UNIVERSITY OF LJUBLJANA

SCHOOL OF ECONOMICS AND BUSINESS

MASTER’S THESIS

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AN ANALYSIS OF INTERNATIONAL COMPETITIVENESS OF CHINA'S SEED INDUSTRY

Ljubljana, September 2020 CHENGTIAN WANG

AUTHORSHIP STATEMENT

The undersigned CHENGTIAN WANG, a student at the University of Ljubljana, School of Economics and Business, (hereafter: SEB LU), author of this written final work of studies with the title AN ANALYSIS OF INTERNATIONAL COMPETITIVENESS OF CHINA'S SEED INDUSTRY, prepared under supervision of professor Katja Zajc Kejžar, PhD

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LIST OF ABBREVIATIONS

ADF – Augmented Dickey-Fuller

APEC – Asia-Pacific Economic Cooperation

ASEAN – Association of Southeast Asian Nations

BRCA – Revealed Comparative Advantage of Balassa

CCFI – China Containerized Freight Index

CNSA – China National Seed Association

CNY – China Yuan

COVID-19 – Coronavirus Disease 2019

DNA – Deoxyribonucleic Acid

ERP – Enterprise Resource Planning

EU – European Union

EViews – Econometrics Views

FAO – Food and Agriculture Organization of the United Nations

GCCs – Global Commodity Chains

GDP – Gross Domestic Product

GMM – Generalized Method of Moments

GVCs – Global Value Chains

HHI – Herfindahl-Hirschman Index

HS – Harmonized System

IFA – International Fertilizer Association

IMD – International Institute for Management Development

IMF – International Monetary Fund

ISF – International Seed Federation

M&A – Mergers and Acquisitions

MOA – Ministry of Agriculture of People's Republic of China

MOT – Ministry of Transport of People's Republic of China

MRT – Multilateral Resistance Terms

NBSC – National Bureau of Statistics of China

NPC – National People's Congress of People's Republic of China

NRCA – Normalized Revealed Comparative Advantage

OECD – Organization for Economic Co-operation and Development

OEM – Original Equipment Manufacture

R&D – Research and Development

RCA – Revealed Comparative Advantage

SITC – Standard Industrial Trade Classification

TiVA – Trade in Value Added

UNDP – United Nations Development Program

UNIDO – United Nations Industrial Development Organization

UPOV – Union for the Protection of New Varieties of Plants

USD – United States dollar

WEF – World Economic Forum

WMO – World Meteorological Organization

WTO – World Trade Organization

INTRODUCTION

China, a large agricultural country endowed with abundant natural resources, produces one fourth of crops across the world with nearly 10 percent of world arable land (FAO, 2019). However, according to a report conducted by International Seed Federation (2017), China's seed industry accounts for merely 1.7% of the global market share, much lower than that of the top three countries: Netherlands (17.1%), France (15.1%) and the United States (14.4%). The seemingly contradictory situation triggers my interest in analyzing international competitiveness of China's seed industry.

International competitiveness is a broad idea. In research works, four levels of competitiveness are frequently discussed, including the level of nations, industries, companies, and products. Despite those detailed classifications, different authors have their own understanding of the concept. This thesis adopts the definition proposed by Momaya (1998) that international competitiveness at industry level refers to the degree an industry satisfies the needs of customers through price, quality and innovation, and meets the expectation of investors with profitable margins.

Many famous researchers have contributed to theory of competitiveness. The theory of Absolute Advantage was put forward by Smith (1776), stating that the absolute difference in production cost between countries brings about absolute competitive advantages for products, which then generates international trade. Later, the law of Comparative Advantage was put forward by Ricardo (1817), who pointed out that comparative difference of labor productivity causes relative cost difference, making international division and free trade possible. To avoid its deficiency of regarding labor as the only production factor (Krugman, 1987), Ohlin (1935) developed the Heckscher-Ohlin Model, emphasizing that comparative advantage exists in international trade due to different factor endowments including not only labor but also land and capital, among other factors. Based on comparative advantage theory, researchers started to analyze the competitiveness of a country or sector through empirical induction since the 1980s (Wang, 2014). One of the famous theories is the Diamond Model developed by Porter (1990). In his opinion, determinants of national and industrial competitive advantage include (1) factor conditions; (2) demand conditions; (3) related and supporting industries; (4) firm strategy, structure, and rivalry; (5) role of chance and (6) role of government. As economic globalization and international capital flows become more active since 1990s, Dunning (1993) argued that Porter's volume underestimates the significance of multinational corporations to competitive advantage and he therefore made some supplements to the model.

Plenty of research has been done on competitiveness of seed industry, and researchers usually focus on specific influencing factors in detail, including intellectual property (Pray, 1999), innovation, technology (Dai, 2002), seed quality (Pray, 1986), advanced labor (Grofik

& Kmetova, 1994), financial risk management (Zhang & Xu, 2006) and government policies (Chen, Zhan & Zhou, 2004), among others. In general, very few frameworks have been developed to analyze the international competitiveness of seed industry systematically.

This thesis aims to contribute a comprehensive understanding of China's seed industry through both qualitative and quantitative methods and seek solutions to increasing its international competitiveness.

Key research questions to be addressed in this thesis are listed as follows:

1) In which kind of seed varieties does China have comparative advantages or disadvantages in global competition?
2) How is the performance of China's seed industry considering intra-industry trade?
3) What influence do factor conditions, government policies and firm strategies have on the competition capability of China's seed industry?
4) How do demand conditions and related industries affect the competition potential of China's seed industry?
5) What could be done to improve international competitiveness of China's seed industry?

The outline of the thesis is as follows. The first chapter covers theoretical foundations of international competitiveness, including its definition, research perspectives and measuring methods. The second chapter clarifies the scope of seed industry and briefly introduces geographical conditions of China. The third section represents previous performance of China's seed industry through descriptive analysis and trade indices, including Revealed Comparative Advantage index and Grubel-Lloyd index of intra-industry trade. To evaluate the capability and potential of China's seed industry, Diamond model is used in the fourth and fifth sections, where production function model and trade gravity model are used to enhance the findings. In the sixth chapter, recommendations will be given on how to improve the competitiveness of China's seed industry. Finally, the concluding section summarizes the main findings.

1 THEORETICAL FOUNDATIONS

1.1 Definition of international competitiveness

Competitiveness has become one of the most attractive but confusing concepts since 1980s. The term international competitiveness increased by approximately 26 listings per year between 1981 and 1986 in ABI/Inform database, and the rate soared to 45 listings per year during the next six years (Waheeduzzaman & Ryans, 1996).

Different measures of international competitiveness are frequently seen in government reports and media, but the concept of international competitiveness itself is rarely defined (Fagerberg, 1988). In the early stage, researchers usually discussed about competitiveness without precise definition or classification, and that concept could in effect serve as a proxy for indices such as international current account balance, compliance cost and national output (e.g. Summers, 1988, p. 349; Stewart, 1993; Windrum & Tomlinson, 1999). Since international competitiveness is more frequently used in comparison between nations and industries, its definition is considered urgent to be established. As Porter (1990, p. 6-7) suggests, the definition of a competitive nation is the wrong question to tackle and the only meaningful concept of competitiveness for a nation is neither cheap labor nor favorable exchange rate, but national productivity. However, the concepts of productivity and competitiveness should not be interchangeably used together since the former refers to internal capability of organizations while the latter indicates the relative position of an organization against its competitors (Moon & Peery, 1995). In addition, the focus on industry in the analysis of national competitiveness (Porter, 1990, p. 33) may lead to confusion about the concept. Instead, international competitiveness should be viewed from different levels of analysis, and classified into the competitiveness of product, firm, industry and nation (Buckley, Pass & Prescott, 1988; Waheeduzzaman & Ryans, 1996).

Although a large volume of studies on competitiveness have been conducted from different units of analysis, few works pay attention to synthesizing them. Based on a literature review by Chaudhuri and Ray (1997), this thesis adopts the definitions of international competitiveness at four levels as follows:

1) Competitiveness at national level: a country's capability to produce, distribute and service products that can compete in global markets and at the same time increase its real income and living standards of its citizens (Scott & Lodge, 1985; Tyson, 1988).
2) Competitiveness at industry level: the extent to which an industry satisfies the needs of customers through product/service characteristics of price, quality and innovation, offers attractive returns on investment and offers the potential for profitable growth (Spence, Hazard, Fellow & Kennedy, 1988; Momaya, 1998).
3) Competitiveness at firm level: a firm’s competitive position vis-à-vis competitors in global markets determined by interrelated factors, including product characteristics, delivered cost and perceptions of consumers about the match between service and their needs (Buckley, Pass & Prescott, 1988; Hamel & Prahalad, 1993).
4) Competitiveness at product level: the ability of a certain product to expand on international markets on condition that its product value is fulfilled (Papadopoulos & Heslop, 2014).

Although this thesis focuses on the competitiveness at industry level, other units of analysis will also be considered. Studies on the national competitiveness help us establish an overview of macro-level distinctions that are important for understanding competitiveness.

Looking at firms with various technologies, management practices as well as different levels of vertical integration and diversification provides a profound perspective for comparison with industries in other countries. Research on products is beneficial for evaluating the strengths and weaknesses of market strategies. In a word, confining the analysis to the industry level makes it extremely difficult to grasp the complexity of international competitiveness.

1.2 Theories on international competitiveness

Research on competitiveness at industry level usually revolves around questions such as: how do crucial factors vary among industries? Where does core competence of an industry lie in international competition? What role does national government play in making policies and shaping competitiveness? Similar questions compose a panorama of an industry and need to be addressed by competitiveness theories.

1.2.1 Comparative advantage of resources

This section introduces classical and neoclassical theories of international trade, including theories of absolute advantage, comparative advantage and factor endowment theory.

1.2.1.1 Theory of Absolute Advantage

The idea of absolute advantage was first put forward by Adam Smith (1776) in his famous publication *The Wealth of Nations*. In the book, he criticized the mercantilism, arguing that producers, instead of consumers, are elaborate contrivers of the mercantile system who carefully attend to their own interest by extorting from legislatures the exemption from duties and oppressing workers. As an advocator of free trade, he pointed out that the colony trade, aiming to exclude other nations from any share of it, not only sacrificed part of England's absolute advantage, but also subjected the country to an absolute disadvantage in other branches of trade. The division of labor that increases dexterity of workmen is not originally the effect of human wisdom, but the propensity in human nature. In this sense, a country should buy commodities produced abroad with lower cost and export those with some cost advantages at home. Any violation of this rule could diminish the value of annual produce of a nation.

The theory of absolute advantage illustrates the rationality of division of labor as well as the exchange between countries with different advantages. However, it is challenged by some scholars and considered to be a logical impossibility (Kemp & Shimomura, 1995). Firstly, it fails to explain why a country with absolute disadvantages in all industries still trades with its partners. Secondly, it cannot explain why the ‘same’ unit of labor and capital is more efficient in one country than the other. The explanation of increase in productivity requires the introduction of an additional productive resource, which violates the basic assumptions (Brandis, 1967).

In a word, the theory describes a special case in international trade but is inadequate in universal significance.

1.2.1.2 Theory of Comparative Advantage and RCA index

To answer the questions unsolved in Smith's theory, David Ricardo put forward the theory of comparative advantage in his 1817 publication *On the Principles of Political Economy and Taxation*. Suppose a country is relatively more efficient in producing a specific commodity than another country, we can say the country has comparative advantage in production of that commodity (Kılıç, 2002). Since resources and level of technologies are limited for each country, it is natural and wise for them to produce goods and services where they have comparative advantage to maximize value of production (Ricardo, 1817, p. 272). That explains why international trade is necessary and mutually beneficial to countries and why countries have the tendency of specialization in production of certain products.

The theory served as a good defense for free trade and enjoyed great popularity for a long period. However, the assumption of free trade was later doubted not due to political pressure for protection, but changes in the theory of international trade itself. Models including imperfect competition and increasing returns to some extent replaced perfect competition and constant returns models, which reduced the validity that trade can be well explained by comparative advantage. Besides, government intervention through import restrictions and export subsidies could in some cases be in the national interest (Krugman, 1987).

Like the imperfections of absolute advantage theory, the theory of comparative advantage regards labor as the only production factor and cannot answer why a country does business with its partners that have equivalent comparative advantages or disadvantages in both products. However, the theory is still considered as a reasonable rule of thumb guiding international trade (Krugman, 1987). It can also be applied to many aspects of life other than trade.

In order to measure relative comparative advantages in empirical research, the revealed comparative advantage (hereinafter: RCA) index was introduced by Balassa (1965). Here, we use BRCA to define country *j*'s comparative advantage of product *i* in the global market as

$$BRCA_{ij} = \frac{X_{ij}/\sum_i X_{ij}}{\sum_j X_{ij}/\sum_i \sum_j X_{ij}} \tag{1}$$

where X_{ij} denotes export value of commodity *i* in country *j*.

When the commodity as a proportion of a country's total export value is higher (lower) than the proportion of the world, BRCA index is above (below) 1 and the country has comparative advantage (disadvantage). In this sense, BRCA = 1 is the comparative-advantage-neutral point. Unfortunately, that characteristic brings about asymmetric property due to different distance between lower and upper bounds to the neutral point. In addition, the index has a bias to indicate strong advantage for those with a small market share worldwide (Yeats, 1985). Therefore, the magnitude of the index has neither cardinal nor ordinal use (Hillman, 1980).

Yu, Cai and Leung (2008) proposed the normalized revealed comparative advantage (hereinafter: NRCA) index in response to the problems of the original one. The deviation of actual export of commodity from the neutral level can be stated as

$$\triangle X_{ij} \equiv X_{ij} - \widehat{X_{ij}} = X_{ij} - \frac{\sum_i X_{ij} \cdot \sum_j X_{ij}}{\sum_i \sum_j X_{ij}} \tag{2}$$

The index can be normalized as

$$NRCA_{ij} \equiv \frac{\triangle X_{ij}}{\sum_i \sum_j X_{ij}} = \frac{1}{\sum_i \sum_j X_{ij}} (X_{ij} - \frac{\sum_i X_{ij} \cdot \sum_j X_{ij}}{\sum_i \sum_j X_{ij}}) \tag{3}$$

The NRCA takes 0 as the comparative-advantage-neutral level and its magnitude becomes meaningful in interpreting competitiveness. For example, a country with an NRCA of 0.04 is four times as much competitive as a country with NRCA of 0.01.

1.2.1.3 Factor Endowment Theory

To make up for the deficiencies of comparative advantage theory, Ohlin developed the factor endowment theory in his 1935 publication *Interregional and International Trade* based on the study of Heckscher. The starting point of his analysis lies in the assumption that production factors are inter-regionally immobile while intra-regionally freely mobile (1935, p. 10). Inequality in the relative prices of factors of production, including land, labor and capital, is a necessary condition for establishing a trade relationship (1935, p. 16). In his opinion, each region should produce goods that require large proportions of the factors relatively abundant there (1935, p. 12).

One of the drawbacks of the theory is that it views factors of production in a static way and neglects endogenous technological development and change in labor productivity via economies of scale or cumulative learning (Linder, 1961, p. 12; Vernon, 1966). Besides, its assumption of free trade also calls for doubt. Later, new point of views against free trade was developed, arguing that government policies could tilt oligopolistic competition to gain excess returns from international trade, and governments should favor industries yielding externalities, especially the generation of knowledge (Krugman, 1987).

1.2.1.4 The Leontief Paradox and the index of intra-industry trade

The failure of comparative cost theory was further represented by the Leontief paradox, which described the fact that the capital-to-labor ratio of exports of the United States was surprisingly lower, not higher, than the like ratio in production of the U.S. displaced by competitive imports (Leontief, 1953).

To answer the questions posed by the Leontief paradox, several new trade theories were developed, including the product life cycle theory (Vernon, 1966), theory of preference similarity (Linder, 1961) and the theory of intra-industry trade (Grubel & Lloyd, 1975).

Vernon does not closely follow the comparative cost doctrine but focuses more on economies of scale, timing of innovation and influence of market uncertainty on international trade patterns. He argues that knowledge is not free, but is an independent factor in the decision to trade or to invest. Before the standardization of production, the ease of access to knowledge and the degree of freedom in changing inputs could deeply influence the outcome. In addition, the need for effective communication with local customers and suppliers is especially important to producers in the early stage. That is the reason why high-income and labor-saving new products are first developed in the United States locally. In the next stage, as standardization takes place, the need for flexibility declines and producers start to take production cost into consideration, which leads to partly shift in the location of production facilities to other advanced countries. Finally, the foreign demand becomes so large that it is wise to service third-country markets and exports back to the U.S. become feasible (Vernon, 1966). The explanation sheds some light on the Leontief paradox.

Linder is more radical and questions the principle of factor proportions theory that is not doubted even by Leontief. He holds the view that it is impossible for a country to gain comparative advantages over products that are not demanded on the home market. Contrary to the hypothesis of the factor proportions model, international trade should be more intensive between countries with similar demand structures, and meanwhile, with more equal per capital incomes (Linder, 1961, p. 17). The theory provides a powerful analytical tool to explain intra-regional trade, which will never happen in Ohlin's assumptions. Linder's model serves as a complement and development of the factor endowment theory.

Grubel and Lloyd (1975, p. 1-5) place their emphasis on intra-industry trade, the export and import of products in the same category. In Ohlin's model, industry is defined as an agglomeration of companies producing perfectly homogeneous commodity. However, according to Lancaster (1966), goods and services are not perfect substitutes between each other because they have a great number of characteristics. Since the criteria of classification represents the extent of substitutability of products in consumption and similarity of inputs in production, it is appropriate to adopt the 2-digit, or even 3-digit level of aggregation of the Standard Industrial Trade Classification (SITC). Although it seems to be somewhat strange to consider an industry as a group of companies that produces a fixed and limited range of products, the method makes it possible to examine the pattern of intra-industry trade at different levels of aggregation.

For the purpose of measuring intra-industry trade, Grubel and Lloyd (1975, p. 20) define intra-industry trade (R_i) as the value of exports matched by the imports in an industry. That is,

$$R_i = (X_i + M_i) - |X_i - M_i| \tag{4}$$

where X_i and M_i are respectively the export and import value of industry *i* at the given level of aggregation.

To facilitate comparison among countries, the intra-industry trade is redefined as:

$$\overline{B_i} = \frac{(X_i+M_i)-|X_i-M_i|}{X_i+M_i} \times 100 \tag{5}$$

The measure of intra-industry trade, ranging from 0 to 100, demonstrates the ratio of trade flows removed by netting. When exports and imports are equal in value, B_i is 100. When there is completely no imports or exports, B_i equals to 0. That index can be used to analyze the distribution of measures among different industries at a given level of aggregation. For that purpose, it is appropriate to summarize the distribution of measures via the mean value. However, the mean is biased if it is an average of a set of industries where exports are not equal to imports (Grubel & Lloyd, 1975, p. 22). Therefore, they adjusted the value for the aggregate trade imbalance, as is shown below:

$$\overline{C_i} = \frac{\sum_{i=1}^{n}(X_i+M_i)-\sum_{i=1}^{n}|X_i-M_i|}{\sum_{i=1}^{n}(X_i+M_i)-|\sum_{i=1}^{n}X_i-\sum_{i=1}^{n}M_i|} \times 100 \tag{6}$$

The adjusted index makes a substantial difference when the trade imbalance is large compared with the total value of export and import. For example, suppose the trade deficit accounts for one-fifth of the total trade value, the adjustment will increase the initial measure by one-fourth. The adjusted index lies within the interval [0, 100].

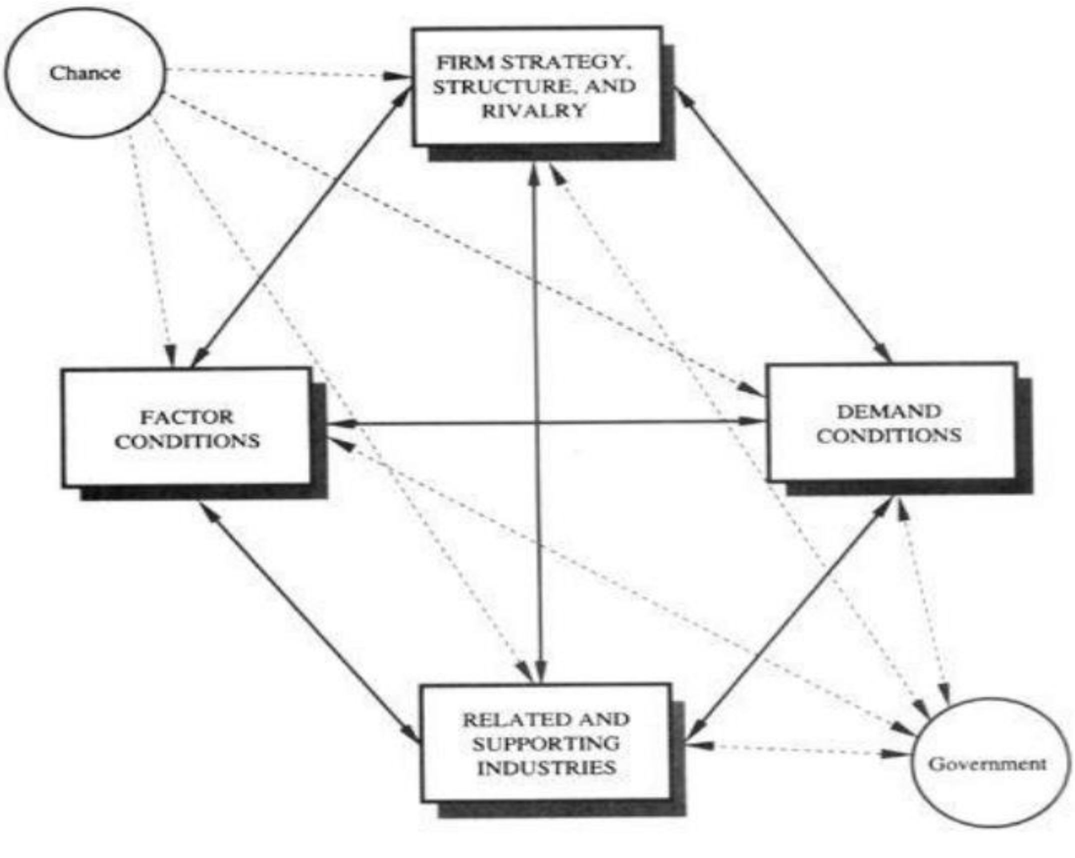
1.2.1.5 A brief summary

The classical theories of international trade, mainly including absolute and comparative advantages theories, were first developed from the mid-18^{th} century based on criticism to mercantilism. They considered division of labor to be a reason for trade and explained the market structure and profit allocation from the perspective of labor productivity. At the beginning of 1920s, neo-classical theories of trade started to gain popularity. They were represented by the factor endowment theory, which attributed the difference of comparative costs to various factor abundance among countries and differentiated factor intensity in production. After the World War II, trade volume among developed countries and intra-industry trade soared, challenging the conventional assumptions of perfect competition and constant returns to scale. New theories, such as the theory of product life cycle and preference similarity, were thus developed and provided us with all kinds of useful analytical tools in studies of trade in the new era.

1.2.2 Comparative advantage of nations

As mentioned above, the traditional comparative advantage theory denies the existence of economies of scale, assumes identical technologies and undifferentiated products everywhere, and regards factors of production to be immobile among nations. As more empirical research was done, the imperfect theory became more frustrating because it does not reflect the real and changing competition.

Figure 1: The diamond model of comparative advantage of nations



Source: Porter (1990).

Under this circumstance, Porter (1990) constructed a new paradigm based on comparative advantage of nations. Porter's theory places emphasis on microeconomic foundations and the role of companies in the competition environment. He argues that production factors are less important than before due to globalization, and prosperity lies in supportive business environment and institutions that encourage nations to efficiently use and upgrade their inputs. Merely assembling resources and redistributing a nation's wealth do not suffice to achieve sustainable competitive advantages around the world (1990, p. 12).

In the modern economy, prosperity is a choice, instead of inheritance, for a nation (1990, p. 13). The primary economic goal for a country is to achieve increasing standard of living for citizens, which is determined by productivity in the long run. In this sense, the only meaningful notion of competitiveness for a country is national productivity (1990, p. 40). Figure 1 demonstrates the framework of Porter's theory of new comparative advantage of nations, which is later depicted as a diamond. The diamond consists of four main facets and two additional environmental variables, and the model facilitates systematic analysis on information, motivations, competition pressures, ease of access to supporting industries and other factors.

1.2.2.1 Factor conditions

Factors of production refers to inputs required for the competition in an industry. Those factors are usually discussed in such a general way that they fail to reveal the real situation in strategically distinct industries. To address the problem, Porter (1990, p. 114) grouped them into five categories, including human resources, physical resources, knowledge resources, capital resources and infrastructure. A nation benefits from possessing low-cost or high-quality factors of certain types that are indispensable for a specific industry.

The extent to which a nation efficiently and effectively deploys the factors has a major impact on international competitiveness. Since the trend of globalization nowadays allows nations to source factors worldwide, the availability of some factors is becoming less essential. It is the creation, instead of inheritance of factors within a nation, that leads to the sustained success. The abundance of factors could even surprisingly undermine competitive advantages (Porter, 1990, p. 116).

To better understand the role of production factors, it is appropriate to view them from the perspective of hierarchies. Firstly, there are basic and advanced factors. Basic factors include natural resources, labor, capital, location and climate while advanced ones contain modern communications infrastructure, research institutes and well-educated personnel. Basic factors are inherited passively by a country and easily accessible due to globalization, but they remain significant in extractive and agriculturally related industries. By contrast, advanced factors require sustained investment to help a country achieve higher-order advantages, such as differentiated products and proprietary technologies. Advanced factors are usually built on the basic ones. Secondly, factors differ in their specificity. Generalized factors involve debt capital, motivated employees and transport system, while specialized factors refer narrowly to skilled labor, knowledge in particular fields, and infrastructure of special properties, etc. Advantages based on generalized factors can easily fleet, while specialized factors, though in need of focused and riskier social investment, are integral to innovation and growth (Porter, 1990, p. 117-119).

1.2.2.2 Demand conditions

Domestic demand is important in facilitating upgrading of industries and innovation of firms. The composition of home demand (characters of buyer needs), the size and mode of growth of home demand, as well as the mechanisms transmitting domestic preferences to foreign markets, are three significant attributes of home demand (Porter, 1990, p. 127).

Firstly, the composition of home demand encourages firms to perceive and respond to needs of consumers. The picture of domestic needs would be much easier to depict than in foreign markets. With appropriate pressures from demanding buyers at home, firms will be guided to innovate faster and gain more sophisticated advantages than foreign competitors. If domestic needs happen to anticipate those of foreign consumers, they can serve as a good indicator of what will be widespread and shape the upgrading of products. What deserves our attention is that demand also has segment structures. The relatively large and promising segments of industries usually attract greater attention and investment from domestic companies, while less profitable segments are neglected and at the risk of being preempted by foreign rivals (Porter, 1990, p. 128).

Secondly, large market size at home can generate advantage through economies of scale and cumulative learning. Firms compete to be the first mover to reap the benefits and local firms enjoy natural advantages because home demand is more certain and easier to forecast. The pattern of domestic market, such as early saturation, will force firms to innovate and lead companies to penetrate foreign market. However, all those advantages will be achieved only on condition that products or services are also demanded in foreign markets when it comes to international competitiveness (Porter, 1990, p. 139).

Thirdly, mobile individual consumers or multinational customers contribute to recognition of brands in foreign markets. The influence on foreign needs can also be realized via training programs, scientific communities, cultural products (such as movies), political alliances and historical ties (Porter, 1990, p. 140).

Those demand conditions above reinforce each other and work together to provide initial and following impetus for competing in more sophisticated segments.

1.2.2.3 Related and supporting industries

Internationally competitive suppliers or related industries are also decisive for national advantage because they provide widely used inputs that are important for internalization and innovation.

It goes without saying that downstream industries can benefit from international strength of suppliers in terms of early and favorable access to cost-effective inputs. In addition, thanks to proximity to essential activities and leaders of those suppliers, ongoing coordination can be achieved between the two parts. World-class partners can also help companies command new methods and grab opportunities to apply advanced technologies. However, it does not happen automatically and both companies and suppliers should share the effort.

Meanwhile, related industries, where companies can cooperate and share activities along the value chain, create new competitive industries. The success of related industries in international market facilitates information and technical interchange within a nation and generates the pull-through effect, which increases global demand for complementary products and services.

1.2.2.4 Firm strategy, structure, and rivalry

The way firms are organized and managed is deeply embedded in a nation's conventions and social structures. One single managerial system will not be appropriate in all cases, and a nation will benefit from where the behavior pattern of its citizens matches the critical source of competitive advantage in an industry. Factors that influence the organization and management patterns of companies are too numerous to generalize. They usually include perceptions towards authority, relationships among colleagues and degree of individualism, which are further rooted in religious history, family structure, educational system and other unique conditions of a nation. For example, since Italy is a country with strong family ties, Italian people prefer to work in small family groups rather than enlarge the firms. That is why they usually adopt focus strategies and are relatively successful in fragmented industries that rely minimally on economies of scale but differentiated products (Porter, 1990, p. 151).

Goals of individuals can also enhance the success of firms if well managed. Desirable reward systems, fair tax structures, stable employment and risk-taking inspirits are among the factors that create a favorable environment for cultivating skilled labors and better understanding the industry (Porter, 1990, p. 156).

Unlike firm strategies, domestic rivalry is sometimes regarded as a waste of resources because it is believed to prevent companies from reaping economies of scale and even cause duplication of work. However, leading companies in the world are usually those that compete proactively in the home market and pressure each other to innovate (Porter, 1990,

p. 160). Rivalry on a home base can be beneficial for several reasons. Firstly, advanced companies clearly reveal the weaknesses of others to be improved, including pricing strategy, production cost and technologies. Secondly, vigorous competition forces local companies to sharpen the advantages and explore foreign market. Finally, domestic rivalry urges companies to seek higher-order and more sustainable advantages and channels the government investment to more constructive forms.

By contrast, foreign rivals are less effective in signaling domestic companies since their success is probably the result of unfair competition and their strategies could be too distant to be applied in the domestic market.

1.2.2.5 The role of chance

Chance events refer to circumstances out of control of firms and even the national government, including major technological breakthroughs, sudden change in world demand, sharp turns of financial system, political decisions of other countries and wars (Porter, 1990, p. 168). They are unstable elements because they have the potential to break continuity of development, nullify previous advantages and allow outsiders to challenge the established competitive position.

However, existence of chances does not mean the success of a nation is totally unpredictable. Chance events merely offer an opportunity for invention, and the conversion of insight to competitiveness still depends significantly on the 'diamond' conditions within a nation.

1.2.2.6 The role of government

Governments influence the four dimensions of the diamond positively or negatively, and vice versa (Porter, 1990, p. 170).

Governments can enhance factors of production through subsidies, financial policies and training programs, and shape domestic demand conditions by establishing standard and regulations on products, the influence of which is usually subtle. It deserves attention that government itself can be a major purchaser and the role may either help or impede the development of an industry. Influence on related and supporting industries can be seen through regulations on advertising media. Finally, domestic rivalry may be affected via antitrust laws and tax policies.

On the contrary, the shifts in conditions can also urge the government to make early movement in regulation or legislation. Government policies will be counterproductive if they remain the only source of advantages. In short, government can facilitate the achievement of competitive advantages but lacks the ability to create competitiveness by itself.

1.2.2.7 A brief summary

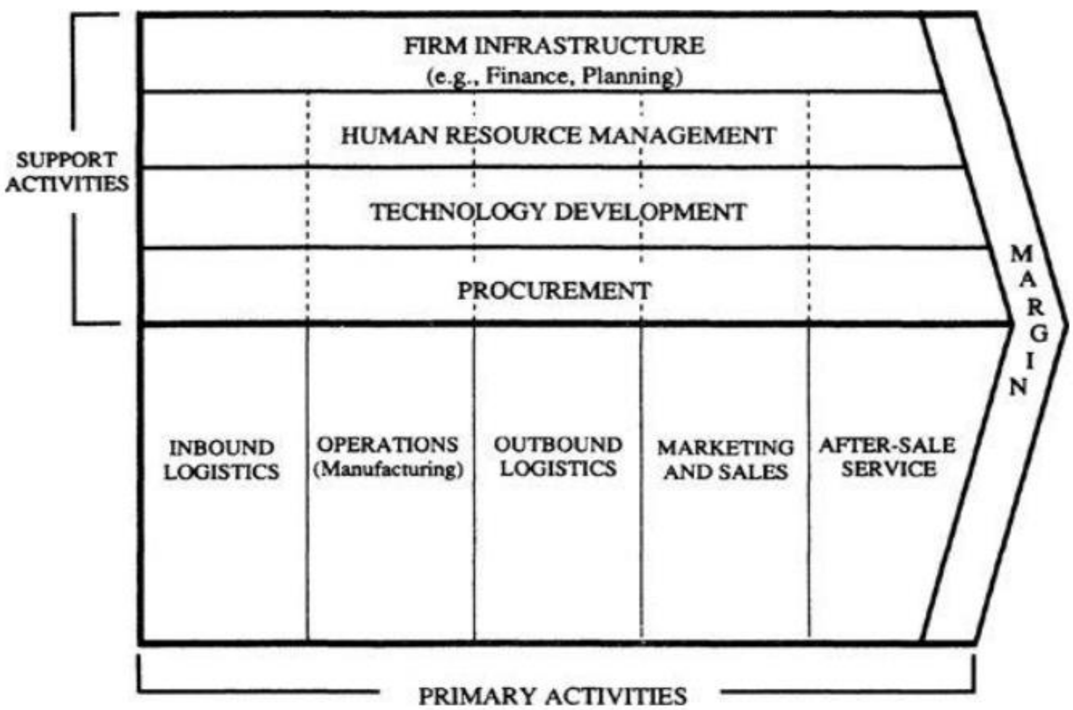
The main topic of the diamond model is innovation. To gain international competitiveness, an industry should find out the areas neglected by market, continuously upgrade the production process and design differentiated products, aided with sustained investment in R&D, skilled labor, advanced equipment, etc.

1.2.3 Competitive strategy and global value chains

Apart from external environment a nation provides for the prosperity of an industry, firms should also seek advantages through competitive strategies. A company gains advantages over its rivals either by creating comparable consumer value with lower cost, or providing differentiated products that command premium value. To develop proper strategies, a firm needs to divide its activities into pieces and reconfigure its resources for a breakthrough. One of the famous analytical tools, known as the value chain, was introduced and developed by Porter (1985, p. 36).

Firms are composed of different business units. The processes that transform raw materials to profits are value-adding activities. As is shown in Figure 2, there are nine generic categories of value activities, which can be further classified into primary activities and support activities. Margin, the size of which is determined by difference between the value to customers and the total cost of production, serves as the tenth field with no actual activities.

Figure 2: The model of value chains



Source: Porter (1990).

Primary activities involve processes related to physical production and selling of products or services. Each of the categories could be crucial to gaining international competitiveness depending on specific industries. Support activities exist everywhere among the primary activities and work to coordinate and ensure their functions. In addition, dotted lines in the model indicate that those support activities can either be associated with a single primary activity or back the entire value chain (Porter, 2001, p. 52).

Table 1 briefly summarizes the fields where companies can track the flow of value-adding activities. It deserves attention that activities listed in Table 1 merely provide a general direction for analyzing the performance of business units. We still need to define and subdivide the value chain when seeking solutions for a specific industry. In addition, a company is more than the sum of those activities (Porter, 1990, p. 80). The linkages among different activities will create trade-off problems due to limited resources, which requires a good management of coordination.

Table 1: Identification of value activities in the value chain

Types	**Generic Categories**	**Distinct Value Activities**
Primary activities	Inbound logistics	Material handling, inventory control, inspection, vehicle scheduling…
	Operations	Manufacturing, packaging, assembly, maintenance of equipment…
	Outbound logistics	Order processing, packing, shipping…
	Marketing and sales	Advertising, promotion, pricing, distribution channel selection…
	After-sale service	Installation, repair, customer training, maintenance…
Support activities	Firm infrastructure	Planning, quality management, finance, accounting and legal affairs…
	HR management	Recruitment, training, retention, motivation, compensation…
	Technology development	Efforts to improve products and processes: Enterprise Resource Planning (ERP) system, telecommunication, office automation…
	Procurement	Function of purchasing input: establishment of procurement routines, purchasing of raw materials, energy, service, transport vehicles and advertising materials…

Adapted from Porter (2001).

Nearly at the same time, Kogut (1985) proposed the idea of value-added chains as a tool to analyze international strategic advantages. In his opinion, when the position of a nation on the value-added chains is decided by its comparative advantages, the role of firms in international division of labor depends on their capability of competition. Based on that theory, Krugman and Venables (1995) discussed about how firms should distribute their inner value-added activities in separate geographic spaces, which made the governance of value chains and relocation of industries two important research fields.

As the global production network among firms became increasingly complicated, Gereffi (1994) designed an analytical framework of global commodity chains (hereinafter: GCCs) when studying the value chains of retail sectors in the United States. The GCCs involve design, manufacturing, marketing among other related activities (Gereffi, 1999) and can be divided into producer-driven and buyer-driven types. The producer-driven GCCs are led by producers with striking R&D capability via investment to stimulate market demand and coordinate vertical production chains. On the contrary, buyer-driven GCCs are organized by firms with brand advantages and sound distribution channels through global sourcing and original equipment manufacture (OEM). In real situations, those two types can exist at the same time.

The value chain theories mentioned above were put forward under the background of international division of labor and global relocation of industries. They are closely related and their research questions and objects are similar. In an international academic conference held in Bellagio in 2000, scholars attempted to establish a normalized analytical framework based on value chains, and the term global value chains (hereinafter: GVCs) was since then gradually accepted by researchers (Gereffi & Kaplinsky, 2001).

Global value chains refer to the fragmentation or unbundling of production that is coordinated across the world (UNIDO, 2018). The network includes not only the import of raw materials, but also the processing and sales of semi-finished and finished products, consumption and recycling. It focuses on the distribution of margins among participants along the chains.

In GVCs, firms trade off the cost of production in one concentrated place by themselves against outsourcing. Admittedly, outsourcing incurs higher fixed cost since coordination and communication costs between production units are nontrivial. However, productivity will increase with the division of labor according to comparative advantages, which means the total cost curve of outsourcing is flatter than that of traditional production method. In this sense, there should be an equilibrium point that influences the decision of firms whether to outsource or not (Jones & Kierzkowski, 1990).

Although GVCs provide companies with the opportunities to participate in international division of labor, firms from developing countries are more likely to be locked in the low-end of the chains with lower margins. They are also prone to the control of leading companies via all kinds of barriers, including technical standards, patents, environmental protection, quality, delivery, inventory, price and other parameters. Being exhausted to fulfill the need of customers, they are confronted with the glass ceiling and enlarged output does not necessarily increase the margins.

In response to the plight, Humphrey and Schmitz (2000, p. 16-27) summarized four types of GVCs according to relations among participants (chain governance) and proposed models of upgrading along the chains respectively, as is shown in Table 2.

Table 2: Relations of participants in GVCs and strategies of upgrading

Types	Definition and strategies of upgrading
Arm's length market relations	Products are standard and there is no need for specialized collaboration between buyers and suppliers.
	Functional upgrading in terms of design and marketing is significant. Firms can keep learning new technologies through export and market diversification strategies (searching for new value chains).
Network	Participants are nearly 'equal' and define the product jointly. E.g. Both buyers and suppliers are close to the market frontiers.
	Firms from developing countries seldom operate in this chain. Those developing countries do gain competences in the process, but upgrading relies more on firm-level than country-level investment.
Quasi-hierarchy	Buyers have more control over suppliers and define the products.
	Firms can upgrade in the sphere of production, such as quality and speed to avoid being replaced by rivals with cheaper labor.
Hierarchy	Buyers directly own the operations of suppliers.
	There is no need of discussion in this case.

Adapted from Humphrey & Schmitz (2000).

Success can never be achieved overnight. Firms seeking to acquire more desirable positions in the global value chains should first recognize the relations with their partners, follow the trajectory of cluster upgrading and then take corresponding strategies.

1.3 Measurement of international competitiveness

Many international organizations have developed systematic approaches to measuring international competitiveness of nations. Among them, the most famous institutes are International Institute for Management Development (IMD), World Economic Forum (WEF) and World Bank.

Published since 1989, IMD *World Competitiveness Yearbook* keeps pace with structural changes and technological revolution of nations and ranks their competitiveness according to 342 competitiveness criteria. Those items are generally classified into economic performance, government efficiency, business efficiency and infrastructure, each of which can be further broken down into 5 sub-factors. Among them, 255 criteria are used for calculation, including 137 groups of hard data representing the performance in the past and 118 from Executive Opinion Survey. The remaining 87 criteria are merely demonstrated for background (IMD, 2018).

Global Competitiveness Report by WEF incorporates the assessment of 12 pillars into three indices, including basic requirements sub-index, efficiency enhancers sub-index and innovation and sophistication factors sub-index. Those three indices account for different shares of the total score according to a country's development stage, which include factor-driven, efficiency-driven and innovation-driven stages (WEF, 2018a). On the contrary, the 10 topics used to measure Doing Business rankings are equally weighted, since complex aggregation of scores yields almost identical rankings (World Bank, 2019).

Meanwhile, many scholars developed their own systematic approaches to assessing international competitiveness at industrial level. Lee and Tang (2000) compared competitiveness between industries in Canada and the United States through relative output price. Jaime, Jonatan and Belen (2012) assessed the effects of cluster phenomenon on international competitiveness of Spain based on data from 2007 to 2009. Tomaselli (2013) analyzed factors constraining the competitiveness development of South-African film industry with the Diamond model.

Two of those research works have provided sharp insight into modeling of the abstract concept of international competitiveness.

The first one is a study on competitiveness of tourist destinations in Brazil that adopts two evaluation criteria: performance (an ex-post concept evaluating results produced by actions) and efficiency (an ex-ante concept measuring production capabilities). With regards to the unit of analysis, a systemic method is adopted to evaluate characteristics of countries, a structural focus is used to examine the capacity of a selected segment, and a business-related focus serves to check the ability of companies to compete. As a multidimensional phenomenon, competitiveness should be measured based on chosen variables, evaluation criteria and the unit of analysis (Barbosa, Oliveira & Rezende, 2010).

The other one is a research work comparing construction industry in Canada, Japan and the United States, where competitiveness is viewed from three perspectives: the ability to procure inputs at competitive terms (competitive assets), efficiency of value-adding processes (competitive processes) and marketing strategies of output (competitive performance) (Momaya, 1998). The classification is conductive to quantification of the multifaceted concept. Factors in detail are listed in Table 3.

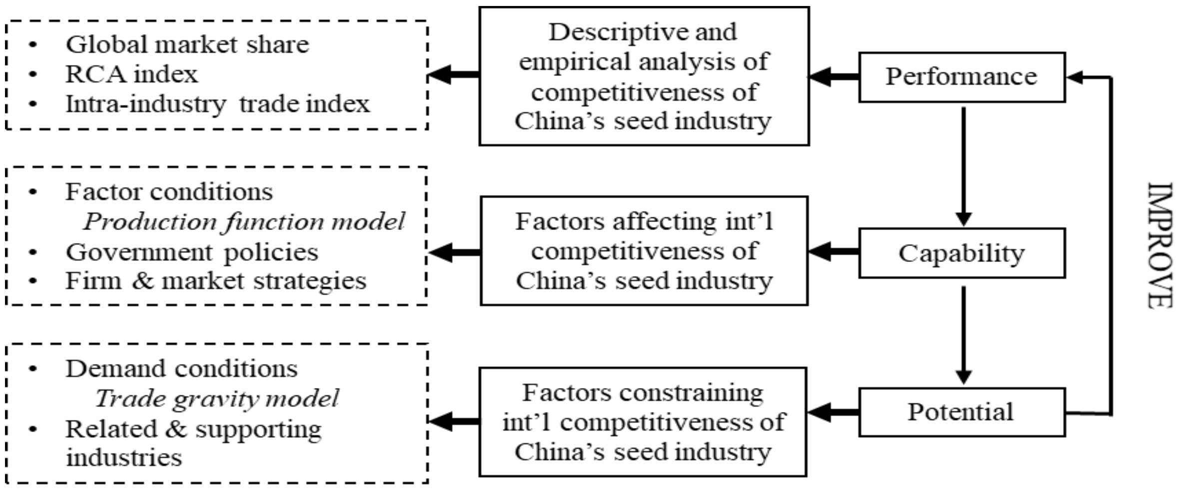
Table 3: Facets and indicators of competitiveness model

Competitive assets	Competitive processes	Competitive performance
Cost of factors	Strategic management	Productivity
Demand conditions	HR development	Human resources
Technologies	R&D Synergies	Quality effectiveness
Human resources	Rivalry	Cost
Infrastructure	Linkages with related and	Financial, international and
Government	supporting industries	technological criteria

Adapted from Momaya (1998).

In the model, assets and performance are evaluated from statistical data in the past while processes are future-oriented. However, from the indicators we can see that there exist some redundancies in the model. To simplify the framework and make it more reasonable, we can redefine the three facets as competitive performance, competitive capability and competitive potential.

Figure 3: Conceptual design of the empirical analysis on international competitiveness



Source: Own work.

The first part demonstrates the global market share of vegetable seeds, flower seeds and crop seeds of China. To see the gap with leading countries, we introduce Reveal Comparative Advantage (RCA) index that is the percentage of a specific industry in a nation's total export value divided by the world average level. The index is applied to seeds under more detailed categories so that we can find where advantages and disadvantages lie. In addition, the index of intra-industry trade is used to show the diversity of China's seed industry and its dependence on import. The second and third parts are studied under the framework of

Diamond model proposed by Porter (1990). In quantitative analysis, two regression models are applied, including production function model based on time series, and trade gravity model based on panel data. Most of qualitative analysis is based on official documents, such as laws, regulations and industry reports, while the rest accords with my intern experience in a seed company.

Figure 3 summarizes the structure of analysis on international competitiveness in this thesis.

2 SPECIFICS OF SEED INDUSTRY

2.1 Definition of seed industry

An industry is a group of producers competing directly through their products or services (Porter, 1990, p. 70). Before we further define the seed industry, it is necessary to figure out the range of seed varieties traded internationally.

According to the seed export and import reports published annually by International Seed Federation (hereinafter: ISF), seeds for sowing are classified into three types: vegetable crop seeds, flower seeds and field crop seeds. That approach, however, is too general for the analysis of global trade. In other words, we need statistics of lower-order categories to explore strengths and weaknesses of selected countries in the seed industry. In that case, the Harmonized Commodity Description and Coding System, also known as the Harmonized System (HS), will be of great help.

The Harmonized System is an international nomenclature to classify traded products on a standardized base (United Nations, no date). The system, first introduced in 1988, is developed and maintained by the World Customs Organization (WCO), formerly the Customs Cooperation Council.

The system comprises some 5300 product descriptions grouped in 99 chapters among 21 sections. It adopts a six-digit coding system. The first two digits indicate the chapter, the next two digits identify groupings in the chapter, and the last two digits provide more specific descriptions. For example, code 10 refers to ‘Cereals’, code 1005 ‘Maize (corn)’, and code 100510 ‘Cereals; maize (corn), seed’ (UN Comtrade, no date).

The HS has been revised for five times in history and came into force respectively in 1996 (H1), 2002 (H2), 2007 (H3), 2012 (H4) and 2017 (H5). Although the H5 is the latest standard compared with H4, data is insufficient for us to Figure out the general trend of trade of seeds. In addition, H4 is more specific than H3 in the classification of seeds since the system separates seeds from the related products. For example, ‘cereals; wheat and meslin, durum wheat, seed’ (100111) and ‘cereals; wheat and meslin, durum wheat, other than seed’

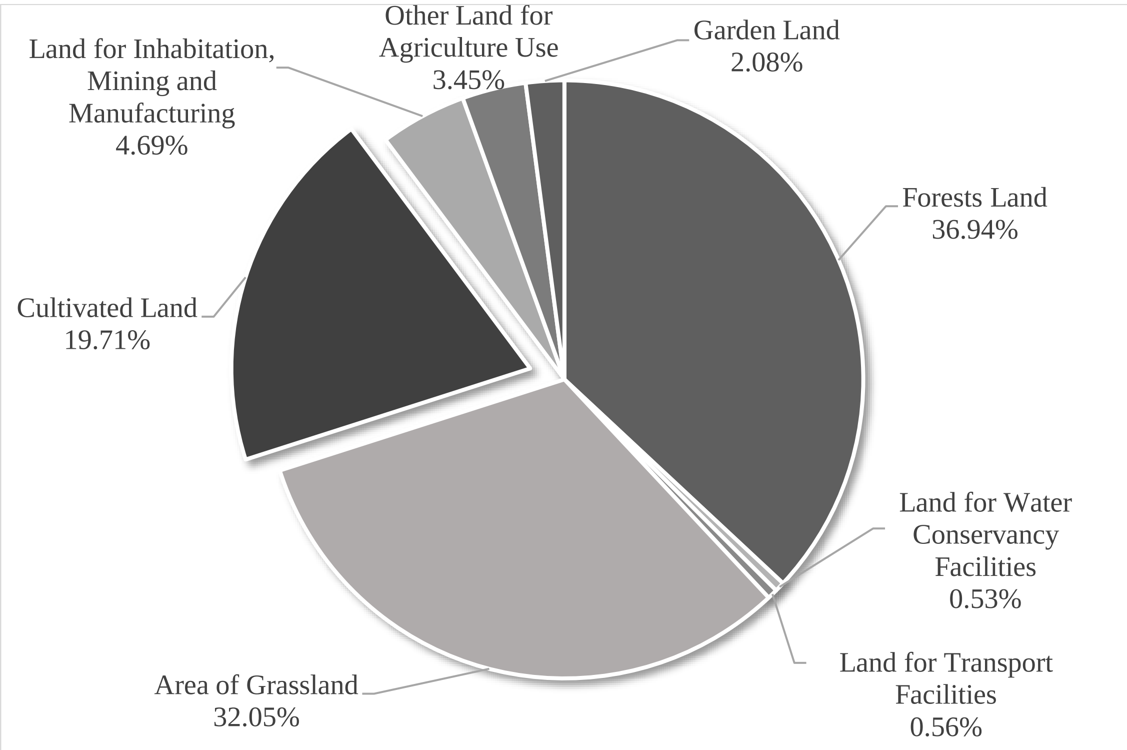
(100119) are under different categories under H4, while they are not distinguished under H3. Therefore, all the categories used in this thesis conform with the 2012 version of classification (H4).

Appendix 2 demonstrates all categories with regards to the seed industry based on the HS2012 at six-digit level. For simplicity of definition, it is appropriate to classify the seed products at four-digit level. Hence, the seed industry in the paper is generally defined as a group of competitors producing seeds for sowing worldwide, including seeds of cereals, oil plants, rice, soya beans, cotton, sugar beets, forage plants, herbaceous plants, vegetables, etc. There may be some deficiencies of the definition according to categories, but it would be enough for the analysis of international competitiveness of China's seed industry.

2.2 Specifics of seed industry and China

China is a country with the second largest territory area and the largest population in the world by 2018 (World Bank, no date). According to a report of the National Bureau of Statistics of China (hereinafter: NBSC) (2019), the cultivated land plus grassland accounts for over half of the total land area of China, as is shown in Figure 4. In 2016, the area of arable land per capita of China (0.086 hectare) ranked 129th across the world, much lower than the world average level of 0.192 hectare, the highest level being 1.904 hectares in Australia (World Bank, n. d.).

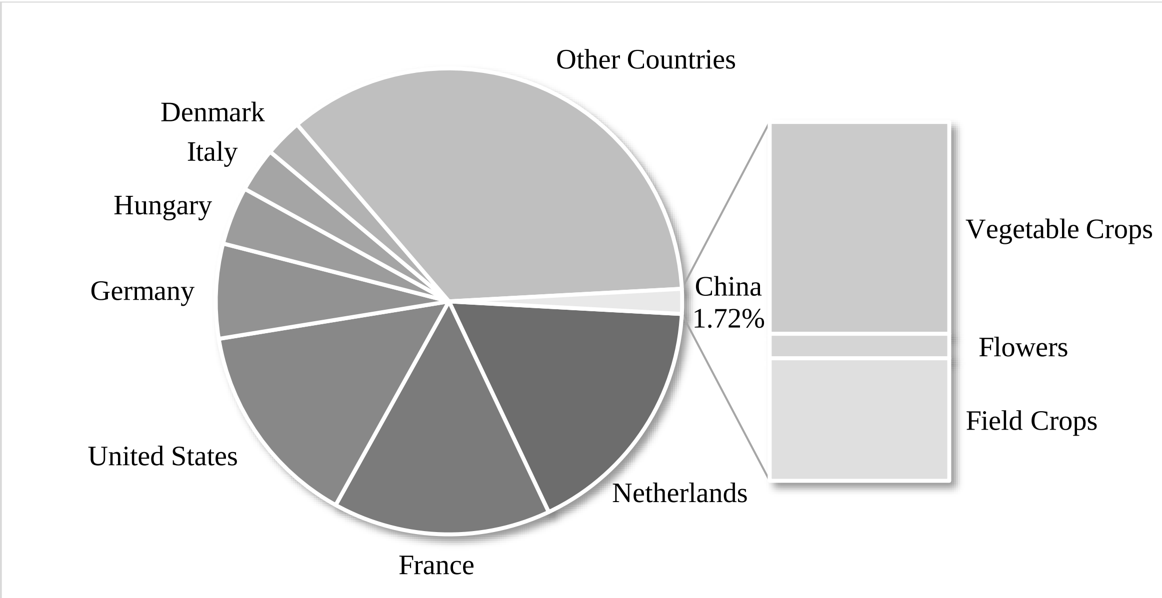
Figure 4: Land characters of China 2017



Adapted from NBSC (2019).

Figure 5 demonstrates the distribution of global market share in seed industry. Although China achieved a relatively competitive ranking of 15th, its market share accounts for merely 1.72% and over half of seed products come from the four largest producers: Netherlands, France, the United States and Germany (ISF, no date).

Figure 5: Global market share of seed industry in terms of sales value 2017



Adapted from ISF (no date).

Despite the large market share occupied by the four countries, the Herfindahl-Hirschman Index (hereinafter: HHI) shows the market structure of global seed industry is not an oligopoly. HHI is an analytical tool measuring concentration by summing the squares of market share of all members (Rhoades, 1993). The index is frequently used to analyze the effects of mergers by the Department of Justice, who has accordingly established the standard for identifying market types, as is shown in Table 4.

Table 4: Market types based on Herfindahl-Hirschman Index

HHI	**Market Type**
Below 1500	Unconcentrated Markets
Between 1500 and 2500	Moderately Concentrated Markets
Above 2500	Highly Concentrated Markets

Source: Department of Justice (2010).

Appendix 3 demonstrates the calculation of HHI based on export value of seeds in 2017. The HHI reaches 865.82, which means the market of seeds is in a competitive structure and the degree of product differentiation worldwide is low.

2.3 China's seed industry in the global value chains

Internationalization of agriculture has become an important facet of economic globalization. Countries participate in international agriculture trade according to their comparative advantages. As a country abundant in labor forces but short of land, China explores the global market mainly through labor intensive products, including vegetables, fruits, animal products and processed agricultural products.

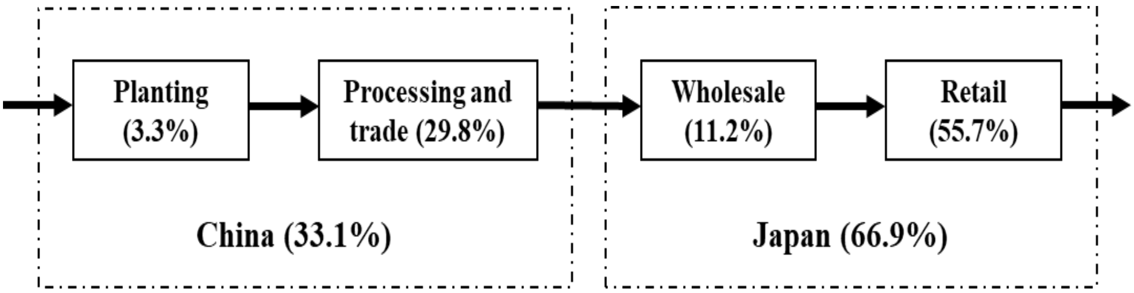
Table 5: Trade in value added of agriculture, forestry and fishing industry

Country	World ranking 2015	Share of trade in value added in the world		
		2005	2015	Changed by
United States	1	5.94%	5.35%	-0.59%
France	4	2.54%	1.77%	-0.77%
China	5	1.41%	1.72%	0.31%
Netherland	7	2.66%	1.40%	-1.27%
Germany	12	0.95%	0.76%	-0.18%
Italy	16	0.82%	0.58%	-0.25%
Denmark	18	0.65%	0.55%	-0.10%

Note: Since the classification of industries is broad in the TiVA database, data of seed industry alone is still unavailable when the data is extracted.

Adapted from TiVA database (no date).

Figure 6: Composition of GVCs of vegetables between China and Japan



Source: Bao (2010).

Table 5 compares the share of value added of primary seed exporters in agriculture, forestry and fishing industry between 2005 and 2015. With the ranking of 5th, China is generating more values in the GVCs. Although it is an inspiring news for China, the result should still be treated carefully. On the one hand, limited by the classification of industries, it is difficult to figure out how much of the progress is contributed by the seed industry. On the other hand, China is still in the low-end of the GVCs in terms of seed industry. According to a case study of China's vegetables exported to Japan (shown in Figure 6), planting accounts for merely

3.3% of the total value added along the GVCs. Improvement of international competitiveness requires upgrading of the clusters.

2.4 Research on international competitiveness of seed industry

Most researchers in this field place emphasis on qualitative analysis in order to evaluate the impact of certain factors or policies on performance of the seed industry. Pray (1986) reckoned that high-quality seeds helped improve India's international performance. Grofik and Kmetova (1994) regarded talents as the most important factor for American vegetable industry. Dai (2002) argued that innovation and application of modern agricultural technology have direct impacts on competitiveness. Focusing on top four seed companies in China, Zhang and Xu (2006) argued that financial risk management exerts great influence on competitiveness. Chen, Zhan and Zhou (2007) pointed out that certain regulations at that time heavily restricted the development of seed industry and could impede its international competitiveness.

Quantitative analysis is also used with the assistance of questionnaire surveys. Pray (1999), for example, proved that private research in India had positive influence on yields of crops through multiple linear regression, identifying variables including private varieties, irrigation, average real price, road length, rainfall and fertilizer.

In addition to performance, internalization is also a common topic for researchers. Howard (2009) visualized a map of M&A and joint ventures of seed companies from 1996 to 2008 through information graphics, and illustrated the practices and necessity of cross-licensing strategy among large corporations despite their competition and disputes.

In general, the concept of international competitiveness is multifaceted and there is a long way to go to have a comprehensive understanding. In the following three chapters, this thesis attempts to combine qualitative and quantitative analysis to present the position of China's seed industry in the world.

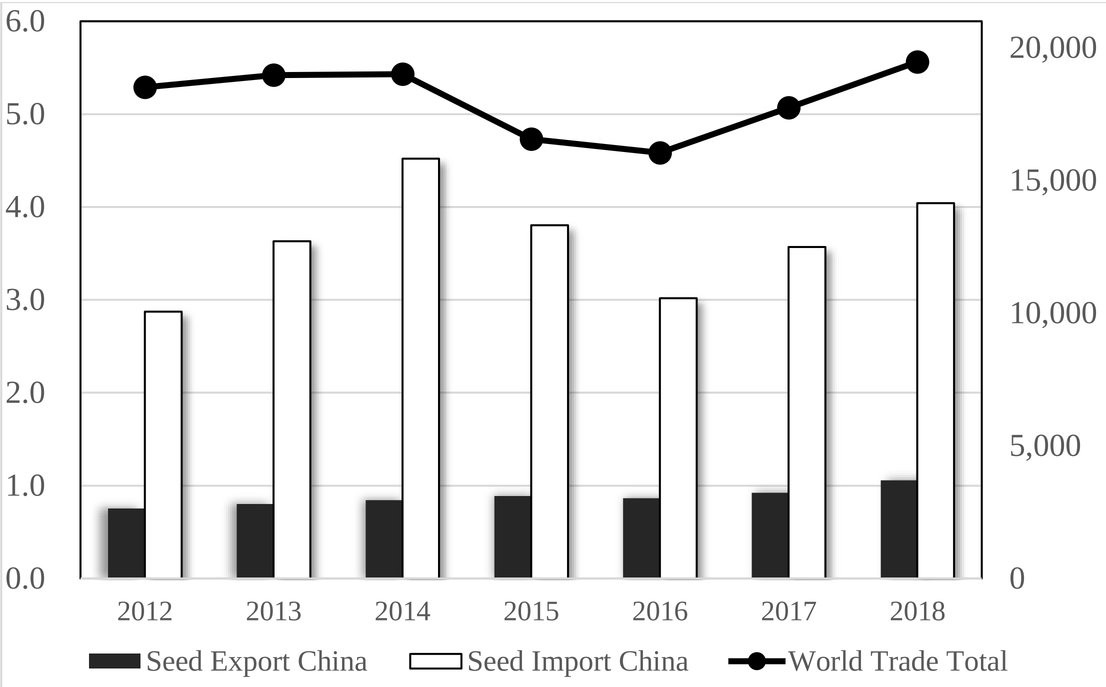
3 COMPETITION PERFORMANCE OF CHINA'S SEED INDUSTRY

3.1 Descriptive analysis

Seeds in China were initially farmer-saved before 1978 and then produced under planned economy until 2000, when the enforcement of *Seed Law of the People's Republic of China* encouraged private companies and multinationals to enter the market (Xu, 2009). Later, the strategic position of seed industry for China was clarified by the Ministry of Agriculture of PRC (hereinafter: MOA) and measures have been taken to deepen reforms and facilitate restructuring (MOA, 2009).

Figure 7 reveals the trade value of seeds in China from 2012 to 2018 against the world trade value (total merchandise). A short period of recession can be clearly seen in 2016, which was partly caused by the debt crisis and failure of stimulus measures taken by major economies. Consequently, the total value of world trade plummeted by 15.6% within two years. Import of seeds in China was also hit hard, while the export was nearly unaffected, indicating that Chinese seed products are rigid demand for their consumers. In general, China's seed industry improves steadily. Export and import value during the period grew up by 40.66% and 40.64% respectively, reaching USD 1.06 bn and USD 4.04 bn in 2018. The total trade value of seed industry in China also increased from USD 3.62 bn in 2012 to USD 5.10 bn in 2018, with an average annual increasing rate of 5.85% (UN Comtrade, no date).

Figure 7: Trade value of seed export and import of China 2012-2018 (Billion USDs)



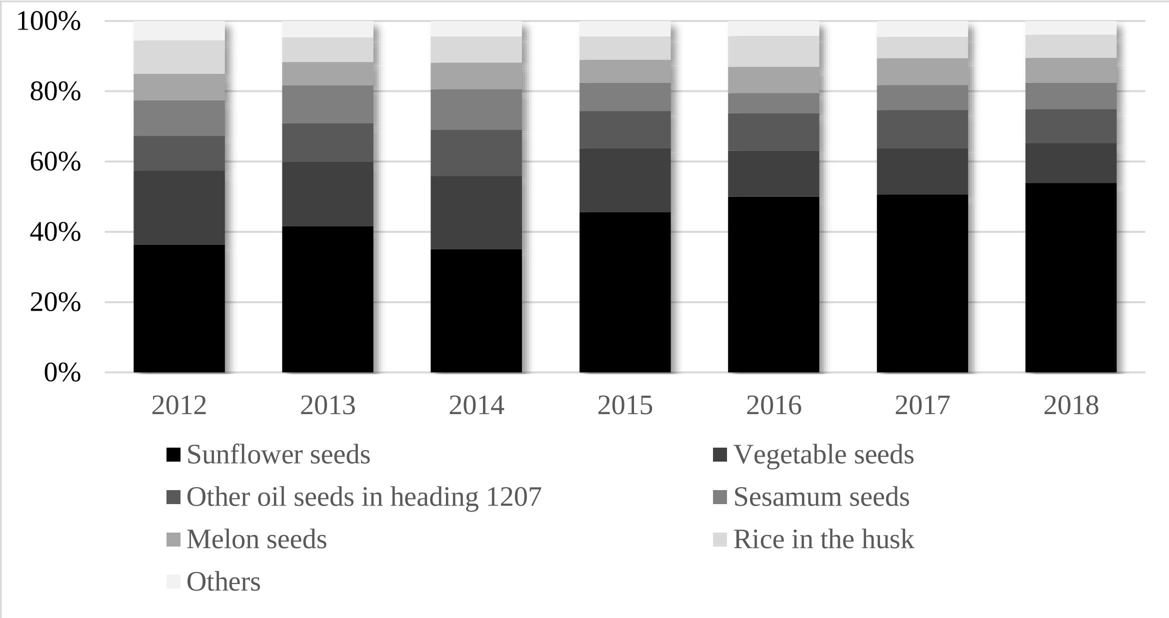
Adapted from UN Comtrade (no date); WTO (no date).

Figure 8 presents the change in export structure of China's seed industry during the past seven years, from which we can see the types of export commodities are limited. Among those major products, sunflower seed is the only one that enjoyed a rise in share, from 36.33% to 53.87%. By contrast, the export share of vegetable seeds was nearly cut by half, and approximately a 30% decline can be seen for sesamum seeds and rice in the husk. Although China is relatively competitive in oil seeds, vegetable seeds and rice, other products heavily needed in the global market, such as wheat, maize and soya beans, account for merely 0.30% of the total trade value.

Another problem of China's seed industry is the narrow distribution of export markets. The situation is especially evident when it comes to sunflower seeds. In 2018, over 73.53% of the trade value was created by Asian partners such as Turkey, Iran and Iraq, and 16.80% by

Egypt in Africa. In terms of vegetable seeds, more than 92.96% of trade value was achieved in Asian, European and North-American markets (UN Comtrade, no date). If the export market continues to be highly concentrated on narrow areas, it will be adverse for China to create diversity of seed varieties and gain sustainable competitive advantages.

Figure 8: Export structure of China's seed industry 2012-2018



Note: 'Other oil seeds in heading 1207' refers to HS code 120799 - Oil seeds and oleaginous fruits; n.e.c. in heading no. 1207, whether or not broken. More detailed information on classification is presented in Appendix 2.

Adapted from UN Comtrade (no date).

3.2 Indices analysis

Descriptive analysis leaves us a direct impression of the position of China's seed industry in the global market. It is also necessary to check our idea and evaluate the performance through indices. In the following parts, NRCA index and index of intra-industry trade will be used to assess the strengths and weaknesses of the seed industry under more detailed categories.

3.2.1 Normalized revealed comparative advantage index

Table 6 presents the NRCA index of the top 7 seed trading countries plus China based on data published by ISF and WTO. ISF divides the seed varieties into vegetable seeds, flower seeds and field crop seeds. Considering the availability of data, we adopt the same method of classification.

From the table we can see diverse situations faced by each country. China has comparative disadvantages in all categories and the trade environment is deteriorating. Field crops are the weakest in the competition while vegetable crops have witnessed a 65% decline in competitiveness during the five years. Similar situations happen in Germany, although its flowers and field crops are relatively competitive.

Table 6: NRCA index of major seed trading nations and China 2013-2017

Year	**Netherlands**			**France**		
	Vegetables	**Flowers**	**Field crops**	**Vegetables**	**Flowers**	**Field crops**
2013	60.51	2.78	3.68	15.55	0.54	64.80
2014	64.62	4.11	4.22	16.86	0.35	61.52
2015	66.26	3.04	0.67	18.01	0.45	59.94
2016	83.92	2.91	2.04	19.95	0.43	64.02
2017	82.75	2.83	4.76	20.52	0.29	60.48
Year	**United States**			**Germany**		
	Vegetables	**Flowers**	**Field crops**	**Vegetables**	**Flowers**	**Field crops**
2013	13.35	2.45	15.31	-10.86	0.62	5.09
2014	13.56	2.30	16.39	-11.56	0.51	2.49
2015	17.79	2.75	17.37	-13.37	0.57	2.14
2016	19.41	2.79	17.85	-15.43	0.55	1.85
2017	14.74	2.67	20.50	-14.34	0.56	3.01
Year	**Hungary**			**Italy**		
	Vegetables	**Flowers**	**Field crops**	**Vegetables**	**Flowers**	**Field crops**
2013	-0.54	-0.04	18.88	1.24	-0.35	-0.07
2014	-0.22	-0.04	19.50	1.17	-0.35	-0.69
2015	-0.34	-0.04	21.82	0.65	-0.35	1.35
2016	-0.58	-0.12	24.02	0.02	-0.40	1.88
2017	-0.79	-0.11	23.66	-0.26	-0.36	2.08
Year	**Denmark**			**China**		
	Vegetables	**Flowers**	**Field crops**	**Vegetables**	**Flowers**	**Field crops**
2013	2.17	0.06	11.31	-14.22	-1.22	-44.00
2014	2.15	0.06	13.90	-15.37	-1.53	-46.95
2015	2.12	0.08	11.37	-20.44	-1.55	-51.92
2016	1.89	0.33	11.72	-25.44	-1.44	-53.82
2017	1.78	0.19	11.74	-23.53	-1.33	-49.44

Note: The NRCA index is calculated according to Eq. (3). Since the original data is too small but has cardinal meanings, all the indexes are multiplied by 1 million for easy comparison.

Adapted from ISF (no date); WTO (no date).

The rest of the countries gain comparative advantages in at least one category and are shoring up their positions. Netherlands is a major vegetable seeds producer and has increased its competitiveness by 37% during the period. France primarily focuses on field crops but is also gaining competitiveness in vegetable seeds. On the contrary, Hungary and Italy, with similar export structure to France, are losing the share of vegetable seeds. The United States gains balanced development in all seed categories. Denmark is the only country that evidently improves competitiveness of flower seeds.

Appendix 4 demonstrates the rankings of seeds trading nations in 2017 based on NRCA index. Since ISF only reports countries with seed exports exceeding USD 1 million, the ranking is not complete and can merely mark general positions of countries in the global market. However, it is enough to signify the fact that although China has a relatively huge absolute value of seed exports, it is the country with least comparative advantage among those major players. In addition, there exists a broad gap between China (-74.30) and South Korea, the second-last country (-17.82). The real ranking of China's seed industry in the world must be much lower.

3.2.2 Index of intra-industry trade

The method of classification adopted by the NRCA index is general and cannot reflect the trade situation of each single product. Meanwhile, intra-industry trade has become a common phenomenon due to diverse properties possessed by similar products. Therefore, we need to calculate the index of intra-industry trade to measure the competitiveness of seed products in China.

Table 7 presents the index of intra-industry trade of several common seed varieties in the past seven years. As we have mentioned in chapter one, larger number indicates higher degree of intra-industry trade.

From the results we can see that seeds of wheat and maize, though in a situation of net import, have been narrowing the trade imbalance and gaining competitiveness. On the contrary, rape and sugar beet seeds are highly dependent on import during the whole period. Among those in net export, seeds of soya beans, forage plants, herbaceous plants as well as sunflowers have been severely frustrated in terms of export value, with their indices declining 99.88%, 81.71%, 41.20% and 33.89% respectively in the seven years. Intra-industry trade of rice in the husk and seeds of melons remain at a medium level and there is increasing demand for diversification. Vegetables seeds are one of the most active participants in intra-industry trade and are relying more on import probably because Chinese people are seeking for pollution-free and organic vegetables abroad.

According to the combined index of all 12 seed varieties, China does not present competitiveness in seed industry and has even been more dependent on imports, leaving it in a passive position in the global competition.

Table 7: Index of intra-industry trade of selected seed products in China 2012-2018

Year	Wheat	Rice	Melons	Rape	Sunflower	Maize	Cotton
2012	0.65*	16.08	8.30	0.04*	23.30	13.53*	0.00
2013	0.00*	10.27	13.87	0.01*	11.18	28.66*	0.00
2014	3.19*	10.51	12.83	0.01*	21.53	21.96*	0.13
2015	2.57*	18.60	17.23	0.04*	17.53	50.00*	/
2016	22.47*	14.71	14.08	0.13*	14.36	65.12*	0.00
2017	44.03*	26.29	19.10	0.02*	18.41	95.83*	0.00
2018	16.10*	18.01	26.74	0.02*	15.40	69.53*	0.00
Year	**Herbaceous plants**	**Soya beans**	**Vegetables**	**Forage plants**	**Sugar beets**		**Total**
2012	99.93	27.76	82.33	10.46*	0.80*		**30.07***
2013	95.80	0.82	92.26	5.21*	0.23*		**27.60***
2014	89.63*	0.34	92.83	6.36*	0.00*		**34.10***
2015	82.26*	0.31	96.78*	4.68*	0.00*		**32.56***
2016	96.98	0.83	78.02*	11.99*	0.22*		**25.21***
2017	55.05*	0.75	74.10*	4.82*	0.00*		**27.73***
2018	58.76*	0.03	69.24*	1.91*	0.00*		**24.22***

*Note: * denotes net import and indices without mark indicate net export.*

Adapted from UN Comtrade (no date).

4 COMPETITION CAPABILITY OF CHINA'S SEED INDUSTRY

4.1 Factor conditions

Factor conditions of seed industry mainly refer to all kinds of indispensable factor inputs, including natural resources, human capital, technologies, capital resources and infrastructure.

4.1.1 Natural resources

Arable land, water, climate, and inherited resources are important natural conditions for China's seed industry.

In general, China does not enjoy advantages in terms of arable land. Its area of arable land has reduced from 124.9 million hectares in 1991 to 118.9 million hectares in 2016, with an annual decreasing rate of 0.2%. China accounts for 8.59% of world arable land (World Bank, n. d.). However, as we have mentioned before, the per-capita area of arable land in China ranked 129th in 2016 and is less than half of the world average level. In addition, 71.3% of arable land is in the low and middle yielding class (Wang & Song, 2013). China is relatively abundant in water resources and ranked 2nd after India with regards to annual freshwater withdrawals among 68 countries that had records in 2016, followed by United States, Mexico and Brazil. However, the renewable freshwater per capita was merely over a third of world average level (World Bank, n. d.). In this sense, the competitiveness created by water resources in China is weak.

Located in the south-east part of Eurasia, China ranges wide in latitude and longitude and bears diverse climate types, including tropical and subtropical monsoon climate, monsoon climate of medium latitudes, alpine, temperate continental climate and tropical rainy climate. Rugged terrain in China even enlarges the tremendous difference in climate. Those elements create favorable external conditions for the breeding of different seed varieties to satisfy diverse needs of the market, and hence raise the international competitiveness of China's seed industry.

Inherited resource, a fundamental element for developing new seed varieties, is also decisive to competitiveness. China is one of the 17 mega-biodiversity nations across the world. It harbors approximately 10% of existing plant species on earth and is home to important crops including rice and soya beans (UNDP, 2016). There are over 600 primary crop varieties and more than 30 kinds of grain crops in China. For now, 195 varieties of crops with approximately 500 thousand samples are preserved in the germplasm bank, the number of which accounts for 6.7% and ranked 2nd across the world. Among those varieties, hybrid rice, hybrid rape and high-oil maize are in the world leading level (Xiao, 2019; CNSA, 2019).

4.1.2 Human resources

China is abundant in human resources. The number of employed persons in 2018 came first in the world and reached 0.78 billion, 26.1% of whom worked in the primary industry (NBSC, 2019; World Bank, n. d.). According to the report of 6th national population census of China, people with primary, lower secondary, upper secondary and post-secondary educational attainment accounted for 8.73%, 13.72%, 37.92% and 26.18% of total population respectively, and average years of education achieved 9.6 years (NBSC, 2010).

There is still a long way to go for China in order to catch up with the educational level of developed countries. Among OECD members, for example, people with tertiary education aged between 25 and 34 account for 44.5% of population in the same age group, while those between 55 and 64 account for 27.0% (OECD, 2018). The gap of education level is already broad between China and average level of OECD countries, let alone compared with the most developed countries such as Japan, the United States and United Kingdom. Low level of schooling years undermines the enlargement of talent pools in China.

4.1.3 Technologies

Seeds are a means of production with high scientific and technological content. The influence of technology on seed industry has penetrated the whole value chain.

Researchers are important technical resources for seed industry. In 2016, China ranked 42nd among 73 countries with records in terms of researchers in R&D per million people. The data in the U.S. and Denmark, the top 1 country, was respectively 2.6 and 5.6 times more than that of China (World Bank, n. d.). There is still much room for improvement.

The world seed industry has been developing for over one century, while the commercialization of China's seed industry lasts for merely 10 years. In 2015, only 1.5% of seed companies possess independent research system, and 5.02% of sales revenue is reinvested in R&D (Xiao, 2019; Li & Wang, 2019). By contrast, world leaders, such as Monsanto and DuPont, spent 10.53% and 7.56% of net sales respectively on R&D (Monsanto, 2016; DuPont, 2016). Lack of experience and capital in research almost makes it impossible for companies to obtain independent intellectual property rights, which impedes their development in the long run.

4.1.4 Capital resources

As the world's second largest economy, China is abundant in capital resources. In 2018, its GDP soured to 13.6 trillion US dollars, right after 20.5 trillion US dollars of the United States. The general public budget revenue was 2.8 trillion US dollars and the total reserves including gold ranked 1st all over the world, 2.5 times the size of reserves in Japan that was in the second place (World Bank, n. d.; NBSC, 2019). The situation brings about opportunities for the development of seed industry.

4.1.5 Infrastructure

According to the *Global Competitiveness Report* (WEF, 2018b), China ranked 29th among 140 countries in terms of infrastructure. It does well in transport connectivity and electric power transmission while lags in water supply, railroad density and quality of roads. Considering China's ranking of 47th in 2008 (WEF, 2008), great progress has been made during the past decade. However, there is still room for improvement compared with developed countries such as Netherlands (4th), Germany (7th), France (8th), the U.S. (9th) and Denmark (14th).

Until 2018, approximately 100 thousand reservoirs were established and the capacity approached 0.9 trillion cubic meters. The area with flood prevention measures was 24.26 million hectares and area of soil erosion under control reached 131.53 million hectares, an increase of 13.24% and 29.48% respectively compared with 2008 (NBSC, 2019). Those efforts have contributed to the increase in seed production.

Favorable infrastructure conditions facilitate restructuring of seed industry. Improved varieties have covered 97% of varieties in the market. Autonomous seed selection and breeding have been fulfilled concerning rice, wheat, soya beans and rapes. The contribution rate of improved varieties to increase in production achieved 45% (CNSA, 2019).

4.2 Production function model

The outbreak of Coronavirus COVID-19 since the end of 2019 has posed threat to food supplies worldwide. Countries such as Russia have been considering limiting grain export for domestic food security (Medetsky & Durisin, 2020). China, with nearly one fifth of world population and approximately one quarter of world grain production, has been seeking the complete autarky of food (The State Council, 2019). In this sense, seeds will be traded on condition that domestic needs are basically satisfied. To understand the roles played by production factors in the specific situation in China, we need to measure the influence of both basic and advanced factors on the total output of seeds through empirical work.

4.2.1 Methods and data collection

As Porter (1990, p. 15) has mentioned, there exist hierarchies among production factors. The basic factors involve natural resources, unskilled labor, location and debt capital, while advanced factors include educated personnel, research institutes and modern infrastructure. According to the characteristics of agriculture, arable land, fertilizer, irrigation, flood disaster and drought can be counted as crucial natural factors. Although seeds were usually cultivated by farmers, the level of mechanization for major crops has been increasing and surpassed 65% (MOA, 2017). Therefore, employees and electricity consumption can be classified as the basic factors together with natural factors. Meanwhile, we assume that government expenditures on education and agriculture contributes to skilled labor and infrastructure, and hence can be regarded as advanced factors.

Production function describes the relationship between the mix of production factors and possible maximum output, which can be expressed as

$$Y = f(A, K, L, \dots) \quad (7)$$

where Y = total output; A = average level of technology; K = capital input; L = labor input.

To measure the influence of international trade on employment in the UK, Greenaway, Hine and Wright (1999) established a model based on the production function proposed by Cobb and Douglas (1928), in which output during period *t* can be expressed as

$$Y_t = AK_t^{\alpha} L_t^{\beta} \varepsilon_t \tag{8}$$

where α and β represent elastic coefficients of capital and labor input respectively, and ε represents random error. The research by Greenaway, Hine and Wright further replaced capital input by the ratio of wage to rent, but Eq. (8) has been enough in this thesis to explore the relationship we need.

To ensure the validity of regression model, we select variables that have been continuously reported for as long time as possible. After referring to *China Statistical Yearbook 2019*, we include variables as follows: sown areas of grain crops (SA), disaster-affected area (DA), consumption of chemical fertilizers (CF), irrigated area of cultivated land (IA), consumption of electricity in rural area (CE), number of employed persons at year-end in primary industry (NE), educational funds (EF) and budgetary expenditure on agriculture (EA). Data under those catalogues have been reported from 1978 to date.

Since we have selected eight independent variables, we take the logarithms of both sides and rearrange the equation as

$$\ln y_t = b_0 + b_i \ln x_{it} + \mu_{it} \quad (i = 1, 2, \ldots, 8) \tag{9}$$

where $b_0 = \ln A$ and $\mu_{it} = \ln \varepsilon_{it}$. To avoid spurious regression, we do stationarity test for each variable, and select the unit root test of Augmented Dickey-Fuller (hereinafter: ADF) test via EViews 10, as is shown in appendix 5. As we can see, the variable $\ln NE$ is neither level nor first difference stationary series, and is hence lack of economic meanings. We therefore exclude employed persons from our model.

Appendix 6 presents the results of cointegration test. The p value 0.0005 rejects the null hypothesis of the existence of a unit root, and indicates residual series are stationary at level.

4.2.2 Results and implications

The results of regression are demonstrated in Table 8. To save space, more detailed information is recorded in appendix 7. In general, the adjusted R^2 is almost 0.7, indicating a medium degree of fitting.

As we can see, disaster-affected area impedes the growth rate of seed output, which is natural. Consumption of fertilizers also exerts negative effects on output, since the abuse of fertilizer usually does harm to soil compaction and leads to shortage of organic materials in the long run.

Table 8: Results of multiple regression for total output of grain crops 1978-2018

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	0.94***	0.17	5.61	0.0000
$dcre \ln SA$	1.14***	0.32	3.55	0.0012
$\ln DA$	-0.06***	0.02	-3.85	0.0005
$\ln CF$	-0.04***	0.01	-4.48	0.0001
$dcre \ln IA$	1.23***	0.42	2.97	0.0057
$dcre \ln CE$	0.19	0.13	1.46	0.1540
$dcre \ln EF$	0.10	0.09	1.10	0.2777
$dcre \ln EA$	0.03	0.02	1.38	0.1784
R-squared	0.750	F-statistic		13.685
Adjusted R-squared	0.695	Prob(F-statistic)		0.000
S.E. of regression	0.024			

*Note: ***, ** and * denote significance at the 1%, 5% and 10% level.*

Adapted from NBSC (no date).

Table 9: Resource endowment of major seed trading nations (world average = 100)

Country	Arable land (ha per person)	Renewable internal freshwater resources (cm^3 per capita)	R&D expenditure (% of GDP)
Netherlands	31	11	91
France	143	51	101
United States	245	149	126
Germany	74	22	135
Hungary	229	10	58
Italy	57	51	62
Denmark	216	18	141
China	45	35	97

Note: Data of arable land and freshwater was reported in 2016 and 2014 respectively, and R&D data represents the average level between 2016 and 2018.

Adapted from World Bank (no date).

Sown area and irrigated area and have significantly positive influence on total output. It conforms with the fact that China has been promoting sprinkling and trickle irrigation, which alleviates land salinization, improves utilization of water resources and increases the output.

China is also serious in the protection of arable land and has demarcated permanent capital farmland aiming at food security.

By contrast, advanced factors, including consumption of electricity, education and expenditure on agriculture, do not show evident influence on seed output, indicating that seeds could be low value-added products in China and are not the focus of agriculture development during the period.

Through regression model we verify the positive influence of natural resources on total output. Table 9 summarizes the resources endowment of major global seed producers. Although resources are clearly limited, China does not rank the last among those leading countries. There is still chance for improvement of seed industry in China.

4.3 Government

The influence of government on international competitiveness of an industry is everywhere, including subsidies, policies and stimulus. As Porter (1990, p. 172) pointed out, that kind of influence is inevitably partial. An industry can remain competitive only when the government assists in creating the power to generate advantages rather than being the sole source of competitiveness.

4.3.1 Reforms of China's seed industry

China's seed industry has experienced several rounds of reforms to adapt to changeable economic situations and international environments. The main body responsible for developing new varieties has shifted from individual farmers, national producer cooperatives, state-owned businesses to the mix of research institutes and private corporations. The Reform and Opening-up policy since 1978 facilitated the birth of the first state-owned seed company in China and marked the beginning of marketization of seed industry. Later, China's accession to the WTO accelerated the improvement of legal system for seed industry, including market supervision and protection for variety rights. Table 10 summarizes those trends of reforms.

From the trend of reforms, we can conclude that China's government has realized the strategic position of seed industry and efforts have been made to encourage R&D of new varieties and improve seed quality. The micro-environment is generally favorable for China's seed industry, but the enforcement of laws and regulations is more important and related to the operation of businesses. In the next section we will assess the performance of China's legal system in seed industry.

Table 10: Historical stages of development of China's seed industry

Time period	Characteristics
1950-1957	People participated in farm work and saved seeds in the unit of families. *Five-Year Plan for Promotion of Improved Seeds* was issued by Ministry of Agriculture to encourage farmers to select and cultivate seeds directly. During the period, production was slightly improved and food shortage was alleviated.
1958-1977	Producer cooperatives were established and replaced individual farmers as the main body for seed selection, cultivation, saving and using. Production of seeds is under the control of central planning, with a vast number of professionals trained and breeding bases built.
1978-2000	China started carrying out the Reform and Opening-up Policy and China National Seed Group Co., LTD., the first seed company in China, was established under the approval of the State Council in 1978 to speed up promotion of improved varieties. Meanwhile, more emphases were placed on mechanization of seed production.
2001-2009	As the *Seed Law* took effect, private seed corporations sprang up and invigorated the seed market. Seed production was no longer constrained by mandatory plan and companies were responsible for their own management. Subsidy policies for improved varieties were also implemented.
2010-	Crop seed industry is declared to be China's national strategic and core industry that facilitates long-term development of agriculture and ensures food security by the State Council. A series of tasks, policies and supporting measures has been drawn up to restructure the industry.

Adapted from Xu (2009); Xiao (2019); CNSA (2019).

4.3.2 Legal protection for rights to new varieties

Generally, since it is difficult for farmers to distinguish good products from bad ones, the seed market is close to perfect competition and buyers are sensitive to prices. Inevitably, companies suffer a lot from confusion acts, such as imitation of brand with low cost, and researchers are frustrated from not being paid for their research achievements. In response to the situation, Ministry of Agriculture issued a series of laws and regulations under the guideline of the State Council to protect owners' rights to new varieties. Some important laws and regulations are shown in Table 11.

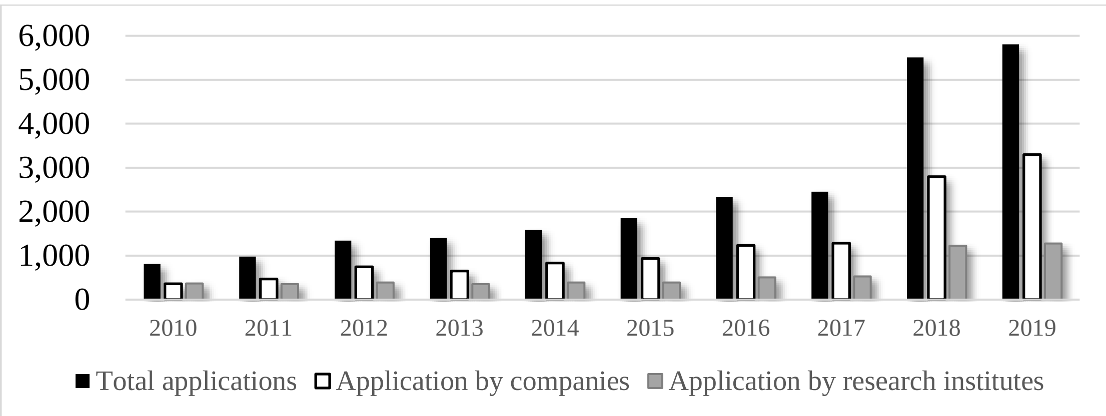
China's law-making in seed industry is to a large extent influenced by the Union for the Protection of New Varieties of Plants (hereinafter: UPOV), an intergovernmental organization working on protecting new varieties, as its name suggests. China became the 39th member of UPOV on Apr 23, 1999 (UPOV, 2020) and the requirements in the *Seed Law* for granting variety rights comply with the *Act of the UPOV Convention* (UPOV, 1991).

Table 11: Laws, regulations and measures for China's seed industry

1.	***Regulation of the People's Republic of China on Protection of New Varieties of Plants*** *Jul 29, 2014 (Initial version: Mar 20, 1997)* The Regulations are formulated to protect the rights in new varieties and encourage cultivation and use of new varieties. They specify the procedures and requirements of application for approval. Specially, Article 15-17 illustrate the definitions of distinctness, uniformity and stability.
2.	***Seed Law of the People's Republic of China*** *Nov 4, 2015 (Initial version: Jul 8, 2000)* The Law is issued to make rational use of seed resources, standardize variety selection, production and business operation, and push forward modernization of seed industry. The Law also protects the right to new varieties of seeds, and safeguards the interests of producers, traders and users. Specially, Article 15 stipulates that varieties in application for approval shall meet the requirements for distinctness, uniformity and stability, which complies with the guideline of UPOV.
3.	***Measures for the Approval of Key Crop Varieties*** *Jul 8, 2016 (Initial version: Dec 27, 2013)* The Measures are formulated to regulate the application for, inspection and granting of licenses for production and business operation.

Adapted from NPC (no date).

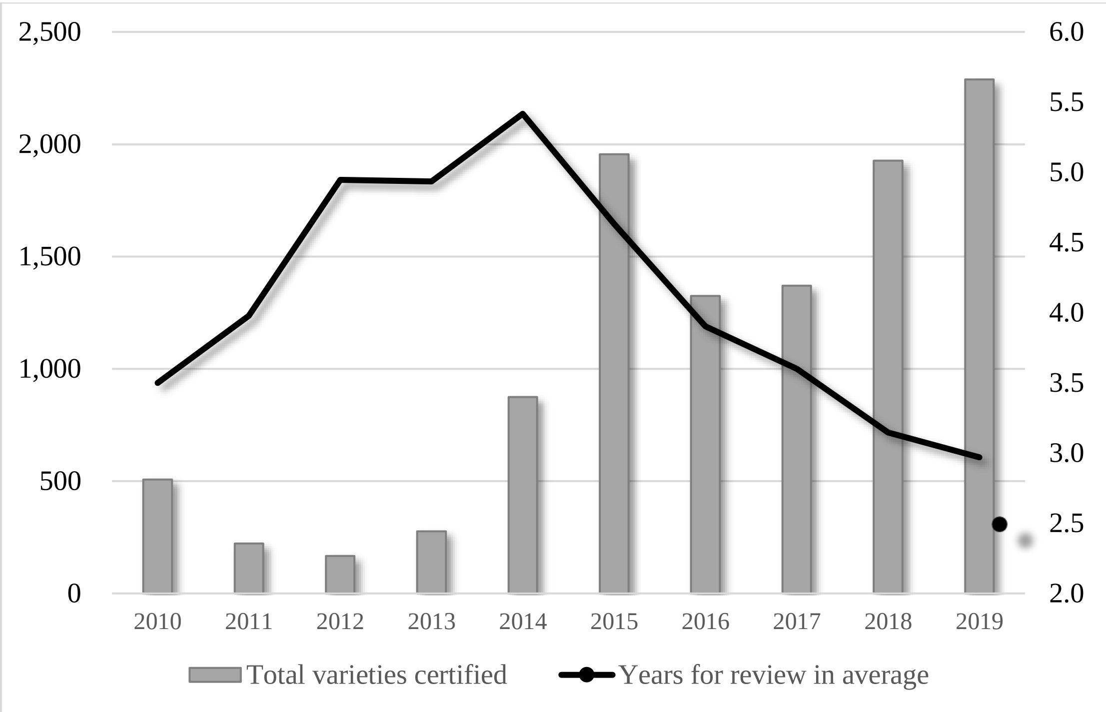
Figure 9: Number of applications for variety rights 2010-2019



Adapted from MOA (no date).

The enactment and revision of those laws and regulations have encouraged breeders to develop new varieties. Figure 9 shows the trend of application for variety rights during the past decade. As we can see, the number of applications grows steadily between 2010 and 2017 and soars in the recent two years, indicating stronger legal awareness of seed producers. In addition, the ratio of applications by companies to applications by research institutes has increased from 0.98:1 to 2.59:1, showing that companies gradually become the main body of seed breeding and the seed market has been more active.

Figure 10: Number of certified new varieties and time span for right granting process



Adapted from MOA (no date).

Figure 10 demonstrates the efficiency of right granting during the past decade. The time span for right granting of each variety is calculated directly by the year of granting minus the year of application without considering dates in detail. Therefore, there could be some mistakes but will not be a problem if we merely care about the general trend.

As the applications increased during the initial period, the efficiency of review process dropped significantly. In response, the government developed an online system for application, simplified procedures and hired additional staff members to deal with backlog cases (Li, 2016). In addition, the fee for application and review plus annual fee was waived since Apr 1, 2017 (Yang et al., 2020).

In recent years, the number of certified varieties has increased dramatically and average time span for review has reduced from 5.42 years in 2014 to 2.97 years in 2019. Again, the ratio of certified varieties bred by companies to those by research institutes changed from 1.18:1

to 2.37:1 during the past decade, indicating the important role played by companies in China's seed industry.

In sum, China's government is attaching greater significance to seed cultivation and is working on legislation, regulation and stimulation of seed market, which makes China's seed industry promising in the international competition.

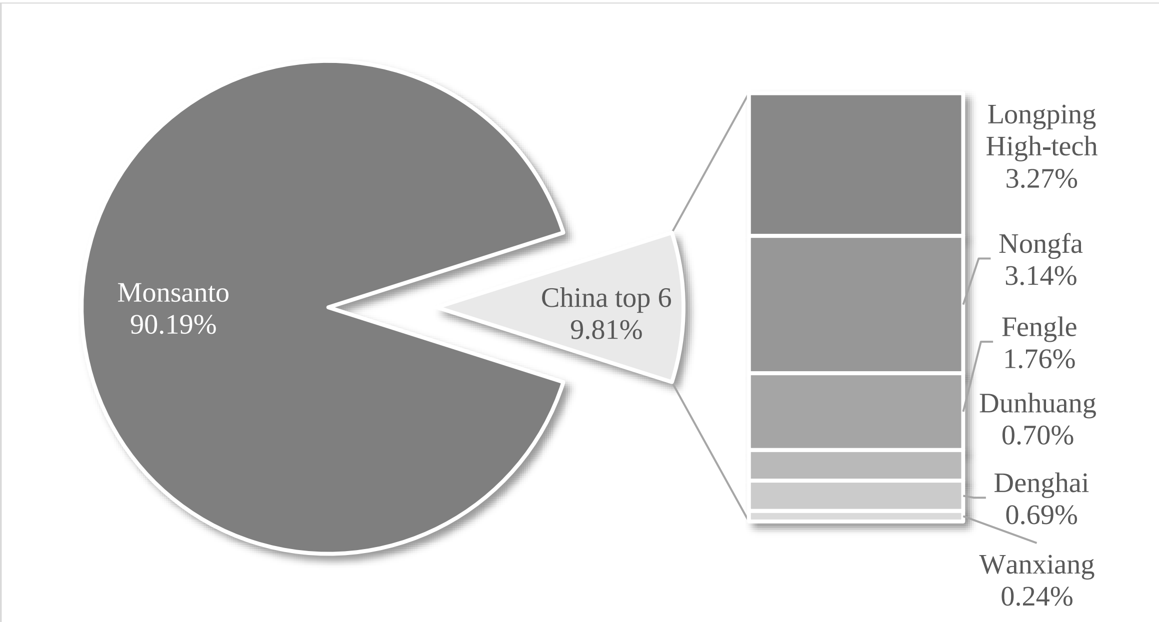
4.4 Market structure and strategies

Factors including the size of companies, organization framework, operation strategies and brand management are all acid tests for the competitiveness of a company. As we have mentioned, the enactment of *Seed Law* has been instilling energy to the seed enterprises. Until 2019, the market value of China's seed industry has achieved CNY 120 billion, or 17.4 billion US dollars, coming second across the world (CNSA, 2019). However, there is still a great gap between China's companies and world giants.

4.4.1 Market structure

Due to restructuring of the seed industry, the number of seed companies in China reduced approximately from 8,700 in 2011 to 4,300 in 2017, among which only 17 companies had total assets of over CNY 1 billion, or 148.1 million US dollars. The concentration ratio of top 50 seed companies approaches merely 35%, indicating a competitive market structure (MOA, 2019).

Figure 11: Net sales of China's top six listed seed companies compared with Monsanto



Adapted from Monsanto (2018); Yuan Longping High-Tech (2019); Nongfa (2019); Fengle (2019); Dunhuang (2019); Denghai (2019); Wanxiang (2019).

Low concentration ratio means that there is no giant leading company in China that can integrate all kinds of resources, which is unfavorable to long-term growth of the industry. Figure 11 reveals the net sales of local listed seed companies compared with that of Monsanto, an American giant. It is evident that sales of one giant company in the U.S. is over 9 times the sales of top 6 listed companies in China. Considering long-lasting trade deficit of China in seed industry, the advantages of those large multinationals are incomparable. In the future, China's local companies are expected to face more severe impact caused by the entry of foreign rivals and it is critical for them to identify their market positions and expand their sizes.

4.4.2 Market strategies

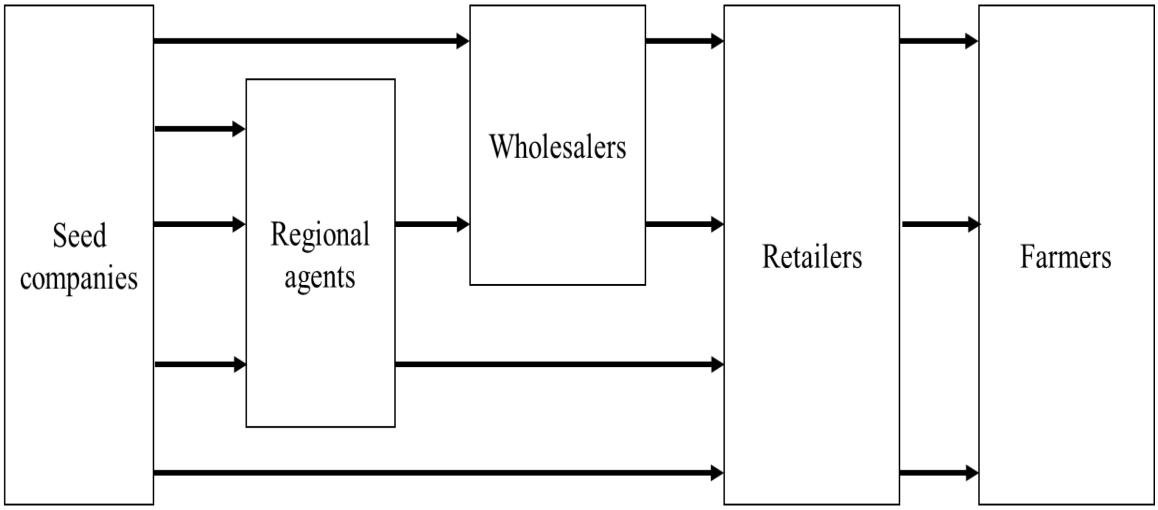
Since the legislation in China facilitates the marketization of seed industry, seed production has gotten rid of the central planning but is encountered with fierce competition. In the future, the war of seeds lies in varieties and marketing channels (Xiao, 2019). In the following section, we study the distribution channel and sales of seeds in China based on previous research and my conversations with seed managers during internship. Since the sizes of those companies are small, their opinions may not represent the situation of the whole industry but are worth referring to.

4.4.2.1 Distribution channels

The modes of distribution channels of most seed companies are shown in Figure 12. According to the managers, over 70% of seeds are sold through the first channel, viz seed companies – wholesalers – retailers – farmers. Since the agents are skipped, the profit margin for retailers is larger and they will be more motivated when selling the products. Approximately 20% of seeds are sold via the most complicated channel. The function of local agents is to enlarge the selling network and increase sales of target products. Meanwhile, there exists some risks for companies. Agents could exert their power and make unreasonable demands, and consequent disagreement will undermine the progress of sales. Only a small part of sales activities skips wholesalers, since it puts forward higher requirements for local agents, who should be equipped with strong sales teams to satisfy the market needs.

According to the export quantities and values of China, the unit price of seeds exported from China remains basically unchanged during 2011 and 2017 (ISF, no date). During the same period, the China Containerized Freight Index (CCFI), published by Ministry of Transport (hereinafter: MOT) and taking the beginning of 1998 as the basic period with basic index of 1000 points, reduced from around 960 to 769 (MOT, 2018). The trend indicates that the pressure of shipping cost is alleviated and there is more freedom for China's seed companies to select proper distribution channels.

Figure 12: Distribution channel of seed products



Adapted from Xiao (2019).

4.4.2.2 Branding

The time cost is relatively huge in seed industry, since introduced new varieties need to pass the test of trial planting to see whether they can adapt to local climate and soil conditions. Therefore, buyers are extremely prudent when making decisions and usually have a general idea of seed qualities from specific countries. For example, managers may think that seeds produced in the United States naturally have higher germination rate and contain fewer weeds. Besides, since the seed certification system is not uniform worldwide, foreign buyers may not acknowledge the documents provided by producers.

This kind of stereotype is an obstacle for China's seed industry to enter the international market, especially when there is no leading company to refer to. As we have discussed in previous chapters, the comparative advantages of most seed products are shrinking in recent years. It is urgent for China to encourage domestic rivalry, support national champions and exert the influence of country of origin.

5 COMPETITION POTENTIAL OF CHINA'S SEED INDUSTRY

5.1 Demand conditions

Home demand can serve as a strong driving force if it correctly forecasts the global trend and is efficiently transmitted to foreign markets (Porter, 1990, p. 127).

Since China has a large population to feed, increase in agricultural output has always been one of the major tasks among national strategies. According to the report by CNSA (2019), autonomous selection and breeding have been realized for staple crops, including rice, wheat, soya bean and rape seeds. Over 87% of vegetables, 90% of maize and 95% of transgenic pest-resistant cotton varieties are produced locally.

In 2017, altogether 692 pieces of research papers by Chinese researchers were published on 37 international journals in field of heredity and breeding of crops with impact factor over 4.0 (MOA, 2018). China takes the lead in terms of directed screening of DNA, oriented improvement of variety and molecular breeding technologies, among others. Until the end of 2018, over 30 thousand agricultural varieties had been certified by governments at national and provincial level. Hybrid rice, transgenic pest-resistant cotton, low erucic acid and glucosinolate rapes and other new varieties have been widely acknowledged and cultivated (CNSA, 2019).

Despite favorable demand conditions, there are still challenges in R&D. For example, the technology of molecular designing is in lack of novelty. Functional genes with great value have not been developed, investment in scientific research by companies is limited and the value chain is hence not closely connected (Li, 2019). National projects of commercialized breeding are mainly undertaken by research institutes and universities. However, they usually focus merely on assessment results but neglect practical use due to unreasonable evaluation system, leading to the waste of financial resources. In addition, subsidy policies for firms that make great contributions to seed breeding are unsound, which saps the enthusiasm of companies.

In summary, there is strong demand for high-tech seed varieties, but the orientation of scientific research and allocation of resources should be well guided by the government.

5.2 Gravity model of trade

Favorable domestic conditions, however, do not mean everything in real trade. Economic environment, population, output of buyers, shipping cost and exchange rates may also generate direct and crucial influence on the outcome of deals. In the following section we will assess the significance of those factors on China's seed industry through empirical work.

There have been a vast number of papers on influence of part of those factors. For example, Amurgo-Pacheco and Pierola (2008) applied a gravity model based on trade data in developing countries from 1990 to 2005 and drew the conclusion that geographical distance and domestic market size of trade partners significantly influence the diversity of export goods. In fact, the idea of trade gravity model was inspired by Newton's Law of Universal Gravitation, and they are not the earliest to apply the law to international trade. Early studies date back to 1960s, when researchers found that trade volume between two countries is in direct proportion to their own market sizes and in inverse proportion to geographical distance (Tinbergen,1962; Pöyhönen, 1963).

5.2.1 Methods and data collection

In this thesis we follow the trade gravity model used by Che and Li (2016) to our analysis. The model adopts six variables, including GDP of China, GDP of partners, distance, output of China, output of partners and the membership of Asia-Pacific Economic Cooperation (APEC), to study the export of China's vegetables to 31 countries.

Anderson and van Wincoop (2003) showed that proper specification of the gravity model grounded in the trade theory requires inclusion of the inward and outward multilateral resistance terms (MRT) which take into consideration how "remote" both regions are from the rest of the world. The main idea is that bilateral trade flows between trading partners "i" and "j" depend on bilateral trade barriers relative to average trade barriers that both trading partners face with all their trading partners.

We plan to apply fixed effects model on entities and select five variables that could influence the performance of China's seed industry: (1) GDP of trade partners, (2) population of partners, (3) shipping cost measured by geographical distance multiplied by unit crude oil price, (4) seed output of partners, and (5) exchange rates of Chinese Yuan against local currencies. GDP of trade partners represents their purchasing power and potential market size. The population and seed output of contracting parties influences the demand conditions. Since seeds are commodities with relatively low added value, transport contributes significantly to the total cost and could be an important factor that impedes trade. Finally, exchange rates serve as an adjustment to international trade (Zhang, 2013). The volume of seed exports from China to partner country i during period t is expressed as

$$\ln Y_{it} = b_0 + b_1 \ln GDP_{it} + b_2 \ln P_{it} + b_3 \ln S_{it} + b_4 \ln O_{it} + b_5 \ln E_{it} + \mu_{it} \tag{11}$$

where Y = seed export volume, P = population, S = shipping cost, O = seed output, E = exchange rate of Chinese Yuan against local currencies, and μ = random error. Considering the availability of data, we take export of sunflower seeds, China's major seed product in the global market, as an example, and time period is settled for eleven years, from 2008 to 2018. The geographical distance between China and its partners is represented by the distance between their capitals gathered from the website https://www.distance.to/. Historical oil prices are collected from OECD Statista, and average annual exchange rates come from International Monetary Fund (IMF). The selection of partner countries conforms with the following principles:

1) seed output is continuously reported in FAOSTAT, the database of Food and Agriculture Organization;
2) export volume is recorded in succession in UN Comtrade Database;
3) GDP and population data during the period can be found from World Bank Open Data.

Finally, there are 17 countries that meet the requirements, including Turkey, Egypt, Iran, Spain, Germany, the U.S., Canada, Greece, Australia, Myanmar, Pakistan, Russia, Thailand, France, Israel, Italy and Poland. The list is not ranked.

5.2.2 Results and implications

The panel data is processed via EViews 10. Appendix 8 presents the correlation matrix of each variable in the model, from which we can see that correlations among variables (1)(3), (2)(4) and (3)(5) are relatively high, ranging from 0.47 to 0.55.

Since there could exist multicollinearity among those variables, we do preliminary panel data regression with fixed effects on the cross-section, as is shown in appendix 9. According to the results, variables (2) population and (3) shipping cost are not significant, and their contributions to the R-squared are 0.000164 and 0.000287 respectively, which are tiny. We hence eliminate those two variables from our model. Then we do stationary test on the new panel data. We test unit root in level and include individual intercept in test equation. The results are shown in appendix 10. Since both p values for Levin, Lin & Chu and ADF tests are less than 0.05, we can reject the null hypothesis that there exists unit root, and the series are therefore stationary.

With fixed effects on cross-section and period in the estimation, we conduct redundant fixed effects test, as is shown in appendix 11. P values are both less than 0.05, indicating that there exist entity and time effects at the same time.

Assuming random effects on cross-section and period in estimation, the correlated random effects (Hausman) test in appendix 12 shows that there are fixed effects on cross-section (p = 0.0001) and random effects on period (p = 1.0000).

Following all the tests above, the model regression is done and shown in Table 12. To save space, it only presents critical information. Fixed effects on cross-section and random effects on period are recorded at large in appendix 13. Adjusted R^2 of the model approaches 0.8, which represents medium goodness of fitting. P value equals to 0.000, showing that the regression model is significant as a whole.

Finally, to check the robustness of our model, we do Sargan's J test under the estimation method of Generalized Method of Moments (hereinafter: GMM), as is shown in appendix 14. Since the p value for J-statistic is 0.256, we accept the null hypothesis and the model specification is proper.

As we can see from the results of regression, the GDP of partner countries, indicating purchasing power, exerts significant positive effects on trade volume of seeds, which meets our general expectation. Seed output of importers is also positively correlated with China's export volume, indicating the developing intra-industry trade in the global market of seeds.

Table 12: Trade gravity model of sunflower seed export volume in China 2008-2018

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-46.970***	11.976	-3.92	0.0001
$\ln GDP_{it}$	3.786***	0.737	5.14	0.0000
$\ln O_{it}$	0.764**	0.299	2.55	0.0116
$\ln E_{it}$	-0.515***	0.153	-3.36	0.0010
R^2	0.795668		S.E. of regression	1.252042
Adjusted R^2	0.772421			
Prob (F statistic)	0.000000		F-statistic	34.22627

*Note: ***, ** and * denote significance at the 1%, 5% and 10% level.*

Adapted from FAOSTAT (no date); OECD Statista (no date); UN Comtrade (no date); World Bank (no date); IMF (no date).

Interestingly, the exchange rates of Chinese Yuan to local currencies are negatively related to export volume, showing that seed producers make future production plans partly based on current exchange rates. For example, when Chinese Yuan depreciates, farmers expect favorable export conditions in the future and will probably increase output in the following years. Meanwhile, the amount of seeds produced cannot be adjusted as flexibly as exchange rates do. In this sense, the 'positive' effects of depreciation on export are delayed, making China's seed industry prone to the impact of foreign exchange fluctuation.

With the regression results of trade gravity model, we can compare the actual export volume with estimated value. The graphs are demonstrated in appendix 15. In 2018, extreme situations appeared in Russia, with the actual import volume being approximately 11 times as much as our estimation. The sudden increase could be explained by the pressure of sanctions imposed by the United States (U.S. Department of State, 2018) and European Union (EU Sanctions, 2018). Another extreme case happening in Turkey (9 times) may also be attributed to political crisis.

5.3 Related and supporting industries

The seed industry is involved in a complicated value chain. The cultivation of seeds relies on fertilizer, pesticides and agricultural machinery, among other factors, which can be regarded as upstream industries. Processing, storage, transport and sales, on the other side, are downstream industries. According to Porter (1990, p. 142), global competitive advantages gained by upstream and downstream industries can motivate firms to innovate their products and services for the purpose of meeting international standards.

5.3.1 Fertilizer industry

In China, the use of fertilizers steadily increases from 1978 to 2016, with an annual growth of 0.61%, and the consumption in recent 3 years drops slightly (NBSC, 2019). According to International Fertilizer Association (IFA), consumption of nitrogen, phosphate and potash fertilizer in China takes up 24.12% of world total in 2017. Considering China accounts for merely 8.59% of world arable land (World Bank, n. d.), we can conclude that application of fertilizers per ha in China is around twice more than world average. Overuse of fertilizers not only has negative effects on crop output, as we have proved before, but also damages the environment and soil conditions in the long term.

In 2015, Ministry of Agriculture published the *Action on zero growth of fertilizer use until 2020*, and initial success has been achieved. However, China's fertilizer industry suffers from overcapacity and stricter environmental standards. After being the largest fertilizer exporter in 2015, the export volume drops dramatically and no signs of recovery is observed yet (Wen, Wang, Shang & Wang, 2019).

5.3.2 Farm chemical industry

As more and more green and efficient farm chemicals are developed and promoted, the utilization rate of those chemicals has reached 39.8% in 2019, an increase of 1% compared with 2017, indicating the reduction of chemical input. In 2019, net sales of China's farm chemicals industry approached 34.8 billion US dollars, and net profit was approximately 3.2 billion US dollars, with an evident slowdown in profit growth. Meanwhile, the export volume and value of farm chemicals dropped by 1.5% and 7.1% respectively (Yang, 2020).

The trade war between China and the United States was a major obstacle to trade. Many foreign trade enterprises in China competed to export their products in advance to avoid risks, leading to the lack of driving force for growth. In addition, climate anomaly disturbs planting season and reduces the global demand for farm chemicals. For example, according to World Meteorological Organization (hereinafter: WMO), Europe has experienced the warmest winter in history, with an average of 1.4℃ higher than the previous peak (WMO, 2020).

5.3.3 Agricultural machinery industry

In 2019, the total export value of China's agricultural machinery reached 5.4 billion US dollars, and the annual growth rate has remained over 14% during the past 3 years (Jin, 2020), indicating that the industry is not significantly affected by trade war or the epidemic. European countries and the United States are major customers of China's agricultural machinery, the primary products being parts and small machines with low added value. Meanwhile, ASEAN accounts for around 20% of China's global market, purchasing mainly low powered tractors and harvesters.

In recent years, China's agricultural machinery industry has been seeking for transformation and upgrading, and to establish overseas offices to improve services. As a result, some small and medium sized machinery has gained popularity among Southeast Asia and Africa with stable market share and reputation (Jin, 2020). It is expected that large and medium sized machinery with higher quality and unit price will replace small ones and become the mainstream of global market. The growth rate of export will hence further improve due to restructuring of the industry.

In summary, the related and supporting industries of seed industry in China are undergoing a transitional period. In the future, emphasis will be placed on the green concept and utilization efficiency. The pain of recession in the short term weeds out companies that are not future-oriented and the recovery of the industries can be expected.

6 RECOMMENDATIONS AND LIMITATIONS

6.1 Recommendations for improving international competitiveness

By now we have finished the analysis on international competitiveness of China's seed industry. On the one hand, the future is not optimistic considering previous performance. Comparative disadvantages are enlarging and share of intra-industry trade in China is decreasing, indicating that China's seed industry could still be at the low-end of GVCs. On the other hand, its capability of competition and potential are worth anticipating. China is abundant in resources and both governments and companies have been making efforts to keep up with global trend. In this sense, some recommendations are given as follows in expectation to improve the international competitiveness of seed industry.

Firstly, China should make better use of basic production factors and invest more in advanced factors. The competition nowadays no longer focuses on abundance in natural resources since basic factors can be more easily purchased worldwide. China is not depressingly short of water, land, and other natural resources but is facing increasing stress of food security, which requires steady improvement of yields. In this sense, advanced factors, including technologies and talents, should be given more priority. Seed companies should not merely pursue returns in the short term and could gradually increase expenditure on R&D to around 10% of net sales. Compulsory education should be enhanced so that farmers are more prepared and willing to apply new technologies. Effective polices on rewarding systems should be made to attract more talents to the seed industry.

Secondly, government should play a more supportive role in market supervision and resource allocation. Since the quality of seeds is hard to test immediately, producers sometimes mix bad seeds with good ones to make quick money even if their brands have been certified. It is important for government to improve legislation so that confusion acts that take advantages of innocence of farmers and disturb market order can be punished and eliminated. Government should also encourage domestic competition and support innovative firms that are professional in breeding new varieties and capable of integrating resources. National champions in domestic competition can not only gain economies of scale but also set a good example for other firms and keep a pulse on the trend of global market. Meanwhile, government could consider allowing companies to undertake more research programs than research institutes so that newly developed seed varieties can be more market-oriented.

Thirdly, seed companies should proactively upgrade strategies of internationalization and exploit overseas market while maintaining domestic market share. In the future, entry of multinationals is expected to further squeeze the saturated market and competition will become fiercer. M&A and cross-licensing could be a trend to strengthen international cooperation and gain more competitiveness, but that requires mature patent pools as bargaining chips. It is critical for companies to develop their core competence first.

Fourthly, crops planting structure should match domestic seed demand. It is undeniable that China's domestic seed market is expanding dramatically, which stimulates competition and encourages firms to apply new technologies. However, China is still highly dependent on import in many seed varieties according to the index of intra-industry trade. For now, commercialization rate of hybrid maize and rice seeds in China has approached 100%, but no breakthrough appears in the breeding of hybrid wheat and soya bean seeds. Farmers are still using self-saving seeds, which impedes the improvement of yields. Due to the volatility of international trade, the unbalanced structure could lead to food shortage. It is urgent for government to guide crop planting through price mechanism. Only when domestic demands are well satisfied can seed companies better participate in the global competition.

Finally, it is indispensable to establish industrial clusters in order to exert the synergy effect. Related and supporting industries, including fertilizer, farm chemicals and agricultural machinery, are facing severe challenges in recent years during the trade war and epidemic, which indirectly increases the production cost of seeds. Although related companies could suffer from transformation of industries, water-, fertilizer- and chemical-saving planting methods as well as light-duty machinery should become mainstream in the future. It is time to reflect on the past cooperation mode, integrate resources and gain more international competitiveness.

6.2 Limitations and future research

Since the time span for the production function model lasts for 40 years, some variables in the model are excluded or adjusted because they are not continuously reported or undergo changes of statistical standards. For example, the agricultural machinery power excludes data of three-wheeled vehicles and low-speed trucks since 2016, leading to a sudden decrease of its value. In addition, the number of employees in the primary industry is published by different government sectors due to consolidation or division of departments, which could cause inconsistency of data (NBSC, 2019).

Similar situations happen to the trade gravity model. Since international trade data is even less continuous, the time span is not long enough and lots of trade partners are excluded. Fortunately, the selected 17 countries include the three largest and the smallest trade partners of China in terms of seeds, which could represent the general situation.

Apart from economic factors, political relations also play an increasingly important role in international trade, which has been illustrated in the extreme cases of Russia and Turkey. In 2018, most seed products of China are on the sanction list imposed by the U.S. (as is presented in appendix 16), and the influence can probably be seen in 2019 data. Introduction of variables related to political relations is expected to improve the goodness of fitting of trade gravity model for China's seed industry.

The COVID-19 also has significant effects on international trade. However, most data have not been updated in official databases and for now we could not make an overall analysis of latest situations. Besides, it is expected that many countries would improve their industrial structures to cope with potential crisis, and seed industry is usually in a fundamental position. There could be dramatic changes in the pattern of the world. Future research can focus on the opportunities and challenges of seed industry in the new era.

CONCLUSION

This paper makes an analysis on the international competitiveness of China's seed industry. The original motion of research is the fact that seed output in China does not match its global market share. In order to find the reasons, we study competitiveness from three aspects: performance in the past, capability at present and potential in the future.

Revealed comparative advantage (RCA) index and index of intra-industry trade are calculated to measure the performance, from which we conclude that China has comparative disadvantages in almost all seed products except rice in the husk. Then Porter's Diamond model is used to assess the capability and potential. It is found that resource endowment in China lags world average level, its investment in R&D is insufficient compared with world giants, seed companies are too small to integrate resources in global competition and related industries are encountered with recessions due to restructuring.

Specially, we apply production function model in factor condition analysis to find that land, irrigation as well as consumption of fertilizers have significant influence on the seed output. In addition, trade gravity model is applied in demand condition analysis to forecast global market size in the future. According to the results, GDP, output, geographical distance and economic cooperation relationship are all important factors that affect export volume.

Despite those unfavorable conditions, Chinese government is aware of the strategic importance of seed industry and has been working to improve legislation and protect rights to new varieties. The foreseeable future under impact of trade war and epidemic is full of opportunities and challenges, and the ability to integrate resources will be the key to improving international competitiveness.

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APPENDICES

Appendix 1: Povzetek (Summary in Slovene language)

Kitajska je velika kmetijska država, relativno obdarjena z naravnimi viri, ki prideluje eno četrtino poljščin na svetu, pri tem pa ima približno 10% svetovnih površin, primernih za obdelavo (FAO, 2019). Vendar pa kitajska industrija semen predstavlja zgolj 1,7% svetovnega deleža, veliko manj od tistega, ki ga imajo vodilne države (ISF, 2017). Da bi bolje razumeli to kontradiktorno situacijo, v tem delu ocenim mednarodno konkurenčnost kitajskega semenarstva s pomočijo različnih kvantitativnih kot tudi kvalitativnih metod in predlagam ukrepe za povečanje njene mednarodne konkurenčnosti.

Glavna raziskovana vprašanja v tem delu so naslednja:

1) Pri katerih vrstah proizvodnje semen ima Kitajska primerjalne prednosti in naprednosti na globalnem trgu?
2) Kako uspešno je kitajsko semenarstvo upoštevajoč znotrajpanožno trgovino?
3) Kakšen vpliv imajo faktorski pogoji, ukrepi ekonomske politike in strategije podjetij na konkurenčno sposobnost kitajskega semenarstva?
4) Kakšen vpliv imata povpraševanje in povezane gospodarske dejavnosti na konkurenčni potencial kitajskega semenarstva?
5) Na kakšen način in s kakšnimi ukrepi bi bilo moč povečati konkurenčnost kitajskega semenarstva?

Na osnovi teorij mednarodne menjave in predhodnih empiričnih raziskav, to delo ocenjuje mednarodno konkurenčnost s treh vidikov: uspešnost, sposobnost in potencial. Prvi del ocenjuje kitajski tržni delež na globalnem trgu v segmentu semen zelenjave, rož in poljščin. Da bi proučil razkorak glede na vodilne države, izračunam indeks izkazanih primerjalnih prednosti (RCA), ki predstavlja delež izbrane panoge v vrednosti celotnega izvoza države glede na svetovno povprečje. Indeks je izračun na primeru semenarstva v bolj podrobnih kategorijah za bolj natančno identifikacijo primerjalnih prednosti in neprednosti. V nadaljevanju je uporabljen tudi indeks, ki meri delež znotrajpanožne trgovine, za proučitev pomena diferenciacije proizvodov in odvisnosti od uvoza. Drugi in tretji del analize pa temelji na Modelu diamanta, ki ga je razvil Porter (1990). Kvantitativna analiza zajema dve vrsti regresijske analize: (i) oceno produkcijske funkcije na podatkih časovnih vrst in pa (ii) gravitacijski model, ki temelji na panelnih podatkih. Kvalitativna analiza večinoma temelji na uradnih dokumentih, kot so zakoni, predpisi in panožna poročila, pri interpretaciji pa sem se uprl tudi na moje lastne izkušnje v podjetju, ki deluje v semenarski panogi.

Skladno z rezultati analize so predlogi za izboljšanje konkurenčnosti kitajskega semenarstva naslednji. Prvič, Kitajska naj bolje izkoristi osnovne proizvodne dejavnike in več investira v napredne dejavnike. Drugič, vlada bi morala igrati bolj aktivno vlogo pri tržnem nadzoru, izboljšati regulativno okolje in prerazporediti več resursov v ustanovitev velikih semenarskih podjetij. Tretjič, podjetja bi morala bolj proaktivno sodelovati v domači konkurenci, neprestano nadgrajevati strategije internacionalizacije in izkoriščati

mednarodne trge. Četrtič, struktura rastlinskih zasaditev bi morala ustrezati strukturi domačega povpraševanju po semenih. Kot zadnje pa bi poudaril potrebo po ustanovitvi industrijskih grozdov, ki bi omogočali lažje izkoriščanje sinergijskih učinkov.

Pod vplivom trgovskih vojn in pandemije so pričakovanja za prihodnost polna priložnosti in izzivov, pri čemer bo sposobnost integrirati resurse ključna za izboljšanje mednarodne konkurenčnosti kitajskega semenarstva.

Appendix 2: UN Comtrade Commodity Classifications of seed industry (HS 2012)

Code	Item
100111	Cereals; wheat and meslin, durum wheat, seed
100191	Cereals; wheat and meslin, other than durum wheat, seed
100210	Cereals; rye, seed
100310	Cereals; barley, seed
100410	Cereals; oats, seeds
100510	Cereals; maize (corn), seed
100610	Cereals; rice in the husk (paddy or rough)
100710	Cereals; grain sorghum, seed
100821	Cereals; millet, seed
100830	Cereals; canary seeds
120110	Soya beans; seed, whether or not broken
120230	Ground-nuts; seed, not roasted or otherwise cooked, whether or not shelled or broken
120400	Oil seeds; linseed, whether or not broken
120510	Oil seeds; low erucic acid rape or colza seeds, whether or not broken
120590	Oil seeds; rape or colza seeds, other than low erucic, whether or not broken
120600	Oil seeds; sunflower seeds, whether or not broken
120710	Oil seeds; palm nuts and kernels, whether or not broken
120721	Oil seeds; cotton seeds, seed, whether or not broken
120730	Oil seeds; castor oil seeds, whether or not broken
120740	Oil seeds; sesamum seeds, whether or not broken
120750	Oil seeds; mustard seeds, whether or not broken
120760	Oil seeds; safflower (Carthamus tinctorius) seeds, whether or not broken
120770	Oil seeds; melon seeds, whether or not broken
120791	Oil seeds; poppy seeds, whether or not broken
120799	Oil seeds and oleaginous fruits; n.e.c. in heading no. 1207, whether or not broken
120910	Seed; sugar beet seeds, of a kind used for sowing
120921	Seeds of forage plants; lucerne (alfalfa) seeds, of a kind used for sowing
120922	Seeds of forage plants; clover (Trifolium spp.) seeds, of a kind used for sowing
120923	Seeds of forage plants; fescue seeds, of a kind used for sowing
120924	Seeds of forage plants; Kentucky blue grass (Poa pratensis L.) seeds, of a kind used for sowing
120925	Seeds of forage plants; rye grass (Lolium multiflorum Lam., Lolium perenne L.) seeds, of a kind used for sowing

(table continues)

(continued)

Code	Item
120929	Seeds of forage plants; other than lucerne, clover, fescue, Kentucky blue grass, and rye grass seeds, of a kind used for sowing
120930	Seeds of herbaceous plants; cultivated principally for their flowers, of a kind used for sowing
120991	Seeds; vegetable seeds, of a kind used for sowing
120999	Seeds; n.e.c. in heading 1209, of a kind used for sowing

Source: UN Comtrade (no date).

Appendix 3: Herfindahl-Hirschman Index of global seed industry 2017

Countries	Sales in million US dollar	MS_i	MS_i^2
Argentina	256	2.15706	4.65291
Australia	111	0.93529	0.87476
Austria	268	2.25817	5.09935
Belarus	1	0.00843	0.00007
Belgium	225	1.89585	3.59426
Bolivia	15	0.12639	0.01597
Bosnia & H.	17	0.14324	0.02052
Brazil	165	1.39029	1.93292
Bulgaria	21	0.17695	0.03131
Canada	282	2.37614	5.64603
Chile	285	2.40142	5.76680
China	205	1.72733	2.98368
Colombia	12	0.10111	0.01022
Costa Rica	10	0.08426	0.00710
Croatia	13	0.10954	0.01200
Czechia	103	0.86788	0.75322
Denmark	312	2.62892	6.91121
Dominican Rep.	1	0.00843	0.00007
Egypt	15	0.12639	0.01597
Estonia	2	0.01685	0.00028
Finland	1	0.00843	0.00007
France	1801	15.17526	230.28855
Germany	783	6.59757	43.52797
Greece	10	0.08426	0.00710
Guatemala	21	0.17695	0.03131
Honduras	1	0.00843	0.00007
Hungary	480	4.04449	16.35789
India	101	0.85103	0.72425
Indonesia	16	0.13482	0.01818
Iran	9	0.07583	0.00575
Ireland	6	0.05056	0.00256
Israel	148	1.24705	1.55514
Italy	367	3.09235	9.56262
Japan	173	1.45770	2.12489
Jordan	8	0.06741	0.00454
Kenya	10	0.08426	0.00710
Korea, Rep.	70	0.58982	0.34789
Latvia	13	0.10954	0.01200
Lithuania	41	0.34547	0.11935
Luxembourg	9	0.07583	0.00575
Mexico	169	1.42400	2.02777
Morocco	2	0.01685	0.00028
Netherlands	2040	17.18908	295.46447

(table continues)

(continued)

Countries	**Sales in million US dollar**	MS_i	MS_i^2
New Zealand	136	1.14594	1.31318
Pakistan	4	0.03370	0.00114
Paraguay	8	0.06741	0.00454
Peru	51	0.42973	0.18467
Philippines	4	0.03370	0.00114
Poland	109	0.91844	0.84352
Portugal	21	0.17695	0.03131
Romania	296	2.49410	6.22054
Russian Fed.	2	0.01685	0.00028
Serbia	46	0.38760	0.15023
Singapore	9	0.07583	0.00575
Slovakia	73	0.61510	0.37835
Slovenia	7	0.05898	0.00348
South Africa	120	1.01112	1.02237
Spain	263	2.21604	4.91085
Sweden	32	0.26963	0.07270
Switzerland	28	0.23593	0.05566
Tanzania	10	0.08426	0.00710
Thailand	116	0.97742	0.95535
Turkey	89	0.74992	0.56237
Uganda	9	0.07583	0.00575
Ukraine	28	0.23593	0.05566
United Kingdom	75	0.63195	0.39936
Uruguay	9	0.07583	0.00575
USA	1712	14.42535	208.09059
Vietnam	13	0.10954	0.01200
Total (HHI)			**865.81781**

Note: Countries with sales value less than USD 1 million are not included in the Table, and their market share is too small to influence the calculation of HHI.

Adapted from ISF (no date).

Appendix 4: Rankings of comparative advantage of seed trading nations 2017

Ranking	Country	Vegetable crops	Flowers	Field crops	Total
1	Netherlands	82.75	2.83	4.76	90.33
2	France	20.52	0.29	60.48	81.28
3	USA	14.74	2.67	20.50	37.90
4	Hungary	-0.79	-0.11	23.66	22.76
5	Romania	-0.89	-0.07	14.97	14.01
6	Denmark	1.78	0.19	11.74	13.71
7	Chile	7.37	0.78	5.31	13.46
8	Argentina	0.00	-0.06	12.27	12.22
9	Austria	-2.25	-0.16	11.15	8.74
10	New Zealand	3.04	-0.04	3.22	6.23
11	Israel	6.23	-0.06	-0.15	6.03
12	South Africa	1.12	-0.08	2.36	3.39
13	Spain	0.06	-0.30	2.95	2.71
14	Serbia	-0.12	-0.02	2.08	1.95
15	Italy	-0.26	-0.36	2.08	1.45
16	Lithuania	-0.18	0.03	1.33	1.18
17	Peru	1.31	-0.04	-0.11	1.15
18	Brazil	-2.07	-0.20	3.32	1.05
19	Slovakia	-1.13	-0.08	2.13	0.91
20	Guatemala	0.42	0.61	-0.26	0.77
21	Bosnia & H.	-0.09	-0.01	0.81	0.72
22	Bolivia	-0.11	-0.01	0.66	0.55
23	Tanzania	0.28	0.11	0.02	0.41
24	Uganda	-0.04	0.00	0.44	0.40
25	Kenya	0.20	-0.01	0.15	0.35
26	Uruguay	-0.11	-0.01	0.32	0.21
27	Costa Rica	-0.13	0.56	-0.23	0.20
28	Latvia	-0.08	-0.01	0.29	0.20
29	Jordan	0.35	-0.01	-0.18	0.17
30	Croatia	-0.22	-0.02	0.35	0.12
31	Paraguay	-0.12	-0.01	0.25	0.12
32	Bulgaria	-0.08	-0.03	0.10	-0.01
33	Canada	-5.36	-0.39	5.70	-0.06
34	Ukraine	0.15	-0.04	-0.17	-0.06
35	Luxembourg	-0.21	-0.01	0.14	-0.09
36	Egypt	0.33	-0.02	-0.43	-0.13

(table continues)

(continued)

Ranking	Country	Vegetable crops	Flowers	Field crops	Total
37	Honduras	-0.06	-0.01	-0.20	-0.27
38	Dominican Rep.	-0.14	-0.01	-0.18	-0.33
39	Estonia	-0.20	-0.01	-0.23	-0.44
40	Pakistan	-0.29	-0.02	-0.29	-0.60
41	Greece	-0.38	-0.03	-0.26	-0.67
42	Colombia	-0.49	-0.03	-0.19	-0.72
43	Morocco	-0.34	-0.02	-0.48	-0.85
44	Turkey	-1.03	-0.03	0.13	-0.94
45	Belarus	-0.39	-0.03	-0.63	-1.05
46	Slovenia	-0.35	-0.04	-0.68	-1.06
47	Czechia	-1.99	0.00	0.89	-1.10
48	Portugal	-0.61	-0.06	-0.51	-1.17
49	Philippines	-0.70	-0.06	-1.62	-2.38
50	Thailand	0.83	-0.22	-3.04	-2.43
51	Australia	-1.80	-0.10	-0.60	-2.51
52	Finland	-0.91	-0.06	-1.55	-2.53
53	Poland	-2.80	-0.16	0.23	-2.74
54	Iran	-1.24	-0.09	-1.68	-3.01
55	Belgium	-5.49	-0.35	2.20	-3.64
56	Sweden	-1.77	-0.09	-2.14	-4.00
57	Ireland	-1.84	-0.13	-2.90	-4.87
58	Indonesia	-2.04	-0.05	-3.42	-5.50
59	India	-0.29	-0.17	-5.20	-5.66
60	Mexico	-4.53	-0.38	-1.08	-6.00
61	Vietnam	-2.87	-0.20	-4.32	-7.40
62	Switzerland	-3.85	-0.28	-5.66	-9.79
63	Germany	-14.34	0.56	3.01	-10.78
64	United Kingdom	-4.45	-0.02	-8.04	-12.50
65	Russian Fed.	-4.62	-0.33	-8.33	-13.28
66	Singapore	-4.50	-0.35	-8.81	-13.66
67	Japan	-3.89	1.15	-13.99	-16.74
68	Korea, Rep.	-4.48	-0.54	-12.80	-17.82
69	China	-23.53	-1.33	-49.44	-74.30

Note: Countries with sales value less than USD 1 million in 2017 are not included in the Table and the rankings are based on NRCA index.

Adapted from ISF (no date); WTO (no date).

Appendix 5: Unit root test of variables in factor production model

No.	Variable	t-Statistic	Prob.	Stationary at
1	$\ln Y$	-3.18	0.0303	First difference
2	$\ln SA$	-3.14	0.0321	First difference
3	$\ln DA$	-6.08	0.0001	Level
4	$\ln CF$	-3.51	0.0129	Level
5	$\ln IA$	-5.24	0.0006	First difference
6	$\ln CE$	-3.66	0.0372	First difference
7	$\ln NE$			Neither level nor first difference
8	$\ln EF$	-4.23	0.0097	First difference
9	$\ln EA$	-7.75	0.0000	First difference

Adapted from NBSC (no date).

Appendix 6: Cointegration test of variables in factor production model

Null Hypothesis: RESID has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.35	0.0005
Test critical values:	1% level	-4.21	
	5% level	-3.53	
	10% level	-3.20	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RESID)
Method: Least Squares
Sample (adjusted): 1980 2018
Included observations: 39 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID(-1)	-0.876683	0.163906	-5.348696	0.0000
C	-0.000629	0.007685	-0.081832	0.9352
@TREND("1978")	0.000004	0.000323	0.012529	0.9901
R-squared	0.442995		**Mean dependent var**	-0.000728
Adjusted R-squared	0.412050		**S.D. dependent var**	0.029557
S.E. of regression	0.022663		**Akaike info criterion**	-4.662319
Sum squared resid	0.018491		**Schwarz criterion**	-4.534353
Log likelihood	93.91522		**Hannan-Quinn criter.**	-4.616406
F-statistic	14.31567		**Durbin-Watson stat**	1.880614
Prob(F-statistic)	0.000027			

Adapted from NBSC (no date).

Appendix 7: Regression of factor production model

Dependent Variable: $dcre \ln Y$
Method: Least Squares
Sample (adjusted): 1979 2018
Included observations: 40 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.94***	0.17	5.61	0.0000
$dcre \ln EA$	1.14***	0.32	3.55	0.0012
$\ln DA$	-0.06***	0.02	-3.85	0.0005
$\ln CF$	-0.04***	0.01	-4.48	0.0001
$dcre \ln IA$	1.23***	0.42	2.97	0.0057
$dcre \ln CE$	0.19	0.13	1.46	0.1540
$dcre \ln EF$	0.10	0.09	1.10	0.2777
$dcre \ln EA$	0.03	0.02	1.38	0.1784

R-squared	0.750	**Mean dependent var**	0.019
Adjusted R-squared	0.695	**S.D. dependent var**	0.044
S.E. of regression	0.024	**Akaike info criterion**	-4.404
Sum squared resid	0.019	**Schwarz criterion**	-4.066
Log likelihood	96.076	**Hannan-Quinn criter.**	-4.282
F-statistic	13.685	**Durbin-Watson stat**	1.730
Prob(F-statistic)	0.000		

*Note: ***, ** and * denote significance at the 1%, 5% and 10% level.*

Adapted from NBSC (no date).

Appendix 8: Correlation matrix of variables in trade gravity model

Variables		(1)	(2)	(3)	(4)	(5)
(1)	Pearson Correlation	1.000				
	Sig. (2-tailed)					
(2)	Pearson Correlation	0.413***	1.000			
	Sig. (2-tailed)	(0.000)				
(3)	Pearson Correlation	0.506***	-0.117	1.000		
	Sig. (2-tailed)	(0.000)	(0.109)			
(4)	Pearson Correlation	0.307***	0.465***	0.060	1.000	
	Sig. (2-tailed)	(0.000)	(0.000)	(0.416)		
(5)	Pearson Correlation	0.345***	-0.251***	0.549***	0.075	1.000
	Sig. (2-tailed)	(0.000)	(0.001)	(0.000)	(0.310)	

*Note: *** denotes that correlation is significant at the 1% level (2-tailed). Variable (1) = GDP of partners, (2) = population of partners, (3) = shipping cost, (4) = seed output of partners, and (5) = exchange rate of Chinese Yuan to local currencies.*

Adapted from FAO (no date); UN Comtrade (no date); World Bank (no date); IMF (no date).

Appendix 9: Regression of trade gravity model with five original variables

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-45.37***	16.28	-2.79	0.0060
$\ln GDP_{it}$	3.36***	0.93	3.61	0.0004
$\ln P_{it}$	1.43	4.05	0.35	0.7241
$\ln S_{it}$	-0.16	0.35	-0.47	0.6411
$\ln O_{it}$	0.82**	0.31	2.60	0.0102
$\ln E_{it}$	-0.45***	0.16	-2.82	0.0054
Fixed Effects (Cross)				
01. TK--C	0.18		10. MY--C	7.28
02. EG--C	7.99		11. PK--C	0.87
03. IR--C	-1.33		12. RU--C	-10.82
04. SP--C	0.16		13. TH--C	4.97
05. GE--C	-1.44		14. FR--C	-10.18
06. US--C	-12.06		15. IS--C	5.43
07. CA--C	-0.35		16. IT--C	-3.89
08. GR--C	6.65		17. PO--C	4.38
09. AU--C	2.16			
R^2	0.783		**S.E. of regression**	1.311
Adjusted R^2	0.755			
Prob.	0.000		**F-statistic**	28.340

*Note: ***, ** and * denote significance at the 1%, 5% and 10% level. This is merely a preliminary regression to further select variables and eliminate multicollinearity.*

Adapted from FAO (no date); UN Comtrade (no date); World Bank (no date); IMF (no date).

Appendix 10: Unit root test of panel data in trade gravity model

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-12.3117	0.0000	68	660
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-5.32239	0.0000	68	660
ADF - Fisher Chi-square	256.759	0.0000	68	660
PP - Fisher Chi-square	290.761	0.0000	68	680

*Note: ** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.*

Adapted from FAO (no date); UN Comtrade (no date); World Bank (no date); IMF (no date).

Appendix 11: Redundant fixed effects test of variables in trade gravity model

Effects Test	Statistic	d.f.	Prob.
Cross-section F	33.821363	-16,157	0.0000
Cross-section Chi-square	279.036994	16	0.0000
Period F	2.438507	-10,157	0.0099
Period Chi-square	26.998391	10	0.0026
Cross-Section/Period F	21.69828	-26,157	0.0000
Cross-Section/Period Chi-square	285.101822	26	0.0000

Adapted from FAO (no date); UN Comtrade (no date); World Bank (no date); IMF (no date).

Appendix 12: Correlated random effects test of variables in trade gravity model

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	21.209323	3	0.0001
Period random	0.000000	3	1.0000
Cross-section and period random	21.785181	3	0.0001

Note: Period test variance is invalid. Hausman statistic set to zero.

Adapted from FAO (no date); UN Comtrade (no date); World Bank (no date); IMF (no date).

Appendix 13: Regression of trade gravity model with selected variables

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-46.970***	11.976	-3.92	0.0001
$\ln GDP_{it}$	3.786***	0.737	5.14	0.0000
$\ln O_{it}$	0.764**	0.299	2.55	0.0116
$\ln E_{it}$	-0.515***	0.153	-3.36	0.0010
Fixed Effects (Cross) / Coefficient				
01. TK--C	0.806		10. MY--C	8.309
02. EG--C	9.021		11. PK--C	3.106
03. IR--C	-1.616		12. RU--C	-9.662
04. SP--C	-0.139		13. TH--C	5.474
05. GE--C	-1.481		14. FR--C	-10.223
06. US--C	-10.733		15. IS--C	3.015
07. CA--C	-1.321		16. IT--C	-4.058
08. GR--C	4.932		17. PO--C	3.879
09. AU--C	0.691			
Random Effects (Period) / Coefficient				
2008--C	0.472		2014--C	-0.217
2009--C	0.300		2015--C	-0.362
2010--C	0.023		2016--C	-0.148
2011--C	-0.181		2017--C	0.354
2012--C	-0.201		2018--C	0.257
2013--C	-0.298			
R^2	0.795668		**S.E. of regression**	1.252042
Adjusted R^2	0.772421			
Prob (F statistic)	0.000000		**F-statistic**	34.22627

*Note: ***, ** and * denote significance at the 1%, 5% and 10% level.*

Adapted from FAO (no date); UN Comtrade (no date); World Bank (no date); IMF (no date).

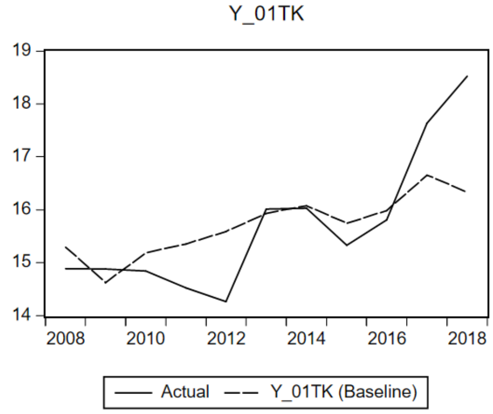
Appendix 14: Robustness test of trade gravity model

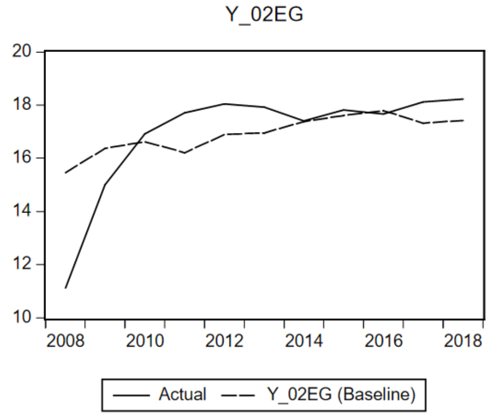
Variable	Coefficient	Std. Error	t-Statistic	Prob.
$\ln Y_{it}\,(-1)$	0.36***	0.10	3.59	0.0005
$\ln GDP_{it}$	2.47***	0.25	9.93	0.0000
$\ln O_{it}$	1.32***	0.18	7.53	0.0000
$\ln E_{it}$	-0.67***	0.07	-10.03	0.0000
Mean dependent var	0.140	**S.D. dependent var**	1.105864	
S.E. of regression	1.243	**Sum squared resid**	230.3592	
J-statistic	15.880	**Instrument rank**	17	
Prob (J-statistic)	0.256			

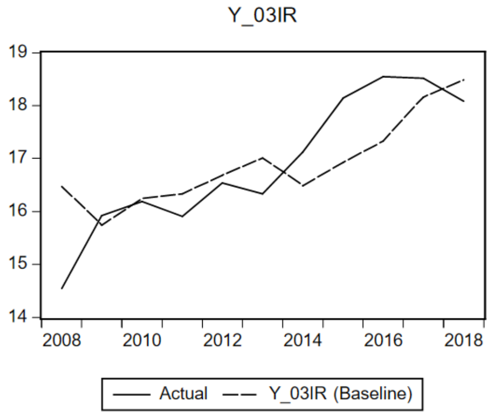
*Note: ***, ** and * denote significance at the 1%, 5% and 10% level.*

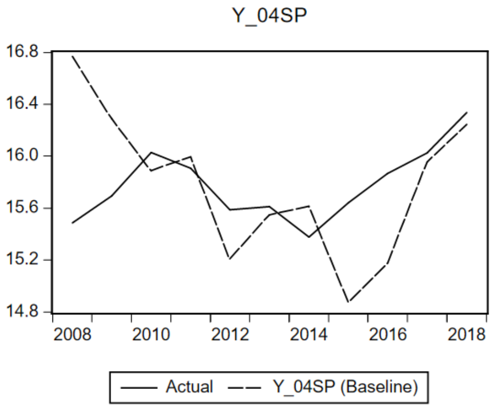
Adapted from FAO (no date); UN Comtrade (no date); World Bank (no date); IMF (no date).

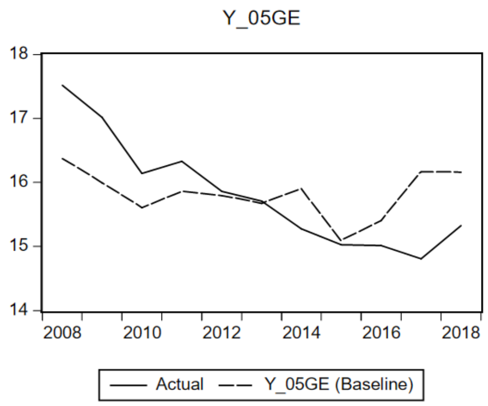
Appendix 15: Model estimation and actual trade volume of China's seed export

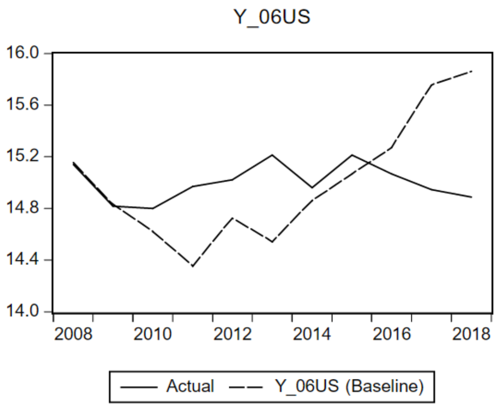












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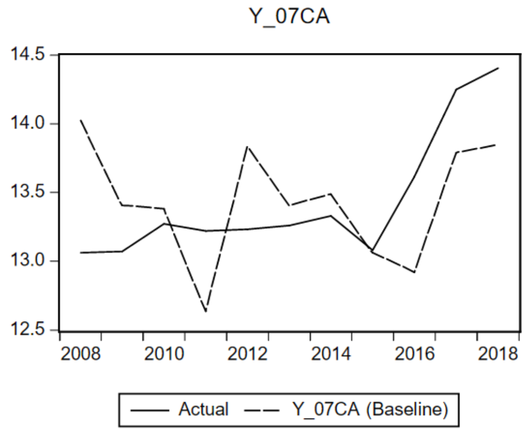

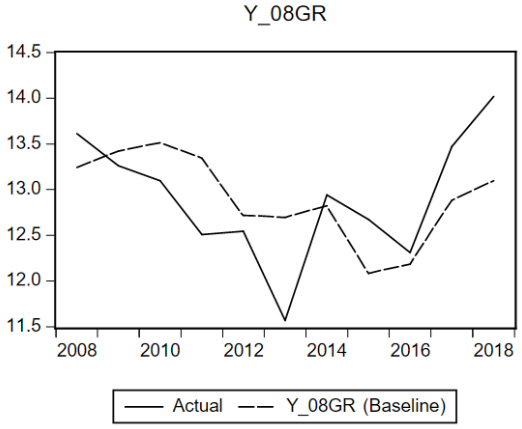

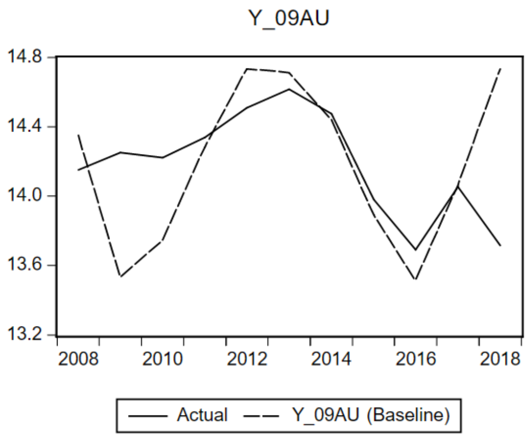

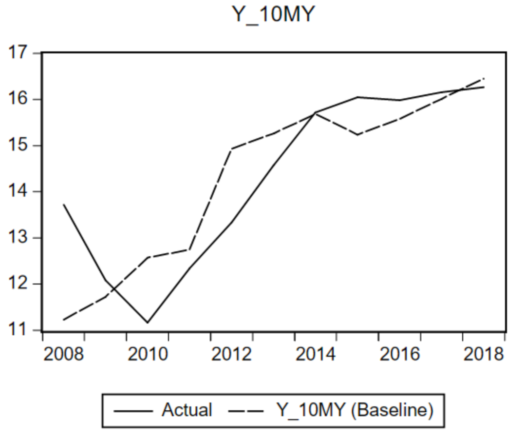

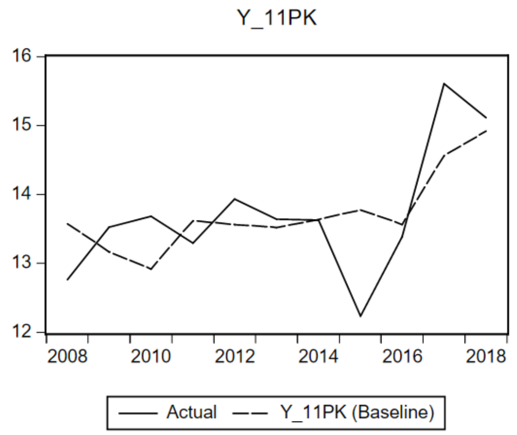

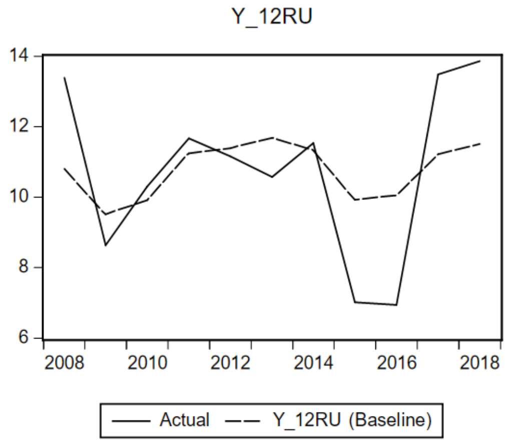

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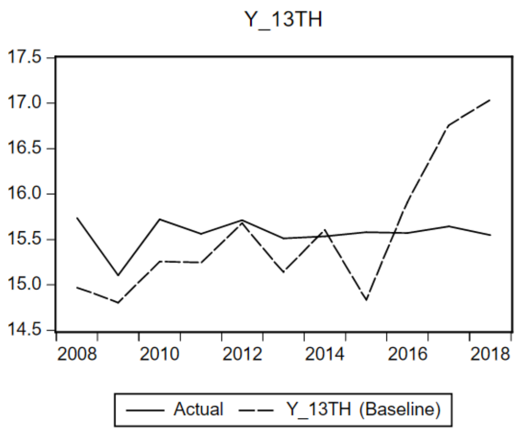

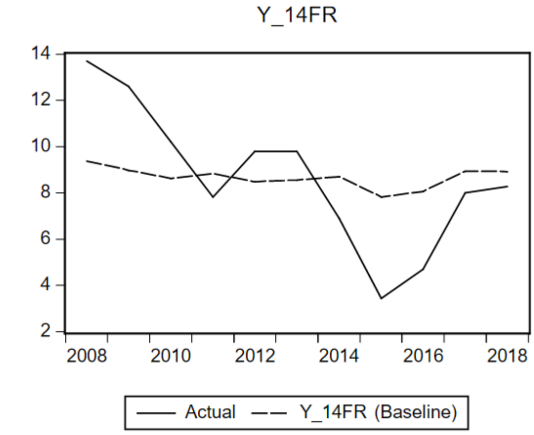

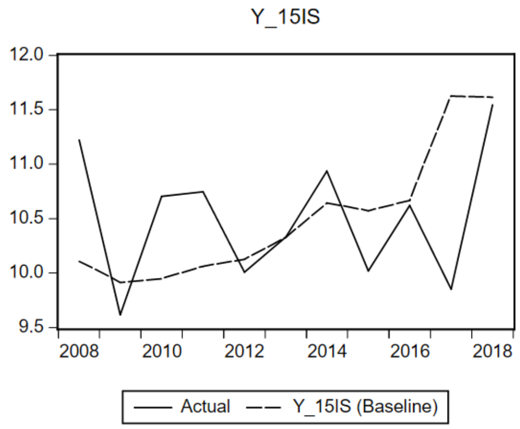

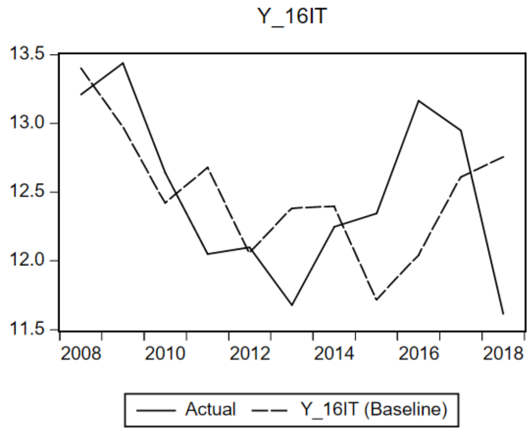

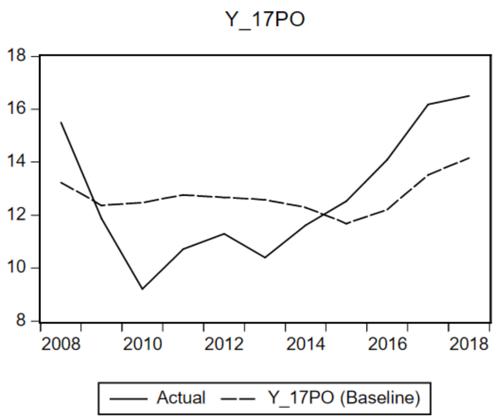

Note: Trade volume (tons) is shown in logarithm form. Y = seed export volume of China, 01TK = Turkey, 02EG = Egypt, 03IR = Iran, 04SP = Spain, 05GE = Germany, 06US = The United States, 07CA = Canada, 08GR = Greece, 09AU = Australia, 10MY = Myanmar, 11PK = Pakistan, 12RU = Russia, 13TH = Thailand, 14FR= France, 15IS = Israel, 16IT = Italy, 17PO = Poland.

Adapted from FAO (no date); UN Comtrade (no date); World Bank (no date); IMF (no date).

Appendix 16: Proposed tariffs on seed imports from China by United States

HTSUS Subheading	Product Description
0713.10.10	Seeds of peas of a kind used for sowing
0713.20.10	Seeds of chickpeas (garbanzos) of a kind used for sowing
0713.31.10	Seeds of beans of a kind used for sowing
0713.32.10	Seeds of small red (adzuki) beans of a kind used for sowing
0713.33.10	Seeds of kidney beans, including white pea beans of a kind used for sowing
0713.39.11	Seeds of beans nesoi, of a kind used for sowing
0713.40.10	Lentil seeds of a kind used for sowing
0713.50.10	Seeds of broad beans and horse beans of a kind used for sowing
0713.60.60	Dried pigeon pea seeds, shelled, if entered for consumption during the period from May
0713.60.80	Dried pigeon pea seeds, shelled, if entered Sept. 1 through the following April 30, or withdrawn for consumption at any time
0713.90.11	Seeds of leguminous vegetables nesoi, of a kind used for sowing
0713.90.50	Dried guar seeds, shelled
0806.20.10	Raisins, made from dried seedless grapes
0806.20.20	Raisins, made from other than seedless grapes
1001.11.00	Durum wheat, seed
1001.99.00	Wheat & meslin other than durum or seed wheat
1003.10.00	Barley, seed
1004.10.00	Oats, seed
1007.10.00	Grain sorghum, seed
1008.21.00	Millet, seed
1008.30.00	Canary seed
1201.10.00	Soybeans, whether or not broken, seed
1202.30.40	Peanuts (ground-nuts), seed, not roasted or cooked, shelled, subject to add. US note 2 to Ch.12
1204.00.00	Flaxseed (linseed), whether or not broken
1205.10.00	Low erucic acid rape or colza seeds, whether or not broken
1205.90.00	Rape or colza seeds (other than of low erucic acid), whether or not broken
1206.00.00	Sunflower seeds, whether or not broken
1207.40.00	Sesame seeds, whether or not broken
1207.50.00	Mustard seeds, whether or not broken
1207.60.00	Safflower (Carthamus tintorius) seeds
1207.70.00	Melon seeds
1207.91.00	Poppy seeds, whether or not broken

(table continues)

(continued)

HTSUS Subheading	Product Description
1207.99.03	Other oil seeds and oleaginous fruits whether or not broken, incl niger seeds, hemp seeds and seeds nesoi
1208.90.00	Flours and meals of oil seeds or oleaginous fruits other than those of mustard or soybeans
1209.10.00	Sugar beet seeds of a kind used for sowing
1209.21.00	Alfalfa (lucerne) seed of a kind used for sowing
1209.25.00	Rye grass seeds of a kind used for sowing
1209.29.10	Beet seed, other than sugar beet seed, of a kind used for sowing
1209.29.91	Seeds of forage plants of a kind used for sowing, not elsewhere specified or included
1209.30.00	Seeds of herbaceous plants cultivated principally for their flowers
1209.91.10	Cauliflower seeds of a kind used for sowing
1209.91.20	Celery seeds of a kind used for sowing
1209.91.40	Onion seeds of a kind used for sowing
1209.91.50	Parsley seeds of a kind used for sowing
1209.91.60	Pepper seeds of a kind used for sowing
1209.91.80	Vegetable seeds, nesoi, of a kind used for sowing
1209.99.20	Tree and shrub seeds of a kind used for sowing
1209.99.41	Seeds, fruits and spores, of a kind used for sowing, nesoi
2008.19.50	Watermelon seeds, otherwise prepared or preserved, nesoi
2008.19.85	Mixtures of nuts or other seeds otherwise prepared or preserved, nesoi
2008.19.90	Other nuts and seeds nesoi, excluding mixtures, otherwise prepared or preserved, nesoi

Note: HTSUS stands for Harmonized Tariff Schedule of the United States.

Source: Office of the United States Trade Representative (2018).