] Available at: https://aberto.univem.edu.br/bitstream/handle/11077/475/Pr%C3%A1ticas%20Ilegais%20de%20Com%C3%A9rcio%20entre%20Brasil%20e%20China.pdf?sequence=1&isAllowed=y.

[6] Available at: https://economia.estadao.com.br/noticias/geral,china-intensifica-inspecoes-de-carne-brasileira-apos-a-proibicao-dos-eua,70001876283.

Figure 9. The top 10 world importers of meat* and the Brazilian market-share in 2018



Source: USDA (2019).
*Note: Meats refer to cattle, pigs, poultry and caprine.

Another important regulatory point of reference is the Regulations on the Administration of Agricultural Genetically Modified Organisms Safety, which controls the imports of foodstuffs produced with, or containing, genetically modified organisms (GMOs). These products need to obtain a technical certification from the AQSIQ, which is specified by the Ministry of Agriculture. The lack of transparency in the processes of approval of the plants certified to export, and of the producers of GMOs, have proven to be more restrictive than the international requirements. The principal products affected, such as meats, soy, and maize are all of major interest to the Brazilian export sector (Moreira et al., 2016).

According to Mapa (2017), the sanitary and phytosanitary negotiations between the two countries have intensified year by year, recently resulting in some specific certification agreements. Negotiations are on course for the establishment of bilateral protocols for beef, pork and poultry, tobacco, maize, and pet food. Brazil also negotiates changing the mode of certification of the entities exporting to China, seeking a pre-listing of producers of pork, poultry and beef. Protocols for export of processed meats are also under negotiation.

Table 2 summarizes trade policies applied to some of the main agri-food exports from Brazil, divided by the level of market restrictiveness they are supposed to cause.

Table 2. Degree of commercial openness of the Chinese market for selected commodities exported by Brazil

Market access restrictions	Product	Tariff
Low	Soybean grains	3%
	Wood pulp	Free
	Coffee	8%
	Cotton	15%
Medium-high	Beef	20-25% and plant approvals
	Poultry	0-20% and plant approvals
	Pork	12-20% and plant approvals
	Sugar	50% to 95% (safeguard)
	Maize	54% and tariff rate quotas
Very high	Wheat	65% and tariff rate quotas
	Rice	65% and tariff rate quotas
	Ethanol	35%
	Offals	12-25% and plant approvals

Source: Authors' elaboration based on ITC (2019) and Comtrade (2019).

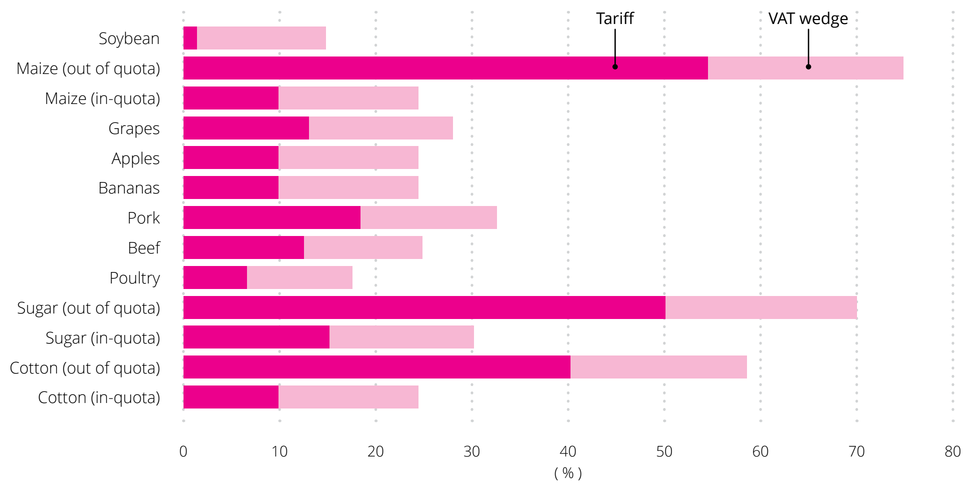
3.3. Agricultural policy

Agricultural protectionism consists of more than import taxes and tariff barriers. In general, agricultural and industrial policies can also involve discriminatory effects, differences between domestic and international prices, and either directly or indirectly make domestic producers more competitive vis-à-vis their foreign counterparts.

Discriminatory taxation between Chinese agricultural products and similar imports provides an example of a policy which illustrates how the effective protection of agricultural producers reaches beyond tariffs. Such discrimination has occurred in China since the late 1990s, when the government conferred exemption on the value-added tax (VAT) to rural producers, including a 13% tax on sales of its products to wholesalers (Moreira et al., 2016).

This exemption was not extended to imported products, despite the orientations of the WTO, and therefore a VAT wedge above the level of protectionism is added in favor of local products according to their level of processing. Contrary to the tariff escalation, the impact of the difference between the VAT is larger relative to the products with a lower value-added, than on products with a higher level of processing or longer value chains. Products such as grains and soy face a 13% discrimination, while meats and dairy products suffer a smaller impact (see Figure 10). This policy is considered by the WTO as a subsidy.

Figure 10. Import tariffs and VAT wedge, China



Source: Extracted from Moreira et al. (2016).

The Organization for Economic Co-operation and Development (OECD) has listed 24 programs in effect in China, from payments based on the use of inputs, to payments based on area, herd, or income, which in 2014 were estimated to total some US$ 54,2 billion. When computed together with the difference in taxation due to the VAT exemption of local agricultural producers, these agricultural subsidies constitute a concern regarding the Chinese agreement of accession to the WTO. According to this agreement, China should maintain the agricultural subsidies of the amber box below 8.5% of the production value (Moreira et al., 2016).

Comparing the average of the triennium 1995/1997 with that from 2014/2016, the Chinese support to rural producers as a percentage of their gross agricultural income originating from governmental support policies, – the Producer Subsidy Equivalent (PSE) – increased from 3% to 15%, approximating the OECD average. Providing an even clearer illustration of this protectionism is the share of this support which is considered as the potentially most market distorting – subsidies linked to the volume produced and to the variation in inputs. During the period in question, this level increased from 64% to 74% of total PSE (OECD, 2017).

For the purpose of comparison, the Brazilian average PSE evolved from negative 14% from 1995/1997, to 4% of gross rural income from 2014/2016. This shows how Brazil changed its policy of net taxation of the agricultural sector to a policy of support, when measured as share of the gross income. In the triennium from 2014/2016, the average share of subsidies considered as most distortive to trade was the 37% of total PSE in Brazil. These subsidies are mainly a result of Market Price Support (MPS) instruments and deficiency payments.

Table 3 compares OECD indicators from four large global players, with regards to their agricultural support profiles in 2016. The Chinese Total Support Estimate (TSE) and PSE were much superior to those of Brazil and the USA, albeit this level still stands below that of the EU. Furthermore, despite a significant rural exodus in China, the share of the population occupied within agriculture is more than double that of Brazil, and eight times higher than in the EU.

Table 3. OECD economic indicators for major trade players (2018)

Description of indicator	Values (2016)			
	Brazil	China	USA	EU
Producer Support Estimate (PSE)	1.5% of Gross Farmer Revenue (GFR)	14.3% of GFR	12.2% of GFR	20.3% of GFR
Agriculture in GDP	4.4%	7.2 %	0.9%	1.5%
Agricultural employment	14.3% (2014)	31.4% (2013)	1.6%	4.4%
Producer protection (ratio)	1.01	1.11	1.07	1.05

Source: OECD (2019).

In sum, although China committed itself to the eventual reduction of the protection of its domestic market with the country's accession to the WTO, tariff policies remain in effect, and the non-tariff barriers are becoming increasingly visible in the trade between Brazil and China. Furthermore, the country has elevated its level of subsidies of certain agricultural products.

Adding to the complexity of future negotiations is the fact that China also adopts a system of administered trade by state-owned companies, apart from intervention measures directed at domestic prices, which also might be defined by provinces. Thus, through its developmental policy of ensuring food security for its growing urban population, China applies protectionist measures in order to guarantee the supply of raw materials, thereby stimulating domestic market supply with local products that often are based on imported raw materials.

4. Strategies for the pursuit of sustainable trade relations between Brazil and China

Although agricultural products might have seen a significant decline in import tariffs since China's accession to the WTO, and despite the stabilization of its subsidies, the difference between domestic and international prices increased exponentially from 2008, which points to other forms of governmental intervention. In 2014, this price gap was 24% and the average tariff 9.2%. Products such as beef, pork, and poultry are amongst the most impacted, with price gaps much above their import tariffs (Moreira et al., 2016).

As a large food exporter, it should also concern Brazil that the average Chinese Specific Commodity Transfers[7] (SCTs), between 2014 and 2016 and mainly through Market Price Support (MPS), were nearly 50% for sugar and close to 40% for milk, rapeseed and wheat. Close to the level of 30% are important products within the Brazilian export composition such as soy and maize. Rice can be found slightly above 30%, while cotton reaches a level above 40% of SCT, and as is the case with soy, payments based on volumes produced have grown in recent years.

Analyzing OECD indexes of commercial impact as a percentage of farmers' gross income, it is possible to perceive how the impact of Chinese agricultural policies rises from 5% in 1995/1997, to more than 10% at

[7] Specific Commodity Transfers are measured by the OECD in the percentage of the gross rural income for each product.

present. This surpass even the OECD average, and runs counter to the global trend.

Food security is an essential issue for both China and Brazil, considering these countries' large populations, and the fact that a significant share subsists with a very low income per capita, subjected to nutritional risks. In Brazil, the agri-food sector has undergone a strong reduction in rural employment, the advancement of economies of scale, and profound technological advances which continue into the digital era. The sector's development has positioned it as one of the most competitive in Brazil, and an important source of external revenues.

In China, although a substantial part of the population is still employed within agricultural activities, the process of rural migration continues in parallel to the advancement of the digital economy. The government conducts planned interventions within the sector, in order to guarantee food supplies. This is both reflected in the increasing variety of domestic vis-à-vis international production, but also in Chinese foreign investment policies in land and natural resource-endowed countries, such as in Africa (Watson, 2016, p.121).

Despite its dependence on food imports, China is also one of the world's largest producers of soy, rice, cotton, pork, chicken, citrus fruits, and legumes. The planning of the food supply system also involves partnerships with large multinational retailers with operations in China. These companies contribute to the organization of production and domestic supply, and to strengthening China's role as an import and export hub for foodstuffs within the global retail network.

Alston and Pardey (2014) conduct an interesting comparative analysis of the evolution of global agriculture. The authors demonstrate how the Chinese increases in productivity growth for labor and land within agriculture has affected the sector's general global performance. Hence, while the annual growth rate in land productivity for 184 countries was around 2.22% from 1990/2011, the Chinese growth rate was around 4% per year, meaning that if the global growth rate is calculated with China excluded, this would be reduced to around 1.78%. Regarding labor productivity, these rates were estimated, respectively, at around 1.71%, 4.13%, and 0.92% annually.

Agricultural research has expanded significantly within large middle-income countries, such as Brazil, India, and China, which together generated

31.1% of public agricultural research globally, contributing to the reduction in global food prices. Although the relative weight of agriculture within their economies has declined recently, these countries hold great responsibility with respect to the future of global poverty and hunger. They are encharged with protecting the poor and vulnerable from shocks in food prices. Brazil, India and China will therefore play an important global role in the coming 50 years, in the same way as the high-income countries did during the previous 50 years (Alston and Pardey, 2014).

One of Brazil's main challenges in its relationship with China is to ensure the development and strengthening of other niches of agricultural and industrialized products, in order to reduce the export dependence on soy and iron ore. There are many opportunities for technological development, like the incorporation of digital resources within agricultural production systems and joint investments in infrastructure, like port terminals and railways.

The recent trade agreement signed between the United States and China has generated insecurity for these countries' other trading partners. Considering the supply of US agricultural products which could substitute Brazilian exports to China, potential consequences of this situation should be discussed. Box 1 sums up some of the expectations related to this issue in Brazil. The main preoccupation is that in the same way as the trade war produced substantial and immediate gains for Brazilian exports, a trade agreement between the USA and China will lead to significant losses for Brazilian exporters.

It is important to reflect on the possibilities for diversification and differentiation of the products within the composition of exports to China. This process, which relates to the trade opening, and to the consumption patterns within modern society, can generate commercial opportunities involving higher value-added products. Notwithstanding the growth in Chinese fruit production, Brazilian exporters of these products could benefit from the expansion of the Chinese consumer market. The growing exports of meats demonstrate that issues concerning logistics and market access, despite the limits that they pose for international competitiveness, are gradually being managed; a trend which also benefits fruit exporters. In spite of the tariff and non-tariff barriers to which meat products are subjected, and in spite of the stiff competition within international markets, attractive possibilities for new investments still exist. With the internationalization of the Brazilian animal protein sector (beef, pork and poultry), certain difficulties, such as understanding culturally different consumer preferences, are also being mitigated.

The terrible African Swine Fever virus (ASF) in China has created a temporary opportunity for Brazil, but what is ultimately important is to make use of the country's comparative advantages in the production of animal protein. These advantages derive from the comparatively cheap inputs for beef production, such as fodder, thereby lowering the price of each ton of animal protein produced.

Regarding beef, estimates from the OECD data bank from 2018 show that while the average global per capita consumption of beef is nearly 6,4 kg annually, in China, this number is around 4 kg. In Brazil and the USA, the consumption is close to 25 kg, while in the EU, the average surpasses 10 kg. Future increases in Chinese demand for beef, and other kinds of animal protein, are thereby likely to be partially met by Brazilian producers, especially if common sanitary, phytosanitary, and environmental standards can be agreed upon.

Dairy products and fish are also sectors which might advance in the trade relations with China. This would require a process of definition and planning of specific commercial instruments. Although Brazil traditionally has not been very competitive within these sectors, there have been significant advances, and today these production chains aim towards foreign market opportunities. Just like fruits, dairy products permit a differentiation and diversification of exports, by constituting niches that, in spite of not containing the same benefits in form of economies of scale such as the soy trade, might benefit from value added gains and consumer preferences.

As these new markets are opened, it becomes of high strategic importance to broaden the trade agreements, and to confront the difficulties which Brazil faces in the harmonization of its interests with those of its Mercosur partners. Advances in trade liberalization are tied to block-type negotiations, which restrict the scope for independent initiative by Brazil in the establishment of new trade agreements.

Considering that negotiations always involve a trade-off, in order for Brazil to obtain larger trade gains, it needs to advance in the discussions about service sector liberalization. Brazil will also have to define innovative instruments in order to capture and sustainably benefit from foreign direct investment, mainly from China. China is already the country with the largest

Foreign Direct Investment (FDI) amongst developing states, and Brazil has been relatively passive in terms of attracting these investments, mainly within the agri-food sector.

Energy production is another interesting sector which confers competitiveness to other economic sectors through cost reductions. With a relatively renewable energy matrix through its widespread use of hydroelectricity, Brazil also possesses an important asset in its sugarcane/ethanol producing sector, which has become increasingly dynamic through the development of second-generation biofuels. China, in turn, has become one of the largest global exporters of solar technology production, highlighting the potential for partnerships (Paixão & Miranda, 2018).

5. Final considerations

Diversifying partnerships and reducing the dependence on a concentrated group of exports should be permanent features of the Brazilian public-private strategy. This could indeed take place in parallel to the promotion of trade relations with China, as other products find space within the Brazilian exports to this country. This is the case for non-traditional goods such as dairy products, for example, which might occupy niches within the Chinese market. Independently of the sectors which stand to gain through either trade or direct investment, Brazil and Mercosur will need to advance quickly in the establishment of trade agreements with China.

China's strong growth in recent decades is slowing, which in the medium or long term will affect suppliers of raw materials and foodstuffs to this country. While growth in Europe and countries in North America and Japan made these markets more attractive for exporters, their consolidation also resulted in a spike in competition, with the intensification of negotiations of preferential agreements, implying tariff reductions and the search for equivalence in technical and sanitary standards. This situation will likely also characterize trade relations with China in the coming decades. The consolidation of trade relations might thereby form the basis for a more sustainable partnership when Chinese growth stabilizes at more modest levels and trade policies become just as important for gaining market access to China, as they currently are in developed countries.

It is therefore relevant to paraphrase Mortatti et al., (2011) when they affirm that "Sino-Brazilian trade relations are, inevitably, inserted within the context of global changes, implying common objectives in the pursuit of economic and development projects (...) as both are likely to implement political formula meant to confront the present reality with point of departure in the situation which defines them: two authentic pan-regions in territorial terms, bound to seek development in order to reach more elevated levels of affluence".

Yet, as Moreira et al., (2016) underscore, it is not likely that China would resume two-digit growth rates, as the country faces diminishing returns. As its capital stocks grow, and the productivity gains associated with the movement of labor towards higher value-added activities becomes exhausted, returns on investments tend to fall, just like economic growth. More modest growth rates, and the increase in the service sector as part of GDP, thereby leads to less dynamic demand for commodities. Competition on quality and price could therefore lead to increasing sustainability in the trade relations between Brazil and China in coming decades.

Typical Brazilian bottlenecks in foreign markets, such as logistics costs, both internal and in maritime shipping, are gradually being managed. A relatively unexplored strategic question relates to the fact that other Asian countries also increasingly consume Brazilian exports, which might lead to lower freight expenditures and thereby favor Brazilian regional transactions.

Yet, in the coming years, China might impose more obstacles, and more disputes will likely emerge related to technical requirements, sanitary/phytosanitary standards, food safety and environmental protection, as can be seen in trade relations with developed countries. Furthermore, the growth in Southeast Asia, and the consolidation of large corporations, which means that a substantial share of transactions occurs between subsidiaries and headquarters, also become important within this future scenario.

Brazil advances in the certification of its products and in the modernization of its sanitary and technical system, but the lack of global harmonization of these norms could lead to costly obstacles for Brazilian companies. Once again, important to the definition of future strategies to strengthen the Sino-Brazilian trade, is the need for flexible and broad negotiations of agreements between the two countries, which would minimize the effects of future shocks to bilateral transactions.

BOX 1

Impact of the USA-China trade agreement in the Brazilian agri-food sector

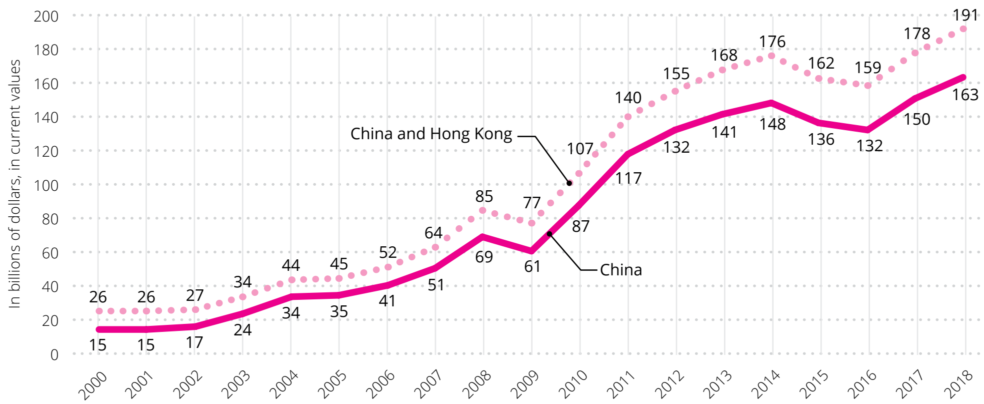
On the 15th of January, 2020, China and the United States (USA) signed the Phase 1 of a broad agreement, which is meant to attenuate the trade conflict which has marked their relations since Donald Trump's inauguration in 2017.

The Brazilian agri-food sector's international trade, which had benefitted strongly from the "trade war", will likely be affected, considering the value of the planned Chinese purchases of North American agro-industrial products in the first phase. This purchase is expected to grow US$ 32 billion in two years, added to the value of the pre-trade-war imports, of approximately US$ 24 billion, with 12,5 billion the first year and 19,5 billion the second year (USTR, 2020). As China is the main destination for Brazilian agri-food exports, accounting for 32% of their total value in 2019, this development should be thoroughly studied, considering the direct impacts which are likely to affect Brazilian trade in the coming years.

As can be observed in Figures 1 and 2, the Chinese demand for Brazilian products grew strongly between 2016 and 2018, while the imported value of North American origin presented a significant decline in the same period. Between 2017 and 2018, this reduction was more than 10 billion dollars, according to the USDA (2019). This is a result of the discriminatory tariffs applied by China on agri-food products from the USA, in response to similar measures adopted by that country against machinery, electronic products, and other Chinese manufactured goods. Consequently, large opportunities to enter the Chinese market presented themselves to other agricultural exporters, such as Brazil, leading to a substantial growth in shipments to this Asian country, which during this period rose with around US$ 9 billion (Figure 2).

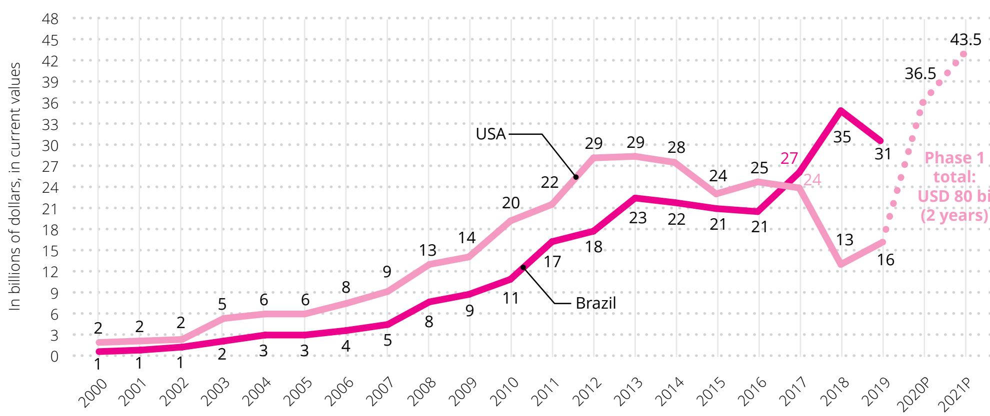
The Brazilian share of the Chinese market for agri-food products has increased since 2017, reaching 19% in 2018 (Figure 3), a value which is based on the growth of products such as soybeans, beef, pork, chicken and cotton (Figure 4). Concerning soybeans and cotton, – but mainly the former – it

Figure 1. Total imports of agri-food products from China, and China and Hong Kong



Source: Authors' elaboration, on basis of USDA (2019) and Comtrade (2019).

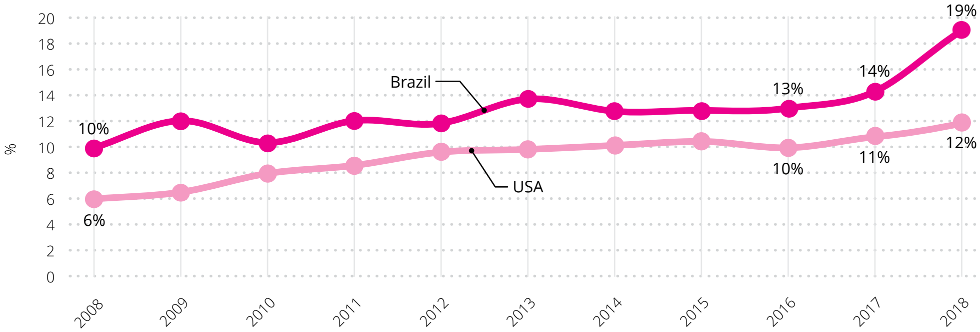
Figure 2. Total exports of agri-food products[8] to China from the United States and Brazil and projections of the phase 1 of the agreement



Source: Authors' elaboration, based on USDA (2019) and Mapa (2019).

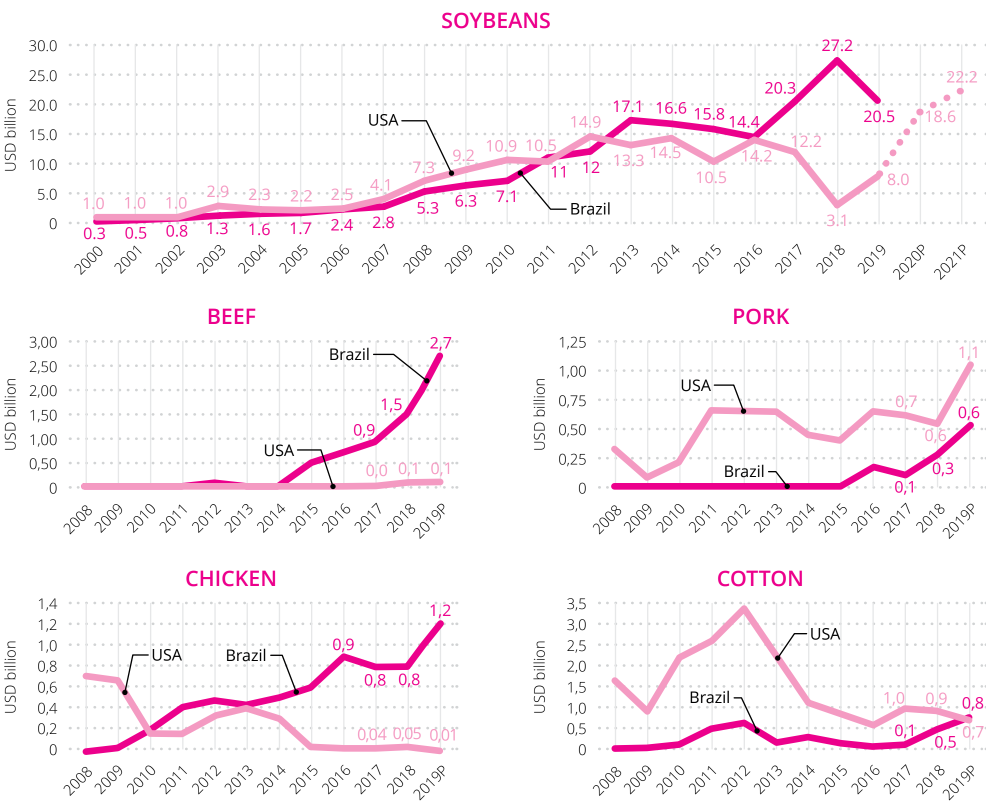
[8] The definition of "agribusiness or agri-food products" used for data presented in this study follows the US Department of Agriculture – USDA definition of Agricultural & Related Products. Further detailing can be found at: https://apps.fas.usda.gov/gats/AgriculturalProducts.aspx. Accessed on December 18th. 2019.

Figure 3. Participation of Brazilian imports in the value of total Chinese agri-food imports and the participation of China in total global imports



Source: Authors' elaboration based on USDA (2019).

Figure 4. Evolution of Brazilian and US exports to China, selected products

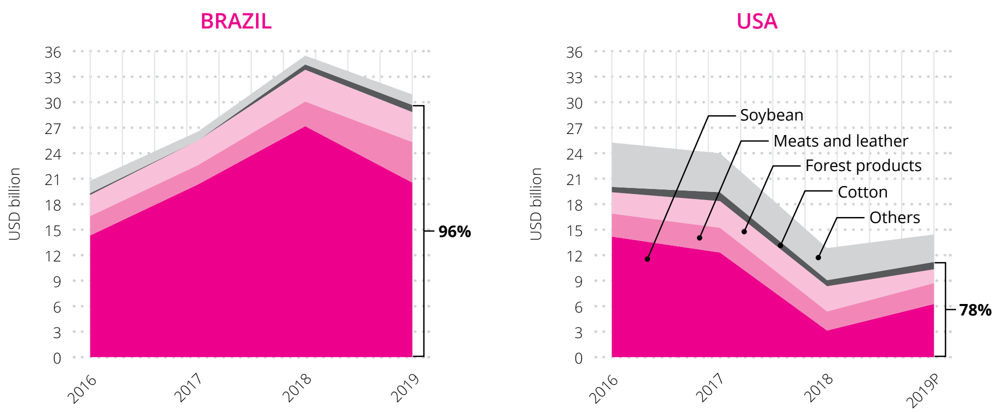


Source: Authors' elaboration based on Mapa (2020) and USDA (2019).
Note: Values for the US during 2019 were projected based on information until November 2019.

becomes evident that in the first part of the trade war, Brazil benefited from the market share that was made available by the over taxation of American products. Concerning meats, it is important to consider the significance of the African Swine Fever (ASF), which diminished the Chinese swine stock, and spurred protein exports to China.

Figure 5 compares the Brazilian and US exports to China in the period of the trade war, by product groups. Apart from the Brazilian gains in market shares, a smaller diversification and the substantial dependence on soy also becomes evident with respect to Brazilian exports. This does not change noticeably during the period.

Figure 5. Value of Brazilian and US exports to China, with aggregation of products, 2016/2019



Source: Authors' elaboration based on Mapa (2019) and USDA (2019).
Note: Values from 2019 for the USA were projected with basis on information until November, 2019.

With the end of the trade conflict, this scenario will likely undergo changes. Yet, it is important to highlight that the materialization of the agreement with the announced values should be viewed with some caution. In order to comply with the intended purchases of US products, China will have to raise its demand to nearly US$ 43,5 billion in 2021, a value which is very distant from the US$ 15,9 billion projected for 2019 (based on USDA data until November). Therefore, it is questionable how this increase will occur within such a short time span.

In 2020, the promised Chinese purchases planned in phase 1 indicate that the value of the shipments from the US to China should reach a level of US$ 36,5 billion (in current values). The likely growth in Chinese imports of protein due to the African Swine Fever crisis faced by the country, as highlighted by the USDA (2020), should be considered in this regard. Until the signature of the agreement, the US faced non-tariff barriers, such as difficulties in certifying slaughterhouses, which resulted in low levels of exports to China. Yet, the facilitation of this process for the USA is inscribed in the document for Phase 1 of the agreement, implying a higher degree of flexibility in the certification of processing plants, as well as a less cumbersome and nontransparent execution of these activities (USTR, 2020).

In the case of beef, the agreement stipulates the removal of restrictions for the age of cattle, an expansion of the scope of products, recognition of the US tracing system, and the acceptance of maximum levels of residues of widely used medical drugs within US beef production. For pork, the agreement increases the scope of products certified for export to China, including, for example, offal and processed products. Regarding chicken, the elaboration of a protocol for the regionalization of diseases is being considered. That would guarantee that future interruptions to trade would be minimal, and based on internationally accepted practices, like the international trade standards of the World Organization for Animal Health (OIE). Together, these measures will likely heighten competition in the meat market recently conquered by Brazil.

For grains, a return of the complementary relation between soybean exports of the Northern and Southern hemispheres can be expected, meaning that a loss of at least part of the Chinese market share which Brazil has obtained in recent years to the US, appears to be inevitable (Figure 4). A higher degree of competitiveness will also characterize the cotton market, thus pressing Brazilian shipments to China.

In sum, in order to attend to the expectations of initial purchases from the US, it is estimated that Brazil might lose around US$ 10 billion in agri-food exports to the Chinese market. Yet, it is important to point out that North American production will have difficulty meeting the growing Chinese demand with immediate effect, (and this would probably not cover the levels of production stipulated in the agreements within the 2-year time period). It is thereby expected that the US will face clear difficulties in terms of meeting these initial values.

On the Chinese side, in order to augment purchases with US$ 32 billion in two years, two parallel measures would become necessary: 1) the opening of new import markets (in relation to products); and 2) discrimination of countries.

In the first case, China will facilitate access or open its market for a wider variety of products, as already is expected with regards to meat products in the agreement, with the possibility of extending this to maize, rice, wheat, ethanol, and others. This could benefit the USA, but also other agricultural exporters, such as Brazil.

In the second case, current suppliers to the Chinese market would lose out due to the resumption of imports from the USA. This possibility is especially worrisome for Brazil, considering the large Chinese participation in total Brazilian exports (32% in 2019). For the USA, these developments related to the trade war with China are less relevant, given the higher degree of trade diversification and lower dependency on China (7.3% in 2018) (Mapa, 2020; USDA, 2019).

Nonetheless, whatever the final emphasis on these two measures (or a combination of the two), a growth in the value imported by the USA in such a short time period will be difficult, given the necessary time for production to respond to the rapid increase in demand.

It still remains to be seen, whether the planned measures in terms of expanding the Chinese imports from the USA will be in accordance with World Trade Organization (WTO) practices, and adhere to existing rules for competitiveness, or whether measures based on managed trade will be pursued, through purchases of North American products by Chinese state-owned companies. In the latter case, China could be brought before this organization due to such privileged trade relations. One example is the sanitary facilitation for US producers inscribed in the agreement which, if restricted only to this country, would violate the article 2.3 of the SPS agreement within the WTO (sanitary and phytosanitary measures), implying the non-discrimination of trade partners under similar conditions. Through this type of market reservation, China could confront sanctions, even in spite of the weakening of the appeal body in recent years.

With this in mind, it is still hard to believe that the announced agreement will be fully complied with, at least in the short time period established. Nonetheless, it is important that Brazil prepares itself for a more competitive environment with a possible loss of market share, due to the high degree of dependence on Brazilian agri-food exports in this situation.

It is also important to consider the possible substitution effect, meaning that Brazilian exports, which previously were destined for China, could be redirected to new markets. However, for this to occur, Brazil needs to; assume a more strategic posture, involving public and private entities; seek possibilities for new trade agreements and long-term relations; reduce logistical bottlenecks; and organize agri-food production chains towards the world market.

BOX 2

The race towards the trade agreements

The difficulty in reaching regional and bilateral trade agreements seems to characterize Latin American countries. Until October 2015, China had signed 13 free trade agreements, negotiating another 7, with only three being signed with Latin American countries: Chile (2005), Peru (2009), and Costa Rica (2011) (Moreira et al., 2016).

Procópio (2014) lists the countries with the most Preferential Trade Agreements in force, as well as those notified to the World Trade Organization, which are shown in Table 1.

In comparison, Brazil and other large players on the international market have negotiated few trade agreements. Apart from its membership of Mercosur, which constitutes a common market with Uruguay, Argentina, and Paraguay, Brazil has signed various agreements with Aladi, and Agreements of Economic Complementarity with different South American countries. Brazil has also signed Free Trade Agreements (FTA) with Israel (2010), Mercosur-Egypt (2010), preferential agreements with India (2009), and with the Southern African Customs Union (Sacu). In 2019, there were some new developments, such as the agreements signed between

Table 1. Countries with most preferential agreements (TPA) in force and notified to the WTO

Countries	TPA in force	TPA notified but not yet into force
USA	14	1
European Union	35	12
China	11	11
India	16	4
Mexico	13	1
Japan	13	4
Singapore	21	3
South Korea	13	3
New Zealand	10	1

Source: WTO, apud Procopio (2014).

Mercosur and the EU in June, and with the European Free Trade Association (EFTA) in August[9].

Yet, in contrast to other regional blocks, even those that only constitute a free trade area, such as Asean, EU and Nafta, the intra-regional trade is not very significant, approximately 15% in 2011. In the three blocks mentioned, the intra-regional trade in 2011 reached 25.3%, 65%, and 48.3%, respectively, according to data from the International Trade Statistics (ITS/WTO).

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Part 6

Promoting sustainability: a challenge for both countries

Chapter 11

Li Gao
Yuquan Chen

China: investing in sustainability to preserve natural resources and prevent natural disasters

Abstract

During the accelerated Chinese development process, land resources have become scarce, as food demand has risen. The current chapter analyses the drivers of this development, as well as the governance challenges related to the sustainable management of cultivated land. An assessment of the hydrographic outlay of the Chinese territory and local water availability issues complements this analysis. Finally, different policy interventions are discussed, and a series of proposals presented which aim at supporting the sustainable management of Chinese land and water resources.

1. Introduction

Although China is the third-largest country in the world in terms of land territory, and in spite of retaining 7% of global freshwater reserves, the country still faces severe soil degeneration and water shortage challenges because of its large population, inappropriate resource utilization, and overwhelming pollution. To overcome these challenges, the Chinese government has issued a series of reliable and efficient policies and regulations to deal with emerging environmental problems, which together provide for an impressive achievement. In this chapter, we discuss the status quo, the challenges, and the Chinese policies and practices to preserve natural resources and promote environmental sustainability. The chapter illustrates the Chinese experience in protecting land and water resources and minimizing the harmful effects of natural disasters though different case studies. These experiences and practices could shed light on better governance of natural resource protection, and explore solutions for global sustainability issues.

2. Land resources

Cultivated land is the most precious resource in China. The quality of cultivated land has a direct impact on the grain output, which determines farmers' income, affects the local economic development, and relates to the national food security. China's cultivated land area is extensive, but because of the large population, the per capita land area is very limited. Hence, China's land situation is not optimistic: since 1958, cultivated land has shown a declining trend. The multiple cropping index of cultivated land has increased overall, but the growth rate is relatively slow, and the regional difference is prominent. The area with rapid economic development is facing pressures from this larger cultivated land area. Examples include:

1. *Development zone planning disorder and relatively low efficiency of land use*. In the process of project investment, due to the relaxation of the project access threshold, some labor-intensive and low-tech projects were allowed, resulting in low investment and output intensity, and low land plot and land use levels.
2. *Ecological damage is serious, and the ecological deficit is worsening*. The ecological deficit is an index used to measure the supply and demand of natural capital and the sustainability of relations between human and earth systems. In recent years, population growth and increases in the use of coal have led to a sharp growth in the per capita ecological footprint, resulting in a rapid environmental deterioration

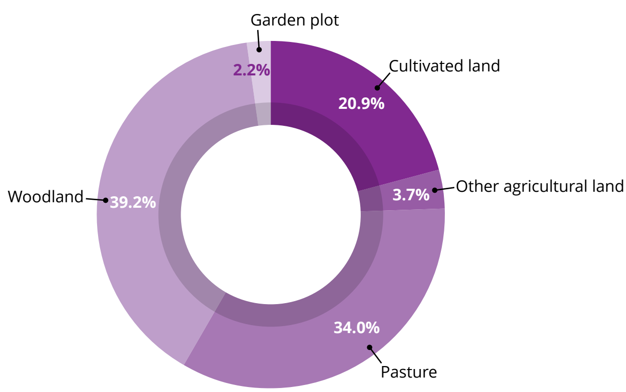
and significant challenges for the sustainable development in China's more economically developed areas.

3. Central characteristics, the current situation, and the main problems of cultivated land resources in China

3.1. Less per capita cultivated land

China is rich in land resources. However, due to the fact that there are more mountains than plains, and due to the country's large population, the per capita cultivated land resources are limited, as shown in Figure 1. In recent years, with the increase of non-agricultural land uses, the cultivated land resources have diminished, and some of the more developed areas fall below FAO's warning line of per capita cultivated land area.

Figure 1. Agricultural land utilization in China in 2016

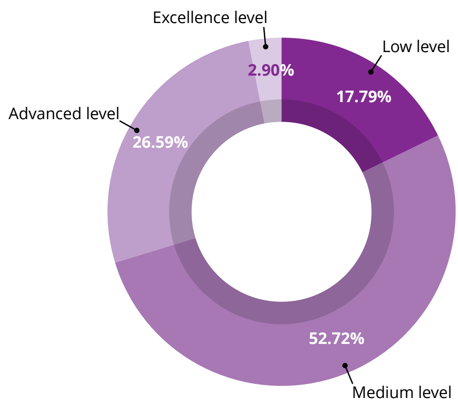


Source: Statistical Bulletin of China's Land, Mineral, and Marine Resources 2017.

3.2. Lack of high-quality cultivated land

In China, cultivated land resources of high quality are very scarce, and the high-yield to low-yield fields ratio has remained about 3:7 for a long time, as shown in Figure 2. In recent years, a large amount of cultivated land has been affected by salinization and desertification due to industrial waste pollution, and therefore there are fewer high-quality land resources.

Figure 2. Quality hierarchy of cultivated land in China in 2016



Source: Statistical Bulletin of China's Land, Mineral, and Marine Resources 2017.

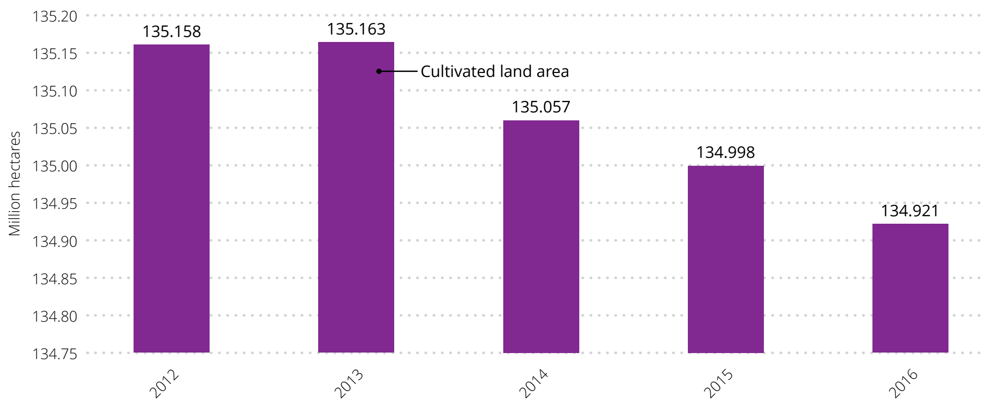
3.3. Decreased cultivated land area

Since the last decade, the total area of cultivated land in China has been decreasing, as shown in Figure 3 and Figure 4. By the end of 2012, there were 135.16 million hectares of cultivated land in China; by the end of 2016, this has decreased to 134.92 million. The main reasons for the decrease in cultivated land in China includes ecological conversion, construction occupation, disaster damage, agricultural structure adjustment, etc. The increase in cultivated land is mainly due to land reclamation and development, and adjustments to the agrarian structure. In recent years, China has strictly controlled the amount of cultivated land occupied by construction, improved the working mechanism of land consolidation and reclamation, and the net reduction rate of cultivated land area has been slowing down.

3.4. Insufficient reserve resources

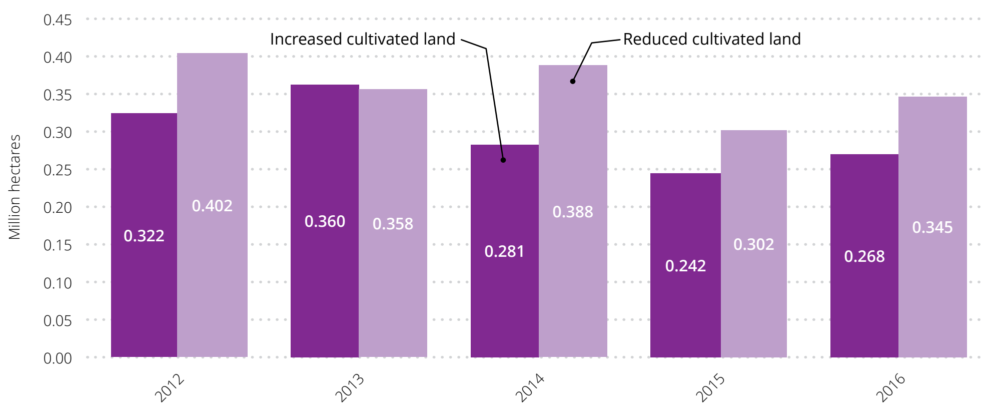
China has a long history of land reclamation. However, the vast majority of high-quality land resources have been developed and utilized.

Figure 3. Changes in cultivated land area in China from 2012 to 2016



Source: Statistical Bulletin of China's Land, Mineral, and Marine Resources 2017.

Figure 4. Changes in cultivated land area in China from 2012 to 2016



Source: Statistical Bulletin of China's Land, Mineral, and Marine Resources 2017.

Furthermore, considering water, light, heat, and other factors, there are only 40% of cultivated land that is suitable for reclamation.

3.5. Serious soil erosion

Due to the acceleration of soil erosion by desertification, China is now one of the countries with the most serious soil erosion in the world. With the expansion of urban construction, urban soil erosion is also increasing. Soil and water loss also causes the loss of organic and mineral matter, which makes the land increasingly barren, and further aggravates the deterioration of land resources.

4. The main challenges of cultivated land resources in China

The proportion of high-quality cultivated land is relatively low, and the distribution is extremely uneven. The average quality of cultivated land in China is generally low, and the medium-sized cultivated land plot accounts for more than half of the total area. The amount of slope farmland is also large. The land is prone to soil erosion, landslides, and other disasters, which lead to the thinning of the arable layer, fertility loss, and other phenomena which greatly affect land quality. If the proportion of paddy fields is too small and the proportion of dry land is too large, it will inevitably reduce the flexibility of land utilization. The proportion of water and soil resources is also unbalanced. If the water content in the soil is too large, flood disasters become more likely. If it is too small, it will lead to drought. The regional distribution of water resources in China is also extremely unbalanced. The highest level of Tibet is 2342 times higher than the lowest level of Tianjin. The content of organic matter, total nitrogen, available phosphorus, and available potassium are all deficient, and the trace elements such as Zn, Cu, Fe, and B are also deficient to some extent.

4.1. The national level

The Chinese government has issued two laws and regulations on the protection of cultivated land, namely, the Land Administration Law of the People’s Republic of China, in 1986, which marked the preliminary system for the protection of land, and the land administration law of the people's Republic of China (Revised) in 1998, which established a significant protection system for land reform and improvement.

In 1986, the CPC Central Committee and the State Council issued *the notice on strengthening land management to stop the occupation of cultivated land*, in order to reduce the abuse of land by township enterprises and rural buildings. In 1998, the State Council issued the regulations on the protection of basic farmland. To meet the demand of future population and national economic development for agricultural products, in 2000 *the circular on strengthening the protection of cultivated land and promoting economic development* was passed in order to adapt to the new situation of land and resource management, and to properly solve the problems of the contradiction between the supply and demand for farmland, and further strengthen land protections and promote economic development. In 2012, the Ministry of Land and Resources passed the *Notice on improving the level of cultivated land protection and strengthening the construction and management of cultivated land quality in an all-round way*. As China's economic development has entered a new normal, the incentive and restraint mechanism is still not perfect, and the protection of cultivated land faces multiple obstacles. In order to further strengthen such protections, and to improve the balance of occupation and compensation, in 2017, the State Council proposed the notice of the *CPC Central Committee and the State Council on strengthening the protection of cultivated land and improving the balance of occupation and compensation (2017)*.

The Ministry of land and resources has prepared the *13th five-year plan outline for land and resources*, which came into effect on April 12, 2016. It contains an outline for national economic and social development of the people's Republic of China and the requirements of building a moderately prosperous society in an all-round way for land and resources management. The outline defines the guiding ideology and main objectives of land and resources for the next five years, and presents a series of major measures and projects to support such development projects.

Some steps have been taken to enhance the prevention and control of land pollution. In order to strengthen the supervision and management of environmental protection and to control the risks of the contaminated land plots, the central government has formulated a series of measures for the recovery of the contaminated land plots.

4.2. The local-level

We select Hubei, Heilongjiang, and Guangdong provinces as examples to illustrate how the protection of land resources in China is implemented at the local government level.

In the Hubei Province, the provincial government has issued successive policies and local laws and regulations[1] and strengthened the implementation of the strictest cultivated land protection system. At the same time, the government constructed relevant indicators to assess results. In the work of farmland delimitation, the location and area of all basic farmland was solidified in accordance with the principle of "first high yield, then low yield, first flat field, then early state-owned land, first suburb, then countryside".

In Heilongjiang province, it was emphasized that the most stringent land conservation system should be implemented along with the most stringent farmland protection system, and that the two systems should be implemented in parallel to form the most stringent land management system. The No. 1 document of the central government issued on February 1, 2009 reiterated the need to stabilize the rural land contract relationship, establish and improve the transfer market for land contract and land use rights, and implement the strictest possible farmland protection system, and the strictest possible land saving system. The government has strengthened the awareness of cultivated land resource protection, put the strictest land conservation system into practice, and enhanced the consciousness and enthusiasm of farmers to cherish and protect land.

In Guangdong province, *the regulations on the administration of basic farmland protection areas*, issued in September 1993, highlighted that the work of basic farmland protection has been subjected to legal management. In January 2002, the Standing Committee of the Provincial People's Congress revised and improved the regulations. In 2004, according to the deployment of the Ministry of Agriculture and the Ministry of Land and Resources, the Guangdong province carried out the inspection of basic farmland protections.

[1] For instance, The opinions on strengthening the rural land improvement work (2011), The opinions on strengthening the protection of cultivated land and constructing a new mechanism for ensuring the leaping development of land use (2012), and The regulations on the quality protection of cultivated land in Hubei Province (2014).

Subsequently, the provincial government issued the *measures for listing and supplementary planning of basic farmland for non-agricultural construction in Guangdong Province* (2007), improving laws and regulations, as well as the mechanism of farmland protection and quality construction. In October 2014, *the measures for the assessment of cultivated land protection responsibility of the people's Government of Guangdong province, and the measures for the assessment of the implementation of the annual land-use plan of the Guangdong Province* were successively issued, which stipulated that the governments at or above the prefecture-level, should be responsible for the amount of cultivated land, and for basic farmland protection within their administrative areas, as determined in the overall land use plan of Guangdong province. The government should increase investments and carry out strict inspection to improve the quality of cultivated land.

4.3. Policy effects

The goal of China's land governance is to increase land supply, enhance land quality, and protect the ecological system. By the end of 2017, China had designated 103 million hectares of permanent basic farmland for special protection, promoted comprehensive land improvement, and built 32 million hectares of high-grade farmland.

1. The total area of cultivated land in China has been slightly reduced, while land quality has been improved. Data from "Statistical Bulletin of China's Land, Mineral, and Marine Resources 2017" shows that from 2012 to 2016, the amount of cultivated land has increased in some areas, but decreased in others. The total amount of cultivated land fluctuated less, remaining above 124 million hectares. This ensures basic self-sufficiency in grain and absolute safety of grain rations. The 2016 national land change survey results show that by controlling the overall implementation of the land and the high standard farmland construction, the cultivated land quantity and quality of management construction occupied 160 thousand hectares of paddy fields and irrigated land in 2016. China has increased paddy fields and irrigated land by 170 thousand hectares through various types of land improvement.

2. Land consolidation and adjustment of agriculture increase the cultivated land area. From 2012 to 2016, a total of 1.47 million hectares of agricultural land was added through land improvement and agricultural structural adjustment, effectively relieving the pressure brought about by construction occupation, disasters, ecological conversion, and agricultural structural adjustment. In 2017, 16,400 land improvement projects were launched and accepted, an increase of 17.1% year on year. From 2012 to 2017, a total of 95,175 land improvement projects were carried out and accepted, with a total construction scale of 14.49 million hectares. These projects not only contributed to the quantity of cultivated land but also improved quality.

4.4. Insufficient utilization of cultivated land resources

1. Urbanization and land pollution. In the face of rising demands for a better life, uncertainties in the global economy, climate change, and other new challenges, the protection of cultivated land faces multiple difficulties, which are reflected in the following four aspects: First, urban construction is still the main reason for the occupation of cultivated land, and the most economically developed areas in China are also the areas of high-quality cultivated land, with a need for the strongest protection. Secondly, the cultivated land resources in China are suffering from pollution. The protection of land resources also faces the tradeoff between food production and the ecological protection by returning cultivated land to forest and grassland. Thirdly, technology application in agricultural production is insufficient. In the United States, the contribution rate of scientific and technological progress to food production is 80%, while in China, it is only about 57.5%.[2] China should continue to increase the contribution ratio of agricultural science and technology in agricultural production.

[2] China agricultural rural science and technology development report (2012/2017), http://data.mofcom.gov.cn/article/zxtj/201809/43969.html.

2. Insufficient soil fertility is one of the characteristics of the Chinese cultivated land. It refers to the low production capacity of the land itself, that is, insufficient soil fertility. Higher soil fertility can support the cultivation of better crops and make the grain yields higher, but the current soil fertility in China is not satisfactory. Relying only on the soil nutrients cannot make the crops achieve a satisfactory yield. The reliance on a large number of chemical fertilizers and pesticides to ensure the yield of agricultural products also results in pollution of the soil and the environment.
3. Internal conflicts within the administrative leadership.
   The administrative system has different goals and interests in land governance. First, the goal of the government is to maximize the interests of the whole of society; the goal of the local government is to maximize the development of the regional economy, and the goal of the farmers is to satisfy their personal interests. Secondly, the central government, as the principal authority, conducts centralized policy planning, while the local government functions as the provider and executor of policies. The rural household, as the protected object, often cannot participate directly in the decision-making of local government affairs, and is in a passive position. Thirdly, there is a lack of coordination. The central government is the macro-policy regulator, while the local government has to make a decision between protecting the agricultural economy and the opportunity cost of the non-agricultural economy, while the farmers make a choice based on their own benefits.

4.5. Policy recommendations

1. Reshaping the concept of farmland protection.
   We will encourage the central government, local governments, and farmers to follow the common interest logic of "Olsen's collective action" in the profit-seeking game. This entails improving coordination between the central government and local governments, defining responsibilities, and forming a system of multiple farmland protection.

2. Improving the supervision and management system.
   In order to effectively manage the cultivated land resources of the whole country, it is necessary to establish a set of intelligent supervision systems. Big data processing can be used to monitor the cultivated land resources in real-time, and it can help to establish an intelligent management platform, develop a terminal application, and provide a channel for data transmission.
3. Strengthening the practical application of agricultural technology.
   We will increase support for the transformation of laboratory agricultural technological progress, as well as the contribution of this factor in agricultural production. It also becomes important to change the traditional agricultural development model of "low cost and pollution" and realize the transformation towards pollution-free agriculture.

Case study 1: Huang-Huai-Hai Plain Land Governance

Background

The Huang-Huai-Hai Plain (3H) of northern China incorporates five provinces (Jiangsu, Anhui, Shandong, Henan, and Hebei) and two municipalities of Beijing and Tianjin. The area encompasses about 387,000 km square, extending from 113 E to the eastern coastline, and from 32 N to 40.5 N.[3] It is a highly important agricultural production area. However, most of the plain is middle or low yield farmland area in China.

Qu Zhou is located on Huang-Huai-Hai plain in the southern part of Hebei Province. It is situated in the Hei Long Gang river basin, which is plagued by drought, flood, alkali, and salt. Therefore, historically, Qu Zhou has been regarded as one of the most impoverished cultivated lands in China, and yield is significantly lower compared with the neighboring area.

[3] Gong, G. (1985), The primary discussion on the range of Huang-Huai-HaiPlain (in Chinese), in The Management and Development of Hong-huai-Hai Plain, edited by Z. Dakang, pp. 1-8, Science, Beijing.

Towards improved land governance

In 1973, in response to the government's call, China Agricultural University set up an Alkali treatment team. The team was composed of leading professors, experts, and researchers in the field of land governance at the time, and has operated in Qi Zhou continuously for almost half a century.

The research team summarizes its three-step strategy:

1. Provide comprehensive agricultural treatment and development that could control and remove natural limiting factors such as salinity, wind, and sand, soil erosion;
2. Promote inclusive agrarian development, such the traditional planting industry, exploring the application to boost production animals, and extending the integrated agricultural and pastoral industry chain;
3. Establish a new model for technology diffusion. The new model is based on the principle of "four zeros" (zero distance, zero-time difference, zero thresholds, and zero cost). In practice, the team also developed the five-step procedure: 1) attracting attention, 2) changing attitude, 3) strengthening knowledge, 4) changing behavior, and 5) optimizing the environment. With the help of large-scale demonstrations, the research team devotes itself to promoting technology diffusion and improve the local farmers planting skills.

Achievements

The 280,000 mu of saline and alkaline land in the northern part of Qu Zhou has been comprehensively treated, and the saline and alkaline flats have been successfully transformed into rice and grain forests. Qu Zhou has become a miracle in the history of China's agricultural development.

Experience from Quzhou, China

The successful experience of soil improvement and alkali treatment in Qu Zhou provides important reference for land management in Brazil: The government should; 1) give full priority to the role of scientific researchers and use science and technology to improve the efficiency of land management; 2) Work with local farmers to find solutions to local needs through field research; 3) issue the corresponding documents and actively promote the development of land management.

5. Water resources

The world's freshwater reserves only account for 2.53% of the earth's water resources. With rapid development, many areas are now severely short of water. Chinese water resources are also facing many problems, which directly relate to China's social and economic development, so protecting water resources is the responsibility and obligation of all residents. This chapter will elaborate on the current situation, major issues, and policies of water resources protection in China.

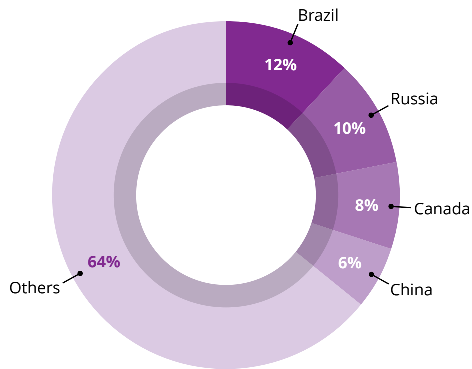
5.1. Characteristics and the current situation

China has a total amount of freshwater resources of 2.8 trillion cubic meters, accounting for 6% of global water resources, ranking fourth in the world after Brazil, Russia, and Canada (Figure 5). Although China covers a large land area, it also has a large population. Hence, the average per capita water availability in China is lower than one-fourth of the world's average, which directly affects agricultural production and irrigation. About 30% of China's farmland is subjected to water shortage. Furthermore, the distribution of water resources is not balanced; for instance, the southern and coastal regions are rich in water resources, while the northwest is scarce.

5.2. The main problems of water resources in China

1. Overexploitation and serious pollution of water resources.
   Due to the search for economic growth, people have over-exploited water resources, causing a series of environmental problems, such as

Figure 5. The proportion of freshwater resources in the world



surface subsidence and seawater intrusion, which has raised concerns about water security and public health. In addition, the soil erosion and pollution of agricultural irrigation, industrial wastewater, and domestic sewage are the main reasons for water pollution.

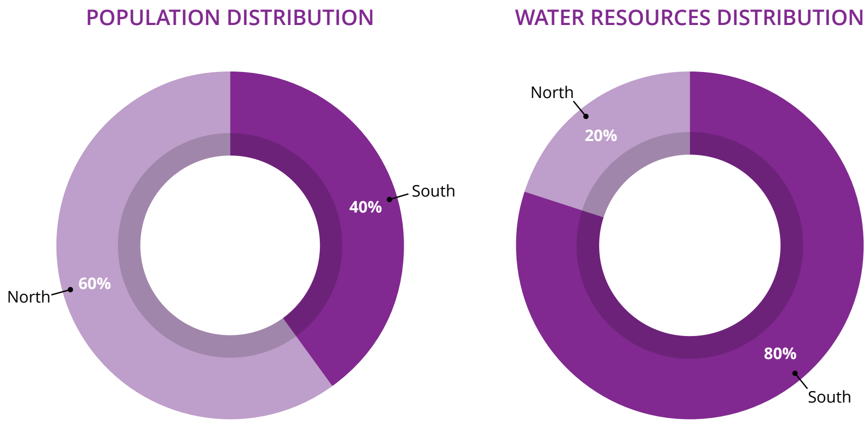
2. Waste of water resources.

The most serious waste of water resources is caused by immature irrigation technology in agriculture. Statistics show that the utilization rate of water resources in China is only about 54.2%, and about half of the water used in farmland irrigation is wasted. At the same time, people's awareness of the need to save water is not well developed, and many habits associated with wasting water can be found everywhere in daily life. The lack of scientific urban drainage planning often leads to the breakdown of the drainage system in severe weather conditions, such as heavy rainfall and typhoons, which result in a large amount of waste of water resources.

3. Unbalanced distribution of water resources.

As is shown in Figure 6, the south of China accounts for about 40% of the total population, but its water resources account for 80% of the total reserve. Although the north is larger than the south, in land area, it accounts for less than 20% of the total water resources. Meanwhile, due to the influence of the monsoon climate, there is a great difference in rainfall between the north and south, with the north experiencing frequent droughts and the south experiencing frequent floods.

Figure 6. Population distribution and water resources distribution in China



6. Policies and measures to protect water resources

In response to the problems mentioned above, China has issued many policies to protect water resources in order to use water in line with the goal of sustainable development of China.

6.1. The national level

At the national level, the Chinese government has issued a package of laws, regulations, and plans to recover the freshwater system, in order to guarantee that the water resources are protected. Firstly, in China there have been a number of laws and regulations for protecting water resources.[4] They are made for the pursuit of rational development, utilization, conservation, and protection of water resources. In addition, they can prevent and control

[4] The water act of the People's Republic of China (PRC); The law of the PRC on the prevention and control of water pollution; The environmental protection law of the PRC; The law of conservation of water and soil of the PRC; The implementation of the Licensing System for water-taking; The implementation regulations of the law of the PRC on water and soil fixation; The regulation on urban water supply; and "Water 10".

water disasters as a part of the sustainable utilization of water resources, thus adapting to the needs of Chinese economic and social development.

Secondly, based on different laws and regulations, administrative rules for the protection of water resources in China are issued.[5] These have been enacted in order to assure the optimal allocation and sustainable use of water resources. In addition, they ensure the rational use of water for construction projects. Moreover, they can control water pollution to protect water quality. Ten plans have been carried out in this regard.[6] These plans aim at the prevention and control of water pollution, water conservation, soil erosion, and water safety.

6.2. The local level

There are seven river basins in China. This section uses the Huai River, the Yellow River, and the Yangtze River as examples and summarizes their water resources protection measures.

1. Measures to protect water resources in the Huai River area.
The Huai River is one of the seven main rivers in China and it currently faces serious water pollution. Therefore, on August 8, 1995, *The Provisional Regulations on Prevention and Control of Water Pollution in the Huai River basin* was promulgated to prevent and control water pollution in the Huai River basin. On May 16, 2012, the Ministry of Environmental

[5] The Administration of the Urban Water Supply Price; Water Resources Argumentation of Construction Project Management Methods; Urban Groundwater Development and Utilization of Protection Regulations; Urban Saving Water Management Regulations; Water Licensing Management Methods; Production and Construction Project Supervision and Management of Soil and Water Conservation Methods; Urban Water Supply Water Quality Management Regulations; Measures for the Supervision and Administration of Water Function Area; The Water Conservancy Engineering Measures for the Management of Water Supply Price; and The National Water Conservation Action Plan, etc.

[6] The National Water Conservation Planning Outline (2001/2010); The National Modern Irrigation Plan; The National Water-saving Irrigation Plan; The National Water Quality Monitoring Plan; The National Development Plan for Water-saving Agriculture in Dry Farming; The National Ground Water Pollution Control Plan (2011/2020); The National Soil and Water Conservation Plan (2015/2030); Key River Basin Water Pollution Prevention Plan (2016/2020); The 13th Five-year Plan for Building a Water-conserving Society; The 13th Five-year Plan for Consolidating and Improving Rural Drinking Water Safety; and The 13th Five-year Plan for the Comprehensive Treatment and Construction of the Water Environment in Key River Basins.

Protection and four other ministries enacted *The Plan for the Prevention and Control of Water Pollution in Key River Basins (2011/2015)*, which includes the protection of the Huai River basin. On June 13, 2017, *The Ministry of Water Resources of the National Development and Reform Commission's Reply on the Water Allocation Planning for the Huai River* was promulgated, calling for the protection of the Huai River's water resources. The specific measures aim to control the sewage discharge and total pollution. These do not only protect drinking water sources and important water areas, but also formulate mechanisms and emergency plans for preventing and controlling water pollution.

2. Measures to protect water resources in the Yellow River area.
The Yellow River is one of the longest rivers in the world and the longest in China, so many policies have been promulgated to protect it. *The Administrative Measures for the Yellow River* estuary has been formulated to manage the Yellow River estuary, which was promulgated on January 1, 2005. It ensures the safety of flood control and prevention, which can also help the economy and society develop in the Yellow River. On July 24, 2006, *The Water Regulation of the Yellow River (2006)* was promulgated, which required that the water supply of the Yellow River should first and foremost meet residents' needs, while the water supply of industry and agriculture should also be arranged in a rational order to achieve the sustainable development of water resources. On January 8, 2020, *the Special Planning for Ecological Protection and High-quality Water Protection Development in the Yellow River Basin* was enacted. It requires the implementation of the idea of "water protection first, spatial balance, systematic governance, and two-handed development" for water control and development. Considering the fragile ecosystem in the Yellow River, the Chinese government has established an administrative bureau at the central level to coordinate and cooperate with different departments in each region.

3. Measures to protect the water resources in the Yangtze River area.
The Yangtze River basin is the third largest river basin in the world, and the largest river in China. Since March 6, 1995, *The Detailed Rules of Yangtze River Water Conservancy Commission Implement Licensing of Water Use* has been implemented. It affords political guarantee for strengthening the unified management of the Yangtze River

basin, saving water and promoting the rational exploitation of water resources. In 2011, *The Detailed Rules of Yangtze River Water Conservancy Commission Implementation Supervision and Management of Sewage Outlets Flow into the Sea* was enacted. It promulgates the measures for supervision and management of sewage outlets in the Yangtze River basin and southwest rivers, which aims to promote sustainable utilization of water resources. On June 16, 2018, the State Council promulgated the bulletin *The Central Committee of the Communist Party of China Opinions of the State Council on Comprehensively Strengthening Ecological and Environmental Protection for Resolutely Launching the Battle of Pollution Prevention and Control*. This law highlights the need to protect and restore the Yangtze River, and pursue a rational distribution of economic industries along its banks, while strictly controlling the discharge of pollutants, and speeding up the restoration of coastal ecosystems, purifying the water quality, and ensuring clean water.

7. Policy effects and future prospects

7.1. Policy effects

China's water resources protection policies mainly focus on the prevention and control of water resources pollution and the development of a water-saving society. After continuous revision and improvement, laws and regulations related to water resources protection in China have gradually formed a system, and the policy effects have over time become evident.

1. Remarkable achievements in water pollution control.
   By 2017, an illegal construction area in the drinking water protection zone of more than 4 million square meters had been cleared up, and more than 3,000 sewage outlets had been closed, while more than 1.3 million square meters of cage culture had been banned. Furthermore, 97.7% of the 338 centralized drinking water protection zones at prefecture-level and above cities completed the establishment of the protection zone signs, and 98.1% established the water source archive system. This will block the pollution from entering the sources

of drinking water. In 2017, the Ministry of Environmental Protection also checked and registered all kinds of sewage outlets, strengthened the management of the water flow into the sea, and focused on 11 lagging provinces, and conducted special supervision over them with the purpose of preventing water pollution.

In the face of China's severe water pollution situation, the effect of water treatment can be seen directly from the sewage discharge. As shown in Table 1, the total discharge of various types of sewages has increased annually between 2011 and 2015. In addition, not only the proportion of industrial wastewater discharge has been decreasing, but also the proportion of chemical oxygen demand and ammonia nitrogen discharge in agriculture, which shows that under the water resource protection policy in China, the sewage treatment technology has improved continuously.

Table 1. The discharge of wastewater and its main pollutants between 2011/2015

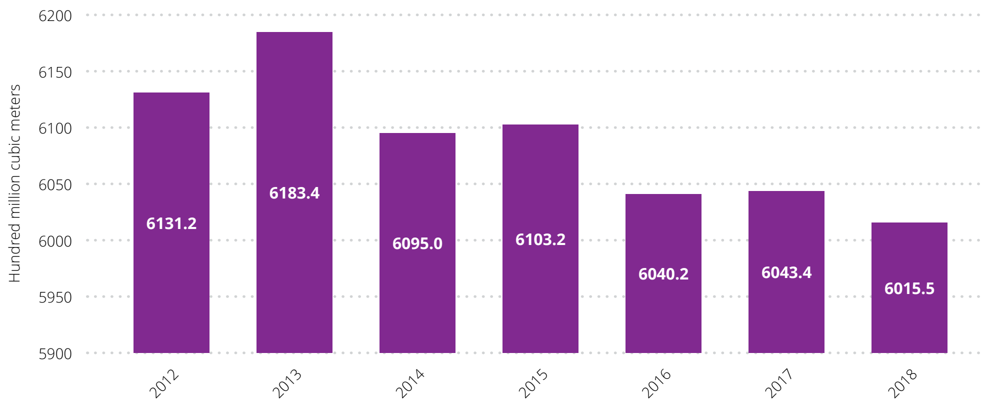
Year	Wastewater discharge (hundred million tons)			Chemical oxygen demand (ten thousand tons)				Ammonia nitrogen (ten thousand tons)			
	Industry	Life	Total	Industry	Life	Agriculture	Total	Industry	Life	Agriculture	Total
2011	230,9	427,9	659,2	354,8	938,8	1186,1	2499,9	28,1	147,7	82,7	260,4
2012	221,6	462,7	684,8	338,5	912,8	1153,8	2423,7	26,4	144,6	80,6	253,6
2013	209,8	485,1	695,4	319,5	889,8	1125,8	2352,7	24,6	141,4	77,9	245,7
2014	205,3	510,3	716,2	311,3	864,4	1102,4	2294,6	23,2	138,1	75,5	238,5
2015	199,5	535,2	735,3	293,5	846,9	1068,6	2223,5	21,7	134,1	72,6	229,9

Source: National Environmental Statistics Bulletin 2011/2015.

2. Continuous development of a water-saving society.

In recent years, a total of 174 water-saving policies have been actively issued throughout the country in order to promote the implementation of water-saving measures. Regions with strong water-saving management capabilities have a relatively complete water-saving policy system (such as Beijing, Shenzhen), which not only widens the scope but also increases the depth of water-saving work. As can be seen from Figure 7, under the promotion of water-saving policies, the total water consumption in China has fluctuated. However, it is generally maintained within a stable range.

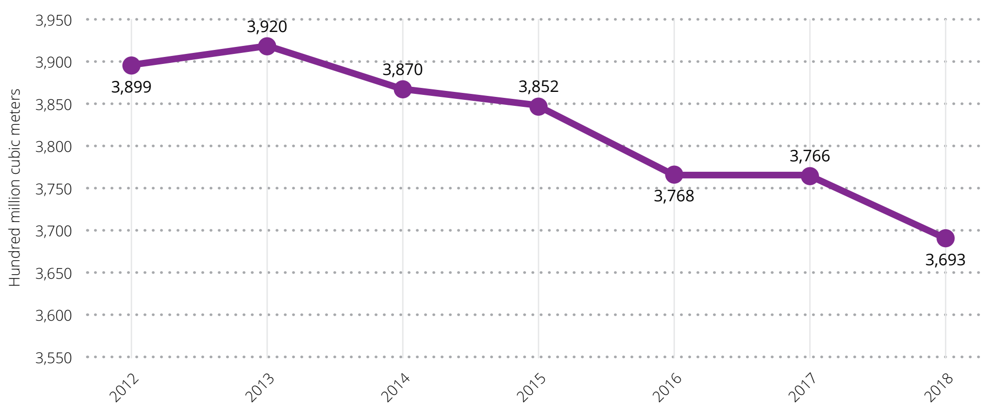
Figure 7. Total annual water consumption



Source: China Water Resources Bulletin 2012/2018.

Since 2012, China has vigorously developed water-saving irrigation, striving to achieve zero growth of agricultural water consumption in 10 years, as shown in Figure 8. In the seven years prior to 2018, China's agricultural water consumption generally declined, basically achieving zero growth, due to the significant effect of the water-saving policies.

Figure 8. Total annual agricultural water consumption



Source: China Water Resources Bulletin 2012/2018.

7.2. Policy recommendations

With the intensification of water resources protection, China has made some achievements on the road towards a cleaner water supply, which provides a foundation for the sustainable development of agriculture. However, as the existing water resources protection policies are not perfect, we present the following suggestions:

1. Improving the utilization rate of water resources.

   The waste of agricultural water resources in China is severe, and the utilization efficiency is not high. Given low per capita water resources, agricultural water will be in short supply. Therefore, we should vigorously develop efficient water-saving irrigation technology, and make efforts to reduce the ground infiltration, carry out scientific irrigation through advanced technology, improve the efficiency of water resources utilization, and realize the sustainable development of agriculture.

2. Improving water resource management systems.

   We should continue to improve laws, regulations, and policies related to water resource protection, and establish a complete water resource protection system. We should also improve the operability of laws, regulations, and policies. At the same time, we should seek public-private solutions to protect the water resources more comprehensively. In addition, we should also increase the punishment of illegal water resources abuses to strengthen deterrence and protect water resources.

3. Strengthening propaganda and improving the ideology of water conservation.

   The government should vigorously promote the idea of water conservation so that it becomes deeply rooted in people's minds. We should also strengthen the supervision and management of agricultural water use, and advocate for the behavior of efficient agricultural water use.

Case study 2: Water pollution control in the Taihu Lake

Background

The Yangtze River is the largest river in China, with a total length of about 6,300 kilometers. The Yangtze River Basin spans three major economic zones in the Eastern, Central, and Western China, with a total of 19 provinces, municipalities, and autonomous regions. It is the third-largest river basin in the world, with a total area of 1.8 million square kilometers. The five major freshwater lakes in China are all located in the Yangtze River Basin.

Taihu Lake is the third-largest freshwater lake in China. It is located at the junction of Jiangsu and Zhejiang provinces. It is at the south of the Yangtze River Delta and is the largest lake in the offshore area of eastern China. Although the Taihu Basin is rich in water resources, its unreasonable industrial structure and rapid urbanization have brought vast amounts of sewage. The cyanobacteria outbreak in Taihu Lake in 2007 caused severe pollution to the water source, leading to a water pollution crisis.

Towards improved water pollution control

Since 2007, the Jiangsu Province has rationally adjusted its industrial structure, implemented governance responsibilities, and gradually explored an effective governance path.

1. Innovative institutional mechanisms.
   Improve the leadership level of the Taihu Lake Water Pollution Prevention Committee, set up a leading group for emergency response work, and establish a decision-making advisory body for expert committees. This system is better at clarifying responsibilities.
2. Improving laws and regulations.
   The "Regulations on the Prevention and Control of Water Pollution in Taihu Lake of Jiangsu Province" were amended to prevent the entry of heavily polluting industries from the source and raise the industry threshold.
3. Issuing a particular governance plan.
   Strict local emission standards in the Taihu Lake Basin and urban sewage treatment plants were issued to reduce pollutant emissions.

Integrated pollution control practice needs inputs from various regions and industries and governments from different levels.

4. Increasing the funding guarantee.
Provincial special guidance funds for Taihu Lake governance have been set up, with 2 billion yuan a year, driving more than 200 billion yuan in governance for the whole society.

5. Effective use of market mechanisms.
Implement environmental and economic policies such as differentiated levy of pollution charges, trials of paid distribution and trading of pollution rights, regional compensation of water environment, ecological compensation, green insurance, green credit, and environmental quality compliance awards.

Achievements

After more than ten years of treatment, the water quality of the Taihu Lake Basin continues to improve. The average water quality of the lake has been enhanced from Category V to Category IV and remains stable.

Taihu governance experience

The governance of the Taihu Lake Basin has achieved remarkable results in the past ten years, and also provides reference and experience for the governance of water pollution. Two important lessons from Taihu Governance: First, we should establish a unified leading department and coordinate the cooperation among all sectors; Second, improve law enforcement and establish a functional supervision mechanism.

8. Natural disasters

8.1. Basic information on agriculture-related natural disasters in China

China is amongst the countries with the most severe natural disasters in the world because of its unique geographical location and complex climate and geological conditions. Natural disasters in China are highly frequent, and in many cases generate far-reaching consequences and economic losses. More than 70% of the cities and over half of the population in China lives in areas where natural disasters have a high probability of occurring. More than two-thirds of the country's land area is threatened by floods. All provinces (including autonomous regions and municipalities directly under the central government) have experienced destructive earthquakes of a magnitude of 5 or above. Mountainous and plateau areas account for 69% of the whole country, and because of the complex geological structure, these areas face risks of landslides, debris flow, and other geological disasters. The Eastern and Southern coastal areas, and some inland provinces, are often hit by tropical cyclones. In the Northeastern, Northwestern, and Northern China, droughts are common, while in the Southwestern and Southern China, severe droughts and floods frequently occur. The agricultural losses caused by various natural disasters in China in 2017/2019 are listed in the table below.

Table 2. Chinese agricultural losses induced by natural disasters in 2017/2019

Year	Population affected	Crop areas affected	Total crop failure areas
2017	140	18,48	1,83
2018	130	20,81	2,59
2019	130	19,26	2,80

Source: China government sites and official sites.

8.2. Policies and measures to deal with natural disasters

In recent years, the National Committee for Disaster Reduction and the Ministry of Civil Affairs have actively developed a national comprehensive coordination system for disaster reduction, integrating provincial, municipal, and county-level committees, and focusing on bringing natural disaster risk management into the existing legal system. The state has successively promulgated a series of laws, such as the Emergency response law of the *People's Republic of China; The Law of the People's Republic of China on protecting against and mitigating earthquake disasters*; and *the flood control law of the*

People's Republic of China. Moreover, the Chinese government has formulated a number of administrative regulations, such as *the regulation on disaster relief; the regulation on geological disaster prevention and control; and the regulation on destructive earthquake responses.* Also, in order to construct a functional emergency response system, the Chinese government has enacted *the national emergency plan; the national special emergency plans at both the national level and department level; as well as the national comprehensive disaster prevention and mitigation plan (2016/2020)*.

The specific policies and relevant measures on the prevention and control of agricultural natural disasters mainly include the following three aspects:

1. **Emphasizing the importance of prevention and control**
   In recent years, Chinese governments have issued *the emergency plan for agricultural natural disasters* and have undertaken much work for the prevention and emergency treatment of agricultural natural disasters, and the recovery of agricultural production after disasters. In January 2019, the Information Office of the State Council held a press conference to report the reform progress and operation status of the emergency management department, proposing that it should give higher priority to the developing areas and remote rural zones in terms of relief materials, funds, and rescue forces, so as to ensure that the government could provide timely emergency aid, and dispatch rescue teams and relief materials on site. The department aims to protect people's lives and properties, and to ensure disaster-affected groups' basic necessities for survival. The emergency management department has focused especially on the prevention and control of natural disasters through the perspective of poverty alleviation and development, and executed the investigation and evaluation of rural natural disaster risks, while increasing the efforts of disaster prevention and relief in rural areas.
2. Implementation of rescue regulations and disaster prevention plans.
   The regulation on natural disaster relief, which builds on the early warning and emergency response system for natural disasters, provides essential assistance to the disaster affected groups with food, drinking water, temporary shelter, and medical services, and guarantees the basic needs of affected people. It also strengthens the

supervision of the use of the relief goods and funds, while ensuring that these funds are fully used for natural disaster relief. The central government has set up a special fund to handle natural disasters, such as floods, hailstorms, droughts, earthquakes, mountain collapses, and tsunamis in rural areas. Once the disaster occurs, the government should strictly follow the principles of this fund and deliver relief to victims as early as possible. Moreover, the No. 1 document of the Central Committee of the People's Republic of China in 2018 clearly proposes to improve the ability of meteorological services for agriculture and strengthen the capacity of rural disaster prevention, mitigation, and relief.

3. Building emergency mechanisms and technology systems for disaster prevention and mitigation.

After years of experience, China has built a functional natural disaster emergency system, which includes six main aspects: a disaster emergency response mechanism; a disaster information release mechanism; a disaster emergency material reserve mechanism; a disaster early warning consultation; an information-sharing mechanism; a major disaster rescue and relief linkage coordination mechanism; and a disaster emergency social mobilization mechanism. Focusing on the needs of national disaster prevention and reduction, the Ministry of Civil Affairs in China continuously establishes and improves its national disaster reduction operation system, and has formed six core operational technology systems, including disaster information management and service, disaster remote sensing monitoring, disaster assessment, disaster emergency technical protection, disaster reduction publicity and education, and international exchange and cooperation in disaster reduction.

8.3. Policy effects

During the 13th Five Year Plan period, China made significant achievements in the prevention and control of natural disasters in rural areas. First, multiple measures have promoted meteorological services for agricultural production. In 2017, the China Meteorological Administration and the Ministry of Agriculture established 10 agro-meteorological service centers, and integrated smart meteorological services into new areas in agricultural production and rural affairs, such as the economic development of villages and climate research on agricultural products. Now, more than 2.4 million smartphone users are clients of this service. The government also provides special services on artificial precipitation and hail enhancement that cover all poverty-stricken counties nationally, and offer direct meteorological services to 140.000 new agricultural operating bodies in poverty-stricken areas, while also undertaking climate poverty reduction and photovoltaic poverty alleviation projects with focus on rural poverty.

Secondly, the systems and mechanisms have been improved, as has the disaster prevention capacity. In recent years, the infrastructure construction as part of Chinese agricultural disaster prevention and mitigation efforts has been continuously strengthened; the disaster management system has been gradually improved under unified leadership; emergency plans and guidelines for natural disasters have been formulated, revised, and repeatedly issued; teams and staffs of agricultural disaster prevention and mitigation have been strengthened; and events such as "disaster prevention and mitigation day" and "international disaster reduction day" have been fully utilized to propagandize disaster prevention and mitigation knowledge and skills. These measures consistently enhance the population’s ability for "self-rescue" and "mutual-rescue", while improving the emergency rescue system. It thereby ensures the proper handling of the numerous major natural disasters, and significantly enhances agricultural disaster prevention and mitigation.

Thirdly, effective and scientific measures against drought and a solid foundation for ensuring food security are essential. The Chinese government continuously improves the water resource management system and water pipe network that includes sprinkler irrigation, drip irrigation, and other facilities and equipment. It continuously strengthens waste water recycling and effectively promotes the healthy development of water-saving agriculture and the improvement of the rural ecological environment. In the work of drought relief in recent years, departments at all governmental levels have undertaken emergency responses in time to guarantee the grain yield, which greatly reduces the economic losses of farmers.

8.4. Future prospects

During the 13th Five Year Plan period (2016/2020), governments at all levels implemented various measures of agricultural disaster prevention and mitigation. However, there are still problems to be addressed, such as the insufficiency of infrastructure, and the weak capacity for disaster prevention and mitigation in most rural areas. To be more specific, some areas fail to develop adaptive agriculture, and therefore cannot adopt species or grazing. The agricultural insurance coverage rate is low, and the insurance products are few. Therefore, in the future, the Chinese government should gradually improve the capacity of agricultural disaster prevention and reduction, integrate it into the national agricultural development plan, and improve the agricultural disaster prevention and reduction system consistently. The government should focus on the following policies:

1. The Chinese government should continue to increase financial investment, steadily promote the construction of high-standard farmland, improve the inputs to the fight against droughts and floods, promote the construction of high-standard breeding facilities, and vegetable greenhouses, fully ensure the safety of facility agriculture, and stabilize and increase production.
2. The Chinese government should expand the scope of agricultural insurance services, increase insurance coverage, innovate regarding agricultural insurance products, build a national agricultural catastrophe risk guarantee system, form a cooperative mechanism between agricultural reinsurance and agricultural disaster prevention, and comprehensively improve the ability to withstand natural disasters in rural areas.
3. Agriculture departments at all levels should strengthen technical support for agricultural disaster prevention and mitigation, improve the mechanisms for disaster prediction and early warning, popularize the knowledge of disaster prevention and mitigation, and at the same time, improve warehouse maintenance and market supervision after disasters. The government should ensure that consumers' access to the agricultural products is unrestricted and that the supply of agricultural materials and commodities is sufficient so that the whole

of society can obtain food security and develop a collective capacity for disaster prevention and "self-rescue."

4. The Chinese government should carry out special agricultural projects for disaster prevention and mitigation, enhance water-saving agriculture, gradually expand the cultivation of water logging tolerant crops, and establish a sustainable mechanism for disaster prevention and mitigation.
5. The Chinese government should improve the level of meteorological services for agricultural production, continue to promote scientific drought resistance technology, implement seasonal fallow for land plots that cannot be sown due to droughts, and promote advanced agricultural technologies, such as plastic film mulching, and intercropping.

Case study 3: The locust control in Hami

Background

There are more than 4 million hm^2 of natural grasslands in the Hami area of Xinjiang. Hami has formed a variety of grassland types due to its special geographical and ecological environment, and unique animal populations inhabit different types of ecological environments here. The Hami area is a famous locust disaster area in Xinjiang. According to a report, the area of grassland locusts in the Hami region is 3533000 hm^2, and there are more than 60 species of locusts. The grassland locusts in the Hami area are characterized by many species, a wide distribution, large quantity, high density, and inconsistent incubation periods. The frequent occurrence of dry locust disasters not only causes certain losses to the agricultural production and animal husbandry, but also deteriorates the natural ecological environment.

Towards locust control

1. Strengthen the work of locust forecasting.
   Since 1990, regular sampling and investigation of grasshoppers has been carried out in the Hami area. According to the development

degree and quantity of grasshopper pupae, the occurrence period, quantity, occurrence degree, and damage area of grasshoppers were predicted in time and accurately. The best period of control and prevention were determined.

2. Biological control of grasshoppers in grassland.

   For many years, in accordance with the medium and long-term planning of grassland biological disasters in Xinjiang Uygur Autonomous Region, the management of grassland locusts in the Hami region has thoroughly implemented the concept of "public plant protection and green plant protection". The main contents are as follows: 1) in the Hami area, chickens and ducks are actively used to control locusts. The specialized households are organized in a planned way to raise the 60-day old chickens on the grassland and feed them with locusts. 2) To protect and utilize the natural enemy of locusts – "pink birds" to control grassland locusts.

   In the Hami area, the pest of grassland locusts is controlled by using the biological technology of pink startled birds. The main food of pink startled birds is locusts, and these birds can consume up to 120-180 locusts every day.

3. In the 1990s, bio pesticide control of grassland locust was carried out successively in Balikun County, Hami district.

Achievements

From 2004 to now, we have carried out animal husbandry of chicken and duck in Hamim which not only reduces the cost of prevention and control but also avoids the environmental pollution caused by chemical pesticides in the grassland and obtains results against locusts. To protect the grassland ecological environment and promote the healthy and stable development of animal husbandry. In recent years, the grassland locust in the Hami area has been maintained under control.

Experiences from Hami, China

The successful experience of locust control in Hami provides important reference for locust management in Brazil.

1. In order to provide scientific and accurate support for the prevention and control of grasshoppers in the grassland, we should collect reports from farmers and herdsmen in the areas.
2. By introducing the natural enemies of locusts, the biological control of locust disaster can be achieved.
3. In the year of the locust disaster, chemical pesticides should be used for emergency control.

9. Chinese experiences and practice as inspiration for the Brazilian government

China and Brazil are similar in terms of natural resource endowments, economic development, the population's standard of living, and climate conditions. Therefore, China's experience in sustainable utilization of natural resources can provide a reference for Brazil's environmental protection. First, the government should play a leading role in protecting natural resources. A valuable experience is that the Chinese government has increased financial support for environmental protection and nature utilization. Natural resources have externalities, so such measures are usually carried out by the government initially. Governments at all levels should invest in the prevention and control of pollution, and the construction of supervision capacities for environmental protection. Second, we should pay attention to science and technology input in natural resource preservation and utilization. Guided by the concept of green development, ecological restoration, and comprehensive management of natural resources, China integrates the innovation of science and technology. We encourage research institutions and experts to carry out investigation and experiments on the sustainable utilization of specific natural resources and help farmers solve practical problems. Third, we should encourage enterprises and the private sector to contribute and promote the usage of renewable energy. Through preferential tax policies and other measures, enterprises and various non-governmental organizations can be encouraged to support environmentally friendly industries. Moreover, the protection of natural resources can be realized by developing renewable energy sources and banning highly polluting agricultural and industrial activities.

10. Conclusion

In this chapter, we summarized the practice and experiences in natural resource utilization and protection. In relation to land, water, and natural disasters, the Chinese government has carried out a series of policies to solve the pollution issues and protect natural resources. These measures have had positive outcomes. From our analysis of the Chinese experiences, we were able to observe that the different actors in environmental governance are complementary and mutually supportive. National and regional strategies should be used to target sustainable development and biodiversity conservation simultaneously. Cooperation between different sectors and sufficient financial support has played, – and will continue to play – a key role in the achievement of sustainable development goals. The examples provided in this chapter highlight the important experience of concerted action in achieving biodiversity conservation, but such measures are also beneficial to poverty reduction, water delivery, food security, and climate change mitigation.

Chapter 12

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Laura Barcellos Antoniazzi

Sustainability in Brazilian agriculture: key challenges and potential collaborations with China

1. Introduction

Brazil has always been an important agricultural player, and, in recent decades, its production has been increased considerably, generating a large surplus of food for export. Brazilian agricultural products are shipped to almost 200 countries, and China has become an increasingly important partner, representing around 32% of total agricultural exports. In 2019, soybeans represented 67% of exports, or US$ 20.6 billion, while beef represented 15%, at US$ 4,5 billion. Soybean is the most important crop in Brazil and occupies 35.8 million hectares of the 70 million hectares agricultural area, while pasture covers 170-180 million hectares.

The relationship between Brazil and China regarding agricultural exports is improving, with sanitary approvals of new beef and poultry slaughterhouses, phytosanitary agreements for melons, and advances in the negotiations around coffee, cottonseed meal, and other products. Agriculture and food systems have always been at the core of the global development agenda, given its role in feeding a growing population, set to reach 10 billion people in 2050, and in curbing hunger that still impacts 820 million people according to the Food and Agriculture Organization (FAO). Assuring food security is a global goal that faces several challenges, such as shortage of arable land, climate restrictions, water shortages, soil degradation, low productivity and technological development, poor infrastructure and sanitary systems, as well as socioeconomic inequalities.

Brazil has a key role to play in tackling global food security. In the meantime, there are social and environmental issues challenging the development of the agricultural systems, including land use changes and deforestation, soil degradation, pollution, biodiversity loss, gaps in productivity, lack of rural extension, and poor infrastructure, especially for small farmers, as well as other social impacts.

The evolution of the environmental multilateral agendas linked to sustainable development positions agriculture at the centre of a multifaceted debate about ending hunger, promoting nutritional improvement, producing food more efficiently, adopting good agricultural practices, recovering degraded areas, promoting native vegetation conservation, and restoring and fostering low carbon agriculture and resilience.

Moreover, agriculture and food systems must consider severe health challenges in developed (obesity and related diseases) and developing countries (hunger and micronutrients deficiency, known as hidden hunger), which opens an important debate regarding shift in diets.[1] Brazil suffers from the two problems, obesity and hunger, as is the case of several emerging and middle-income countries. Considering the potential for increasing agri-food partnerships between Brazil and China, it seems quite relevant to explore key sustainability issues related to agricultural production and expansion in Brazil. The aim of this chapter is to present important social and environmental challenges and opportunities to foster sustainable development of agriculture, as key attributes to addressing food security, food safety, and sustainability in the Brazil-China partnership. The first section of this chapter presents social

[1] EAT Lancet Report (2019). Healthy Diets from Sustainable Food Systems.

challenges in Brazil, highlighting poverty and inequalities in rural areas, and then briefly describes the precarious position of family farmers in terms of productivity and income, despite governmental programs. The second part will discuss climate change and environmental policies related to agriculture, and their impacts on rural development. Here, the discussion will be centred around issues related to land use, deforestation, low carbon agriculture, the Forest Code and other policies. Based on the key social and environmental challenges presented, the final part will draw some conclusions on how to foster win-win benefits for Brazil and China based on a food production and approaches to consumption.

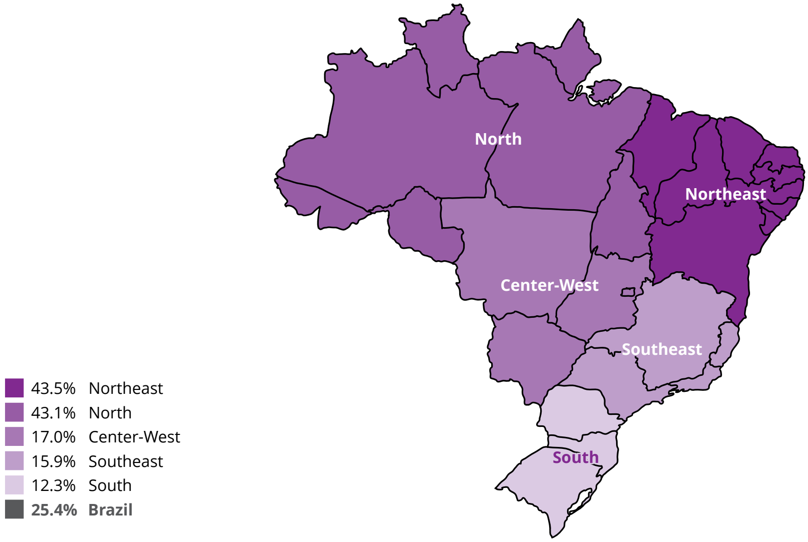
2. Rural Brazil and its challenges

Brazil is a middle low-income country and one of the 10 largest global economies in terms of GDP, population, and territory. Although the country has experienced noticeable economic and social improvements from the 1990s to the first decade of the 2000s, economic and political crisis from 2014 has made important indicators such as GDP, poverty, and many other social indicators retrocede. A constitutional amendment in 2016 has limited the real value of primary expenses, significantly reducing the budget for social demands and reducing investments in environmental programs. In 2016, a quarter of Brazilians were living in poverty according to the World Bank index for Upper Middle-Income Class Poverty Line (US$ 5.50, 2011 PPP, per day per capita).

There are several indexes for measuring poverty and using the international poverty line, Brazil is better positioned, with a 4.8% rate (10 million people)[2]. Most indexes display a similar trend, with decreasing poverty rates up to 2014 and an increase afterwards. Inequalities among regions, age, and rural-urban residents is also very problematic, and the Gini index has decreased very modestly, which makes Brazil one of the most unequal countries in the world. The poverty rates in rural areas are double those of urban areas, and in the North and Northeast they reach 43%, and 12% in the South.

[2] World Bank (http://povertydata.worldbank.org/poverty/country/BRA).

Figure 1. Percentage of poverty population in 2016 by the World Bank index (per capita household income of less than US$ 5.5/day)



Source: IBGE (2018).

Brazil has experienced a strong urban migration during the last century, especially in the 1960s and 1970s, and it is one of the most urbanized populations in developing countries. The rural population is relatively small – 29.7 million, or 15.6% of a total population of 205 million – and is concentrated in the North and Northeast, – exactly the poorest regions. Several important social and economic indicators demonstrate a lower standard of living of the rural population compared with the urban population, which indicates that improvement of living conditions for the rural population is still a challenge in Brazil. Rural-urban migration has continued in the last decades, made up especially of young people and women, meaning that the rural population is becoming older with a higher concentration of men. Other significant social and economic changes in rural Brazil are the increasing number of residences and the importance of retirement for family incomes. Rural retirements are mostly subsidized and governmental social programs play in important role for the poorest among the population.

Some specialists also consider the phenomenon of the decreasing importance of agricultural activities in the rural world, meaning that jobs and income are increasingly found within other sectors, such as services and social programs. Even the concept of rural population is challenged by some specialists, due to the fact that a large number of municipalities (30% of the total) are very small (3 to 5 thousand population) and thus could be classified as rural[3]. People living in these municipalities depend on agriculture for a living. Despite the debate about the concept and the numbers of rural populations it is worthwhile to present a profile of farmers in Brazil, which is very heterogeneous and unequal, as is Brazilian society. In 2006, the category of family farming was established by law, defined by four requirements: land holdings of up to 4 fiscal modules (varying among municipalities from 5 to 110 hectares for each module); the predominant use of family labour for agriculture activities; farm income coming predominantly from agriculture; and management of the farm by the family. This means that a farmer must fulfil the four requirements in order to be classified as family farmer and access governmental programs. The official category was also used for statistical purposes to assess social, economic, and environmental indicators of farms by the Agriculture Census led by the official government data bureau, IBGE. Thus, while some specialists and policymakers refer to smallholders in Brazil, the proper term is family farming. The country even helped to spread the term worldwide through FAO and academic contributions, and today this is broadly used, even when the definitions vary among users.

The rationale undergirding the classification is that family and business farmers have different needs, interests, and impacts. Targeted incentives for each of them are necessary in order to increase their production and to improve environmental practices. Public policies tailored separately are (at least potentially) more efficient. Due to their social importance, there are a set of specific governmental programs for family farmers and, as is the case for general agricultural policy, accessible credit (Pronaf) is the most significant measure (in terms of resources). There are also programs for increasing demand for products, such as the School Meals Program – PNAE (Programa Nacional de Alimentação Escolar) and Food Acquisition Programme – PAA (Programa de Aquisição de Alimentos). Other relevant programs are the Harvest Guarantee – GS (Garantia de Safra) and the Price Guarantee Program for Family Agriculture – PGPAF (Programa de Garantia de Preços para a Agricultura Familiar).

[3] Veiga, J.E.D., 2005. A relação urbano/rural no desenvolvimento regional. Cadernos do Ceam, Issue 17, pp. 9-22.

The Harvest Guarantee Program had almost 1 million farmers registered, and in the 2015-16 harvest it allocated around R$ 850 to 500.000 individual farmers (around the monthly minimum wage per harvest/year).

Brazilian agricultural policy has historically been based on two objectives: guaranteeing food supply around the country, especially staples (rice, beans, wheat, sugar) and financing farmers, mainly through subsidized credit. The programs designed for family farmers introduced the objective of inclusion into the production system, aimed at facilitating market access for family farmers. The School Meals Program – PNAE (Programa Nacional de Alimentação Escolar) – and the Food Acquisition Programme – PAA (Programa de Aquisição de Alimentos) – created quotas for family farm products in public schools and other governmental bodies, which is a huge market, spread all over the country.

Family farmers account for 77% of rural farms in Brazil (around 3.9 million farms), and 23% of the total area, according to the last Agricultural Census (2017). These farms have been reduced in number since the previous Census in 2006, when they accounted for 83% of total properties (4.3 million farms). The total occupied area was almost equal, pointing towards land consolidation, probably due to the aging of the rural population and other associated factors discussed above. Even more relevant and problematic is these farmers´ loss of jobs and decreasing participation in production value. Family farmers represented about 33% of total Brazilian agricultural GDP in 2006, and they have been losing participation in total Brazilian agricultural production, mainly in crops that are more technology dependent.

The yield gap is at the root of these differences and of the loss of participation in production value. Family farmers' productivity is between 10% to 45% lower compared to commercial agriculture, and there are several reasons for that, mostly related to resource scarcity (financial, land, technical assistance, among others).

3. Climate and environmental policies in Brazilian agriculture

Brazilian agriculture is intrinsically linked to the sustainable development agenda for a number of different reasons. The size of the agricultural areas

(70 million hectares of agricultural areas and 170 to 180 million hectares of pastures), the amount of native vegetation across six distinct biomes – Amazon, Cerrado, Mata Atlântica, Caatinga, Pantanal and Pampa (around 66% of the territory), the native vegetation requirements within productive areas, under the Forest Code, and the coexistence of different agricultural systems link farming to sustainability.

Land use and deforestation have become an increasingly important agenda due to their connection with agricultural expansion in the recent decades. The manners in which the productive sectors and the supply chain deal with deforestation is, today, an issue that affects not only the image of agricultural production in Brazil, but also international trade as a demand related to sustainability. In Brazil, there are small scale/low and high productivity agriculture, agroecology, organic, agroforestry, monocultures with conventional or biotechnology crops, low and high productivity livestock based on grassland, integrated crop-livestock-forest systems and planted forests.

In order to tackle productivity gaps, the potential to adopt innovations and recover degraded areas, the need to expand rural extension and capacity building, and the possibility of diversifying food production are extremely relevant opportunities to foster a win-win approach towards production and conservation in Brazil. In fact, Brazil is an agricultural and environmental leader, which attracts increasing attention at the international level. Historically, the country has been at the centre of the sustainable development agenda. Brazil hosted the United Nations Conference on Environment and Development, known as the Earth Summit, in 1992, which resulted in the Rio Declaration on Environment and Development, and the Declaration on Principles on Forests, aimed at strengthening the role of forests and their management at the global level. Moreover, the Convention on Biological Diversity (CBD) and the United Nations Framework Convention on Climate Change (UNFCCC) were agreed upon, attributing sustainable development with a higher status at the multilateral level. Considering the importance of climate change impacts on the agricultural systems, and the role of the country in addressing climate change within the Paris Agreement, it is worth noting how agriculture is connected to the Brazilian Nationally Determined Contribution (NDC) presented to the UNFCCC in 2015.

Since 2010, when Brazil took its national mitigation actions to the Copenhagen Agreement, adopted in 2009 at the 15th Conference of the Parties of the UNFCCC (COP15), agriculture has been at the center of the actions to be voluntarily adopted, aimed at reducing GHG emissions and fostering climate adaptation. The National Policy for Climate Change, approved in December 2009, establishes the approval of sectoral plans aimed at delivering emissions reduction from 36.1% to 38.9% by 2020. In this context, the Low Carbon Agriculture Plan (ABC Plan) was approved in 2011, as a policy aimed at improving and encouraging the adoption of technologies and practices that would allow for more efficient production while reducing emissions. The table below presents the technologies, their respective goals, and data from the deployment of the technologies up to 2018:

Table 1. Low carbon agriculture Plan goals and adoption

	Targets up to 2020	Estimated reach up to 2018
Pasture recovery	15 million ha	4.46 to 10.5 million ha
No-tillage	8 million ha	9.97 million ha
Biological nitrogen fixation	5.5 million ha	9.97 million ha
Integrated crop-livestock-forestry systems (ILPF)	4 million ha	5.83 million ha
Planted forests	3 million ha	1.10 million ha
Animal manure treatment	4.4 million m^3	1.70 to 4.51 million m^3

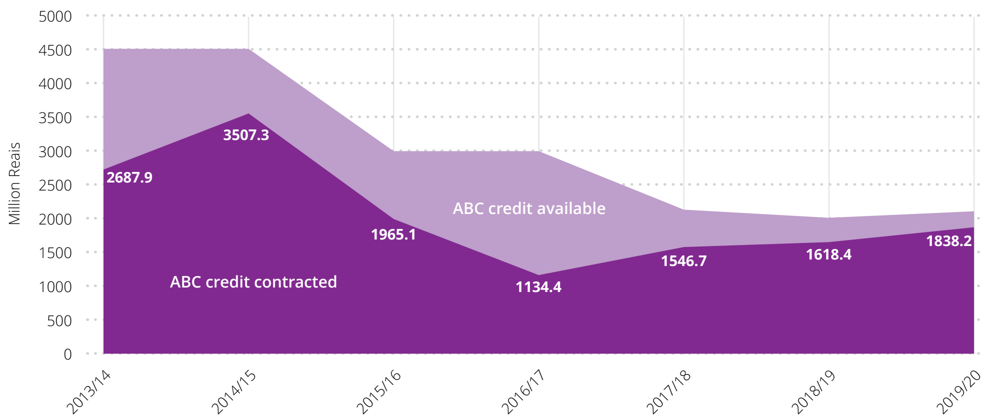
Sources: Low Carbon Agricultural Plan, 2011; Adoção e Mitigação de GEE pelas tecnologias do Plano ABC, 2018.

Moreover, the ABC Plan considers adaptation as an extremely relevant set of tools that must be adopted as regional priorities. As key examples, it develops studies to improve and expand rural insurance and other instruments for preventing and compensating for climate losses in agriculture to support adaptation actions, and create the Climate Intelligence Program in Agriculture, integrated with the National Risk and Disaster Reduction Plan.

The ABC Plan foresaw the adoption of several strategies as a manner to disseminate knowledge and the implementation of actions, such as strengthening technical assistance, training, technology transfer strategies, field studies, seminars, workshops, the implementation of Technological Reference Units at the state level, and publicity campaigns. The technologies are financed as investments in the rural area, using official credit, according to the amount and interest rates approved every year within the Federal Harvest Plan. The Low Carbon Agriculture Program defines the amount of credit available for each crop season, and the interest rates applicable.

The graph below sums up the credit available and contracted to incentivize the adoption of the low carbon technologies since the beginning of the Program in the crop season 2013/2014.

Figure 2. Official credit to incentivize low carbon agriculture in Brazil



Source: Sicor, Central Bank.

The deployment of the ABC Plan technologies is critical to promote a resilient and sustainable agriculture in Brazil. In line with this, Brazil included agriculture at the iNDC, as the first developing country to present an absolute emission reduction target of 37% compared to 2005 levels, by the year 2025. In addition, it indicated a potential reduction of 43% below emission levels from 2005 to 2030. For the agricultural sector, the suggested actions include:

- Strengthening of the ABC Plan, as the main strategy for the sustainable development of agriculture;
- Additional recovery of 15 million hectares of degraded pastures by 2030;
- Increase of 5 million hectares of ILPF systems by 2030.[4]

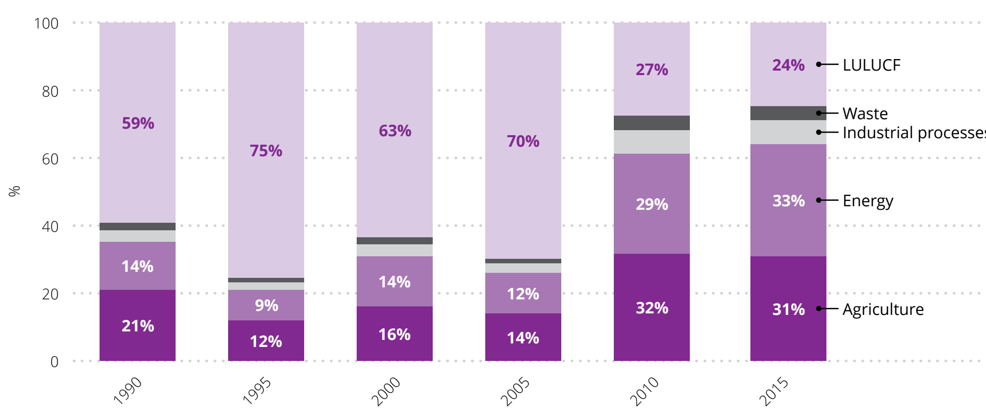
Moreover, Brazil adopted the following actions vis a vis land use, land use change and forestry (LULUCF), as they relate to privately owned areas for agriculture:

[4] Brasil, 2015. Intended Nationally Determined Contribution.

- Strengthen compliance with the Forest Code, at the federal, state and municipal levels;
- Strengthen policies and measures with a view to achieving zero illegal deforestation in the Brazilian Amazon by 2030 and offsetting greenhouse gas emissions from legal suppression of vegetation by 2030;
- Restore and reforest 12 million hectares of forests by 2030, for multiple uses;
- Extend the scale of sustainable management systems for native forests, through georeferencing and traceability systems applicable to the management of native forests, with a view to discouraging illegal and unsustainable practices.[5]

Another initiative that is considered for the energy sector, but relates to agriculture, is to achieve 18% of the energy matrix from biofuels by 2030, which comprise ethanol from sugarcane, corn, sugarcane straw and other biomass sources, and biodiesel from soybean meal, animal fat, and other sources. The Brazilian emissions profile over time indicates that LULUCF is the main source of emissions, with energy and agriculture as the second and third sources.

Figure 3. Evolution of GHG emissions in Brazil by sector



Source: Brazilian Ministry of Science and Technology (MCTI), http://www.mct.gov.br/upd_blob/0235/235580.pdf.

[5] Brasil, 2015. Intended Nationally Determined Contribution.

The evolution of the GHG emissions profile makes agriculture, forestry and land use (Afolu) extremely relevant for climate policy in Brazil. Up until 2005, deforestation (land use) was the activity that contributed most to GHG emissions, reaching 1,905 million ton of CO_2 equivalent (CO2eq.) which represented more than 70% of total emissions.

Energy usually represents a large proportion of emissions in industrialized and rich countries, but it is not that representative in Brazil due to deforestation and large use of renewable energy sources, notably hydropower and biofuels, as seen on Figure 3. Deforestation still plays a critical role in total emissions and also implies negative consequences for biodiversity, water resources, soil degradation and indigenous peoples. The policies to curb deforestation in the Amazon were organized around the Action Plan for Prevention and Control of Deforestation in the Legal Amazon (PPCDAM), that had its fourth phase approved in 2016 with actions up to 2020.[6]

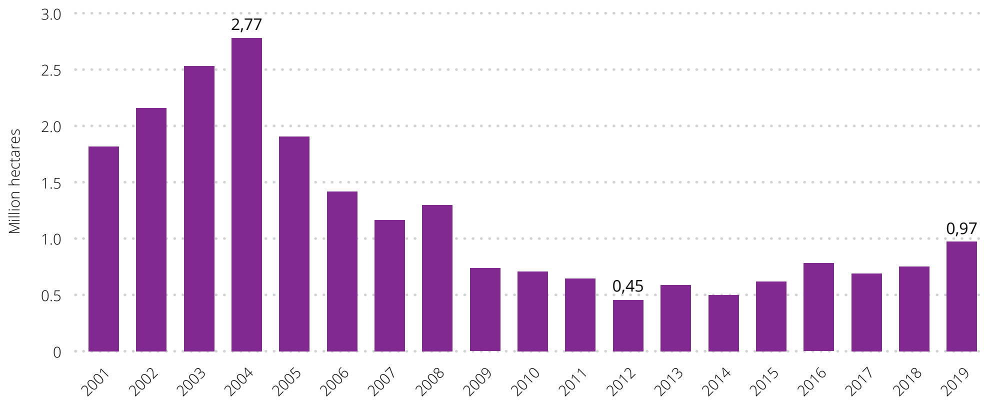
In 2020 the Federal government approved the National Council of the Legal Amazon, coordinated by the Vice President, congregating 14 Ministers, aimed at coordinating and integrating governmental actions related to the Legal Amazon, propose policies and initiatives related to the preservation, protection and sustainable development of the Legal Amazon, and articulate actions for the implementation of public policies related to the Legal Amazon, in order to confront situations that require special measures or emergencies, among others, and monitoring the implementation of public policies with a view to social inclusion and citizenship in the Legal Amazon.[7]

Deforestation rates decreased significantly from 2008 to 2012 and started to increase during 2018 (Figure 4). Although deforestation may be legal in specific circumstances, the bulk of it is illegal and takes place in land with no regular titling, conservation units (preservation areas), rural settlements, and at a smaller scale, indigenous lands.

It is worth noting that to separate deforestation by land use category is an important goal aimed at defining strategies to tackle deforestation. The data in Figure 5 reaches up to 2016 given the fact that the total deforestation from 2017 to 2019 was not yet divided by land use category. Agroicone estimates

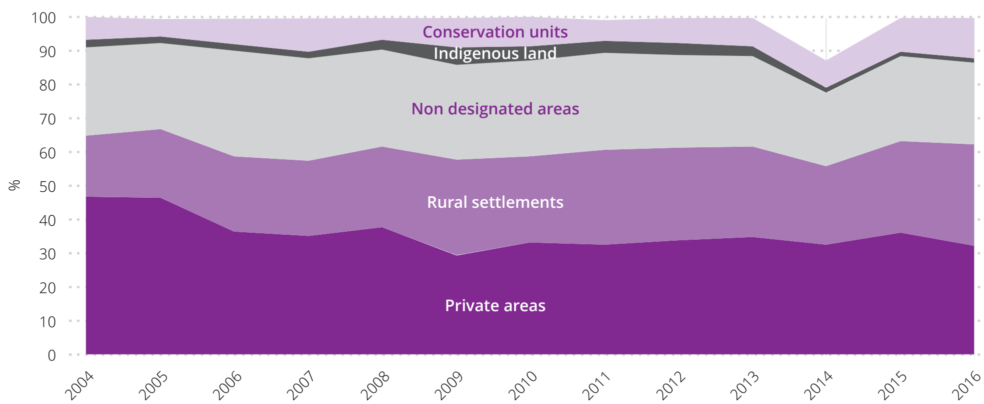
[6] PPCDAM. Operational Plan 2016/2020.
[7] Decree 10.239/2020. National Council of the Legal Amazon.

Figure 4. Deforestation rates in the Legal Amazon



Source: Inpe/Prodes, 2020.

Figure 5. Deforestation by land use category in Brazil



Source: Ministry of Environment. PPCDAM 2016/2020.
Note: Data from 2014 lacks the total amount of deforested area by category.

that only conservation units (protected areas categories) represented 20% of total deforestation in 2017 and 22% in 2018, while non-designated areas (public land with no titling) accounted for 24% in 2017 and 31% in 2018.

This puts strong pressure on the land governance agenda, given the fact that tackling deforestation is predominantly combating illegal activities. When it comes to agriculture, around 32% of the total deforestation in the

Amazon takes place in private areas, mixing legal and illegal deforestation. It is relevant to understand land use in Brazil prior to further analysis of deforestation dynamics and control. Areas dedicated to agriculture occupy 9% of the Brazilian territory (70 million hectares), comprising soybeans, sugarcane, rice, beans, cotton, coffee, eucalyptus and many other annual and perennial crops. Second crop cultivation is very significant, reaching around 19.3 million hectares of corn cropped after soybeans in the season 2019/2020.[8]

As a tropical country, climate conditions allow two or even three crops a year when there is sufficient rain. Genetic improvement is increasing second crop area by providing suitable crops varieties for this use (especially shorter cycles). Pastureland, natural and planted, occupies 21% of the country (around 170 million hectares), and represents a very diverse type of use. Native vegetations, including forests, savannahs and other native vegetation comprise more than 61% of the territory (566 million hectares).

As explained above, deforestation control in the Amazon is challenging and requires public and private actions. Illegal logging, land grabbing, mining, rural settlements and deforestation on areas less than 5 hectares and agriculture are drivers of deforestation that must be managed. Those are the key challenges to be addressed to curb illegal deforestation in the Amazon.

When it comes to deforestation on private areas, the implementation of the Forest Code is critical. First, it allows to separate illegal from legal deforestation of areas with remaining natural vegetation that exceeds the conservation requirements (Legal reserve areas ranges from 80% to 50% of the area in the Amazon, 35% in the Cerrado, and 20% in the other biomes; and the requirements for Permanent Preservation Areas on a case by case basis). Moreover, the compliance process with the Forest Code will lead to restoration of native vegetation and promote the conservation of native vegetation. Agricultural expansion is connected to deforestation in different and complex ways. Soybeans and livestock used to be significant drivers of Amazon deforestation which raised serious concerns among scientists, environmental NGOs, value chain and consumers worldwide, particularly in Europe.

[8] Acompanhamento da safra brasileira de grãos, v. 7 - Safra 2019/20 - No. 6.

The Soybean Moratorium, adopted as a private sector initiative, carried out with the cooperation between government and civil society organizations, aims to monitor deforestation in soybean areas in the Amazon. According to the Brazilian Association of Vegetable Oil Industries – Abiove:

> "However, even looking only at that portion of the Biome where 97% of the soy is grown (the 95 municipalities), it is still responsible for just 4.6% of the deforested area, which means that 95.4% of the deforestation that occurred during the Soy Moratorium is associated with other land uses, taking into account only the area evaluated by the Moratorium.
>
> Finally, it is important to highlight that, since the beginning of the Soy Moratorium, the soy area in the Amazon Biome has more than quadrupled, going from 1.14 million hectares in the 2006/07 crop year to 4.66 million hectares in the 2017/18 crop year, corresponding to 13.3% of Brazil's total soy area (35.1 million hectares). Soy has primarily expanded into pasture areas that were deforested before the Soy Moratorium was implemented, showing the efficacy of this initiative in allowing food production to develop without stimulating forest conversion into soy production."[9]

Although deforestation is a big issue when it comes to Brazil and agriculture, it is important to separate the agenda from the broader sustainability debate. The implementation of the Forest Code and enforcement of regulations against illegal deforestation should generate low deforestation rates in the near-future. Achieving low rates of deforestation is dependent upon effective public policies and private commitment and actions.

It is not within the scope of this paper to discuss the different concerns and options related to the deforestation control but it is quite relevant to consider that deforestation is an issue to be considered, especially when it comes to trade relations. It seems extremely important to point to the opportunities to improve agriculture aligned with sustainable development based on the experience Brazil has gained with the low carbon agricultural agenda and other policies. The first lesson is that promoting low carbon agriculture is critical to foster the adoption of innovation, technologies, good practices, improve rural assistance, deploy adaptation measures, and reduce emissions.

[9] Soy Moratorium: monitoring soy crops in the Amazon biome using satellite images.

There is a huge gap in the adoption of technologies and good agricultural practices, especially for small scale and family farmers, as highlighted in section 1 of this chapter. In this sense, it is worth remembering the three pillars of the climate smart agriculture approach adopted at the FAO: i) Sustainably increase food security, raising agricultural productivity and yields; ii) Build resilience and adapt to climate change; iii) Reduce and/or remove GHG emissions, when possible.[10]

Moreover, it is extremely important to quote the FAO principles of sustainable agriculture:

1. Improve efficiency in the use of resources;
2. Conserve, protect and improve natural resources;
3. Protect and improve rural livelihoods, equity and social welfare;
4. Increase the resilience of people, communities and ecosystems;
5. Develop responsible and effective governance mechanisms.[11]

According to each country's needs and realities, these principles drive the development of policies aimed at fostering agriculture. The ABC Plan and the implementation of the Forest Code, for instance, are pillars of the deployment of sustainable agriculture in Brazil. In addition to the adoption of the technologies and good practices, training and knowledge, increased productivity, the recovery of low-production areas and other practices that favor adaptation over time, as well as the reduction of emissions, are effects that can drive sustainable development for agriculture towards meeting food security and also different Sustainable Development Goals.

Before discussing key activities that emerge from the experience of the ABC Plan, it is important to highlight that by January 2019, 2,785 municipalities had adopted ABC Plan practices and 16 states adopted ABC state plans, focusing on actions that should drive the development of agriculture at the state level. Pasture recovery is one important example that emerges from the Brazilian case when it comes to policies aimed at promoting sustainable agriculture. The arguments against meat consumption, particularly beef, for instance, rely on the significant negative impact in terms of GHG emissions, soil degradation, water, and health issues.

[10] Climate-Smart Agriculture Policies, Practices and Financing for Food Security, Adaptation and Mitigation.
[11] http://www.fao.org/sustainability/en/.

Low productivity livestock is not just a source of higher emissions, but a cause of several socioeconomic impacts as well. The feasibility to promote productivity gains relies on pasture recovery and management, the adoption of good production practices such as pasture rotation, integration with agriculture and, if possible, forests, the adoption of genetics and animal welfare practices, having rural extension, capacity building and access to credit as a basis.

According to Agroicone, extractivist livestock, with a stocking rate of 0,5 heads/hectare, covers approximately 68 million hectares in Brazil. Low productivity livestock, about 1.5 heads/hectare, covers 104 million hectares, while high productivity livestock with 3 heads/hectare, accounts for 7.5 million hectares.[12] These figures point to a huge opportunity to recover pastureland, promote good production practices, increase livestock productivity and release pasture areas for agriculture and forest restoration in compliance with the Forest Code. It is also relevant to mention the benefits of avoiding the conversion of new areas to pasture and the consequent degradation of already open areas.

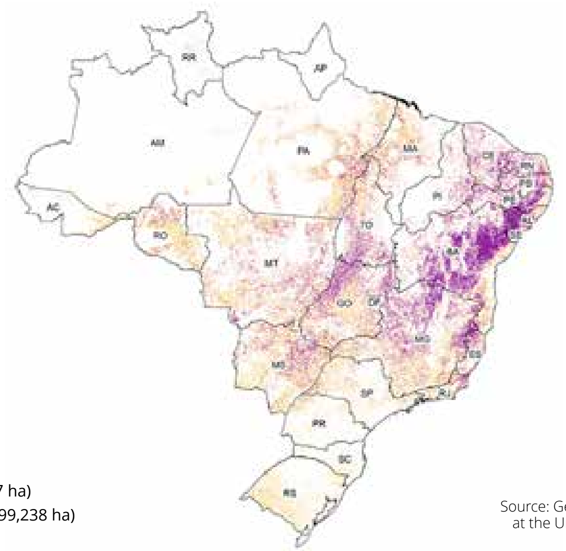
A broad mapping of pasture areas in Brazil, conducted by the University of Goias Geoprocessing Laboratory – Lapig, called the Atlas of Brazilian Pastures, – made a comprehensive analysis of the different levels of pasture degradation, concluding that there are 63.7 million hectares of pastures with different levels of degradation. With no management, those areas can become less productive and, in some cases, degraded to the point where they are unsuitable for production.

The intensification of livestock production through pasture recovery will be fundamental to the sustainable development of agriculture and livestock free from deforestation and within the standards of the Forest Code. Moreover, the potential to expand agriculture over pastures and other degraded areas relates to the amount of degraded areas, proximity of logistics, existence of technological packages, and other aspects.

The recovery of degraded pastures is an immense opportunity to encourage increased production, combining technology and optimizing land

[12] Cattle ranching intensification as a key role on sustainable agriculture expansion in Brazil. Agroicone, Input/2016.

Figure 6. Pasture degradation in Brazil



Degraded pastures (63,745,727 ha)
Non-degraded pastures (114,999,238 ha)

Source: Geoprocessing Laboratory at the University of Goias (Lapig).

use. According to data from the consultancy Athenagro and the "Rally da Pecuária", in 2018 the degradation of pastures generated losses equivalent to R$ 7.23/@ produced, due to expenses with reforming pastures in an advanced stage of degradation. These losses can reach up to R$ 15/@ which reduces the revenues of the producer, requires more time to finish the animals, increases degradation and generates higher GHG emissions.[13] The conversion of degraded pastures into highly productive and resilient pastures in agricultural areas and the implementation of integrated systems are fundamental not only for improving productivity and income for rural properties, but also for reconciling production with environmental conservation.

The costs of recovering degraded pastures depend on several factors, such as the level of degradation, the access to inputs and specialized labour, the cost of capital, amongst others. On average, the costs to promote pasture recovery range from R$ 3,000 to R$ 6,000 per hectare (implementation

[13] Degradação do pasto custou mais de R$ 15 por arroba para o pecuarista em 2018, http://www.rallydapecuaria.com.br/node/1624.

and maintenance), depending on the specific situation of the terrain. The investments needed to foster pasture recovery at a million hectares scale imply different opportunities for technology adoption, financial products suited to long term investment projects, specialized labour, among other issues. In this regard, the ABC Plan as a policy that incentivizes pasture recovery and good production practices is an important strategy.

The goal of recovering 15 million hectares by 2030 included in the Brazilian NDCs reflects the importance of pasture recovery as a strategy directly linked to the socioeconomic and environmental impacts arising from this activity. The more areas that are recovered, allowing for improved livestock productivity, transition to agriculture or restoration of native vegetation, the greater the benefits that will be achieved. The less area that is recovered, the greater the area that will become degraded, prompting lower productivity, generating negative socioeconomic impacts and pressure for the conversion of new areas. It is also worth mentioning that there are several aspects of what can be considered sustainable production, which can improve and promote incentive policies. Themes such as irrigation, water conservation, integrated pest management, rational use of inputs, agroforestry systems, integrated systems, among others, should motivate the adoption of new policies aimed at fostering innovation into agricultural systems.

4. Final reflections

Brazil and China have been constructing a solid partnership in relation to agricultural trade and investments, which will be important to promote food security, allowing access to safe, nutritious, and sustainable food. The diversification of the food products exported to China, including beef, fruits, dairy and other agricultural goods can play an important role, not just from an economic perspective, but more importantly, can help to drive demand for diverse products with higher aggregated value. This is crucial from a nutritional perspective, and implicitly drives the demand for consideration of key sustainability issues.

From a social perspective, Brazil faces huge challenges and poor farmers and communities living in rural areas are part of these. Even though the country is mainly urban and presents highly technological agricultural chains, rural poverty is at the centre of social and economic inequalities. Natural resources and the climate allow for strong increases in family farmers yields, while at the same time several agricultural products with good market value could be cultivated. Tailored public policies for these farmers are needed, combining governmental, private and international cooperation and support. A positive win-win agenda must be built for bringing these farmers to national and international markets and providing access to technologies and finance.

Brazilian agriculture faces several challenges when it comes to environmental issues. The case of climate policies and opportunities arising from this agenda highlight the potential for agriculture to have production efficiency, innovation, mitigation and adaptation as key targets. The experience of the Low Carbon Agriculture Plan up to 2020 is extremely important as a driver of sustained and long-term benefits into the agricultural systems based on technology that will allow a reduction of emissions and foster resilient agricultural systems. The conservation and restoration of native vegetation on farms, within the Forest Code, plays a critical role when it comes to assuring not just compliance with environmental regulation, but also in assuring sustainable assets embedded in the products, such as carbon, biodiversity, soil and water services.

The possibility of fostering innovation and partnerships aimed at improving agricultural production on a sustainable basis is also relevant when it comes to Sino-Brazilian relations. Academic collaborations and business flows have the potential to increase and thereby support the Brazilian sustainability agenda for agriculture. The forest restoration agenda is a good example, since a key bottleneck is the lack of demand for timber and non-timber products (nuts, fruits, oils, for several uses). There is a similar situation with respect to renewable technologies. The exchange of Brazilian biofuels and Chinese solar equipment can prove mutually beneficial for both countries.

Fostering sustainable agriculture relies on producers, policies, international trade, consumers and, from a broader view, civil society. Having this in mind, it is worth noting that Brazil and China can build stronger relations when it comes to mutually supportive food security connected to sustainable production. This is the challenge of sustaining life, while having the sustainable development agenda as a core basis.

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Postface

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Cross the river by feeling the stones.
Deng Xiaoping

Brazil and China are amongst the four largest global producers and exporters of agriculture and food products. Together, China and Hong Kong are the largest global agricultural importers. They are also the main destination of Brazilian agri-food exports (US$ 33 billion per year, or 34% of total agri-food exports). Brazil is the main supplier of China, representing nearly 20% of that country's imports of agricultural products. In the years leading up to 2030, China will account for a fourth of the rise in the global consumption of animal protein. It is therefore not a coincidence that China has become one of the main sources of foreign direct investment in Brazilian agribusiness.

The recent trade war made China raise its import tariffs on North American agri-food products. In 2018/19, the Chinese swine heard was reduced by nearly 40%, due to the terrible African swine fever epidemic. These two factors led to a spike in the Brazilian exports of cotton, poultry, and beef, making Brazil the main Chinese supplier of these products, apart from already being the most important source of that country's soybean imports. The fact of the matter is that a large share of the Brazilian supply of agriculture and food products is "married" to the Chinese demand, as there is no other fitting spouse on the market. What is more, both of these parties are very well aware that they need each other.

It is interesting to note that both the Brazilian and Chinese agricultural and food sectors have undergone profound reforms since the 1970s. Deng Xiaoping led the largest Chinese migration movement in history, in which more than 200 million Chinese left the countryside in order to supply the Chinese manufacturing industry's immense demand for labor, as it was in the process of integrating within global value chains. This step on behalf of the Chinese government permitted the modernization of parts of Chinese agriculture, and in particular, sectors such as fruits and vegetables, and more recently, the explosion of the so-called agriculture 5.0, with drones, greenhouses, and digital technologies. At the same time, China has recognized the impossibility of becoming self-sufficient in certain commodities, leading it to open its domestic market gradually and pragmatically for imports of soybeans, pulp, cotton, and meats, particularly from Brazil.

In Brazil the 1970s were marked by the beginning of the "tropical agricultural revolution" of the Cerrado in Brazilian mid-west. On the technological front, this implied innovations such as new crop varieties, soil correction, no-tillage, two crops in the same agricultural season, and the phenomenon of crop-livestock integration. On the human side, a new generation of young, motivated and dynamic farmers migrated to the frontiers with new ideas of management, economies of scale, and sustainability.

These two trends consecrated the “natural marriage” between Brazil and China in the agri-food sector, which prospered in spite of the infrastructure shortcomings of the former, and the market access challenges in the latter. This development was rooted in the strong Chinese demand for food, as well as the high productivity reached by the tropical agricultural technology, but not as a “strategic vision” of both governments’ planning capacity.

At the present moment, a new challenge presents itself for the two countries: the risk of zoonoses and their impacts on the quality and safety of food products. Throughout the past 30 years, we have become accustomed to qualify global warming, inequality, and unemployment as the major problems of mankind. We have not been aware of the invisible enemy which always has been lurking, and who now has gained an enormous strength with globalization: the pandemics with origins in zoonoses.

The Covid-19 was not the first, and neither will it be the last epidemic to emerge from domesticated and wild animals. Before that, we had HIV/AIDS, Ebola, SARS, MERS, as well as the avian and swine flu. None of these, whatsoever, has had the capacity to halt the global economy.

If climate change bears the promise of gradually exterminating humanity as a result of our inaction, the Covid-19 arrives without warning to kill people in hospitals unprepared to handle pandemics, and through the depression caused by the economic inactivity.

The fall of the Berlin Wall in 1989 marked the reorganization of global politics, with the end of the Cold War. In September 2001, the attack on the Twin Towers in New York led to a similar reorganization in the field of international security, with an increased focus on the risks implied by global terrorism. The Coronavirus marks a reorganization of human & animal health, now called One Health, the surprising vulnerability of which was laid bare by contemporary globalization.

I am convinced that food safety can become one of the main points of cooperation between Brazil and China, two countries which have always been amongst the leaders in the global production, consumption, and trade of proteins of animal and vegetable origins.

If trade and investment dominate the Sino-Brazilian relationship today, issues such as innovation, infrastructure, and sustainability will gain increasing importance within the bilateral agri-food agenda. If productivity and food security were the main words in the past, quality; and food safety will be as important in the future.

Finally, we need to recognize that in the marriage between Brazil and China, the fiancées will always be very different. China has a socioeconomic homogeneity and millennial culture, constructed around the Confucian ethics, which has led to a unitary and stable government. Brazil is marked by an immense ethnic and cultural diversity, as well as fragmented and disorganized governmental bodies.

China has a strategic long-term vision about its future, having undertaken collective investments in its education system and infrastructure. Brazil is incapable of gazing beyond short-term emergencies, a field in which we nonetheless demonstrate a unique combination of creativity, improvisation, and resilience.

The phrase by Deng Xiaoping which opens this text illustrates the essence of the Chinese pragmatism. That is what we need: to construct confidence and cooperation in order to jointly traverse the turbulent river of global food security and food safety global challenges.

This book was composed
in Open Sans in June 2020.

As the leading universities within agriculture and food-related subjects in China and Brazil, CAU and USP launch this joint publication presenting in-depth analyses about the strategic importance of stronger bilateral cooperation in trade, investments, innovation, infrastructure, and sustainability.

Vahan Agopyan - *President, University of Sao Paulo (USP)*

This book, written by a highly qualified group of Chinese and Brazilian experts, is the most comprehensive publication on China-Brazil relations and cooperation perspectives within the agri-food sector.

Roberto Rodrigues

Former Minister of Agriculture, 1st holder of the Luiz de Queiroz Chair (Esalq)

Even with the backdrop of anti-globalization trends, the two largest emerging economies in Asia and Latin America have continued to strengthen productive partnerships in agriculture and food security, creating strong mutual complementarities in trade, investments and technology, as highlighted in this truly captivating book.

Shenggen Fan - *Chair Professor at CAU, former DG of IFPRI*

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