Industrial Policy, Market Structure, and Market Power in Agribusinesses of China

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Abbreviation

AIDS Model	Almost Ideal Demand System Model
CPI	Consumer Price Index
CSP	Centralized Slaughtering Policy
D20	China Dairy 20 Alliance
FTA	Free-trade Agreement
GLCM	Generalized Leontief Conditional Method
GNHS	Guidelines for National Hog Slaughtering Industry
HACCP	Hazard Analysis Critical Control Point
MARA	Ministry of the Agriculture and Rural Affair
MFN	Most Favored Nation
MOA	Ministry of Agriculture
NLSUR	Nonlinear Seemingly Unrelated Regression
NSBC	National Statistics Bureau of China
NEIO	New Empirical Industrial Organization
SRB	Solow Residual Based Model
SCPP	Structure-conduct-performance Paradigm
UHT Milk	Ultra-high Temperature Processing Milk
VMP	Value of Marginal Product

Acknowledgment

It is not an easy journey. I am so thankful for eventually reaching this momentous place, and I could not say I am not thrilled and wild with joy.

I would like to express my special thanks of gratitude to Prof. Xiaohua Yu, my supervisor and my life-coach. I could not imagine having a better advisor and mentor for my Ph.D. study than him. He provides me with this golden opportunity to study at such a great university. During my three-year stay here, I accomplished a lot of achievements together with him: my first publication, my first international conference presentation, and my first job offer. So many memorial experiences could not occur if he does not share his pearls of wisdom and expertise with me. Many thanks!

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Executive Summary

The Chinese agri-food industry is evolving into an imperfectly competitive market in our observation. The issue deserves more attention from the policymakers since any negligible departure from the perfectly competitive market in agriculture would generate enormous extra profits for firms and welfare loss for the society (Sexton, 2000a). This consequence is determined by the agricultural industry's natures of small price elasticity of demand and frequent consumption behaviors. Therefore, ignoring imperfect competition in the marketing sector may result in erroneous government implements and policy recommendations. The objective of this dissertation is to better understand the roles of industrial policies on market structure and market power in the agribusiness of China.

To measure the impact of policy intervening on the competitiveness of the agricultural industry, we choose to estimate two important policy tools: (1) centralized slaughtering policy and (2) subsidies. These two policies are typical representatives of government regulations and industrial support policies, respectively. The sampled industries involved in my dissertation are the (1) hog slaughtering industry and (2) fluid milk industry. They share some similar characteristics, such as sheer-size production and consumption, concentrated market structure, and daily-essential livestock products. But the difference should be noted as well between which the hog slaughtering

industry mainly produces homogenous products, while the fluid market industry is strong product differentiated.

Concerning the research methodology, the first topic employs the New Empirical Industrial Organization model with industry-level data in terms of the homogenous products. In the second topic, we estimate the firms' marginal costs and Lerner indexes directly with the product differentiated, firm-level information. But both topics are restricted in the domestic market and do fail to consider the imported players. Therefore, in the third topics, we extend our research by allowing the imported players and domestic firms to compete in one integrated market, aided with more accurate elasticities estimated by the AIDS model.

In general, we observe more and more concentrated market structure for both the hog slaughtering industry and fluid milk industry. But the impacts of market power strongly depend on the objective and industry we research. In chapter two, we find the oligopsonistic market power indicator of the slaughtering industry is 0.0593 and statistically significant, which generates 1.85 billion Yuan markup value just in 2016 and 13.65 billion Yuan from 2008 and 2016. There are possibly two reasons for the market power: (1) the CSP causing high barriers of entry; and (2) squeezing out small-size incumbents that lead to a high concentration ratio.

For chapter three, our results show that subsidies have a significant negative impact on market power for privately-owned listed dairy firms, while no significant effect for the state-controlled firm after controlling for advertising, time trend, and proprietorship. It is possible that the subsidies

give more room for private firms to increase the scale or suppress the price, which eventually reduces the market power and benefits dairy customers in the downstream.

For chapter four, we identify imported fluid milk owns a significant Lerner index (0.79), but its markup value is much smaller than that of the Chinese domestic competitors. It is possible that the brand loyalty of the consumers promotes the market power of the quality-guaranteed imported products from overseas. However, limited access to imported fluid milk and marginal sales reduce the imported's extra profits.

General policy implications can be derived from these findings. In the past decades, the Chinese agri-food chain is becoming more and more concentrated. Policy intervening is part of the reasons since the government is aiming at higher sanitary standards, competitive productivity, and less regulation cost for the agri-food industry. However, the policymakers should be cautious on the side-effects of these industrial policies. Firstly, it might generate high entry and exit barriers for the market participants, which empowers the incumbents with a privileged position. Moreover, the oligopolistic or oligopsonistic firms are more flexible to absorb the financial and cost burdens induced by the industrial regulations and transfer these burdens to the upstream and downstream partners in the food chain. Secondly, in the presence of the market power, the welfare distribution between the buyers and sellers would be distorted, and the oligopolistic/oligopsonistic players could execute their market power to get more rents from the policy benefits (e.g., income-support subsidies). Finally, since the Chinese agricultural market is becoming more open to the exporters, the government should keep the top exporters under constant surveillance. The industrial policy

should promote a more competitive environment for both domestic and imported competitors such as dispersing the exporters or applying the tariff more equally and homogeneously.

Chapter 1 Introduction

1.1 Introduction to the topics

Are we facing a perfectly or imperfectly competitive market in the Chinese modern food chain and agricultural industry? Answering the question is of vital importance in the background of sheer-size consumption and inelastic price response on agricultural food products. Sexton (2000a) identifies that a modest 0.2 increase in oligopolistic and oligopsonistic power (U.S food sector) would eventually reduce the total welfare by 31% at the benchmark against the competition. Implicitly, any small amount of departure between price and marginal cost matters since it risks generating severe supernormal profits and deadweight losses at multiple stages (Bresnahan, 1989). Thence, in the past decades, substantial studies are shifting their focus into the field of market power and market structure measurement, attempting to understand how the market functions and firms' behaviors.

The trend is in line with the stylized facts that characterize today's agricultural markets. Based on our observation and literature review, I namely outlets three attributes that capture the recent evolution of the food chain.

- ***Successive market power.*** A first and foremost is the occurrence of market power at the multi-stage level. McCorriston (2002) dedicates it as a "successive oligopoly", where firms, particularly in manufacturing, processing, and retailing sectors, are pursuing to set the

"effective marginal revenue" (Perloff, Karp, & Golan, 2007) equate to marginal cost (McCorriston, 2002; Rogers & Sexton, 1994; Sexton, Lavoie, Gardner, & Rausser, 2001). Much is presented and observed in the context of an emerging concentrated industry and vertical integration and control.

- ***Non-price competition strategies.*** Non-price strategies prevail in the competition strategy. 1) Product strategy involves product differentiation, promotion, product assortment, competitive package size, salience to consumers, product in length, etc. (Yonezawa & Richards, 2016) As we could infer from here, retailing sector should be more confidence to execute product strategies, since they deal with the consumers much continuously and directly, so that rich preference information of consumers floods through purchasing behaviors. This inference could be further strengthened by the raising consolidation and market power of supermarkets and stores (Bukeviciute, Dierx, & Ilzkovitz, 2009; Sexton & Xia, 2018). 2) Operating strategy includes advertising strategy, merger, and takeover, vertical integration, R&D investment. The extensive practice of the operating strategy is driven by the upgraded demands from the consumption side. Not too much literature is devoted to the effects of operating strategies on the competitiveness in the argi-food industry, due to the shortage of data.

- ***Market power in international trade.*** Market power is raising in international trade. Agricultural production and consumption are more relied on global trade than ever before, while farming resources and products are also allocated and consumed at a worldwide level.

The integration process speeds up at the beginning of the new century, because of FTA, WTO, as well as the multinational, agricultural companies. Now we could reasonably say this new trend changes the competition environment hugely. Domestic products are forced to compete with international imported products. Nonetheless, the impact on market power is still ambiguous. On the one hand, imported food, as alternatives of the domestic producers, are becoming a competitive player in the food chain. It would reduce the prices and compel the domestic firms to apply multiple operating and product strategies so that they could survive or maintain their advantaged position in the agri-food market. The pro-competition firm behaviors would probably increase the consumers' welfare in the end. However, this is just part of the story. In some case, such as soybean and dairy powder industry in China, we observe the exporters are powerful enough to overturn the domestic competitors or financially capable of carrying out a harsh price-war strategy. In the long term, the imported goods evolve towards the dominators and price makers of the markets (Karp & Perloff, 1989; Song, Marchant, Reed, & Xu, 2009). Even at the macroeconomic level, market power is widely existed and executed. For instance, Broda, Limão, & Weinstein (2008) use empirical evidence to prove that an importer who owns market power intend to set the tariff 9% higher for the inelastically supplied imports.

The critical transitions demand a more comprehensive policy analysis where market power and imperfect competition should be involved. However, most previous research assumes the agriculture market is perfectly competitive, even though the reality is somewhat against it (e.g.,

Russo, Goodhue, & Sexton, 2011). Clearly, in the modern food chain, the assumptions fail to stand of numerous suppliers and buyers, homogenous products, and symmetric information. But what is the consequence of incorporating an inappropriate economics model? In the presence of the market power, the welfare distribution between the buyers and sellers would be distorted, and the advantaged players could execute the market power to get more rents from the policy benefits (e.g., income-support subsidies). Moreover, industrial regulations can affect the entry and exit decision of the firms (Rude & Meilke, 2018). A food safety regulation, such as centralized slaughtering or wastewater treatment would increase a firm's fixed costs to update the facilities, squeezing out small-size enterprises, and resulting in a limited number of players in the market. In the perspective of price-transmission, the additional cost burden would not be absorbed by the oligopoly firms themselves but transferred to the upstream or downstream suppliers and consumers, depending on the oligopolistic or oligopsonistic power the firms own. As a result of this, an inappropriate, oversimplified market hypothesis would be cast in poor policy implementation.

1.2 Problem statement

With this dissertation, I especially focus on the interaction between the oligopoly/oligopsonistic market and the agricultural policies for two important intervention tools: centralized slaughtering policy (CSP) and dairy subsidies. Then, I extend the research to the competition between the domestic and international players.

The sample industries I pick up here are Chinese hog slaughtering industry and fluid milk industry. Both industries are of vital importance in Chinese agri-food chain and experience radical consolidation and development in the past decades. The changes could be reflected in two respects as follows.

■***Sheer-size production and consumption.*** Pork is the main variety of meat production in China, which is nearly up to half of the world pork market share (Gale, Marti, & Hu, 2012). According to the National Bureau of Statistics of China (NSBC), Chinese pork production grew from 38.84 to 54.52 million tons from 1998 to 2017 (See in Figure 1.1). It indicates each Chinese could be assigned for roughly half of a hog per se statistically. Furthermore, the pork production takes up around 60% of the total meat production, and it is still and would continue to be the most popular meat in China (Y. Chen & Yu, 2018b; X. Yu & Abler, 2014). Since the swine meat is essential and inelasticity food (D. Chen, Abler, Zhou, Yu, & Thompson, 2015) in China, price volatility could raise deeply concerned. In the recent year, price growth is mainly explained by the rising labor and feed cost, hog cycle, and food safety regulation (Gale et al., 2012; D. Zhou & Koemle, 2015). However, as we argue in the second chapter, the high price can be, at least, partly explained by the imperfect competition on the supply side.

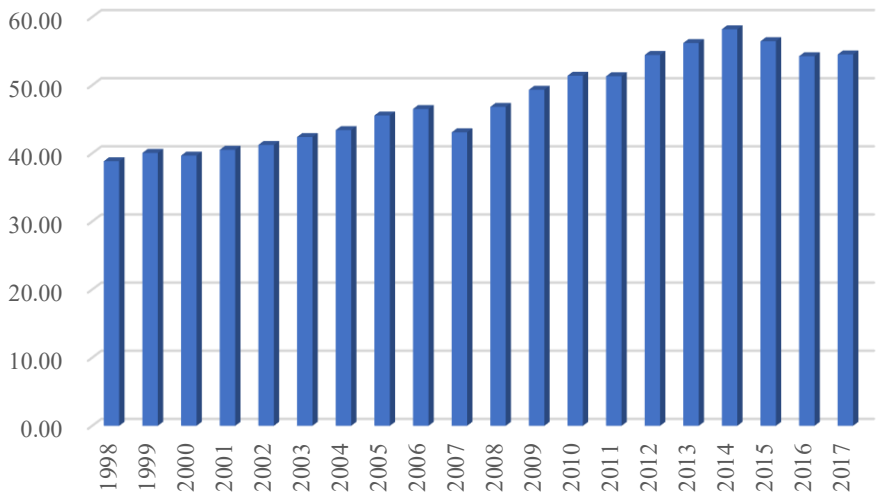

Figure 1. 1 China pork production, 1998-2017

Data Source: National Bureau of Statistics of China

Regarding milk production, China has the third largest milk yield on a worldwide scale. In the past decades, the milk sector experiences a continuous and fast expansion. The production jumped from 6.63 to 30.39 million ton in the past 20 years, with an average 9% annual growth rate. The trend is supported by gradual import growth from the international market. From January 2008 to December 2015, the imported dairy products increased from 36.12 to 190.95 thousand tons, with a peak of 247.57 in January 2014. In the perspective of the imported's market share, the percentage was only up to 8% in 2008. The number was then increasing and remained stable at around 36.4% in 2015. Since the relaxation of the One-child policy in 2015, we further expect the imported and domestic products should enjoy another round sustainable growth in the near short term.

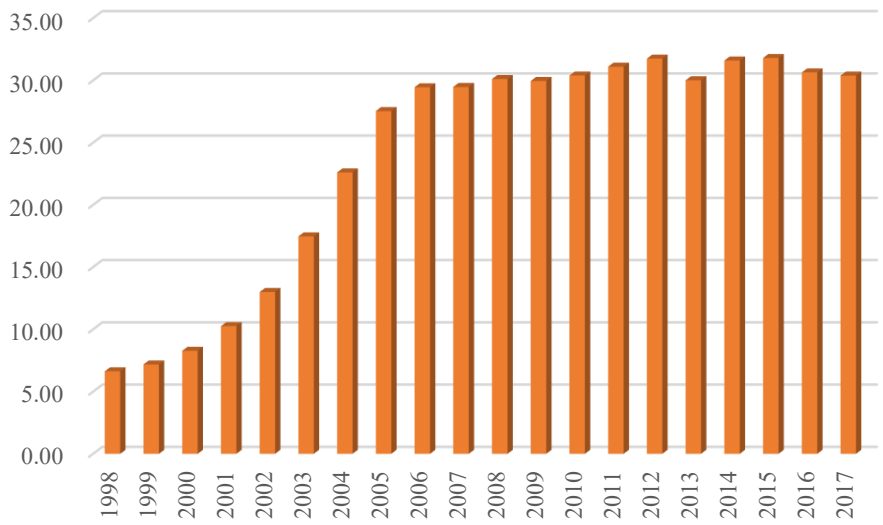

Figure 1. 2 China milk production, 1998-2017

Data Source: National Bureau of Statistics of China

As far as we concerned, the increasing and sheer-size output are driven by the emerging middle-class and a diverse diet structure. Efforts to promote varied and healthy intake pattern eventually motivate Chinese consumers to involve more high-protein foods on their tables (Ge, 2011). Consequently, meat and milk consumption in total food expenditure increase fast and steadily.

- ***Concentrated market structure***

As mentioned, the argi-food chain is evolving into a concentrated market with limited numbers of players. We focus on the hog slaughtering and fluid milk processing industries here in the dissertation.

(1) Hog slaughtering industry. In 2009, the Ministry of the Agriculture and Rural Affair (MARA) formulated Guidelines for National Hog Slaughtering Industry (GNHS) from

2010 to 2015. It sets up the ceiling of the slaughtering industry number in the local market. Principally, the number of "designated slaughtering plants" should no more than four in the provincials with more than 5 million inhabitants. Other provincials with fewer population should own less than two. For each county, the local market usually could only have one slaughtering plant (Ministry of Commerce, 2009). The Guideline strengthened the role of government in adjusting and controlling the number of firms in the slaughtering industry.

(2) Fluid milk industry. One nature of the dairy industry in China is fast consolidation. For instance, the top three players' (Yili, Mengniu, and Bright Dairy) outputs account for >60% market share in 2016 with 26.8% Yili, 27.4% Mengniu, and 7.6% Bright Dairy respectively on the fluid milk (DBC Group Research, 2017). After the 2008 melamine scandal, the Chinese government seeks this opportunity to improve the food safety regulation and support large-size firms. The number of large dairy firms has dropped from 815 to 638 from 2008 to 2015, while the top 20 firms' production and sales are more than half of the total industry with respect to dairy products (Ministry of Agriculture, 2016b).

We admit that a concentrated market is not always equivalent to an oligopolistic or oligopsonistic market. But the nature of the agri-food chain gives us a reason to suspect the imperfect competitiveness in our sampled industry. Of course, a consolidation might root in numbers of factors such as high entry and exit barriers, disease epidemics prevention, substantial sunk costs, or merger/vertical integration strategies. As the discussion above, we mainly consider

that policy interventions' role here in the dissertation. Thence, we narrow down our study about the industrial policy impacts on the agribusinesses of China.

1.3 Objectives and research questions

Before we dive into the research questions and hypothesis, I briefly introduce the industrial policies that are going to be dropped in the following chapter.

(1) Centralized Slaughtering Policy

The basic idea of CSP is to create a system that slaughtering is only allowed to be conducted in "licensed slaughtering plants." Individual butchers or farmers are only allowed to slaughter pigs for their consumption but forbidden to handle slaughtering for commercial purpose. Each region is permitted to issue a limited number of slaughtering licenses (Y. Chen & Yu, 2018c).

Food safety concern keeps perplexing Chinese livestock market, and slaughtering is the crux. Occasional food incidents make consumers becoming much warier of pork products such as the slaughter of sick hogs or discarded hog carcass near the waterway. Under strong appeals, the Chinese officials are promoting "ecological" and "civilized" slaughtering modes and drive the trend toward consolidation (Gale et al., 2012). CSP was born in the context.

Chapter two studies the impact of the central slaughtering policy on the Chinese pork industry with the New Empirical Industrial Organization (NEIO) method (Bresnahan, 1981, 1989, Muth &

Wohlgenant, 1999b, 1999a). One of its contributions is the estimation of the oligopsonistic power that mostly ignored by agricultural economists.

Hypothesis* I*: The centralized slaughtering policy increases the oligopsonistic power in Chinese hog slaughtering industry

(2) Dairy industrial subsidies

Chapter three mainly discusses the dairy subsidies impacts on competitiveness. The goal of dairy subsidies is to promote the industry to update facilities and relieve financial burdens. In terms of the purposes, we could classify the subsidies into four sub-categories: *Fixed asset support, Tax refund, Subsidized loan, and Direct public funding transfer*. Based on our research, we indeed find that the distribution of subsidies prefers large-size firms. For instance, the top five listed firms receive 1883.4 million Yuan in 2016, which is around 265.9 million Euro[1].

In the perspective of research methodology, even though the first paper is a relatively pioneering job to study Chinese agricultural products, the limitations should be as well addressed. And they soon become the start points of the second and third papers. Firstly, the NEIO approach applied here employ the aggregated data of the entire slaughtering industry. It results in a loss of individual firm-level information, and the firm's behavior could not be observed in our results. Second, the carcass pork meat in our research scope is homogeneous products, but now, the characteristic of Chinese agri-foods market is widely product differentiation. Therefore, in the second paper, we

[1]. Calculated by currency rate on date Jan.1st, 2016.

explore the market power and structure at the firm-level by studying the Chinese fluid milk processors, and we focus on the impact of industry subsidies on the competition degree. Differentiated products information is reflected in varying brand prices.

Hypothesis* II*: Subsidies improve firms oligopolistic market power and reduce the competitiveness of the dairy market

As discussed in Section 1.1, we conclude that market power is raising in international trade. We shift our research topic on the integration of the domestic and international market and aim to identify the market power of the imported products. The research objective we focus on is imported fluid milk products because of the data accessibility. In Jan. 2008, the milk from the international market only took accounts for 0.15% in total, but at the end of 2015, the ratio had reached 14.06%. It is evidential to say that the imported fluid milk act as a strong competitor in the Chinese dairy market. Chapter four is the sequel to the first research regarding the theoretical model and second research regarding the topic. We elaborate the study at the firm-level by using the firm supply elasticity and extend our analysis to the competition between the domestic dairy processors with the imported.

Hypothesis* III*: The imported fluid milk has strong oligopolistic market power in China dairy industry

The topics we study here are diverse, but the dissertation, taken together, aims to capture the underlying characteristics of the modern Chinese food chain. We review the industrial regulation

(e.g., CSP), support policy (e.g., subsidies) and trade environment's impacts on the market power of the food chain and estimate the markup profits of each firm or industry.

1.4 Summary of major findings

1.4.1 Centralized slaughtering policy on the Chinese pork industry

In Chapter two, we try to answer the question "Does the centralized slaughtering policy create oligopsonistic market power for the pork industry in China?" From January 2008 to December 2016, we observe the number of the slaughtering firms dropped largely, and Chinese government employed license regulations to strictly control the number and size of the slaughtering house in response to the food safety concern. The market structure is undoubtedly concentrated.

Using a structural model and the industry-level data, we detect sizable and significant market power (0.5% price margin) for the slaughtering industry in the pork supply chain. We further calculate the hog supply elasticity of price (0.0868) and estimate the supernormal profit of the slaughtering firms in the industry is 1.85 billion Yuan in 2016 single year and 13.65 billion Yuan in the total observation period. Since we are estimating the buyer power here (oligopsonistic power), the supernormal profits gained by the slaughtering processors are the loss from upstream suppliers. As we can see from here, what looks like a marginal, insignificant departure from the competition amounts to a considerable welfare loss on condition that the commodity is frequently consumed.

From our results, we believe the centralized slaughtering policy is part of the source for market power execution. Firstly, CSP sets up a high barrier for the new entry. Within the CSP policy context, slaughtering license turns into a scarce resource controlled by the existing firms. Newcomers are mostly blocked out of the business. Secondly, CSP gradually squeezes the small-size incumbents out of the competition, resulting in a more and more concentrated market. The goal of this paper is reminding the policymakers to pay more attention to the side-effect of industrial regulation on welfare loss and profit distribution among the food chain.

1.4.2 Industrial-supported subsidies on the Chinese fluid milk market

In Chapter three, we aim to study the impacts of subsidies on the competition degree of the fluid milk market in China. Driven by the 2008 melamine scandal, Chinese fluid milk is transformed into a concentrated industry. The Chinese government believes limited numbers of large-size dairy processors demand less regulation cost but better surveillance on food safety. Amongst multiple policy interventions, subsidies play as an important tool in consolidating the industry. We apply the panel data of the top eight listed firms for the period from 2010 to 2015 at the firm-level. The research objective is to see how the subsidies affect the market power in our case.

We find that the Chinese fluid milk industry has strong oligopolistic powers for each top eight firms. The sampled firms seized 60.31 billion RMB (8.81 Billion USD) extra money just in 2015, which took account of 18.11% of total industry sale revenue in the corresponding year. However, based on our estimation, government subsidies have a negative impact on the Lerner Index for the

top privately-owned firms, but no significant effect on state-controlled ones after controlling for advertising, time trend, and proprietorship.

The negative impacts could be attributed to that subsidies reduce the private firms' financial burdens. Therefore, they have more room to increase the output or suppress the price, which eventually reduces the market power and benefits dairy customers in the downstream. The impact is insignificant to the state-controlled firms probably because of their soft budget constraint. In the perspective of the policy implication, we argue that, even though subsidies promote a concentrated market structure of the dairy industry, it also motives the firms to expand production, reduce the price, and conduct a fiercer competition within the group. Executing the subsidies policy would be safe in the short term.

1.4.3 The market power with imported fluid milk products

In Chapter four, we construct a NEIO model to identify the imported fluid milk's market power in the Chinese market. Until 2015, the proportion of the imported to the total is 14%, reflecting the imported has become an important player in the dairy industry. Ignoring it would lead to an inconsistent estimation. Therefore, we combine the imported fluid milk data filed by China Customs with the domestic brand sales to calculate the Lerner index within one integrated market.

Our results indicate that imported milk has a significant market power and Lerner index. It might be rooted in the brand loyalty of the consumers on the quality- guaranteed imported products. However, compared with the domestic players, the markup profits generated are marginal. The result depends partially on the limited sales and inconvenient purchasing path. One such

implication arising from our findings is that the market power of the imported fluid milk indeed exists, even though the markup profits are limited-size. But along with the continued growth in the future, the Chinese government should not overlook the long-run effect. It should promote a more competitive industry environment for both domestic and imported competitors in the Chinese dairy market.

1.5 Links between topics

(1) In terms of the research methodology, Chapter two chooses to use the NEIO approach. The approach employs a structural model to estimate market power via a conduct parameter. The NEIO has become the mainstream technology in this field after the pioneering research by Appelbaum (1982). Extensive follow-up literature attempts to improve our understanding of market attributes on food, cattle, tobacco, meat industries, and so on. Since in the slaughtering industry, there are uncomfortable limits on the absence of nonspecialized input quantities. Chapter two adopts the method of Muth & Wohlgenant (Muth & Wohlgenant, 1999b) to estimate the market power of the hog slaughtering industry where varied proportion assumption and envelope theorem are imposed.

However, the estimation procedure is not perfect because of the difficulty of obtaining reliable measures of the elasticity. In Chapter two, we apply a conjectured elasticity (Y. Chen & Yu, 2018c), which is based on the simple supply regression model. The result could be problematic since the elasticity would be inconsistent without imposing homogeneity and symmetry restraints. Thence, in Chapter four, we improve the estimation of the elasticity by an AIDS model (Deaton &

Muellbauer, 1980; Green & Alston, 1991; Hyde & Perloff, 1998). It could be considered as an improvement of the NEIO method applied in the previous research.

Another issue in Chapter two is that it uses the industry-level data. It is possibly valid to employ aggregated data on measuring the market power for homogenous products. But in Chapter three and Chapter four, our research objective is fluid milk market. The previous methodology will overlook the heterogeneity amongst the brands if we keep using the industry level data. Therefore, we rely on the firm-level data to estimate the policy impacts on different brands and firms. Firm-level price information could reflect the characteristic of product differentiation in the fluid milk industry.

(2) In terms of the research scope, we investigate the market power in various market types. The second chapter concerns on homogeneous products where the consumers do not distinguish brands from each other very much. The third chapter is down to the firm level and applies the accounting data to catch the heterogeneity of the products. The fourth chapter extends our research in a more integrated market where both domestic and imported players compete.

(3) In terms of policy intervening, we divide the industrial policy into two categories: industrial regulations and industrial support policies. These two types of policy are generally perceived to have opposite impacts on firm activities and industry growth. To understand the interaction between the market power and the industrial policies, we need to narrow down our scope into specific policies. Thence, for the former one we pick up the centralized slaughtering policy as a representative, and for the latter one, we choose the subsidies instead.

1.6 Author contributions

The second chapter - Does the centralized slaughtering policy create market power for pork industry in China? - has published in *China Economic Review*, Volume 50 in August 2018. Prof. Yu is the corresponding author. I assisted Prof. Yu conceive of the presented idea and develop the theoretical formalism. I performed the analytic calculations and performed the numerical simulations. I also contributed to the interpretation of the results and took the lead in writing the manuscript in consultation with Prof. Yu. All authors provided critical feedback and helped shape the research, analysis and manuscript.

(1) Chen, Y., & Yu, X. (2018). Does the centralized slaughtering policy create market power for pork industry in China? *China Economic Review*, *50*, 59–71. https://doi.org/10.1016/j.chieco.2018.03.005

The third chapter - Do subsidies cause a less competitive milk market in China? - has published in *Agricultural Economics*, Volume 50, Issue 3 in May 2019. Prof. Yu is the corresponding author. I, together with Prof. Yu, designed the model and the computational framework. I am responsible to collect and process the data, perform the analysis, drafted the manuscript and designed the figures. Prof. Yu supervised the project. All authors discussed the results and commented on the manuscript.

(2) Chen, Y., & Yu, X. (2019). Do subsidies cause a less competitive milk market in China? Agricultural Economics (United Kingdom), 50, 303–314. https://doi.org/10.1111/agec.12485

The fourth chapter - Identifying the Chinese dairy market power with imported dairy products is a working paper at the present time. Prof. Yu is the corresponding author. I conceived of the presented idea, designed the model and the computational framework with the support from Prof. Yu. I wrote the manuscript with inputs from all authors. Prof. Yu contributed to the numerical simulations and were involved in planning and supervised the work.

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Chapter 2 Does the centralized slaughtering policy create market power for pork industry in China?

Abstract: In order to ensure safe meat supply and protect consumers' health, the government of China made a law in 1997 which started to enforce centralized slaughtering of hogs in licensed slaughtering houses. We use a structural model and the industrial level data to test the hypothesis whether the "centralized slaughtering policy" creates market power. The results detect sizable and significant market power (about 0.5% price margin) for the slaughtering industry in the pork supply chain, mainly due to high barriers of entry and stringent license regulations which reduce competition in the market. The total profit markup for the slaughtering industry reaches 1.85 billion yuan just in 2016. The welfare transfer and loss from market power should be taken into account for such a policymaking.

KEYWORDS: Pork industry, Centralized slaughtering policy. China, Market power

JEL: Q13, L66, L52

2.1 Introduction

> 60% of meat consumed in China is pork. It plays an important role in Chinese agricultural economy and people's daily dietary (X. Yu & Abler, 2014; Zhang et al., 2017). While total pork supply was only 39.7 million tons in 2002, the figure increased to 54.9 million tons in 2015. As the world largest population, China consumes or produces > 50% of world pork supply with very limited trade volume. Consumers in China are very sensitive to pork prices. Yu (2015) infers that the weights of pork in the CPI could be well above 6%. Supplying enough pork with affordable prices for consumers is one of the food policy priorities. However, many factors could cause pork price volatility in line with the famous "hog cycle," such as feed price, market speculation, animal diseases, etc. (D. Zhou & Koemle, 2015).

In tandem with the market-oriented economic reform after 1978, it is observed that food supply chains become longer, and the concentration ratio of agribusiness firms is higher. Market power in the supply chain could affect food price at different stages. The pork industry is no exception. Chen, Abler, Zhou, Yu, and Thompson (2015) use a meta-analysis and find that average income elasticity and own price elasticity for pork demand are 0.61 and −0.67, respectively. It implies that pork in China has already been a necessity. A small supply shock could lead to an over-proportional reaction on price. For instance, a 10% reduction in supply will cause a 15% increase in price. Small price elasticities are an intrinsic motivation for firms to seek for market power, which could help them to obtain excessive profits by controlling the supply. Traditional pig industry in China was characterized by small "backyard" farms, and it gives ways to large

commercial pig farms in recent years. However, the small-scale farms (< 500 pigs output per year) are still dominating the supply in China (X. Yu & Abler, 2014). Along with the structural change in pig production, the pig slaughtering industry, an important but largely neglected link in the pork supply chain, has experienced a structural transformation as well, transferring from dispersed and nonstandard butchers to designated centralized slaughtering plants in past two decades. Traditionally, slaughtering was operated by unlicensed butchers, or even small pig farm owners in villages. The quality and safety of meat under the traditional slaughtering system cannot be controlled so that it posed threats to public health. In response to the call for safer and better-quality meat supply, the central government of China started to promote "Centralized Slaughtering Policy (CSP)" at the end of 1997, by issuing the Decree of Pig Slaughtering Administration. The decree was subsequently amended in August of 2008, January of 2011, and February of 2016, with putting more stringent regulations and stricter penalties for violation.

The basic idea of CSP is to create a system that slaughtering is only allowed to be conducted in "licensed slaughtering plants." Individual butchers or farmers are only allowed to slaughter pigs for their own consumption but forbidden to handle slaughtering for commercial purpose. Each region is allowed to issue a limited number of slaughtering licenses. According to the statistics from the Ministry of Commerce in China, the total number of licensed slaughtering firms was 14,720, in which the number of designated large slaughtering firms was 4585 in 2012. From an economics perspective, the "Centralized Slaughtering Policy" artificially increases the entry cost of the slaughtering industry and creates market power, since the number of licenses is limited. The

government encourages small slaughterhouses to be progressively squeezed out of the industry. In a campaign in 2012, the governments reduced the licenses of small slaughtering firms from 14,019 to 10,135, reduced by 27.7%; and the licenses of designated large slaughtering firms from 5919 to 4585, reduced by 22.5%. According to the "Yearbook of Livestock Slaughtering Monitoring System" from the Ministry of Commerce, the proportion of the processing capacity for large-scale slaughtering plants increased from 68% to 78% between 2008 and 2012, and the top 50 firms in the slaughtering industry took up 14% of the total slaughtering amount in 2012 (Ministry of Commerce, 2013a, 2013b). A concentrated market structure is evidential. According to a statistical research of 222 cities whose population is above 500 thousand, nearly half of the cities' top five slaughtering firms have more than 60% sales of the local market, while one thirds of the cities occupy > 80% market share in sales for the top five. In the National Pig Production Development Plan (2016-2020) issued by Ministry of Agriculture and Rural Affair, the central government aims to increase the ratio of the above-the-scale[2] slaughtering firms up towards 75% in 2020. It is plausible that the CSP outlines a regional oligopsonistic market in each local area. In such a market structure, it is interesting to know if the slaughtering firms exert their market power and reap some additional profits from pig farms or upstream of the pork supply chain.

Although pig market in China has been widely studied in different dimensions, such as price transmission, statistical accuracy, and international trade (X. Yu, 2015; D. Zhou & Koemle, 2015),

[2]. Above-the-scale slaughtering firms: The actual annual slaughtering of pigs with more than 20,000 pigs.

little attention has been paid to examine the possible market power of the pig slaughtering industry particularly after the CSP took effect. In order to fill in the literature gap, we use the new empirical industrial organization, specifically the Muth & Wohlgenant Model (1999a, 1999b), to empirically estimate the market power of slaughtering industry in China. Our results find significant evidence to support the hypothesis that the "Centralized Slaughtering Policy" has developed some market power in the pig industry.

2.2 Theoretical model

The market power lies at the heart of the industrial organization. Aguirregabiria (2012) defines it as the ability of a firm, or group of firms to get markup profit above competitive market price. There are basically three categories of methods in measuring market power – Solow Residual Based Model (SRB), Nonparametric Model, and New Empirical Industrial Organization Model (NEIO). The first approach was initially applied by Hall (1988) to test the excessive profit in 26 industries. Since then, a number of models under alternative assumptions have been developed and conducted (Domowitz, Hubbard, & Petersen, 1986; Norrbin, 1993; Raper, Love, & Shumway, 2007; Roeger, 1995). In 2007, Raper, Love, and Shumway (2007) further came up with an improved Primal-Dual approach based on the SRB model with aggregated data at the industry level, shedding light upon profit allocation between the upstream and downstream process. This method, as a milestone, extended the SRB model from oligopolistic to oligopsonistic market. Since the SRB model does not require a particular function specification or the demand and supply

relationships in the opposing market, it has been widely used to examine the industries of agriculture products in China. Dai and Wang (2014) employed the improved Primal-Dual model and discovered China dairy process industry is both strong oligopolistic and oligopsonistic. Guo, Wang, & Chen (2016) re-conducted the research with a sample of 511 firms. By controlling the price heterogeneity, the authors asserted that the dairy industry is competitive in total, though large firms own strong bargaining power. As the SRB is based on an assumption of Hicks-neutral technical progress, the hypothesis is too strong for China slaughtering industry. When the scale of a slaughtering firm increases, technological progress is more likely to bias towards labor saving (Harrod Technological progress). Hence the residual in SRB could be a mixture of an index of market power exertion and an index of technical change, which is a potential risk leading to a biased estimation result. Another alternative is the nonparametric test. To our best knowledge, the initial research was conducted by Ashenfelter and Sullivan (1987). Instead of the requirements of *ad hoc* specifications of functional form and a populous data sample, the nonparametric approach is more flexible to estimate the market power based on revealed preference arguments (Noelke & Raper, 1998). The prototype model is continuously revised by followers like Love and Shumway (1994), Raper, Love, & Shumway (2007) by relaxing the assumption of a stable cost function and demand curve in opposing market. However, the nonparametric test follows the basic principle of SRB model where it uses the residual as a measurement of excessive profit growth. The interpretation of unobserved error suffers the similar issue as SRB model. Additionally, Noelke and Raper (1998) compared the NEIO and nonparametric test by the Monte Carlo experiments

proposed by Raper, Love, & Shumway (2000)[3], and showed both approaches perform equally well to distinguish the market power. Therefore, we resort to the NEIO approach, even though the nonparametric is relatively flexible.

Other non-mainstream approaches are concentrated in the field of differentiated products. Hastings (2004) used mergers as quasi-experiments to estimate the price effects in spatial differentiation market. Allen, Clark, & Houde (2014) developed and estimated a search and bargaining model designed to measure the welfare loss associated with frictions in oligopoly markets. To be noted, the attribute of the hog slaughtering industry is relatively different from a differentiated-products industry. We could not apply these nonmainstream approaches into our context.

Since distinguishing the market power from a technical change in residual is extremely difficult, if not impossible, we, therefore, choose the NEIO method instead. The approach employs a structural model to estimate market power via a conduct parameter. The NEIO has become the mainstream technology in this field after the pioneering research by Appelbaum (1982). Extensive follow up literature attempts to improve our understanding of market attributes on food, cattle, tobacco, meat industries and so on (Bhuyan & Lopez, 1997, 1998; Bouras, Frank, & Burgess, 2017; Bresnahan, 1982, 1989; Kadiyali, Sudhir, & Rao, 2001; Koontz, Garcia, & Hudson, 1993; Lau,

[3]. The paper was published in 2000. Noelke and Raper (1998) used the methodology based on the primary working paper in 1997. *Raper, K. C., H. A. Love, and C. R. Shumway. "Determining Market Power Exertion Between Buyers and Sellers" Department of Agricultural Economics, Texas A&M University, Working Paper (July 1997).*

1982; Murray, 1995; Roy, Kim, & Raju, 2006; Roy & Raju, 2011; Schroeter, 1988; Shankar & Bayus, 2003). Even though the NEIO model has been widely applied in varied areas, traditional NEIO models were commonly undertaken with the fixed proportion technology (Goodwin & Brester, 1995; Wohlgenant, 1989).

The assumption characterizes the industries that are inertia to substitute input factors, which is apparently not coordinated with the hog slaughtering industry. Another challenge is the data requirement of input quantities. Whereas Murray (1995) improves the model to be compatible with varied proportion assumption, his model could not be conducted without input quantities involved. But again, the data is not available for our objective industry. The data availability for slaughtering industries is very limited in China. The uncomfortable limits are later further relaxed by Muth and Wohlgenant (1999b) with the application of the envelope theorem, who estimate the market power of US beef packing industry in the absence of nonspecialized input quantities. This paper adopts the method of Muth & Wohlgenant (Muth & Wohlgenant, 1999b) to estimate the market power of the hog slaughtering industry, which is created by the policy.

2.2.1. Profit function and market power measure

Assuming that a hog slaughter plant i in some region maximizes its profit with the following profit function:

$$\pi_i = pf(x_{1i}, \mathbf{x_i}) - w_1 x_{1i} - \boldsymbol{w}'\mathbf{x_i} \quad (1)$$

where p is the market price of carcass meat, w_1 is the price of the hog, and x_{1i} is the hog slaughtering quantity for ith slaughtering plant respectively. In this case, x_i represents other input quantities except for hog such as labor, water, etc. And $\boldsymbol{w}$ is a scalar of price variables. Since we hypothesize the existence of licenses for slaughter plants may create some market power, w_1 is considered as a possible endogenous variable influenced by the aggregated hog slaughtering quantity at the industry level (x_1). Therefore, we now substitute w_1 by a function of the input quantity x_1 and $\mathbf{z}$, which is also the inverse factor demand function of hog.

$$w_1 = g(x_1, \mathbf{z})$$

(2)

Where $x_1 = \sum_{i=1}^{n} x_{1i}$, the aggregated n slaughtering plants' hog demand in the industry. $\mathbf{z}$ denotes other exogenous variables that could impact hog price.

The first-order condition for profit maximization of slaughter plant i, shows

$$\frac{\partial \pi_i}{\partial x_{1i}} = p \cdot \frac{\partial f(x_{1i}, \mathbf{x_i})}{\partial x_{1i}} - \frac{\partial g(x_1, \mathbf{z})}{\partial x_1} \cdot \frac{\partial x_1}{\partial x_{1i}} \cdot x_{1i} - w_1 = 0$$

(3)

Rearranging Eq. (3) yields

$$p \cdot \frac{\partial f(x_{1i}, \boldsymbol{x_i})}{\partial x_{1i}} = \frac{\partial g(x_1, \mathbf{z})}{\partial x_1} \cdot \frac{\partial x_1}{\partial x_{1i}} \cdot x_{1i} + w_1$$

(4)

Eq. (4) indicates that the value of marginal product in the left equals the marginal factor cost in the right. Linking the marginal input factor from individual firm level to the industry level by averaging all n slaughter plants' marginal revenue, we can obtain

$$\frac{p}{n} \cdot \sum_{i=1}^{n} \frac{\partial f(x_{1i}, \boldsymbol{x_i})}{\partial x_{1i}} = \frac{\partial g(x_1, \mathbf{z})}{\partial x_1} \cdot \frac{1}{n} \cdot \sum_{i=1}^{n} \frac{\partial x_1}{\partial x_{1i}} \cdot \frac{x_{1i}}{x_1} \cdot x_1 + w_1$$

(5)

By plugging x_1, we construct the demand elasticity δ of input x_1.

$$\delta = \frac{1}{n} \cdot \sum_{i=1}^{n} \frac{\partial x_1}{\partial x_{1i}} \cdot \frac{x_{1i}}{x_1}$$

(6)

If one slaughtering plant owns oligopsonistic power in the industry, it could make a difference to the entire hog market demand. Apparently, δ could be interpreted as a measurement of market power. If δ is 0, the slaughtering capacity of each firm is negligible to the whole market. Thus, the industry is a perfectly competitive market. If δ is equal to 1, it means only one firm in the industry whose slaughtering capacity change is as much as the entire industry change. In an oligopsonistic industry, the range of δ is from zero to one. Here, we further explain why the partial output $\frac{\partial x_1}{\partial x_{1i}}$ is not equal to 1. NEIO approach assumes each firm believes that its choice of quantity will affect the quantity selected by its rivals and that the rivals' reaction can be captured by the constructed parameter (Iwata, 1974). Thence, the output of one slaughter might not be

inertia to other competitors, leading to a mixing, uncertain impact on the whole industry. That is the reason we should not assert $\frac{\partial \mathbf{x_1}}{\partial x_{1i}} = 1$.

Furthermore, if we assume that the mean value of marginal product of all slaughtering plants is equivalent to the aggregated value of marginal product at the industry level.

$$\frac{1}{n} \cdot \sum_{i=1}^{n} \frac{\partial f(x_{1i}, \mathbf{x_i})}{\partial x_{1i}} = \frac{\partial f(x_1, \mathbf{x})}{\partial x_1}$$

(7)

Then rearranging Eq. (5) yields our objective equation,

$$p \cdot \frac{\partial f(x_1, \mathbf{x})}{\partial x_1} = \delta \cdot \frac{\partial g(x_1, \mathbf{z})}{\partial x_1} x_1 + w_1$$

(8)

Eq. (8) could be easily estimated by industry-level data, rather than the individual firm's data, which is often not available for researchers. In the next part, we are going to discuss how to estimate δ with joint input supply and demand equations in the slaughtering industry.

2.2.2. Oligopsony Lerner index

In the form of oligopsonistic slaughtering industry, market power is a derivation where input price is less than the value of marginal product (VMP). We would use the Oligopsony Lerner Index (σ) to measure it.

$$\sigma = \frac{VMP_1 - w_1}{w_1}$$

(9)

where VMP_1 is the value of marginal product of hog input. In this context, $VMP_1 = \frac{\partial f(x_1,\mathbf{x})}{\partial x_1}$. σ measures a possible price margin generated through market power. When the output price (Carcass meat price) is given, market power implies that the VMP_1 of the hog is significantly higher than the hog purchase price ($\sigma > 0$), while $\sigma = 0$ indicates perfectly competitive behaviors (Raper et al., 2007).

Substituting equation (8) into (9), we could transform the Lerner index into

$$\sigma = \frac{VMP_1 - w1}{w1} = \frac{P \cdot \frac{\partial f(x_1,\mathbf{x})}{\partial x_1} - w_1}{w1} = \frac{\delta \cdot \frac{w_1}{\partial x_1} x_1}{w1} = \frac{\partial w_1}{\partial x_1} \cdot \frac{x_1}{w1} \cdot \delta$$

(10)

Defining the hog supply elasticity of price e_1

$$e_1 = \frac{\partial w_1}{\partial x_1} \cdot \frac{x_1}{w1}$$

(11)

Then the market power could be arranged as follows,

$$\sigma = \delta \cdot e_1$$

(12)

From Eq. (12), we could decompose the oligopsony Lerner index into two parts: a market power indicator δ and a hog supply elasticity of price e_1. Since hog is a normal good, the supply

elasticity of hog input is positive. Therefore, there is a positive relationship hold between δ and Lerner index σ in which if the market power δ is approaching zero, the markup profit from the oligopsony market will be close to zero as well. If δ is close to one, the markup value for slaughtering plants would accordingly increase by the supply elasticity.

In the next part, we are going to discuss how to estimate δ with joint input supply and demand equations in the slaughtering industry.

2.3 Empirical structure model

This section specifically uses the data from China's pork industry and estimates δ that measures the market power for the hog slaughtering industry. Apparently, the joint estimation of Eq. (2) and (8) could give us the value of δ in an imperfect market.

2.3.1 Profit function

First, we define the production function $f(x_1, \mathbf{x})$ of the slaughtering plants and obtain the marginal product $\frac{\partial f(x_1,\mathbf{x})}{\partial x_1}$. Normally, the data on inputs quantities are required since they are parts of marginal products. However, the information is not available in the hog slaughtering industry in China. We now take a detour by applying the Bresnahan (1982) and Muth & Wohlgenant Model (1999a, 1999b). They solved this problem with the envelope theorem by redefining the profit equation. Besides hogs, other major input factors for slaughtering plants are labor (x_2), water (x_3),

land (x_4), and energy & transportation (x_5) in the production process.[4] We now assume the quantities of the above nonspecialized inputs depend on the core input—hog slaughtering quantity. Therefore, the profit function (1) can be rewritten as follows,

$$\pi = p \cdot f(x_1, x_2^*, x_3^*, x_4^*, x_5^*,) - g(x_1, \mathbf{z})x_1 - w_2 x_2^* - w_3 x_3^* - w_4 x_4^* - w_5 x_5^*$$

(13)

Where $x_2^*, x_3^*, x_4^*,$ and x_5^* are the optimal quantities of the inputs on condition of the level of x_1. $\boldsymbol{w_i}$ is the price vector. This relationship makes sense in the slaughtering industry. The usage of labor, water, land, and the cost of transportation are not self-determined. Instead, the hog slaughtering quantity strongly affects them. We hence could specify $x_2^*, x_3^*, x_4^*,$ and x_5^* as functions of x_1 and other input prices. For instance, $x_2^* = x_2(x_1, w_2, w_{3,} w_4, w_5)$.

We now take the first-order derivation of profit function (13) with respect to x_1 and obtain

$$\frac{\partial \pi}{\partial x_1} = p.\frac{\partial f(\cdot)}{\partial x_1} + p.\frac{\partial f(\cdot)}{\partial x_2^*}\frac{\partial x_2^*}{\partial x_1} + p.\frac{\partial f(\cdot)}{\partial x_3^*}\frac{\partial x_3^*}{\partial x_1} + p.\frac{\partial f(\cdot)}{\partial x_4^*}\frac{\partial x_4^*}{\partial x_1} + p.\frac{\partial f(\cdot)}{\partial x_5^*}\frac{\partial x_5^*}{\partial x_1} - \delta \cdot \frac{\partial g(x_1, \mathbf{z})}{\partial x_1}x_1 - w_1 - w_2\frac{\partial x_2^*}{\partial x_1} - w_3\frac{\partial x_3^*}{\partial x_1} - w_4\frac{\partial x_4^*}{\partial x_1} - w_5\frac{\partial x_5^*}{\partial x_1} = 0$$

(14)

Since we assume that these nonspecialized inputs are obtained in a perfect market, the maximum condition (14) could be simplified as

[4]. In the designated slaughtering plants, the investment of facilities is normally considered as "sunk cost" (or a fixed cost) Therefore, during the operation, the slaughtering plant managers would not include the capital factor in their decision of hog demand and carcass meat output. In other words, this will not affect the profit maximization condition.

$$p.\frac{\partial f(\cdot)}{\partial x_1} - \delta \cdot \frac{\partial g(x_1, \mathbf{z})}{\partial x_1} x_1 = w_1$$

(15)

2.3.2 Factor demand function

To empirically estimate equation (15) and get market power parameter, we need to identify δ with a reduced-form value marginal product specification. Similar to the model of Muth & Wohlgenant (1999a), we also apply a linear specification for the term $p.\frac{\partial f(\cdot)}{\partial x_1}$, so that

$$w_1 = -\delta \cdot \frac{\partial g(x_1, \mathbf{z})}{\partial x_1} x_1 + \alpha_1 x_1 + \alpha_2 w_2 + \alpha_3 w_3 + \alpha_4 w_4 + \alpha_5 w_5 + \alpha_6 p$$

(16)

Function (16) can also be regarded as the inverse factor demand function. The slaughtering demand quantity of hog (x_1) depends on hog price (w_1), output carcass meat price (p), and other input factor prices $\boldsymbol{w_i}$.

2.2.3 Input supply function

Second, we have to specify the input supply equation of x_1 in Eq. (2) to complete our estimation. Based on *2015 the National Cost and Profit of Agri-products Materials Compilation*[5], three major components of the hog production cost are: piglets (20%), feed (50%), and wage (27%). Specifically, we construct the input supply equation as a function of piglet price (g_1), concentrated feed price (g_2), and per capita GDP (g_3) that could proxy both wage level and consumption

[5]. Sources: National Development and Reform Committee.

capacity. To gauge the impact of "designated slaughtering plants" policy, we add policy dummy τ to measure the policy treatment. In August 2008, China central government amended the "*the Decree of Pig Slaughtering Administration*", which puts more compelling, rigorous rules and stricter penalties for violation. τ is a dummy variable to estimate the minor adjustment of CSP. To satisfy the requirement of homogenous function, we normalize the input supply function through dividing w_1 and g_1~g_3 by the feed corn price (C). That is,

$$\frac{x_1}{I} = \beta_0 + \beta_1 \frac{w_1}{C} + \beta_2 \frac{w_1}{C} T + \beta_3 T + \beta_4 \frac{g_1}{C} + \beta_5 \frac{g_2}{C} + \beta_6 \ln\left(\frac{g_3}{C}\right) + \beta_7 \tau$$

(17)

where I represents the beginning-of-year inventories of hog, and $\frac{x_1}{I}$ is the slaughtering-inventory ratio. T is time trend to capture the omitted factors that might cause quantity changes of hog slaughtering. We use the implicit function to get the first derivative.

$$\frac{\partial g(x_1, \mathbf{z})}{\partial x_1} = \frac{C}{I}\left(\frac{1}{[\beta_1 + \beta_2 T]}\right)$$

(18)

All parameters could be obtained from OLS estimation of the input supply function Eq. (17), and Eq. (18) allows us to generate the marginal effect of slaughtering quantity on hog price. Then we substitute $\frac{\partial g(x_1, \mathbf{z})}{\partial x_1}$ into the maximum profit condition of Eq. (16), yielding our final estimation function of market degree δ.

$$w_1 = -\delta \cdot \frac{C}{I}\left(\frac{1}{M}\right) x_1 + \alpha_1 x_1 + \alpha_2 w_2 + \alpha_3 w_3 + \alpha_4 w_4 + \alpha_5 w_5 + \alpha_6 p$$

(19)

Where $M = \beta_1 + \beta_2 T$.

Furthermore, as the market power could change over time, for instance, due to an expansion of policy enforcement, we could assume that δ could be a function of time T, such that $\delta = \delta_0 + \delta_1 T$, and then the inverse demand equation is constructed as follows,

$$w_1 = -(\delta_0 + \delta_1 T) \cdot \frac{C}{I}\left(\frac{1}{M}\right) x_1 + \alpha_1 x_1 + \alpha_2 w_2 + \alpha_3 w_3 + \alpha_4 w_4 + \alpha_5 w_5 + \alpha_6 p$$

(20)

In order to improve the estimation efficiency, we jointly estimate the input supply function Eq. (17) and the factor demand function Eq. (16). In an oligopsonistic market, the slaughtering plant might own the ability to influence hog price w_1 by adjusting its own demand quantity x_1. In particular, the centralized slaughtering policy could help firms create such a power in local markets. If this hypothesis is true, the welfare loss due to market power should be taken into account by policy analysis.

In addition, we also use the generalized Leontief conditional method (GLCM) to get a robust estimation result. Comparing the reduced-form linear specification, the GLCM assumes the marginal rate of substitution is much lower. It is relatively difficult for slaughters to substitute one input factors with another. In the specification of $\frac{\partial f(x_1,\mathbf{x})}{\partial x_1}$, we replace the independent variables by their square roots.

$$\frac{\partial f(x_1, \mathbf{x})}{\partial x_1} = \rho_1 x_1^{1/2} + \rho_2 w_2^{1/2} + \rho_3 w_3^{1/2} + \rho_4 w_4^{1/2} + \rho_5 w_5^{1/2} + \rho_6 p^{1/2}$$

(21)

Substituting (21) into (15), we could obtain our objective function for the GLCM,

$$\frac{w_1}{p} = -\delta^L \cdot \frac{\partial g(x_1, \mathbf{z})}{\partial x_1} \frac{x_1}{p} + \rho_1 x_1^{\frac{1}{2}} + \rho_2 w_2^{\frac{1}{2}} + \rho_3 w_3^{\frac{1}{2}} + \rho_4 w_4^{\frac{1}{2}} + \rho_5 w_5^{\frac{1}{2}} + \rho_6 p^{\frac{1}{2}}$$

(22)

Where δ^L is the measurement of market power by GLCM estimation. We could simulate δ^L with time trend as well, then the specification of δ^L is $\delta^L = \delta_0^L + \delta_1^L T$.

2.4 Identification

To get a consistent estimator δ in an econometric model, we need to deal with the endogeneity problem in our simultaneous equations. The key identification problem in our case is that the carcass meat price is an endogenous regressor in the demand equation. It is plausible to infer that carcass price p is correlated with the unobserved market errors, or endogenously determined when there is market power in the slaughtering industry. In order to solve this problem, we carefully choose wholesale beef price, wholesale chicken price, and the ratio of M2 to average monthly GDP as instrumental variables. Firstly, as substitutive goods, wholesale prices of beef and chicken have an obvious correlation with that of hog carcass meat. However, since the hog is the most important and popular meat source in China, it plays a special role in Chinese food

structure. It is very unlikely that beef or chicken's price could have a direct impact on farmers' hog pricing and output decision. The change of hog price mainly depends on its own production cost and market demand, instead of the substituted meat. On the other side, wholesale beef and chicken prices are the downstream products of carcass meat, thereby, the price change would be independent to hog price in the upstream. Secondly, the ratio of M2 to average monthly GDP is a good indicator of price change as the monetary supply could impact meat price in the long run in China (X. Yu, 2014). Increasing ratio often results in an increasing carcass meat price, but both carcass meat price and hog price would have a negligible impact on the currency policy at the macro level. Furthermore, the endogeneity could be tested by a Hausman Test.

2.5 Data

The paper uses monthly data series of the hog slaughtering industry for the period from January 2008 to December 2016. The slaughtering quantity of "designated slaughtering plants" for hogs is obtained from the periodic reports from the China Ministry of Agriculture (MOA). Since 2008, China government establishes the full-fledged regulatory system, compelling all the designated slaughtering plants to report their slaughtering quantity. With the development of information technologies and improved public consciousness of food safety, hog product traceability systems have been developed and applied in China (Qian et al., 2017). Data sharing amongst different stages of the supply chain has led to an increase in credibility and analysis capacity. Supervision agencies could double check the hog slaughtering quantity by monitoring slaughtering plants and

downstream distributors and retailers simultaneously. This would sharply lower the motivation of slaughters to manipulate hog quantity reports. For the input supply equation, the hog price, piglets' price, corn price, and feed price are compiled from a well-known China data company on China agriculture industry - Bric Group. The prices of hog, piglets, and corn are daily time series, and the feed price is weekly data. We average the data according to the monthly hog slaughtering quantity. GDP per capita is subtle since we could only get the annual information from the National Statistics Bureau of China (NSBC). The annual data fails to provide much variation to our estimation. We collect the quarterly GDP data from NSBC and divide it by the annual population from *China Population and Employment Statistics Yearbook*. Price index and GDP are deflated by the CPI from the National Statistics Bureau.

The data used to estimate the demand function is from NSBC and multiple financial data companies. The price of carcass pork meat and the prices of wholesale beef and chicken are taken from Bric Group. Figure 2. 1 shows the trend of hog prices and carcass meat prices. They have a similar trend.

Monthly M2 data is from the website of China Finance Corporation. The NSBC only quarterly reports the labor wage. We average the labor wage to fit the monthly requirement. The diesel price, water price, and industrial land price are from Wind database — one of the biggest financial database service companies in China. Unfortunately, there is no national-level price for water. We use the average water price of two China cities-Beijing and Shanghai instead. The diesel price

could be an approximate indicator for the energy & transportation cost. All the price information in the demand function is deflated by the CPI from the National Statistics Bureau.

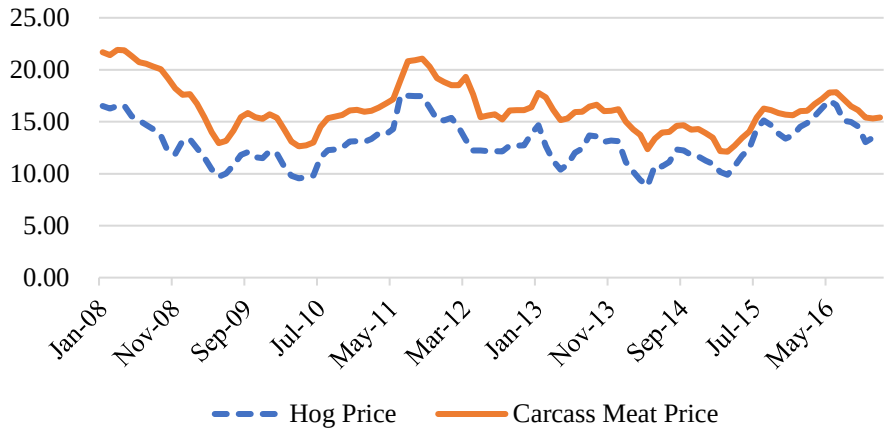

Figure 2. 1 Price change in hog and carcass meat from 2008 to 2016 (Deflated by Jan. 2008 CPI)

Since the dataset we employed here is stochastic process describing the evolution of the hog industry for the months from Jan. 2008 through the end of 2016, we should apply a unit root test for the concern of the nonstationary risk. Otherwise, the presence of spurious regression or random walk could weaken the estimation results. The augment Dickey-Fuller test indicates that our key variables - hog price and carcass meat prices - reject the null hypothesis that the variables carry out a unit root at 5% and 1%. The result is in line with our visual observations in Figure 2.1. No obvious trends are observed in our research period.

2.6 Results

We use the simultaneous equations model to estimate the input supply function and inverse factor demand function jointly. The estimation results are reported in Table A.1 for the linear

specification and Table A.2 for the generalized Leontief conditional method of the production function. The results for the two specifications are consistent. It indicates that our results are robust and reliable.

2.6.1 Market power indicator

First of all, the results identify that oligopsonistic power indicator δ is 0.059 in Table A.1 and 0.003 in Table A.2 respectively. Both values are significant from zero. For the time variation specification of market power, we add time trend to simulate the variation of δ over time, but the variable is neither significant in both case and the value is close to zero, which implies the market power is relatively stable in our observed period. We also reject the null hypothesis of no market power for the hog slaughtering industry in China, similar are the results of the generalized Leontief conditional method. That is, the statistical result shows each single slaughtering plant could influence the aggregated hog demand in the industry. The result evidentially supports the concern that "Centralized Slaughtering Policy" could create market power for pork industry.

A few reasons lead to such a significant result. First, the CSP policy intrigues high barriers of entry, and potential entrants would be difficult to attain the slaughtering license. Due to the scarcity of the license, the degree of competition in one regional market could decrease considerably. Second, since the CSP is executed along with the small-size slaughtering houses exit, surviving firms are normally large plants with high sunk cost. The concentration ratio is high at the local market. For instance, the proportion of the processing capacity for large-scale slaughtering plants

increased from 68% to 78% between 2008 and 2012 (Ministry of Commerce, 2013a, 2013b). Consequently, the incumbents would incline to exert their market power and improve their payoffs from pig farms.

2.6.2 IV regression test

Next, we investigate the extent of the endogeneity problem arising from carcass meat price and examine whether the instrumental variable is able to address the issue adequately. As shown in Table A.3 and Table A.4, the estimates obtained with moment restrictions are not evidently different from those without them. The Hausman tests indicate no significant systematic difference between the OLS model and IV regression, suggesting that no endogeneity bias in our case.

In summary, the instrumental variables (beef price, chicken price, and the ratio of M2 to average GDP) safely pass the test, and we accept the null hypothesis that carcass meat price is exogenous for the input demand function, and the slaughtering plants, as a price taker, could not significantly affect the carcass meat price.

2.6.3 Markup value estimation

According to the Eq. (12), the oligopsony market power depends on two factors: a hog supply elasticity of price e_1 and the market power indicator δ. To give a clearer description of the impact, we run a factor supply function and roughly estimate the elasticity is 0.0868. It is close to the estimate of Zhang and Abbott (2007), which is 0.128.

As we could see from Table A.5, the Lerner index in the linear model is 0.52%. That means, in the presence of an oligopsonistic market, the slaughters can generate 0.52% extra price margin from market power. Though this seems a small number, the welfare impact would be very large given the huge market value of pork industry in China.

Now we use the example of 2016, China slaughtered 208.7 million heads in 2016, and the averaged weight of an adult hog is 100 kg around (technical factors). For each kilo hog, the slaughter could generate approximately 0.52% markup value because of the market power created by the CSP. The estimated size could be huge in the context of the massive hog slaughtering quantity in China. Table A.6 reflects that the nominal markup profit would be 1.85 billion yuan (1.52 billion yuan deflated) in 2016 only on the oligopsonistic market side. As we could see, what looks like a relatively insignificant departure from competition amounts to a considerable welfare loss when the product in question is a frequently purchased, staple item (Sexton, 2000b). It is surely an industry needed to be attention seriously.

2.6.4 Other covariates estimation

We now discuss our estimation results separately. In the input supply function, we find four significant parameters whose signs are also consistent with our expectations. As expected, slaughtering quantity has a negative relationship with the price of piglets and concentrated feed (at the 0.1% level), but positive with GDP per capita (at the 5% level). The rising nonspecialized cost of hog production will curb the demand for the slaughtering plants in the downstream. With respect

to GDP per capita, we have already known it is a composite proxy that reflects both wage level and pork consumption capacity. The direction of GDP per capita depends on two counter effects. On the one hand, wage increase puts a restraint on slaughtering quantity demand. On the other hand, growing consumption capacity promotes more pork consumption. It seems that the latter effect is dominant in our case. Moreover, while the hog price is not significant in our model, it still deserves a further discussion. The positive relationship between slaughtering quantity and hog price is valid because slaughtering plants in the imperfect market have a higher tolerance on the change of specialized input price. They could maintain their profits by adjusting both input and output simultaneously. On the part of demand equation, the carcass meat price has a positive impact on hog price in both constant and time varied δ cases, as the parameters are 0.894 and statistically significant at 0.01% for all three models. It implies that there is a good price transmission between hog and carcass meat prices. The slaughtering plants could vertically transfer the cost growth downwards to downstream firms. It is consistent with the above-mentioned results that the market power for slaughtering industry exists.

In our first linear demand model, we assume the input factors would be substituted easily. As we could see, when the nonspecialized input prices go up, the impact depends on the comparison between substitution and expansion effects. The increase of one input factor will cause slaughters to substitute that factor with other inputs, leading to more substantial hog demand for slaughtering. Another effect is because the rising price enhances cost and forces slaughters to reduce their production, eventually lowering the hog demand and price. Two different effects both exist in the

slaughtering industry. If the substitution effect plays a more influential role, the parameter is positive as the case of water (α_3), and industrial land (α_4) If the latter one is dominant, then the parameter is negative as the case of labor (α_2), diesel (α_5). However, from Table A.1 and Table A.2, we only find the significant parameter of water price in our estimation with the assumption of imperfect market, but most parameters are significant under the assumption of perfect market.

It is possible that the linear specification could be too strict. We then apply the Generalized Leontief Conditional Method (GLCM) to test whether the estimation results are sensitive to the functional forms of $\frac{\partial f(x_1,\mathbf{x})}{\partial x_1}$. Table A.2 reveals the estimation results are essentially the same.

2.7 Conclusion

Small scale farms characterized the hog industry in China. In order to ensure safe meat supply and protect consumers' health, China's government made a law in 1997, which started to require centralized slaughtering of hogs in licensed slaughtering houses. The law has been amended a few times later to make it more stringent. It is possible that such a policy could create market power for slaughtering industries in China. If so, the welfare loss from market power should be taken into account.

We employ a structural economic model and the data of the hog slaughtering industry of China between 2008 and 2016 to empirically study the impact of the centralized slaughtering policy on market power. The empirical results show that the market power indicator δ is 0.0593 and statistically significant, which generates 1.85 billion yuan markup value just in 2016 and 13.65

billion yuan in our eight-year observation. Therefore, there is an evidential market power exertion in the hog slaughtering industry in China. This possibly results from (1) the CSP causing high barriers of entry; and (2) squeezing out small-size incumbents that leads to a high concentration ratio.

Data availability is always a challenge for empirical industry organization studies. A limit of this study is that we only have the data after 2008, which cannot cover the full period of the policy change. Before the Central Slaughtering Policy at the end of 1997, every farmer or butcher could operate slaughtering business and sell carcass meat in the market. Back then, the market had free entry with approximately zero cost barriers. Therefore, we could claim that the slaughtering industry was a perfectly competitive market before 1998. But with NEIO, we detect the market power (0.52%) from 2008 to 2016. The market power is certainly caused by the CSP, as the number of slaughtering licenses is limited, and the barrier to entry is very high.

From the policy perspective, the Chinese government is putting a lot of efforts to increase the concentration ratios of the slaughtering industry and reduce the number of existing small firms (Ministry of Commerce, 2013b), in order to cut down regulation costs for food safety and quality control. But it also generates low efficiency and welfare transfer and loss due to the creation of market power. The high barriers induce incumbent slaughtering firms to get markup profits from upstream pig farms. This consequence deserves more serious attention from the Chinese government in the future.

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Appendix A

Table A. 1 Simultaneous equations models results of input supply equation and demand equation for slaughtering industry: Linear specification (2008-2016)

Variables/ (Coefficient)	Imperfect Market		Perfect Competition
	Constant δ	$\delta = \delta_0 + \delta_1 T$	
Input Supply Function (dependent variable =x_1/I)			
$\frac{w_1}{C}(\beta_1)$	0.777	0.777	0.777
	(0.939)	(0.939)	(0.939)
$\frac{w_1}{C}T(\beta_{2)}$	0.0123	0.0123	0.0123
	(0.0101)	(0.0101)	(0.0101)
$T(\beta_3)$	-0.000221**	-0.000221**	-0.000221**
	(8.76e-05)	(8.76e-05)	(8.76e-05)
$\frac{g_1}{C}(\beta_4)$	-1.268***	-1.268***	-1.268***
	(0.316)	(0.316)	(0.316)
$\frac{g_2}{C}(\beta_5)$	-0.0172***	-0.0172***	-0.0172***
	(0.00594)	(0.00594)	(0.00594)
$\ln(\frac{g_3}{C})(\beta_6)$	0.0205**	0.0205**	0.0205**
	(0.00828)	(0.00828)	(0.00828)
$\tau(\beta_7)$	0.000416	0.000416	0.000416
	(0.00211)	(0.00211)	(0.00211)
Constant	0.260***	0.260***	0.260***
	(0.0813)	(0.0813)	(0.0813)

Factor Demand Equation (dependent variable = w_1)			
(δ_0)	0.0593***	0.0646***	
	(0.0171)	(0.0219)	
$T(\delta_1)$		9.61e-05	
		(0.000246)	
$x_1(\alpha_1)$	0.00173***	0.00203**	0.000232
	(0.000564)	(0.000957)	(0.000383)
$w_2(\alpha_2)$	-9.67e-05	-3.89e-05	0.00163***
	(0.000586)	(0.000607)	(0.000329)
$w_3(\alpha_3)$	2.159***	2.330***	1.749***
	(0.606)	(0.751)	(0.626)
$w_4(\alpha_4)$	0.00209	0.00193	0.00101
	(0.00208)	(0.00213)	(0.00217)
$w_5(\alpha_5)$	-9.16e-05	-3.61e-05	-0.000328***
	(0.000124)	(0.000189)	(0.000110)
$p(\alpha_6)$	0.894***	0.896***	0.872***
	(0.0430)	(0.0436)	(0.0448)
_cons	-5.646***	-6.411**	-6.469***
	(1.930)	(2.757)	(2.019)
Observations	107	107	107
R-squared	0.844	0.845	0.825

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A. 2 Simultaneous equations models results of input supply equation and demand equation for slaughtering industry: Generalized Leontief conditional method (2008-2016)

Variables/ (Coefficient)	Imperfect Market		Perfect Competition
	Constant δ^L	$\delta^L = \delta_0^L + \delta_1^L T$	
Input Supply Function (dependent variable =x_1/I)			
$\frac{w_1}{C}(\beta_1)$	0.777	0.777	0.777
	(0.939)	(0.939)	(0.939)
$\frac{w_1}{C}T(\beta_{2)}$	0.0123	0.0123	0.0123
	(0.0101)	(0.0101)	(0.0101)
$T(\beta_3)$	-0.000221**	-0.000221**	-0.000221**
	(8.76e-05)	(8.76e-05)	(8.76e-05)
$\frac{g_1}{C}(\beta_4)$	-1.268***	-1.268***	-1.268***
	(0.316)	(0.316)	(0.316)
$\frac{g_2}{C}(\beta_5)$	-0.0172***	-0.0172***	-0.0172***
	(0.00594)	(0.00594)	(0.00594)
$\ln(\frac{g_3}{C})(\beta_6)$	0.0205**	0.0205**	0.0205**
	(0.00828)	(0.00828)	(0.00828)
$\tau(\beta_7)$	0.000416	0.000416	0.000416
	(0.00211)	(0.00211)	(0.00211)
_cons	0.260***	0.260***	0.260***
	(0.0813)	(0.0813)	(0.0813)

Demand Equation (dependent variable = w_1)			
δ_0^L	0.00328***	0.00343***	
	(0.000982)	(0.00124)	
$T(\delta_1^L)$		2.79e-06	
		(1.41e-05)	
$x_1^{1/2}(\rho_1)$	0.00825***	0.00897*	0.00126
	(0.00273)	(0.00458)	(0.00184)
$w_2^{1/2}(\rho_2)$	3.09e-05	0.000200	0.00796***
	(0.00281)	(0.00295)	(0.00159)
$w_3^{1/2}(\rho_3)$	0.362***	0.375***	0.291***
	(0.0976)	(0.120)	(0.1000)
$w_4^{1/2}(\rho_4)$	0.00405	0.00390	0.00166
	(0.00431)	(0.00440)	(0.00446)
$w_5^{1/2}(\rho_5)$	-0.00162	-0.00138	-0.00370***
	(0.00109)	(0.00160)	(0.000934)
$p^{1/2}(\rho_6)$	0.0609***	0.0616***	0.0503**
	(0.0202)	(0.0206)	(0.0209)
_cons	-0.0736	-0.133	0.0470
	(0.220)	(0.374)	(0.228)
Observations	107	107	107
R-squared	0.528	0.528	0.475

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A. 3 Linear demand equation with IV and OLS estimation

	Non-Time Trend		Time Trend	
VARIABLES	IV_1	OLS_1	IV_2	OLS_2
$p(\alpha_6)$	0.846***	0.894***	0.848***	0.896***
	(0.0648)	(0.0430)	(0.0660)	(0.0436)
(δ_0)	0.0565***	0.0593***	0.0598***	0.0646***
	(0.0168)	(0.0171)	(0.0217)	(0.0219)
$T(\delta_1)$			5.88e-05	9.61e-05
			(0.000240)	(0.000246)
$x_1(\alpha_1)$	0.00150**	0.00173***	0.00169*	0.00203**
	(0.000592)	(0.000564)	(0.000987)	(0.000957)
$w_2(\alpha_2)$	-3.50e-05	-9.67e-05	-8.29e-08	-3.89e-05
	(0.000571)	(0.000586)	(0.000586)	(0.000607)
$w_3(\alpha_3)$	1.968***	2.159***	2.074***	2.330***
	(0.618)	(0.606)	(0.771)	(0.751)
$w_4(\alpha_4)$	0.00235	0.00209	0.00225	0.00193
	(0.00203)	(0.00208)	(0.00207)	(0.00213)
$w_5(\alpha_5)$	-8.46e-05	-9.16e-05	-5.06e-05	-3.61e-05
	(0.000120)	(0.000124)	(0.000183)	(0.000189)
Constant	-4.445**	-5.646***	-4.923	-6.411**
	(2.239)	(1.930)	(3.076)	(2.757)
Hausman Test				
chi2(8)		0.99		0.97
Prob>chi2		0.9949		0.9984
Observations	107	107	107	107
R-squared	0.842	0.844	0.843	0.845

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A. 4 GLCM demand equation with IV and OLS estimation

	Non-Time Trend		Time Trend	
VARIABLES	IV_3	OLS_3	IV_4	OLS_4
$p^{1/2}(\rho_6)$	0.0487	0.0609***	0.0479	0.0616***
	(0.0300)	(0.0202)	(0.0310)	(0.0206)
(δ_0^L)	0.00319***	0.00328***	0.00324***	0.00343***
	(0.000962)	(0.000982)	(0.00123)	(0.00124)
$T(\delta_1^L)$			1.10e-06	2.79e-06
			(1.39e-05)	(1.41e-05)
$x_1^{1/2}(\rho_1)$	0.00765***	0.00825***	0.00787	0.00897*
	(0.00286)	(0.00273)	(0.00479)	(0.00458)
$w_2^{1/2}(\rho_2)$	0.000221	3.09e-05	0.000306	0.000200
	(0.00274)	(0.00281)	(0.00284)	(0.00295)
$w_3^{1/2}(\rho_3)$	0.345***	0.362***	0.349***	0.375***
	(0.0990)	(0.0976)	(0.123)	(0.120)
$w_4^{1/2}(\rho_4)$	0.00437	0.00405	0.00434	0.00390
	(0.00420)	(0.00431)	(0.00429)	(0.00440)
$w_5^{1/2}(\rho_5)$	-0.00159	-0.00162	-0.00149	-0.00138
	(0.00105)	(0.00109)	(0.00155)	(0.00160)
Constant	0.00374	-0.0736	-0.0125	-0.133
	(0.257)	(0.220)	(0.415)	(0.374)

Hausman Test				
chi2(8)		0.30		0.36
Prob>chi2		0.999		0.998
Observations	107	107	107	107
R-squared	0.526	0.528	0.526	0.528

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A. 5 Input supply elasticity, market power indicator, and Lerner index in slaughtering industry in multiple model specifications

	e_1	δ	Lerner Index
Linear without Time trend	0.0868	0.0593	0.52%
Linear with Time trend	0.0868	0.0646	0.56%
GLCM without Time trend	0.0868	0.0033	0.03%
GLCM with Time trend	0.0868	0.0034	0.03%

Data Source: Filed by Authors.

Table A. 6 The estimated markup profit in an oligopsonistic slaughtering industry from 2008 to 2016

Unit: million yuan

Year	Linear Model 1		Linear Model 2		GLCM Model 3		GLCM Model 4	
	Nominal	Deflated	Nominal	Deflated	Nominal	Deflated	Nominal	Deflated
2008	1212.95	1198.58	1387.46	1371.03	70.47	69.64	73.64	72.77
2009	1176.81	1170.24	1375.28	1357.58	69.85	68.95	73.00	72.06
2010	1321.56	1272.48	1364.88	1348.85	69.32	68.51	72.44	71.59
2011	1769.92	1616.47	1351.49	1336.92	68.64	67.90	71.73	70.96
2012	1598.36	1422.79	1333.07	1320.33	67.71	67.06	70.76	70.08
2013	1662.16	1442.76	1311.84	1300.74	66.63	66.07	69.63	69.04
2014	1486.57	1264.52	1293.72	1284.52	65.71	65.24	68.67	68.18
2015	1567.24	1312.57	1285.80	1278.59	65.31	64.94	68.25	67.86
2016	1854.25	1521.70	1288.43	1282.57	65.44	65.14	68.39	68.08

Data Source: Filed by Authors

Chapter 3 Do subsidies cause a less competitive milk market in China?

Abstract: After 2008, China dairy industry has experienced a consolidation supported by the government mainly for the reason of food safety. Subsidies are one of the tools to shape a concentrated market with goals of reducing regulation cost and accomplishing quality control. It gives a serious concern that subsidies would generate a less competitive dairy industry. We construct a parametric model and use the firm-level panel data, specifically the top eight dairy firms, to test if government subsidies strengthen the market power in the dairy industry. Our empirical results indicate government subsidies have a negative impact on the Lerner Index for the top privately-owned firms, but no significant effect on state-controlled ones after controlling for advertising, time trend, and proprietorship. It is possible that the subsidies give more room for private firms to increase the scale or suppress the price, which eventually reduces the market power and benefits dairy customers in the downstream.

Keywords: Dairy industry Subsidies, Market Power, Fluid Milk, China

JEL: Q13, L66, L52

3.1 Introduction

China owns the third largest dairy industry in the world, following the USA and India. In 2015, China produced 38.70 million tons of raw milk and 27.82 million tons of processed dairy products. Sheer-size population and steady income growth generate an expanding demand for various types of dairy products. Compared to that in 2000, the production of dairy products in 2015 is almost tripled (292%) (National Bureau of Statistics of China, 2018) in which fluid milk increased by 65.3% from 2008 to 2015 (Ministry of Agriculture, 2016b). This trend would not be stagnant or reverse in near short future. On a per capita basis, dairy consumption in China is estimated at 26.2kg in 2016 (OECD/FAO, 2017), which is lower than 45.3kg in Japan, 39.4kg in Korean, and 30.5kg in Thailand. It is expected that dairy consumption per capita would increase to around 33kg by 2025, which is roughly equivalent to the average consumption of other Asian areas (DBC Group Research, 2017).

However, along with the rapid consumption growth, the domestic dairy products are still struggling to regain public trust. The consequences of the 2008 melamine scandal in milk are grave and on-going (Bai, Zhang, & Jiang, 2013). Until now, Chinese consumers are yet willing to pay more money for imported dairy products than the domestic, especially for infant milk formula whose reputation was ruined devastatingly in 2008 (DBC Group Research, 2017). Since then, the Chinese government opts for a reform pathway that supports the large milk firms[6] in compliance with more stringent food safety regulations, because the milk scandal could be (either directly or indirectly) traced back to small-size dairy firms[7] who endures the most blames (Jia, Huang, Luan,

[6]. Large industrial firms, also called firms above designated size. This includes all state-controlled firms as well as non-state firms with sales exceeding 20 million RMB (Brandt, Biesebroeck, & Zhang, 2014).

[7]. In our research, we define dairy firms whose annual revenue under 20 million RMB as small-size dairy firms.

Rozelle, & Swinnen, 2012; Yu, 2012). A number of research works claim that small-size firms have a higher likelihood of provoking food safety issues because of their limited capacity in responding to strict quality requirements and sanitary standards (Farina, Gutman, Lavarello, Nunes, & Reardon, 2005; Reardon, Barrett, Berdegué, & Swinnen, 2009; Yu 2012; Yu, Wang, & Li, 2018). Thence, to improve food safety and reduce regulation costs, many areas have implemented the strategy of replacing small-size dairy firms with larger ones (Zhong, Chen, Kong, & Tracy, 2014; Yu, 2012).

Because of this, a sweeping reshuffle on the structure of China dairy industry is realized by consolidating the dairy sector towards best players throughout the past decade. The number of large dairy firms has dropped from 815 to 638 from 2008 to 2015, while the top 20 firms' production and sales are more than half of the total industry (Ministry of Agriculture, 2016b). The large gets larger. Particularly on the fluid milk, the top three players' (Yili, Mengniu, and Bright Dairy) outputs account for >60% market share in 2016 with 26.8% Yili, 27.4% Mengniu, and 7.6% Bright Dairy respectively (DBC Group Research, 2017).

One of the tools for the China government to achieve a concentrated market structure is subsidies. Dairy firms in China receive a variety of subsidies that cover all the manufacturing processes including quality control, technology innovation, logistics systems, facilities updates, etc. Figure 3.1 gives an illustration that the received subsidies significantly increased after the 2008 melamine scandal in some representative listed dairy firms[8]. Compared to 2008, the 2009 governmental subsidies jumped to an impressive new level, ensuring the dairy firms surviving in

[8]. Because only four firms went public before 2008 in our sample, Figure 3.1 only provides the subsidies data of Yili, Want want, Sanyuan, and Bright dairy.

the food safety crisis and improving product quality. For instance, the growth rate for Want Want is 116% in 2009, 202% for Bright dairy, and 380% for Sanyuan. Critics argue that subsidies result in a disproportionate share of rents among firms. As an example, the government of Inner Mongolia Autonomous Region (well known as "China dairy capital") allocated 800 million yuan to support the construction of 2000 standard dairy farms ("Cow hotels") from 2009 to 2012. Amongst the program, the Chinese top two dairy companies - Mengniu and Yili- received 400 places for each, utilizing 40% of the funding correspondingly (Inner Mongolia Autonomous Region Government, 2009). Intuitively, because of the unevenly support received by the dairy firms, it is reasonable to concern that subsidies might empower the best players within the industry and strengthen the market power of the giants. However, this critique might be misleading, because subsidies could also intensify large firms' motivation for cutting down the price or increasing the output to promote sales and develop brand loyalty. This action would eventually reduce firms' market power and benefit customers. Since we do not have data for all the large firms and all types of dairy products, we cannot estimate the market power for each firm. In our case, we narrow down our research scope to the top eight listed companies in China where the firm-level data is accessible. This paper proposes a direct measurement of the market power of each listed firm and attempts to build up a bridge between market power and government subsidies.

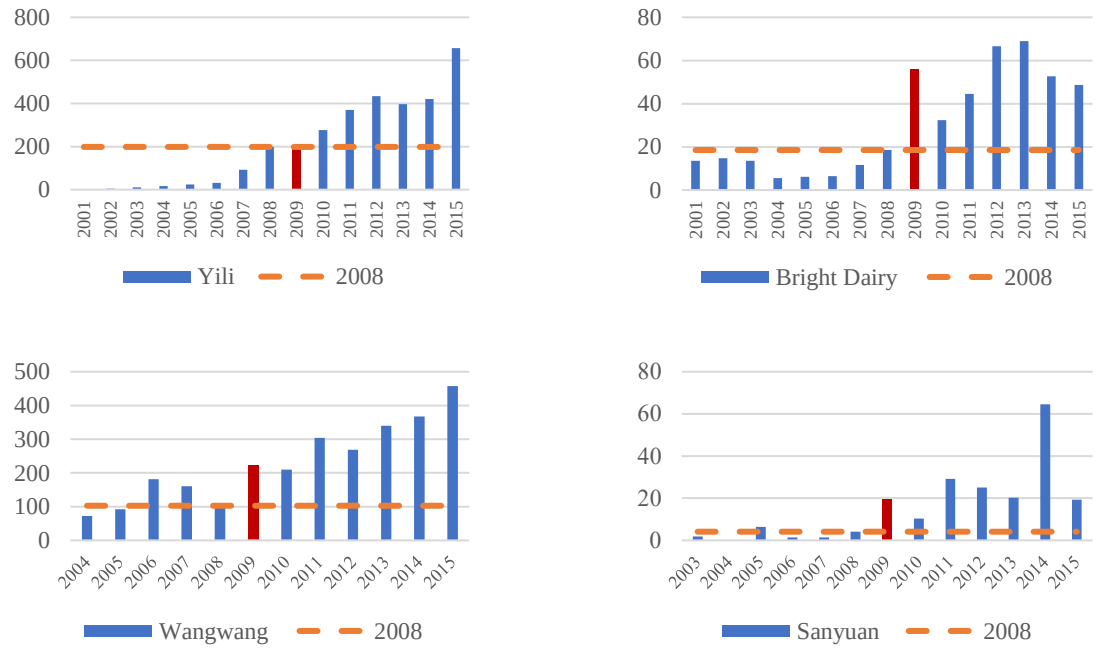

Figure 3. 1 The governmental subsidies of the top four dairy companies by brand (Unit: Million Yuan)

Note: Calculated by authors from the Annual Financial Reports of these listed companies

Although the dairy industry in China has been widely studied in different dimensions such as quality control, market structure, and milk demand elasticity (D. Chen et al., 2015; Dai & Wang, 2014; Guo et al., 2016; Pei et al., 2011), little attention has been paid to examine the possible relationship between market power and government subsidies. One reason might be the difficulty in market power estimation, and the other might be the data unavailability. In order to fill in the literature gap, we use the parametric estimation of marginal cost brought up by Koetter et al. (2012) and Delis et al. (2014) to construct the market power indicator – Lerner index. Then we empirically estimate the impact of subsidies on market power. Our results find that the subsidies could significantly reduce the market power for privately-owned listed dairy companies, but no significant impact on the state-controlled ones. We believe the privately-owned listed dairy firms might increase their production to get more subsidies. This action results in a decline in price and

a fiercer competition because the bestowed subsidies could give more room for the top privately-owned firms to take a low-price strategy and cover the cost. In the end, it causes a shrink in the firms' markup profits. Downstream retailer and consumer's welfare could be protected and improved.

The rest of the paper proceeds as follows. The next section provides a brief review of the Chinese dairy industry including market structure and subsidies information. Section 3.3 presents our methodological approach for measuring the marginal cost and Lerner index and uses the panel data to explore the impact of subsidies on market power. Section 3.4 describes the data. Section 3.5 summarizes the key points of our estimation results. And in the final section, we conclude and offer policy implications.

3.2 Background

There is limited literature on estimating the market power of Chinese dairy industry, and most of them are descriptive (C. Chen, 2004; He & Li, 2004; He, Zheng, & Zeng, 2010; Wang, Ge, & Geng, 2005). Dai & Wang (2014) used the Solow-residual model to demonstrate that dairy firms have both strong oligopolistic and oligopsonistic power in China. Hence, they could exert their ability to dominate both upstream raw milk sellers and downstream distributors simultaneously. According to their results, the Lerner index is 0.80 from 1987 to 2007, which implies the oligopoly power in dairy sector is strong, and firms can set their product prices five times of the marginal cost. Another milestone is Guo et al. 's study in 2016. By controlling the price heterogeneity, they indicate that large firms can exercise market power (0.32)[9] while small firms operate in a

[9] In original paper, Guo et al. only estimated the markup value is 1.48. By the definition, markup value = p/MC, we recalculate the Lerner index ($(p - MC)/p$) is 0.32.

competitive market (Guo et al., 2016). Our results lie in the middle of the previous researches, but the differences are reliant on various factors. For instance, the Solow-residual model applied here runs a risk of inconsistency, since the residual could be a mixture of an index of market power exertion and an index of technical change (Y. Chen & Yu, 2018c). Guo et al. 's research, to a certain extent, oversimplifies the cost function into a linear combination, which is likely to fail in simulating the change of cost with regards to the factor price variation. Moreover, subsidies also play a crucial role in understanding the Lerner index of the firms. Ignoring them would lead to a biased estimation of the Lerner index. Further discussion could be seen in our theoretical model section.

Though the estimates of Lerner index in China dairy firms are not perfectly the same, most researches agree that there is oligopolistic market power in the dairy industry. This argument is supported by the practice as well. In 2015, the top 20 dairy firms collectively founded the "China Dairy 20 Alliance (D20)" that is designed to maintain high-quality control and promote a renaissance and credible image for the whole dairy industry. At the 2016 annual summit of dairy industries, the minister of agriculture publicly supported the D20 alliance and called up the top 20 firms to unify with each other, to be the foundation of the dairy industry.

Hard to assert that the existing market structure has nothing to do with government policies. 2008 is a turning point where small-size firms are gradually squeezed out of the business for the sake of strict regulations and subsidy policies for large firms. From 2010 to 2016, the top five milk brands (Yili, Mengniu, Bright Dairy, Sanyuan, and Want want) have received 7.69 billion yuan (1.12 billion USD) subsidies from the central and local governments. There are no general subsidy standards in the dairy industry because it heavily depends on firms' bargaining power, job or tax contribution, and profitability. However, according to the financial statements of these listed dairy

companies, we could discover that both the growth rate and size of the dairy subsidies are improving strikingly. Overall, the top five firms' subsidies boosted up by 210% in just five years even though the annual growth rate fluctuated widely. According to Table B.1, Yili, the largest dairy firm in China, received almost four times subsidies in 2016 compared to that in 2010 and surpassed the sum of the next four biggest firms at that year. Sanyuan, the only brand that was not stained in the scandal, has increased to 1289.03 million yuan from 103.42 million in 2010, which is as much as 12.46 times high. All the evidence shows that the volume of industrial subsidies is discriminative, massive and expands rapidly.

[Insert Table B.1]

We could roughly classify the subsidies into four parts: 1) fixed asset support 2) tax refund 3) subsidized loan, and 4) direct public transfer.

- *Fixed asset support*. The government helps dairy firms on the installation of facilities and technologies in an earlier stage. One of the most representative supports is the standard dairy farms (or "Cow hotels") subsidy. The expenses of the "Cow hotel" share proportionally between firms and the government. Since the construction and operation standards (as technology barriers) are extremely high and too expensive for ordinary dairy farmers to afford, most of the subsidies flood into the large firms (Enderwick, 2009; Zhong et al., 2014).
- *Tax refund*. Large milk companies are usually principal taxpayers within local areas. Therefore, they have a higher possibility to get a tax return from the government.
- *Subsidized loan.* Compared to small-size dairy firms, large firms are more accessible to the discounting loans subsidized by the government. Banks prefer to lend money to large dairy

firms since they have better collaterals, lower transaction cost, and higher anti-risk capability.

- *Direct public funding transfer*. The direct public funding transfer is a package that contains subsidies and allowances on plant construction, equipment installation, R&D investment, e-commerce buildup, logistics enforcement, and quality control. It is relatively arbitrary and delivered through special projects or rewards. And it is closely related to the current year's cost and revenue of each firm. To be noted, some of the items could only be obtained by large firms. For example, the "Leading Enterprises Fund," "Famous Brand Prize," and "Premium Quality Prize" are typical national titles which are extremely difficult, if not impossible, for small-size firms to be received or rewarded since they are not qualified.

As illustrated, all four subsidies are relevant to the firm scale. By comparison, large firms are relatively more possible to achieve subsidies, particularly for the direct public funding transfer. The case of Yili's subsidies could be used as a typical example. Figure 3.2 mirrors a drastic increase in direct public funding transfer for Yili in recent nine years which is allocated heavily relating to firm scale and output capacity. In contrast, the fixed asset investment and subsidized loans are relatively stable, while the tax refund is shrinking during the same period. Critics point out this transition might result in a severe consequence. The government can target at firms with large production scale and benefit them with special funds/prizes in the name of public funding transfer, while small-size firms would be squeezed out of the market.

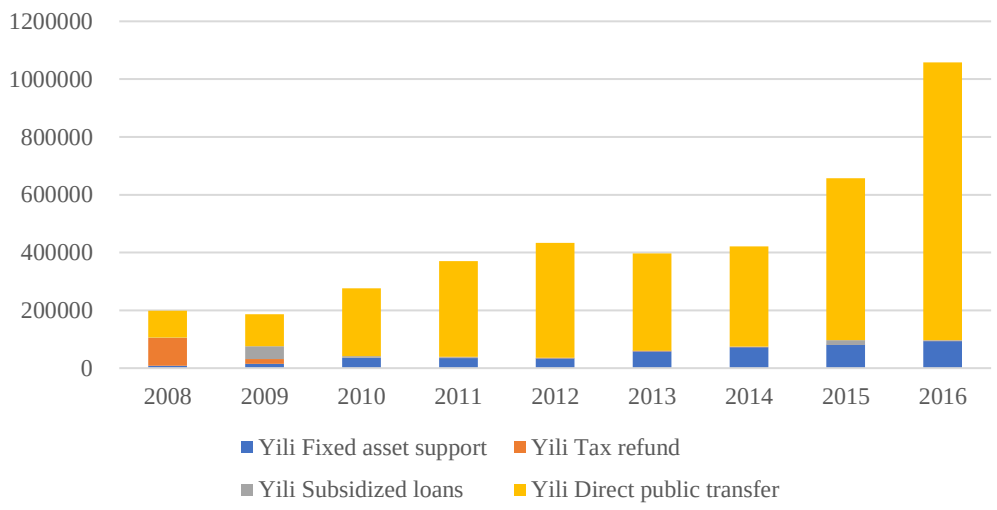

Figure 3. 2 The governmental subsidies of Yili dairy company by items in 2008-2016 (Unit: 1000 Yuan)

Note: Calculated by authors from the Annual Financial Reports of these listed companies

Since the large firms take more funding supports than the small-size ones, would the growing subsidies increase the market power and generate more supernormal profits for the large? To test our hypothesis, we pick up the top eight firms in the dairy industry and empirically estimate the impact of government subsidies on market power in the following section.

3.3 Methodology

3.3.1 Marginal cost estimation

Lerner index has been traditionally used for measuring market power. One of the challenges in constructing the Lerner index is the absence of marginal cost (MC) information. Only a few industries where researchers can observe the actual marginal cost directly (Borenstein, Bushnell, & Wolak, 2002; Genesove & Mullin, 1998). Mostly, MC could only be observable to firms but unobserved by researchers. A great deal of New Empirical Industrial Organization (NEIO) avoids this issue by using conjecture variations at the industry level to calculate the Lerner index (Azzam, 1998; Bresnahan, 1989; Iwata, 1974; Muth & Wohlgenant, 1999b; Nevo, 2001). But this approach

is limited since it fails to calculate the marginal cost and market power of each firm. Normally, there are two categories of methods used in measuring the marginal cost at the firm level – Parametric Model and Nonparametric Model. For instance, Delis, Iosifidi, & Tsionas (2014) use semiparametric and nonparametric models to approximate the marginal cost in California electricity industry. Compared to the parametric approach, the nonparametric model is not required to specify the specification of the cost function, which is more flexible in estimating firms with different production technologies. However, this advantage on multiple production technologies cannot hold back the adoption of the parametric model in our case, because the technologies employed to transform fluid milk from raw milk are much identical amongst the industry--- UHT Milk (Ultra-high temperature processing milk) and Pasteurized Milk. These are the only two ways of producing fluid milk, and all top eight firms have their product line to produce both milk products. No technological difference exists. Also, few inventions can be patented, and most innovations are copied shortly after their introduction. Since nonparametric model demands a much larger data sample to obtain an efficient estimation, we, thus, resort to applying the approach that is consistent with the parametric method proposed by Koetter, Kolari, & Spierdijk (2012) and Delis et al. (2014), given the limited data in our research.

In the context of Chinese fluid milk industry, we specify labor, gas, and raw milk as three main input factors of production. On the assumption that the factor market is complete and perfectly competitive, we employ both the Translog cost model and Loglinear cost model to simulate the marginal cost for firm $j = 1, \dots, m$ at time $t = 1, \dots, T$.

We start the cost function with the homogeneity condition

$$\frac{C_{jt}}{w_{1jt}} = C(1, \frac{w_{2jt}}{w_{1jt}}, \frac{w_{3jt}}{w_{1jt}}, y_{jt})$$

(1)

where C donates total operating cost, y_{jt} is firm j's output, and $\boldsymbol{w_{ijt}}$ is a price vector of input factors with respect to w_{1jt} is the gas price of firm j at period t, w_{2jt} is the raw milk price, and w_{3jt} is labor wage. We impose the homogeneity of degree 1 on the input prices by dividing all the factors and total cost by the gas price. Since we have no knowledge on the real specification of function (1), we apply the Second-order Taylor Expansion to construct the Translog cost function as following form,

$$\begin{aligned}\log C_{jt} = {} & \alpha + \sum_{i=2}^{3} \beta_{i-1} \log\left(\frac{w_{ijt}}{w_{1jt}}\right) + \gamma \log(y_{jt}) + \frac{1}{2}\sum_{i=2}^{3} \delta_{i-1}[\log(\frac{w_{ijt}}{w_{1jt}})]^2 + \frac{1}{2}\theta\,(\log y_{jt})^2 \\ & + \sum_{2\le i<k} \sum \kappa_{ik} \log\left(\frac{w_{ijt}}{w_{1jt}}\right) \log\left(\frac{w_{kjt}}{w_{1jt}}\right) + \sum_{i=2}^{3} \varphi_{i-1}[\log\left(\frac{w_{ijt}}{w_{1jt}}\right) \log(y_{jt})] \\ & + \omega \log w_{1jt} + \varepsilon_{jt}\end{aligned}$$

(2.1)

where $\alpha, \beta, \gamma, \delta, \theta, \kappa, \varphi$ and ω are respectively parameters to be estimated for the Translog cost function, while ε_{jt} is the error term. In order to ensure the cost function is well-behaved,

(1) $\boldsymbol{\kappa}$ is used to decribe the concavity in the cost function Eq (2.1) with respect to the factor price. Concavity in input prices of the cost function requires the Hessian matrix of the cost function with respect to the input prices is negative semidefinite. The elements of the Hessian matrix are

$$\mathrm{H_{ik}} = \frac{\kappa_{ik} C_{jt}}{w_{ijt} w_{kjt}} + \frac{x_{ijt} x_{kjt}}{C_{jt}} - \Delta_{ik} \frac{x_{ijt}}{w_{ijt}}$$

(2.2)

Where x_{ijt} is the input quantity of factor x_i for firm j at the t period, and x_{kjt} is the input quantity of factor x_k for firm j at the t period. w is corresponding factor price. C_{jt} is firm j's cost at the t period, and Δ_{ik} denotes Kronechker's delta.

$$\Delta_{ik} = \begin{cases} 1 \ if \ i = k \\ 0 \ if \ i \neq k \end{cases}$$

(2.3)

With the value of κ_{ik}, we should ensure all diagonal elements of the Hessian matrix are negative (Henningsen, 2014).

(2) $\boldsymbol{\theta}$ is used to decribe the concavity in the cost function Eq (2.1) with respect to the output quantity. Theroretically, $\boldsymbol{\theta}$ should be negative in our estimation, which ensures the second-order Hessian matrix is negative semidefinte. It implys that the elasticity of scale is decreasing along with a growth output quantity (Henningsen, 2014).

$$\mathrm{Z} = \frac{\partial lnC_{jt}}{\partial lny_{jt}} = \gamma + \theta lny_{jt} + \sum_{i=2}^{3} \varphi_{i-1} \log\left(\frac{w_{ijt}}{w_{1jt}}\right)$$

$$\frac{\partial \mathrm{Z}}{\partial lny_{jt}} = \frac{\partial \ln^2 C_{jt}}{\partial lny_{jt} \partial lny_{jt}} = \boldsymbol{\theta}$$

(2.4)

(3) k denotes the factor that is not factor i and factor 1. For instance, if we have three input factors where factor 1 is gas, factor i is labor, factor k represents raw fresh milk so that it is distinguished from the former two items.

Based on Eq (1) and Eq (2.1), we could derivate the total cost function and calculate the marginal cost for each observation,

$$MC_{jt} = \frac{\partial lnC_{jt}}{\partial lny_{jt}} \cdot \frac{C_{jt}}{y_{jt}} = [\gamma + \theta lny_{jt} + \sum_{i=2}^{3} \varphi_{i-1}[\log\left(\frac{w_{ijt}}{w_{1jt}}\right)] \cdot AC_{jt}$$

(3)

where AC_{jt} is the average cost of firms at the time t and we can obtain AC_{jt} by $AC_{jt} = C_{jt}/y_{jt}$. Alternatively, we also specify a Loglinear cost function which has been commonly used in literature,

$$logC_{jt} = \alpha + \sum_{i=2}^{3} \beta_{i-1} \log\left(\frac{w_{ijt}}{w_{1jt}}\right) + \gamma \log(y_{jt}) + \omega \log w_{1jt}$$

(4)

Correspondingly, the marginal cost of the Loglinear cost function is as follows,

$$MC_{jt} = \frac{\partial lnC_{jt}}{\partial lny_{jt}} \cdot \frac{C_{jt}}{y_{jt}} = \gamma \cdot AC_{jt}$$

(5)

3.3.2 Market power measurement

In industrial organization, market power is the ability of a firm, or group of firms, to get rents above those needed to remunerate the inputs at market prices (Aguirregabiria, 2012; Raper et al., 2007). Massive literature employs the Lerner index formalized by Abba Lerner (1934) to describe a firm's market power. It could be defined as follows,

$$\Phi_{\mathrm{jt}} = \frac{P_{jt} - MC_{jt}}{P_{jt}}$$

(6)

Φ_{jt} reflects the degree of firm j selling incremental output for more than what it pays for incremental input. Lerner index falls into a range between 0 and 1. If the industry is perfectly competitive (where $P_{jt} = MC_{jt}$), Φ_{jt} is equal to zero. Otherwise, if the industry is close to a monopoly, Φ_{jt} would be close to one. By the results of Eq (3) and Eq (5), we could obtain the marginal cost and calculate our Lerner index for each firm j at t period.

3.3.3 Effects of subsidies on market power

3.3.3.1 Theoretical model

We now examine the impact of the subsidies on firm behaviours. For numerical convenience, we drop the time subscript temporarily in this section. The profit function for firm j is

$$\Pi_j = P_j y_j - C_j(y_j) + S_j(y_j)$$

(7)

where $S_j(y_j)$ is the subsidies which are often linked to the firms' individual output.

The optimizing behaviour of each firm is determined by the corresponding first-order condition (FOC) for profit maximization,

$$MC_j = P_j + y_j\left(\frac{\mathrm{d}P_j}{\mathrm{d}\boldsymbol{y}}\frac{\mathrm{d}\boldsymbol{y}}{\mathrm{d}y_j}\right) + \frac{\partial S_j(y_j)}{\partial y_j}$$

(8)

where the output produced by firm j is y_j, while the aggregation of the industry output denotes $\boldsymbol{y}$. By constructing the Lerner index on the left-hand side of Eq (8), we could obtain the market power as following,

$$\frac{P_j - MC_j(y_j)}{P_j} = -\frac{y_j}{P_j}\left(\frac{\mathrm{d}P_j}{\mathrm{d}\boldsymbol{y}}\frac{\mathrm{d}\boldsymbol{y}}{\mathrm{d}y_j}\right) - \frac{MS(y_i)}{P_j} \tag{9}$$

If we incorrectly assume the dairy firms compete without considering the subsidies' impact, we could derive the FOC as

$$\frac{P_j - MC_j(y_j)}{P_j} = -\frac{y_j}{P_j}\left(\frac{\mathrm{d}P_j}{\mathrm{d}\boldsymbol{y}}\frac{\mathrm{d}\boldsymbol{y}}{\mathrm{d}y_j}\right)$$

Comparing with Eq (9), we could see the impact of subsidies on the market competition depends on the subsidy function $S(y_i)$. An incorrect specification of omitting subsidies will generate an inconsistent result.

The explanations of the subsidies impact in Eq (9) are as follows,

i. If $MS(y_i) > 0$, which implies that subsidies are positively correlated with the scale and increasing subsidies will increase competition. Companies will increase the output size to get more subsidies, which eventually dump the market prices.
ii. If $MS(y_i) < 0$, which implies that subsidies are negatively correlated with the scale, then subsidies will decrease competition. Firms will decrease their output size to get more subsidies, which eventually reduces market supplies to push up the market prices.
iii. If $MS(y_i) = 0$, which implies that subsidies have nothing to do with the firms' output, then subsidies are neutral for the market power of the firm.

3.3.3.2 Empirical model

Then the empirical model of Eq (9) could be carried out for firm j in the following

$$\Phi_{\mathrm{jt}} = \alpha_0 + \alpha_1 \mathrm{S}_{jt} + \alpha_2 \mathrm{S}_{jt} \Gamma_j + \alpha_3 Year + \sum_{i>3} \alpha_i \mathrm{X}_{\mathrm{jt}} + V_j + U_{jt} \quad (10)$$

Here, $\Phi_{\mathrm{jt}} = \frac{p_{jt} - MC_{jt}}{p_{jt}}$ which we could obtain from Eq (3) and Eq (6). S_{jt} is the subsidies amount of firm j at period *t*. Γ_j is the dummy variable for the state-controlled firm[10]. Note that we interact the subsidies with Γ_j to control for the asymmetric responses of state-controlled or private-owned firms' subsidies on Φ_{jt}, by testing the null hypothesis $\alpha_2 = 0$. $Year$ is a time dummy variable. $\mathbf{X_{jt}}$ is a vector of covariates including advertising expenditure and the number of employee. Moreover, $\mathbf{X_{jt}}$ also includes the price index of fixed investment asset. The literature has discussed fixed asset investment would be a cause of market power. Industries with large fixed costs normally have a relatively small number of large firms because of entry barriers (Aguirregabiria, 2012; Koutsoyiannis, 1982). However, we do not add it into our marginal cost calculation since fixed asset investment is normally independent from scale and production. In addition, we divide the error term into two parts: the firm-specific term V_j (quality, flavor, product-line length, production capacity, state-controlled etc.) and idiosyncratic term U_{jt}. Because brand effects are suspiciously correlated with the Lerner index, we apply the Fixed-effect Panel data estimation to reduce the risk of endogeneity.

[10]. Within the 8 firms, there are 3 state-controlled firms which are Yili, Guangming and Sanyuan.

We now further discuss the economic implication for the parameter α_1 and α_2. For the privately-owned firms, if α_1 is negative, we could reasonably infer that subsidies will lead to a more competitive market by increasing the output and lowering down the market price. If $\alpha_1 > 0$, it infers government subsidy will empower the oligopolistic players and promote a less competitive market. The sign of α_1 reflects the relation between the subsidies and the Lerner index for the privately-owned firms.

However, for the state-controlled firms, the marginal effect for subsidies will be $\alpha_1+\alpha_2$, and the variance can be calculated as $\mathrm{Var}(\alpha_1)+Var(\alpha_2) + 2Cov(\alpha_1, \alpha_2)$. Similarly, if $\alpha_1+\alpha_2 > 0$, the government subsidies will make the firms gain more market power and the market is less competitive; If $\alpha_1+\alpha_2 < 0$, the government subsidies will make the firms gain less market power, and the market is more competitive.

3.3.3.3 Identification strategy

As we mentioned, "No general subsidy standards in the dairy industry because it heavily depends on firms' own bargaining power, job or tax contribution, and profitability." There is a very good reason to suspect the subsidy variable (S_{jt}) is largely determined by the market power of firm j itself (Φ_{jt}), which confronts simultaneity problems and an inconsistent estimation. Because of the presence of the endogenous variable S_{jt}, we could estimate it with an IV regression using province-level exogenous variables for each firm as IVs. The subsidies from the government strongly depend on two factors: (1) public finance capability (2) The importance and status of the dairy industry in provincial GDP. The proxies we employ for factor (1) are the general expenditure of province government and the gross tax of province government, and for factor (2) is the milk production per capita for each province. We also believe that the government's financial

expenditure, tax income, and milk production per capita are not subject to the specific firms' market power. Since the interaction in our empirical model is the product of subsidies and state-controlled indicator, we also multiply the government's financial expenditure, tax income, and milk production per capita with the state-controlled dummy variable to generate instruments. Furthermore, the endogeneity could be tested by the Hausman Test.

3.4 Data

In this paper, we only focus on the fluid milk segment in China dairy industry. Unfortunately, data on marginal costs of the top eight firms is often not directly available, so the variable should be inferred from Eq (3) or Eq (5). The cost and revenue information used here is extracted from yearly accounting statements reported for the period from 2010 to 2016. One challenge is that the sale quantity/output of each brand is not available in our case. We obtain the sale quantity by dividing the total sale value in the firm accounting statements by the price. Since the top eight firms are all publicly listed companies, the total sale revenue is available for each year, while the prices of fluid milk products are from Beijing Muding Commercial Information Center, a data mining and statistical analysis company in China. It collects price information of different varieties and aggregates the raw data into the brand level. Since the data employed here is the supermarket average retailing sale prices, we might have two potential risks: (1) supermarkets might own market power that influence shelf price in the downstream (2) Transportation costs, as an essential part of sales cost, contribute a large portion of the final shelf price. With these settings, we assume all sale costs are internalized and fixed. It is realistic in Chinese dairy market. Thus, the Lerner index applies to the brand, not the manufacturing firm per se. We acknowledge some quality difference across product varieties, which however could be captured by the fixed effect in our

estimation[11]. Note that the last three dairy firms, Shengmu and Huishan went public after 2010 (Shengmu was in 2012, and Huishan was in 2013 respectively), which leads to an unbalanced panel dataset. Moreover, Xinxiwang postpones the dairy business in the middle of our observation period from 2012 to 2013 because of the business separation, and corresponding information is not reported in the financial report.

Other input price variables in the marginal cost estimation are from National Statistics Bureau of China (NSBC) and multiple financial data companies. Since input factor prices of each individual firm are not accessible, we use the province level data of headquarter location to substitute (since Want want is a brand from Taiwan, we use the neighbouring province Fujian instead for the sake of data missing). Average wages of each province are taken from NSBC, and gas prices are from Wind database --- one of the biggest financial database service companies in China. The key input variable - raw milk price is from Hai Tong Security. Since the average wage is quarterly time series data, and raw milk and gas price are monthly data, we average the data to be according to the annual cost and sales information.

To estimate Eq (10), we extract subsidies, the number of employees, and advertising expenditure from yearly accounting statements spanning from 2010 to 2016. To be noted, Want want's subsidies are reported in dollar-denominated price, so we change them by multiplying with the current exchange rate in each year. Since the government normally decides the subsidies, it is

[11]. There are few concerns whether the sample should involve Want want, since its flagship product is flavor milk instead of pure milk. We insist on including Want want in our estimation model for two reasons: First, customers do not very much distinguish flavor milk from other liquid milk products. They are strong substitutions with modest product differentiation, which means Want want's product is in competition with other firms' products directly within dairy industry. The effects of product differentiation can be fairly controlled by Fixed-effects Model. Second, Want want has a large sale and revenue in China market. Its sale revenue is 3.41 times larger than Sanyuan in 2015. If we ignore the importance of Want want, or replace with other smaller firms, it might generate an inconsistent estimate in our research.

reasonable to question that the state-controlled firms might have more advantages than that of the private to get and utilize subsidies. In our sample, Yili, Bright Dairy, and Sanyuan are controlled by the state where $\Gamma_j = 1$, and others are private firms. The price index of fixed investment asset is taken from the statistical yearbooks from each province individually. We deflate the price data, wage data, and subsidies data by CPI from NSBC, and all the independent variables are transformed into logarithm if it is possible.

3.5 Results

We use the panel data of the top eight listed firms for the period from 2010 to 2015 to estimate the Lerner index and the effect of subsidies on it. The estimation results of the cost function are reported in Table B.2 for both the Translog model and Loglinear model. Table B.3 and Table B.4 report the calculated Lerner index and super profits in our observation period. Also, the effect of subsidies on market power is discussed in Table B.5.

3.5.1 Marginal cost estimation

Using the accounting data, we obtain the estimates for two different cost function specifications (Loglinear and Translog) in Table B.2. The high adjusted R-squared values show our model fits the data very well. In addition to a more flexibility specification for Translog function, the Likelihood ratio test (see Table B.2) also significantly rejects the Loglinear cost function and favours the Translog cost one. Hence, the following discussion would be based on the Translog function.

[Insert Table B.2]

First of all, the coefficients of raw milk price and output have a positive effect on the change of total cost, and the variables are statistically significant at 5% level respectively in the model

(3)[12]. Compared to that in the Loglinear model, the input prices in the Translog function have a much stronger effect on the total cost of each firm. Moreover, the quadratic terms of raw milk price and output are negative in our estimation as expected, indicating the curve of the total cost is concave with respect to raw milk price and unit output. The cost function is well behaved. Intuitively, holding other prices and the output constant, minimum costs will never increase at more than a linear rate, even if the dairy firm continues to use the same raw milk input with rising price. Other quadratic terms are not significant and close to zero, which shows they have a negligible impact on our model.

3.5.2 Lerner index and markup estimation

Following the estimation results of the Translog cost function, Table B.3 gives the Lerner index of each firm. As we can see, at the end of our observation, Huishan has the highest Lerner index (0.611), while Shengmu owns the lowest (0.242). Since the market power is a degree of firm j selling incremental output for more than what it pays for incremental input, it means that Huishan might have the ability of generating supernormal profits three time higher than that of Shengmu in our case. As we have discussed, when the Lerner index gets closer to 1, it means the market is becoming less and less competitive. For instance, the Chinese largest dairy firm Yili's Lerner index is 0.552 in 2015, reflecting that the oligopolistic market power contributes more than 55% of the price value in the Yili fluid milk brand. In other words, besides remunerating the inputs at market prices, the downstream supermarkets or consumers have to pay 55% more just because of the

[12]. The variables are not significant in model (4) with regards to Translog cost specification in Bootstrap. However, since bootstrap will not affect the consistency of our estimation and parameters are the same, our estimation in Lerner Index would not be affected by it.

oligopolistic market existence. Evidentially, Table B.3 results indicate the Chinese dairy industry has very strong market power.

[Insert Table B.3]

The trend of market power should not be overlooked either. Yili, Mengniu, Sanyuan, Bright Dairy, and Xinxiwang have experienced a significant increase, while Want want, Shengmu, and Huishan's Lerner index drops around 10% respectively. This fluctuation indicates that the market power of each firm is uncertain even in a highly concentrated market.

The literature shows that, even with a small deviation from the competitive market, the welfare impact would be enormous given the vast market of the food industry (Rogers & Sexton, 1994; Sexton, 2000a). To give a more straightforward picture of the consequence, we calculate the supernormal profits of each firm. Table B.4 indicates how much of the nominal markup that each individual firm could generate just because of the market power. It reflects the top eight listed firms seized 60.31 billion RMB (8.81 Billion USD) extra money just in 2015, which takes account of 18.11% of total industry sale revenue in the corresponding year[13]. Considering the massive fluid milk consumption, we believe consumer welfare loss could be extremely large.

It seems that the rents for the Chinese dairy industry are too high. If we compare the milk price in China with that in Germany, we can find that the number is credible. The average retail price for drinking milk is 11.4 yuan/liter for China in 2015, while the price is 0.64 Euros/liter[14]. Given

[13]. According to China Dairy Association, the total industry sales revenue is 332.85 Billion Yuan.

[14]. Source: Beijing Muding Commercial Information Center for China's milk price and AMI for German milk price https://www.ami-informiert.de/ami-maerkte/maerkte/ami-maerkte-verbraucher/meldungen.html

that the average exchange rate between Chinese Yuan and Euros is 6.95 in 2015[15], retail milk price in China is almost triple of that in Germany.

And if we narrow down our analysis into just one firm, we find that the largest dairy firm-Yili has gained 106.24 Billion Yuan in six years. The enormous supernormal profits should be offset in a competitive market. Since Yili faces an oligopolistic market with few players, it could raise the price much higher than the marginal cost and enjoy fruitful markup value. The consequence would hurt the welfare of downstream retailers and consumers.

Based on our theoretical model, we could infer that the impact of subsidies on firms' Lerner index could be linked to consumers' welfare. To study the relationship between them, we use the panel data and a fixed-effect model to estimate the impact of subsidies on the Lerner index by controlling other covariates.

[Insert Table B.4]

3.5.3 Effects of subsidies on market power

3.5.3.1 IV Regression and specification

We first investigate the possible endogeneity problem arising from subsidies and examine whether our instrumental variables can address the issue adequately. First, the instrumental variables (government's financial expenditure, tax income, and milk production per capita, and interactions)

[15]. Source: European Central Bank
https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-cny.en.html

safely pass the tests of weak instruments[16] and over-identification, and it evidences that the instruments are valid.

As shown in Table B.5, the estimates obtained with moment restrictions are not evidently different from those without them. The Hausman tests indicate no significant systematic difference between the OLS model and IV regression, suggesting that the government subsidies are exogenous.

[Insert Table B.5]

3.5.3.2 Analysis of subsidies effects

As the sample size is not large enough, so we use the bootstrap method (200 times) to generate robust standard errors. Both the Loglinear and Translog estimated Lerner index are listed in Table B.5 for the purpose of comparison. Since the Likelihood ratio test has rejected the Loglinear model in the cost functions, we will mainly explain the result for the model with Lerner index estimated from the Translog specification (the last column in Table B.5) in the following discussion. The coefficient of subsidies is -0.051 and is statistically significant at 10%[17]. It means that the Lerner index would decrease around 0.051 when the subsidies increase 1%, particularly for the privately-owned firms.

The impact on state-controlled firms might be different due to the natural connections between the firms and the state. The coefficient of the interacted term (0.0614) is positive and not significant in our model so that the marginal effect of subsidies can be calculated as 0.0104 (-0.051+0.0614)

[16]. F-values for subsidies and subsidies-interaction terms are respectively 13.89 and 102.99.

[17]. Our results are robust. It is also significant at the 5% level with robust standard errors.

for the state-controlled firms. We also can calculate the stand error which is 0.030, so that the t-ratio = 0.342. It is not statistically significant. It indicates that the state-controlled dairy firms do not significantly react to the subsidy policies, perhaps due to the nature of their soft budget constraints.

As discussed in the theoretical model, the direction of subsidies variable is determined by the elasticity of subsidies on the scale. A negative coefficient (-0.051) indicates that dairy firms increase their output sizes to get more subsidies, which eventually improves industrial competition. To be more specific, the listed privately-owned dairy firms might produce and process more so that they could convince the government to allocate additional funds to them. This strategy results in a cut-down in price and a fiercer competition, since the bestowed subsidies could give more room for the top firms to carry out a low-price strategy. This result can also be supported by other similar empirical researches in which larger sellers' existence would lead to lower goods prices for buyers (Reardon & Gulati, 2008; Swinnen & Vandeplas, 2010). It would decrease the Lerner index and consequentially increase consumer welfare.

However, other independent variables are not statistically significant in different models and will not be discussed here due to limited interest in the paper.

3.6 Conclusion

China has the third largest dairy industry in the world, but its dairy products' quality suffers from public trust crisis for a long time. After the 2008 milk scandal, China government promotes consolidation of the industry to reduce regulatory costs and improve quality control. Subsidies, along with other regulations, are one of the main tools to realize it. From 2010 to 2015, the top

five firms have received 7.69 billion yuan directly from the government with a goal of updating production facilities and meeting stringent quality standards.

In the background of a concentrated market, many people worry the subsidies would further generate a less competitive market. We employ a parametric model and the unbalanced panel data of the top eight listed firms from 2010 to 2015 to estimate the marginal cost and construct the Lerner index. Our empirical study shows that the subsidies have a significant negative impact on market power for privately-owned listed dairy firms, while no significant effect for state-controlled firms. That is, one percent increase in subsidies could reduce 0.051 in the Lerner index, ceteris paribus, for the privately-owned major dairy firms. This result is possibly due to that top firms intend to produce more induced by the subsidies from the governments. In turn, the listed dairy firms then use the subsidies money to exert a low-price strategy. It would result in a reduction of market power and benefit the customers eventually.

This research answers the question whether subsidies would create a less competitive dairy market in China. Our research indicates this should not be a severe situation in the near term. Though subsidies promote a concentrated market structure of the dairy industry, it also motives the firms to expand production, reduce the price, and conduct a fiercer competition within the group. The effects mainly occur for privately-owned large firms, while the state-controlled firms do not significantly react to the subsidies.

This does not show that the policy maker should not pay attention to the oligopolistic market power anymore, because, in the perspective of subsidy, there is still a potential risk that the low-price strategy would squeeze out the small competitors and create a less competitive market in the long term. The impact of subsidies could be overturned if the number of the competition dropped

too much along with predatory, low-price strategies. As mentioned, we have already discovered a high Lerner index existing in our sample. When other small competitors gradually leave the dairy industry, the large firms would generate a strong motivation to keep their advantaged competition positive and execute their market power. But so far, no evidence proves the concern. One of the limitations of this paper is that our data is only concentrated on the firms which go public and report their financial information regularly, we could not see the impact of subsidies on the small-size producers. More data sample should be involved in it.

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Appendix B

Table B. 1 Subsidies size and growth rate of top five dairy firms from 2010-2016 (unit: 100 thousand yuan)

	Yili		Mengniu		Bright Dairy		Sanyuan		Want want	
	Size	Rate	Size	Rate	Size	Rate	Size	Rate	Size	Rate
2010	2766.26		773.65		323.99		103.42		2096.64	
2011	3702.51	34%	594.88	-23%	445.87	38%	291.88	182%	3038.04	45%
2012	4333.52	17%	1626.00	173%	665.40	49%	250.90	-14%	2690.26	-11%
2013	3971.04	-8%	911.60	-44%	689.11	4%	201.50	-20%	3394.70	26%
2014	4211.58	6%	1715.20	88%	526.89	-24%	644.85	220%	3677.36	8%
2015	6567.60	56%	2614.14	52%	487.22	-8%	192.36	-70%	4570.95	24%
2016	10582.65	61%	2208.02	-16%	1066.13	119%	1289.03	570%	3687.89	-19%

Note: Calculated by authors from the Annual Financial Reports of these listed companies

Table B. 2 Marginal cost estimation results from Loglinear cost function and Translog cost function from 2010-2015

	(1) Loglinear	(2) Loglinear Bootstrap 200	(3) Translog	(4) Translog Bootstrap 200
VARIABLES	$\log C_{jt}$	$\log C_{jt}$	$\log C_{jt}$	$\log C_{jt}$
$\log(w_{2jt}/w_{1jt})$	0.359**	0.359*	7.137**	7.137
	(0.160)	(0.209)	(3.243)	(8.854)
$\log(w_{3jt}/w_{1jt})$	0.778***	0.778**	-4.153	-4.153
	(0.158)	(0.382)	(5.989)	(18.02)
$\log(y_{jt})$	0.930***	0.930***	3.022**	3.022
	(0.0355)	(0.161)	(1.119)	(2.643)
$\log(w_{2jt}/w_{1jt})^2$			-0.103	-0.103
			(0.292)	(0.980)
$\log(w_{3jt}/w_{1jt})^2$			0.668	0.668
			(0.533)	(3.185)
$\log(y_{jt})^2$			-0.0167	-0.0167
			(0.0194)	(0.155)
$\log(w_{2jt}/w_{1jt})\log(w_{2jt}/w_{1jt})$			-0.410	-0.410
			(0.710)	(3.034)
$\log(w_{2jt}/w_{1jt})\log(y_{jt})$			-0.109	-0.109
			(0.138)	(0.449)
$\log(w_{3jt}/w_{1jt})\log(y_{jt})$			-0.0936	-0.0936
			(0.143)	(1.032)
$log\, w_{1jt}$	1.207**	1.207**	0.945	0.945
	(0.577)	(0.597)	(0.617)	(0.941)
Constant	-0.326	-0.326	-28.55	-28.55
	(1.792)	(2.774)	(26.30)	(45.46)

Observations	41	41	41	41
R-squared	0.968	0.968	0.979	0.979
Number of id	8	8	8	8
Likelihood-ratio test				
LR chi2(6)			18.13	
Prob > chi2			0.0059	

Note: Bootstrap standard errors in parentheses for (2) and (4) - Generate 200 times; Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table B. 3 Lerner index of the top eight dairy firms in China from 2010 to 2015

Year	Yili	Mengniu	Bright Dairy	Sanyuan	Want want	Shengmu	Huishan	Xinxiwang
2010	0.451	0.304	0.496	0.455	0.420			0.336
2011	0.484	0.303	0.526	0.544	0.433			0.373
2012	0.386	0.311	0.626	0.563	0.333	0.266		
2013	0.472	0.369	0.587	0.540	0.258	0.401	0.687	
2014	0.530	0.365	0.594	0.467	0.351	0.301	0.650	0.480
2015	0.552	0.367	0.588	0.499	0.380	0.242	0.611	0.499

Note: Calculated by authors.

Table B. 4 Extra profits of the top eight dairy firms in China from 2010 to 2015 (unit: billion yuan)

Year	Yili	Mengniu	Bright Dairy	Sanyuan	Want want	Shengmu	Huishan	Xinxiwang
2010	12.15	8.19	3.54	1.18	3.02			0.50
2011	15.62	10.27	4.62	1.67	3.86			0.57
2012	12.46	10.13	6.36	2.04	3.58	0.01		
2013	17.52	14.09	6.82	2.05	2.70	0.12	1.57	
2014	22.48	16.02	8.96	1.52	4.29	0.22	1.57	1.59
2015	26.03	16.05	8.39	1.60	4.16	0.40	1.89	1.79
Total	106.24	74.76	38.69	10.07	21.61	0.75	5.03	4.45

Note: Calculated by authors.

Table B. 5 Subsidy impacts analysis with IV and OLS estimation

VARIABLES	Loglinear IV Lerner Index	Loglinear OLS Lerner Index	Loglinear Bootstrap 200 Lerner Index	Translog IV Lerner Index	Translog OLS Lerner Index	Translog Bootstrap 200 Lerner Index
S_{jt}	-0.0592*	-0.0613*	-0.0613*	-0.0491*	-0.0510**	-0.0510*
	(0.0319)	(0.0261)	(0.0321)	(0.0285)	(0.0210)	(0.0294)
$S_{jt} \cdot \Gamma_j$	0.0752	0.0715	0.0715	0.0670	0.0614	0.0614
	(0.0710)	(0.0459)	(0.0745)	(0.0635)	(0.0383)	(0.0670)
Year	0.00607	0.00661	0.00661	0.0107	0.0114	0.0114
	(0.0147)	(0.0137)	(0.0188)	(0.0132)	(0.0104)	(0.0163)
Advertising	-0.0208	-0.0203	-0.0203	0.00614	0.00649	0.00649
	(0.0261)	(0.0199)	(0.0398)	(0.0234)	(0.0191)	(0.0390)
Number of Employee	0.0317	0.0322	0.0322	0.0298	0.0301	0.0301
	(0.0347)	(0.0395)	(0.0578)	(0.0311)	(0.0293)	(0.0481)
Price Index of Investment in Fixed Assets	0.234	0.253	0.253	0.191	0.215	0.215
	(0.738)	(0.766)	(0.959)	(0.660)	(0.646)	(0.839)
Constant	-13.06	-14.24	-14.24	-22.10	-23.66	-23.66
	(32.52)	(30.31)	(41.35)	(29.10)	(23.07)	(35.70)
Observations	41	41	41	41	41	41
R-square		0.249	0.249		0.255	0.255
Number of id	8	8	8	8	8	8
Hausman Test						
chi2(6)		0.02			0.03	
Prob>chi2		1.0000			1.0000	

Note: Standard errors in parentheses;

*** p<0.01, ** p<0.05, * p<0.1.

Bootstrap Generates 200 times

Chapter 4 Identifying the Chinese dairy market power with imported dairy products

Abstract: The prospect of market power abused by large, domestic dairy brands is an important policy concern in China, while the imported milk players are not given enough attention. In this section, we construct a New Empirical Industrial Organization (NEIO) model to identify their market powers, aided by the elasticities estimated by the AIDS model. The empirical results indicate that imported fluid milk owns a significant Lerner index (0.79), but its markup value is much smaller than that of the Chinese domestic competitors. It is possible that the brand loyalty of the consumers promotes the market power of the quality-guaranteed imported products from overseas. However, limited access to imported fluid milk and marginal sales reduce the imported's extra profits. In term of the policy implication, the welfare loss of the Chinese consumers should not be overlooked along with continuous volume increase of the imported. In the long run, the Chinese government should promote a more competitive environment for both domestic and imported competitors within the dairy market.

Keywords: Dairy Industry, Imported fluid milk, China, Market Power

JEL: Q13, L66, L52,

4.1 Introduction

Despite the proportion of dairy products in the Chinese diet structure is keep growing, dairy consumption remains well below the world average, especially in the small cities and towns. The consumers' milk consumption is only 34.1kg per capita, which is less than one-third of the world average (Inouye & Anderson, 2017; Inouye & Ward, 2018). Therefore, there is plenty of potential growth that is untapped, aided by continued population growth and urbanization. In order to meet sheer-size consumption, the dairy industry develops at a very fast speed. China is now the third largest dairy producer in the world, with an estimated 38.7 million tons of dairy products and 15.07 million dairy cows in 2015. Compared with 1.37 million tons in 1980, the production grows almost 30 times at an impressively fast rate (Dairy Association of China, 2015).

The gap between supply and demand is partially fulfilled by overseas suppliers. As an importer in the international dairy market, Chinese demand is considerable and continuously expanding in the scale and scope. From January 2008 to December 2015, the imported dairy products grew from 36.12 to 190.95 thousand tons, with a peak of 247.57 in January 2014 (reported monthly). The import makes its way on the Chinese table in a decade. In 2008, the percentage of imported products in the whole dairy market only accounted for 8%. The number was then growing especially well and remained stable, around 32% in 2015[18](See in Figure 4.1). The trend reflects that imported dairy products, as a brand-new player in the Chinese dairy market, have evolved into a more and more critical and essential role than ever. The

[18]. The volume of the imported dairy product is reported in China Customs (Code: HS0401 – HS0404). The volume of the gross dairy product is reported in China dairy Yearbook.

substantial growth could be attributed to two reasons: first, Chinese consumers are experiencing an expansion in access to the global market and a boosting in income, which enriches consumers' choices. They are willing to pay more for international products from abroad. Second, in the aftermath of the 2008 melamine scandal, the public starts a strong concern on the food safety of the dairy products. Researchers have repeatedly proved that the consumers have a higher trust of the quality of imported dairy products than that of the domestic (Fuller, Beghin, & Rozelle, 2007; Zhou, Tian, & Zhou, 2001).

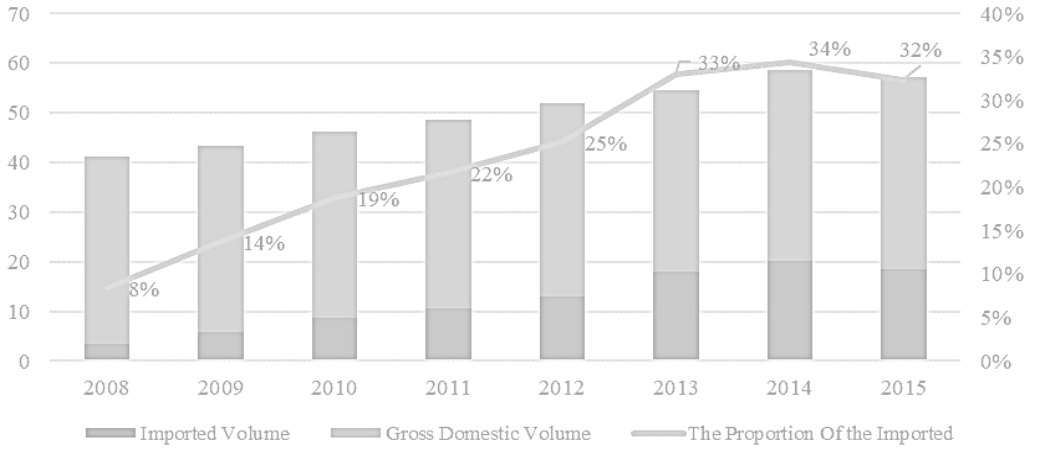

Figure 4. 1 The imported and domestic dairy products in 2008- 2016 (Unit: Million Tons)

Data Source: China Customs; Statistical yearbook of Chinese dairy industry

Since the dairy import scale surges from 2008 onwards and the imported is favored by the Chinese consumers, it renders us suspicious of market power existing in imported dairy products. In this section, we define the market power as the ability of a firm to gain extraordinary rents above those needed to remunerate all the inputs at market price[19], and the

[19]. In this chapter, we restrict our research interest on oligopolistic market power.

formula is $\Phi_i = \frac{P_i - MC_i}{P_i}$ (Aguirregabiria, 2012; Lerner, 1934). Theoretically, if the firm stays in a perfectly competitive market, the market power should be equivalent to zero while prices are fully used to compensate additional input cost. As the market power increase, the price of the product would depart from the marginal cost, and the markup value is generated simultaneously. The research objective of this section is to identify whether the exporters own the ability of pricing when they compete with China domestic brands. Once our hypothesis is valid, it means the exporters could exploit their bargaining power to get a better deal by charging more expensive from Chinese consumers.

Unfortunately, even though imported dairy products serve a large portion of the Chinese dairy market, fewer researches give enough focus on the role of imported milk in the imperfectly competitive market. The literature principally discusses the imperfect competition limited within China domestic firms, while exporters' market power does not heighten the research attention. Two pioneering papers that initially investigate the Chinese dairy market power is Dai (2014) and Guo (2016). Dai (2014) indicates the Chinese dairy market has a strong oligopoly and oligopsony power. Guo (2016) applies DeSouza's approach to proving that large firms have a significant market power while the whole industry stays in a relatively competitive status quo. This argument is in line with the latest research carried by Chen & Yu (2019). They directly use the large dairy processors' data to prove that the top eight firms in the dairy industry all enjoy a significant market power and relatively large markup profits.

The main culprit is that, if the imported product remained as a minor player in the Chinese milk market, the overall impact of it would be dispensable. However, Figure 4.1 shows that from 2008 to 2015, the proportion of the imported to domestic dairy production increased

intensively, then ignoring the magnitude of the imported would lead to an inconsistent analysis. In this chapter, we restrict our research on the imported fluid milk sector that accounts for >30% of the entire dairy import. We find that imported fluid milk only accounts for negligible 0.15% in Jan. 2008. But at the end of 2015, the market share of the imported fluid milk has reached 14.06% (See in Figure 4.2). Therefore, calculating the market power with respect for the imported is more reasonable than just ignoring it.

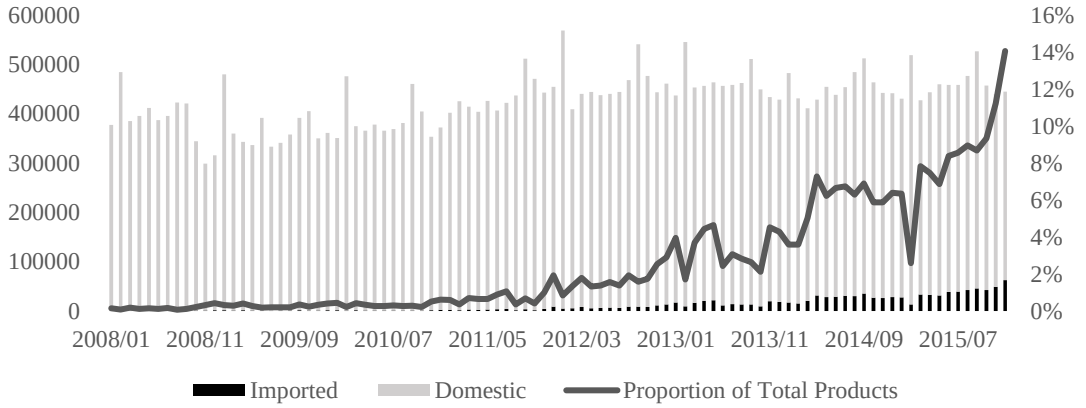

Figure 4. 2 The imported fluid milk volume and proportion of total sale in 2008 – 2016 (Unit: Ton)

Data Source: China Custom; China Wind data; Beijing Mudding Commercial Information Center.

To involve the imported fluid milk products into our analysis framework, we apply the New Empirical Industrial Organization (NEIO) model which is widely used in identifying the market power at both firm-level and industry-level (Bresnahan, 1989; Hyde & Perloff, 1998; Muth & Wohlgenant, 1999). However, as known, one bottleneck is the elasticity we apply in the NEIO model is a usually prejudged, approximate value that is roughly conjectured by the author (Chen & Yu, 2018). It would skew the estimation and jeopardize the conclusion. To minimize the impact of the issue, we employ the AIDS model in the demand side (Hyde & Perloff, 1998), so that the accuracy of the elasticities in our model could be ensured.

In this section, we employ the data of imported fluid milk products monthly reported by the China Customs and combine it with the Chinese domestic milk consumption by brands from January 2008 to December 2015. According to the *2015 China Dairy Yearbook*, the number of fluid milk firms is 638 in 2015, and we are not able to exhaust all the dairy firms in China because of the inaccessibility of all firm data. Therefore, we pick up three representative dairy firms into the AIDS model with a constructed, artificial player who is a compound variable involving the rest in the market. The standards for choosing are the market share of sales and data continuity. The market share of the top 3 brands (Yili, Mengniu, and Guangming) accounts for 61.5% of the liquid milk industry in 2016 (DBC Group Research, 2017), which reasonably ensures the representativeness of the industry.

Our results show the heterogeneity of market power among the brands in the Chinese dairy market. Though the market power widely exists, the Lerner index of the imported (0.79) is much higher than that of the domestic firms (e.g., Yili:0.47, Mengniu: 0.44). The gap might be due to the brand loyalty of the imported as Chinese consumers perceive imported fluid milk is a safer, trustful, and relatively high-quality product. Regarding the markup profit, we interestingly find a contrast result in which the Chinese domestic brand generates a much impressive amount of markup profits in our observation time than that of the imported. The imported fluid milk's extra profits are marginal since its sales and market share is lower. It might result from that (1) Though Chinese consumers have a high willingness to pay for the imported milk, only the high-income consumers might be capable of consuming it. The consumer group is strongly confined by income. (2) Average consumers do not have equal access to imported milk as Chinese domestic brands. Some imported milk products are only available in high-end hotels, special supermarkets, and online shopping stores.

The chapter will proceed as follows. The next section would briefly provide a background on the status quo of the imported dairy products and trade policy. Section 4.3 and 4.4 would introduce the theoretical framework and the empirical model. Section 4.5 is the data description. Section six is the results and conclusion. Finally, we would discuss the policy implements and the limitations of this chapter.

4.2 Competition environment for the imported fluid milk

The imported dairy products are an essential competitor in China dairy market, especially after the eruption of the melamine scandal. One of the eye-catching sectors driving the growth is the fluid milk that is largely ignored by researchers. The growth rate takes off from the beginning of 2012 and is fair high in the past decade. By 2015, the ratio of fluid milk in total imported dairy products had reached 34%. (See in Figure 4.3). We believe the lagged increase of fluid milk might be due to that the adulteration milk scandal stormed the milk powder sector the most rather than the fluid milk sector, but the fluid milk regains its market popularity with the demand of both adults and children as well as better, fresh taste. On the other hand, the international transportation cost is dropping largely in our observation period in terms of fuel price and travel time, making the imported bulk and packed milk more available and accessible to Chinese consumers.

In the perspective of import sources, we can see Germany, New Zealand, and Australia are the top three fluid milk leading exporters to China (See in Figure 4.4). According to the volume reported in 2018 by a Dairy Economic Consulting firm CLAL.IT, Germany and New Zealand own almost the same market share (31% each), while Australia follows by 15% as the third. Most of the major exporters are developed countries from Europe and Oceania. It validates us

to use the New Zealand farm-gate price and US manufacturing sector wage for estimating the marginal cost of the imported in the empirical section.

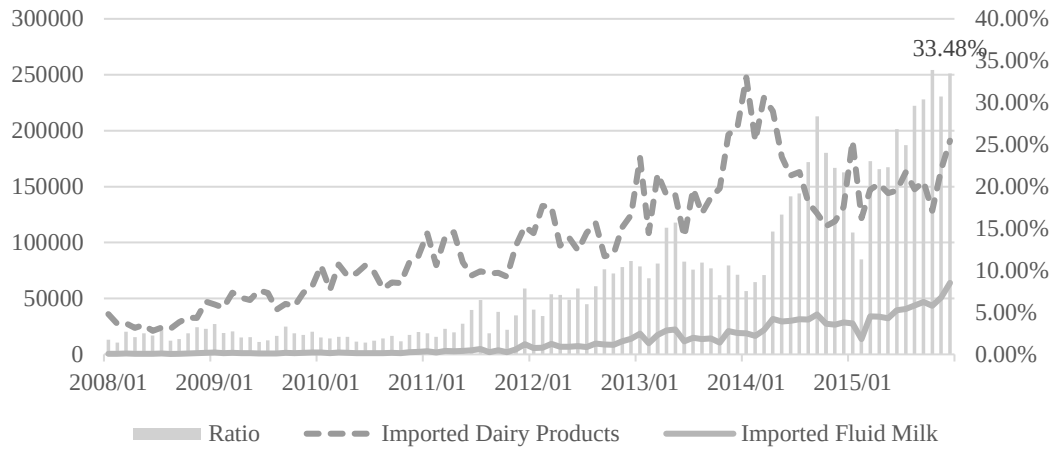

Figure 4. 3 The volume of imported dairy products and fluid milk reported monthly in 2008- 2015 (Unit: Ton)

Data Source: China Customs

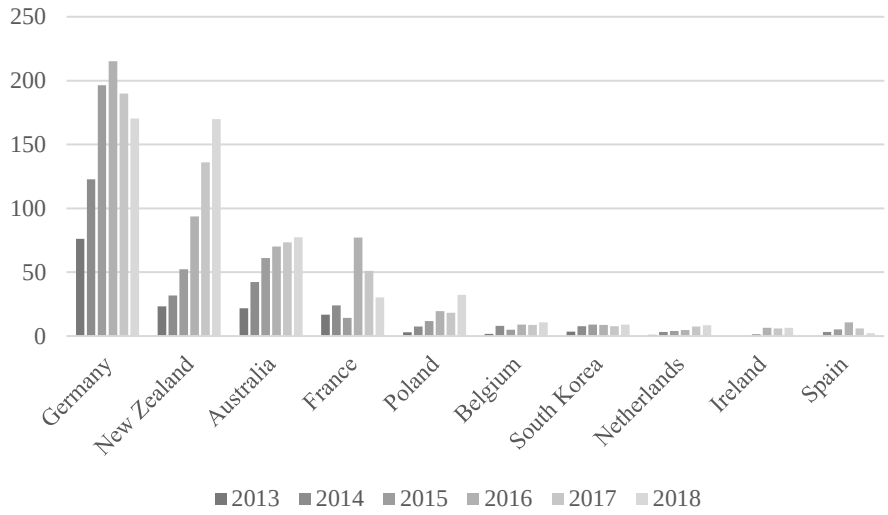

Figure 4. 4 The volume of imported fluid milk products by nations (Unit: Ton)

Data Source: https://www.clal.it/en/?section=stat_cina

[Insert Table 4.1]

One of the issues we need to clarify beforehand is whether the competitive environment between the Chinese domestic brands and the imported fluid milk are at the same level. If not, then their market power might be strongly affected by the institution and policy setting, resulting in an incomparable estimation result. In the chapter, we argue that the market barrier is moderate for the imported brand, and its position would be continued critical and competitiveness in China dairy industry. The reasons could be attributed to three parts:

Firstly, the dairy tariff rate is relatively modest in general, and the Free Trade Agreement (FTA) is applied to the major dairy exporters. China becomes a member of WTO since December 11th, 2001. Before that, the average tariff of imported fluid milk is 25%. According to the latest report from the WTO tariff profile, the tariff has dropped to 15% in 2017 (World trade organization, 2019). Moreover, according to *the Free Trade Agreement between the Government of the People's Republic of China and the Government of New Zealand*, China gradually exempts imported dairy products tariff of the largest dairy exporter since 2008 (13.5%) until free duty in 2019 (0%). Also, a similar agreement is signed between China and Australia after 2015. These preferential policies, aided by currently low international milk price, provide a market-friendly environment for the exporters who are engaging in the Chinese dairy market. The imported price can keep at a low-level without being dragged down by the burden tariff too much, while the domestic market faces few trade protections so that the abroad rivals could get relatively same treatments under the FTA framework.

Secondly, the orientation of relying on imported dairy products is officially supported by the China government, since dairy production is a resource-intensive industry. For instance, according to the estimation by Khan (2010), about 2.5 and 8.5 million liters of water is required to sustain the pasture growth and other operations per cow per year, given the average output

is 5231 liters of milk per cow in Australia. China produced 37.54-million-ton milk in 2015, indicating around 17.4 to 59.3 billion tons of water is consumed to maintain the production volume.[20] In 2015, China utilized 610.3 billion ton of water totally, meaning dairy industry accounts for roughly 3% to 10 % of it. A large amount of water consumed is eventually transformed to be heavy pressure on environmental sustainability. A consensus is reached that importing dairy products is equivalent to importing land, labor, water, and other resources from overseas. Considering notorious environmental issues undergoing in nowadays China, we believe the imported, as a practical alternative, would alleviate the burden of environmental protection and contribute resource-saving.

Thirdly, the melamine adulteration milk scandal jeopardizes Chinese consumers' trust to domestic dairy brands, while both the government and the public have a strong request for safe dairy products. The research of Wang (2008) indicates the consumers would like to pay 0.54 Yuan/liter premium for an extra food safety certification (HACCP)[21]. The shadow of the scandal lasts after ten years, and the plummeted confidence still does not find its way back. Consequently, food safety concerns become one of the major drives to the changes in purchase pattern. Chinese consumers are more receptive to imported dairy products where milk is believed to be more hygiene and free of illegal feed additives. Related research done by Yan (2014) indicates consumers in Shanghai would pay 16.54% premium on the safe, imported

[20]. The estimation might be underestimated. According to the FAPRI-ISU 2011 World Agricultural Outlook issued by Iowa State University, only 2458-kilogram milk could be produced per cow in China. Considering the water utilization inefficiency, the water consumption could be higher than the amount provided.

[21]. In the original paper, the proxy of the food safety certification is Hazard Analysis Critical Control Point (HACCP).

cheese. In all, the imported dairy products would stay popular under a higher food safety appeal from the Chinese government and the public.

4.3 Theoretical framework

The research objective is to investigate the competitiveness in a unified market with both the imported and domestic dairy brands. In order to measure the degree of competitiveness[22], economists normally estimate it by means of market power and Lerner index (Elzinga & Mills, 2011; Lerner, 1934). The first approach that is traditionally employed in estimating the competitiveness is the structure-conduct-performance paradigm (SCPP) brought up by Mason (1939). The principle idea is to build up a regression model on the Lerner index and the measure of market structure (e.g., Herfindahl-Hirschman Index, or the market share of the top firms) (Bain, 1951; Perloff, Karp, & Golan, 2007). By the hypothesis of the SCPP, the oligopolistic market power would reduce in along with the increasing number of firms in the industry. However, this approach has been criticized by subjectively assuming the market structure is predetermined and orthogonal with the sellers/buyers conducts, leading to a biased, inconsistent estimate result. To overcome the weaknesses of the SCPP model, subsequent research studying the static model evolves to three types respectively: 1) nonparametric model 2) Solow-residual based model (SRB), and 3) new empirical industrial organization model (NEIO).

However, the nonparametric model fails to estimate the degree of market power since the null hypothesis is that market stays perfectly competitive (Ashenfelter & Sullivan, 1987;

[22]. In contrast to legal discussions, we use the terms “market power” and “competitiveness” interchangeably.

Perloff et al., 2007; Raper, Love, & Shumway, 2007). The characteristic limits its application for the policymakers and the industry since the nonparametric model could not provide a quantitative analysis of the welfare loss and markup profits calculation. As another alternative, the SRB model is widely used in previous literature (Dai & Wang, 2014; Hall, 1988; Raper et al., 2007; Roeger, 1995). Basically, it decomposes output growth into input factor growth, productivity shock, and the exercise of market power. To be noted, as Paquet & Robidoux (1997) points out, the interpretation of residual growth could be exogeneity of productivity shock, degree of increasing returns to scale, or idiosyncratic market power. Thus, we could not empirically distinguish market power value in the residual from the rest factors. Due to the concerns on the approaches mentioned above, it has become a common practice to estimate the market power with NEIO. The basic idea could be revealed in the following theoretical models.

One of the challenges is the perceived difficulty of incorporating the information of the imported in our analysis framework. To solve this issue, we take a detour to treat all the imported dairy products as one, representative, compound player. The model we applied here is brought up by Hyde & Perloff (1998). Compared with the classic NEIO model, the Hyde and Perloff model approaches a more accurate estimation by calculating the elasticity through an AIDS estimation rather than conjecture elasticity (Deaton & Muellbauer, 1980). The method imposes adding up, symmetry, and homogeneity properties so as to be in line with economic theory.

We start with the profit function of brand i, where y_i is the output of brand i, $p_i(y)$ is the corresponding price, and $C_i(y_i)$ is the cost function of the brand i.

$$\pi_i = p_i(y)y_i - C_i(y_i)$$

(1)

We assume all the dairy brands here are rational and attempt to maximize the profit by adjusting their output, and then we could derive the first-order condition (FOC) through the chain rule here,

$$\frac{\partial \pi_i}{\partial y_i} = p_i + \frac{\partial p_i}{\partial y}\frac{\partial y}{\partial y_i}y_i - \frac{\partial C_i(y_i)}{\partial y_i} = 0$$

(2)

From Equation (2), we could find differences between perfectly competitive and imperfectly competitive market. The fundamental precept of the former market is each seller is a price-taker, and the equilibrium price is independent and exogenous. This assumption is overturned in an imperfectly market by assuming the price of each product is influenced by the output of the brand i.

For simplicity, we further define the marginal cost of player i is

$$mc_i = \frac{\partial C_i(y_i)}{\partial y_i}$$

(3)

And we rewrite the Equation (2) by replacing the last term with marginal cost formula,

$$p_i + p_i \cdot \frac{\partial p_i}{\partial y}\frac{y}{p_i} \cdot \frac{\partial y}{\partial y_i}\frac{y_i}{y} = mc_i(y_i)$$

(4)

Simply rearranging the Equation (4) by moving marginal cost towards LHS, we could find that the Lerner index for each brand could be introduced by two parts: (1) market power indicator (Λ_i) and (2) the absolute value of demand elasticity (e_i).

$$\frac{p_i - mc_i(y_i)}{p_i} = -\frac{\Lambda_i}{e_i} \quad (5)$$

Where $\Lambda_i \equiv \frac{\partial y}{\partial y_i}\frac{y_i}{y}$, and $e_i \equiv \frac{\partial y}{\partial p_i}\frac{p_i}{y}$. Here, we follow the argument brought up by Hyde & Perloff (1998), the Λ_i should not be interpreted as a conjecture variation[23], but, together with the elasticity as a whole, is used to measure the gap between price and marginal cost. The gap is created by some unknown game that we could not verify and determine. Economically, If the RHS of Equation (5) approaches to zero, the market tends to be a perfectly competitive market in which price p_i equals to marginal cost $mc_i(y_i)$, while the if RHS of Equation (5) gets larger, it indicates that the deviation of p_i from $mc_i(y_i)$, and the player owns market power instead. It should be noted that, since the Lerner index $\in [0,1)$, the market power indicator Λ_i must be larger than the absolute value of the demand elasticity e_i in accordance with the economic sense.

For the convenience of the empirical model, we could write the concise formula as follows instead,

$$p_i = mc_i(y_i)\left(1 + \frac{\Lambda_i}{e_i}\right)^{-1}$$

[23]. According to Bresnahan (1981), the conjectural variation parameter characterize how the brand react when its rivals respond to a change in its own output. It could be mathematically defined as $\omega = dQ_{-i}/dq_i$, where q_i is brand i's output and Q_{-i} is the aggregated output of the brand i's rivals.

(6)

4.4 Empirical structural model

4.4.1 Almost ideal demand system

We start with the estimation of the demand elasticity e_i in Equation (6). A key reason why the NEIO approach being criticized of estimating market power is the difficulty of obtaining reliable measures of the demand elasticity. In this chapter, we could calculate the elasticity e_i with an AIDS model to complete the optimality condition. In some pioneering research, the researchers apply a conjectured elasticity (Chen & Yu, 2018), which is based on a simple linear regression model. The result could be problematic, since the elasticity would be inconsistent without imposing homogeneity and symmetry restraints. Thence, we improve the estimation of the demand elasticity by an AIDS model (Deaton & Muellbauer, 1980; Green & Alston, 1991; Hyde & Perloff, 1998). We set up the model as follows,

$$s_i = \alpha_i + \sum_{j=1}^{n} r_{ij} \ln p_j + \beta_i \ln\left(\frac{X}{\boldsymbol{P}}\right)$$

(7)

Where the budget share allocated to the brand i is $s_i = p_i y_i / X$, and p_i and y_i are the price and quantities of brand i respectively. X is the total market revenue on all the fluid milks being analyzed, and $\boldsymbol{P}$ is the price index that is defined as

$$ln\boldsymbol{P} = \alpha_0 + \sum_i \alpha_i \ln p_i + \frac{1}{2}\sum_i \sum_j r_{ij} \ln p_i \ln p_j$$

(8)

Here we argue that the estimation model should fit the adding-up, homogeneity, and symmetry restrictions.

$$\sum_i \alpha_i = 1, \quad \sum_i \beta_i = 0, \quad \sum_i r_{ij} = 0, \quad r_{ij} = r_{ji}$$

(9)

As mentioned in Green & Alston paper (1991), the quadratic model often leads to computational difficulties, and our time-series data sample would even worsen the situation. Thus, we apply the LA/AIDS model that employs the Stone's index. Then Equation (8) is rewritten as follows,

$$\ln \boldsymbol{P} = \sum_i s_i \ln p_i$$

(10)

And we could drive from the AIDS model and calculate the uncompensated price elasticity that is equivalent to

$$e_i = -1 + \frac{r_{ii}}{s_i} - \beta_i$$

(11)

4.4.2 Cost function estimation

Next, to estimate the equilibrium Equation (6) with an empirical model, we should conduct the cost function specification - $c_i(y_i)$. We assume the total cost function should follow the quadratic form and monotonically increase and convex with positive quantities. Therefore, the cost function and marginal cost function could both slope up (Bresnahan, 1981). Since the

production technology of the fluid milk industry is homogenous (Chen & Yu, 2019), we further assume all the dairy firms share the same marginal cost curve.

We start the cost function of brand i with the homogeneity condition

$$\frac{C_{it}}{w_{1it}} = C(1, \frac{w_{2it}}{w_{1it}}, \frac{w_{3it}}{w_{1it}}, y_{it})$$

(12)

Where w_{1it} is soybean price that is used to represent fodder input, w_{2it} is raw milk price, w_{3it} is the wage that is used to represent labor input price, and y_{it} is the output of brand i at t period. Assuming the marginal cost is linear with input price and output, we specify the marginal cost as

$$\frac{mc_{it}}{w_{1it}} = \beta_0 + \beta_1 \frac{w_{2it}}{w_{1it}} + \beta_2 \frac{w_{3it}}{w_{1it}} + \beta_3 y_{it}$$

(13)

In order to comply with the marginal cost used in Equation (6), we should multiply the w_{1it} by both sides and generate the original specification of the mc_{it},

$$mc_{it} = \beta_0 w_{1it} + \beta_1 w_{2it} + \beta_2 w_{3it} + \beta_3 y_{it} \cdot w_{1it}$$

(14)

4.4.3 Optimality condition

Replacing the RHS of Equation (6) with the marginal cost specification fully expressed in Equation (14), we construct the optimality as follows,

$$p_{it} = (\beta_0 w_{1it} + \beta_1 w_{2it} + \beta_2 w_{3it} + \beta_3 y_{it} \cdot w_{1it}) \left(1 + \frac{\Lambda_i}{e_i}\right)^{-1}$$

(15)

In the empirical model, the model is estimated with time trend, constant, and the error term.

$$p_{it} = (\alpha_0 + \beta_0 w_{1it} + \beta_1 w_{2it} + \beta_2 w_{3it} + \beta_3 y_{it} \cdot w_{1it} + \beta_4 t)\left(1 + \frac{\Lambda_i}{e_i}\right)^{-1} + \varepsilon_{it}$$

(16)

Where α_0 is constant, t is year, and ε_i is the error term for brand i at t period.

4.5 Data

The section describes the data used in this article, both the source and content. Here, we focus on the fluid milk sector. To start with the AIDS model, the imported fluid milk volume we employ here is reported monthly by the China Customs in the observation period from January 2008 to December 2015. According to statistical standards issued by *Statistical Yearbook of Chinese Dairy Industry*, the imported volume variable is defined as the sum of the bulk and packed milk (HS0401)[24]. Ninety-six observations are involved in our sample. The corresponding domestic fluid milk sales are collected by Beijing Mudding Commercial Information Center, a data mining and statistical analysis company in China. Since hundreds of domestic brands exist in the Chinese dairy market, we could not involve all of them in our AIDS model. Thence, we pick up the top three brands based on sales rank and time continuity, and then we compress all the rest as one artificial player and insert it in our AIDS model.

For price information, the average price of the imported fluid milk is collected and filed by the Wind database, one of the Chinese largest data service companies. It should be noted that both the sale value and price reported by the China Customs are dollar-based. We recalculate

[24]. HS0401: Milk and Cream; not concentrate, not containing added sugar or sweetening matter.

them into Yuan (RMB) by multiplying the sale value with the corresponding currency rate. We admit there are many different sources and quality variation of fluid milk. For this article, we use only the total imported volume and average price without considering the distinctions between sources of the imported milk. Also, the prices of the domestic brands are presented from the Beijing Mudding Commercial Information Center. It collects price information of different varieties and aggregates the raw data into the brand level. With these settings, we assume all sale costs are internalized and fixed to avoid the impact of the downstream supermarket. It is realistic in the Chinese dairy market. Thus, the Lerner index applies to the brand, not the manufacturing firms per se (Chen & Yu, 2019). The prices used in this paper are deflated by the CPI provided by the National Statistics Bureau of China (NSBC).

To estimate the optimality Equation (16), we also need to consider the factor input in the cost function. In dairy processors, two major input factors are farm-gate raw milk and labor. Unfortunately, we do not have specific information for each brand. Therefore, we resort to using the proxy data at the provincial level where the headquarter of the brand is located. We implicitly assume there is a high correlation between input cost change of the individual brands and the wages and farm-gate milk elsewhere in the headquarter-located province. The price of the farm-gate milk in our observation period is extracted from the Hai Tong Security, while the average wage, the price of the labor input, is taken from NSBC. Because only quarterly information is accessible for the wage, we divide it by the number of months to get time-series data following other variables in the model. All the information is compiled by the CPI provided by NSBC. One of the challenges is labor price and raw milk price of the imported. Since the imported brand is regarded as one, compound competitor, we use the proxy input factor prices to solve the marginal cost estimation problem. For the farm-gate raw milk price,

we employ the New Zealand price provided by CLAL, an Italian dairy economic consulting firm. For the labor cost of the imported, we alternatively use the seasonally adjusted wage of the manufacturing sector that reported monthly by the U.S. Bureau of Labor Statistics. Unfortunately, the monthly wage is not available reported by the EU zone and Oceanian countries, leading us to employ the American wage instead as a substitute. Likewise, the raw milk price data is in Euro, while wage data is in US dollar. We convert them to Yuan by corresponding currency rate.

4.6 Results

We use nonlinear seemingly unrelated equation (Gallant, 1975) to estimate the optimality condition, aided by the elasticities obtained from the AIDS model. The estimation results of demand elasticities are presented in Table C.2, and market power indicators Λ_i are presented in Table C.3. To calculate the Lerner index and markup value, we match each brand's market power indicator results with the elasticity at means respectively, listing the result in Table C.4. In this article, we find that though the market power widely exists, the Lerner index of the imported (0.79) is much higher than that of the Chinese domestic firms. However, in terms of the markup value, the imported markup is marginal since the sale is not as comparable as that of the Chinese domestic brands.

[Insert Table C.2 & C.3 & C.4]

4.6.1 Market power indicator and Lerner Index estimation

To estimate the parameters Λ_i in Equation (16), we choose the nonlinear seemingly unrelated regression approach (NLSUR) to simultaneously estimate the optimal condition of each brand,

in that the corresponding error term of each period might be correlated as all the brands receive the same market shock in one single dairy market. The estimation results of the market power indicator are reported in Table C.3.

The results indicate all the brands here in our estimation model have a significant market power indicator at 1% level. The domestic brands, Yili, Mengniu, and Guangming, have a relatively smaller value than that of the imported. It means the whole industry output would respond to the imported supply shock much more active than that of the domestic brands according to the defintion of Λ_i in Equation (5), where $\Lambda_i \equiv \frac{\partial y}{\partial y_i}\frac{y_i}{y}$. One possible explaination is that each Chinese demostic brand dominates its own regional market, such as the Guangming is continually cultivate its own customer group in the south-eastern China. Other competitiors may be inertia to the output change of the brand since the impact of quantities variation are normally absorbed within its own market segreation. However, the inflenece of the imported milk products is rather national, leading the Chinese domestic brands to earnestly increase their output or reduce their price to block or defend their market share. Therefore, the whole industry is much responsive to the volume change of the imported fluid milk.

Furthermore, the following Lerner index results are shown in Table C.4. The Lerner index is designed to indicate the deviation of the price from the marginal cost. If the players are staying in a perfectly competitive market, the Lerner index is zero, since the price would be equivalent to the marginal cost for each brand. However, when the brands have the market power of setting up the price by themselves, the price would be higher than the marginal cost for markup value. By the economic theory, the domain of the Lerner Index should be [0,1). In

our case, we could find that the largest dairy processor, Yili, owns a visually high Lerner index (0.47) in our estimation. It means that around half of the price can be assigned for the advantaged competition position, rather than leading productivity. Of our particular interest, the imported fluid milk' Lerner index is relatively higher (0.79). It could be attributed to the brand loyalty of the Chinese consumers on the imported brand since they hold stronger trust in the imported quality and have a high willingness to pay for the imported.

Next, we calculate the markup profits so as to understand the Lerner index at the economic level better. There is a very interesting, substantial gap between the domestic brands and the imported. The difference is due to the sale of the imported is not at the same level as those of the domestic brands. The sheer-sized sales contribute the domestic brands to grab more extra profits from each product. With the utilization of market power, the domestic brands have a strong intention to occupy a larger market share. By contrast, imported milk might be an auxiliary selection restricted in the upper class. The number of customers who are affordable to the expensive imported milk on their table is marginal, so the consumption is much lower. Besides, the inaccessibility of imported milk is another reason that drags down the markup profits. For example, some imported milk products are only available in high-end hotels, special supermarkets, and online shopping stores, while average consumers do not have easy access to imported milk. Again, the result proves the point that market power is essentially an important concept in the food industry. In the context of sheer-size consumption, even a very much small departure of price from the marginal cost could result in impressive markup profits and welfare loss (Rogers & Sexton, 1994; Sexton, 2013).

In all, the imported fluid milk has strong market power in China, but the markup profit is under control since its marginal sales. The result is in line with our previous research on the

fluid milk sector (Chen & Yu, 2019), which further confirms our estimation is robust and consistent.

4.6.2 AIDS model estimation

We now discuss the estimated elasticities of the dairy industry brands from the AIDS model. The results are presented in Table C.2. It is to be noted that the AIDS elasticities we estimate here are different from the conventional approach of estimating every single equation separately, since AIDS model assumes the brands would be more related to their market share changes within the fluid milk industry rather than the change of supply (Syriopoulos & Sinclair, 1993). To obtain a result that is consistent with the economic theory, we impose the adding-up, homogeneity, and symmetry restrictions in our estimation model.

As we could discover from Table C.2, the elasticities of the domestic brands (Yili, Mengniu, and Guangming) are smaller than that of the import fluid milk products (-3.679). The result is coordinated with the previous discussion in which Chinese consumers have a higher willingness-to-pay for the imported. They might accept the imported fluid milk as high-end alternative products, and the consumption of this type of goods usually is more sensitive to price. Thus, consumers could easily substitute it with other cheaper domestic alternatives. However, the consumer group of the Chinese domestic brands might not as free choices as the imported milk consumers, and they are relatively inelastic to the price variation of the products.

4.6.3 Other covariates estimation

In this subsection, we focus on the rest of the optimality estimation in Table C.3. We find the input factors affect the market price as expected. Again here, we assume all the firms conduct

the same marginal cost curve. The parameters are the same for each firm's output and input factor prices concerning the degree of impact. Both soybean and raw milk price are positive and significant at the 1% or 5% level, indicating the price will grow up simultaneously as the marginal cost increases. For the output interaction, we can see the output change would bring out an opposite movement of the price variation. Since the fluid milk is a normal good, the result is in line with the common reality. The coefficient of wage is negative, but the value is small and very close to zero. Therefore, we think it would not jeopardize the find conclusion.

4.7 Conclusion

Since 2008, China starts to import more fluid milk from abroad. Until the end of 2015, the market share of the imported reaches 14%. It shows that imported fluid milk has become an essential player in the Chinese dairy market. The growth is probably driven by the high safety trust of the imported from Chinese customers and relatively friendly trade policy from the Chinese government.

However, literature has not given enough attention to the imported in the Chinese dairy industry. In this chapter, we employ a structural model and imported data to test whether the imported fluid milk competitors have market power. Our results indicate that imported milk has a significant market power and Lerner index. It might be rooted in the brand loyalty of the consumers on the quality- guaranteed imported products. However, compared with the domestic players, the markup profits generated are marginal. The result depends partially on the limited sales and inconvenient purchasing path. One such implication arising from our findings is that the market power of the imported fluid milk indeed exists, even though the markup profits are limited-size. But along with the continued growth in the future, the Chinese

government should not overlook the long-run effect. The government should promote a more competitive industry environment for both domestic and imported competitors in the Chinese dairy market.

Two limitations should be listed at the end of the chapter. First, the elasticities are computed over a one-period horizon, and it is reasonable to assume one might have different elasticities over longer time horizons. Second, the imported proxy we apply in our chapter is a compound, artificial player that aggregates all the import suppliers as a whole. It would ignore the heterogeneity among the top exporters, and put restraints on the final policy implication.

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Appendix C

Table C. 1 The tariffs of imported dairy products by items in 2000-2015

Year	Fresh Milk	Milk Powder	Butter	Cheese and curd
2000	25	25	50	50
2001	25	25	50	50
2002	21	20	36.7	34.8
2003	18	15.67	27.8	23.4
2004	15	10	10	23.4
2005	15	10	10	12
2006	15	10	10	12
2007	15	10	10	12
2008	15	10	10	12
2009	15	10	10	12
2010	15	10	10	12
2011	15	10	10	12
2012	15	10	10	12
2013	10	10	10	12
2014	15	15	10	12.6
2015	15	15	10	12.6
2017	15	15	10	12.6

Data source: 2000-2013 http://www.fapri.iastate.edu/;

2014-2015 http://tariffdata.wto.org/ReportersAndProducts.aspx

Table C. 2 Estimation results of the Almost Ideal Demand System (Homogeneity and Symmetric)

Group	i	Estimated Coefficients							
		α_i	β_i	γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	γ_{i5}	Own-price Elasticity
Yili	(1)	-0.00035	0.0219	0.0351	-0.0977*	0.0293	0.0634	-0.0302***	-0.873
		(0.175)	(0.0138)	(0.0524)	(0.0556)	(0.0246)	(0.0398)	(0.0111)	
Mengniu	(2)	0.168	0.0194		0.300***	-0.277***	-0.0322	0.107***	-0.254
		(0.277)	-0.0219)		(0.0972)	(0.0318)	(0.067)	(0.0192)	
Guangming	(3)	-0.329***	0.0341***			0.0576***	0.139***	0.0515***	-0.012
		(0.127)	(0.00992)			(0.0219)	(0.0289)	(0.00953)	
Others	(4)	0.826***	-0.0483***				-0.0941	-0.0760***	-1.220
		(0.206)	(0.0163)				(0.0627)	(0.0145)	
Import	(5)	0.336***	-0.0270***					-0.0527***	-3.679
		(0.112)	(0.00872)					(0.00844)	

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table C. 3 Summary of the optimality condition estimation

Variable	Coefficient/Asymptotic Standard Error
Constant	0.399***
	(0.111)
Raw Milk	0.0822***
	(0.017)
Wage	-6.75e-05***
	(1.23E-05)
Soybean	0.0309*
	(0.0181)
Output * Soybean	-2.16e-07***
	(7.01E-08)
Year	-0.0507***
	(0.0107)
	Market Power Indicator
Yili	0.413***
	(0.0517)
Mengniu	0.111***
	(0.00834)
Guangming	0.00558***
	(0.00147)
Other Domestic Brands	0.470***
	(0.092
Imported	2.924***
	(0.0763)
Observation	96

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C. 4 The Lerner Index and supernormal profits of the dairy competitors in China (Unit: 10 thousand Yuan)

	Market Power Index	Elasticity	Lerner Index	Supernormal profit
Yili	0.413	-0.873	0.47	6266612.88
Mengniu	0.111	-0.254	0.44	7930287.22
Guangming	0.006	-0.012	0.47	1564459.34
Other	0.470	-1.220	0.39	30850.18
Import	2.924	-3.679	0.79	1872.20

Note: (1) Supernormal profits are calculated with deflated sale values based on CPI in Jan.2008.

(2) The unit of supernormal profits listed is 10 thousand Yuan.

Chapter 5 General conclusion

5.1 Conclusions from empirical studies

During the past decades, China has experienced a continuous consolidation of the argi-food system. The movement is intensified with higher food safety standards and new technology enforcement. Obviously, industrial policy interventions play an important role in this process. To better understand the impact of agri-food policies on competitiveness in an empirical scope, we employ the structural models to estimate market powers and extra profits for both fluid milk and pork slaughtering industry. The second chapter focuses on the hog slaughtering firms at the industry level. We attempt to answer whether the Centralized slaughtering policy increases the market power in the pork industry. In the third chapter, we move our research into Chinese dairy fluid milk. We aim to understand how industrial subsidies affect the competition degree at the firm level through directly estimating the marginal cost and Lerner Index instead. The last paper is the following research on the market power of the fluid milk industry involving imported players in our framework. The objective of this dissertation is to discuss how the industrial policies cause a departure from a perfectly competitive market and what the loss is.

In terms of the research scope, we investigate the market power under various contexts of market type. The second chapter concerns on homogeneous products from which the consumers do not distinguish brands from each other very much. The third chapter is down to the firm level and applies the accounting data to catch the heterogeneity of the products. The

fourth chapter extends our research in a more integrated market where both domestic and imported players compete.

In terms of the policy intervening, we divide the industrial policy into two categories: (1) industrial regulations and (2) industrial support policies. These two types of policies are usually perceived to have opposite impacts on firm activities and industry growth. To understand the interaction between the market power and the industrial policies, we need to narrow down our research scope into very specific intervening tools. Thence, for the former one we pick up the Centralized slaughtering policy as a representative, and for the latter one, we choose the subsidies instead.

In chapter two, we find the oligopsonistic market power indicator of the slaughtering industry is 0.0593 and statistically significant, which generates 1.85 billion Yuan markup value just in 2016 and 13.65 billion Yuan from 2008 and 2016. The market power is possibly due to (1) the CSP causing high barriers of entry; and (2) squeezing out small-size incumbents leads to a high concentration ratio.

In chapter three, we observe the Chinese government increased subsidies intensively on the dairy market in our observation period, with a goal of updating production facilities and meeting stringent quality standards. However, our empirical results indicate that subsidies have a significant negative impact on market power for privately-owned listed dairy firms, while no significant effect for the state-controlled firm. 1% increase in subsidies could reduce 0.051 in the Lerner index for the private-owned. One possible reason is that top firms might intend to produce more by the subsidies from the governments. In turn, the listed dairy firms then use

the subsidies money to exert a low-price strategy. It would eventually result in a reduction of market power and benefit the consumers eventually.

In chapter four, we identify that imported fluid milk has become a strong competitor in the Chinese market. Thence, we use a structural model to detect its oligopolistic market power. Our result shows that though the market power widely exists, the Lerner index of the imported (0.79) is much higher than that of the domestic firms (e.g., Yili:0.47, Mengniu: 0.44). The gap might be due to the brand loyalty of the imported as Chinese consumers perceive imported fluid milk is a safer, trustful, and relatively high-quality product. Regarding the markup profit, we interestingly find a contrast result in which the Chinese domestic brand generates a much impressive amount of markup profits in our observation time than that of the imported. The imported fluid milk's extra profits are marginal since its sales and market share is lower. It might result from that (1) Though Chinese consumers have a high willingness to pay for the imported milk, only the high-income consumers might be capable of consuming it. The consumer group is strongly confined by income; (2) Average consumers do not have equal access to the imported milk as to Chinese domestic brands. Some imported milk products are only available in high-end hotels, special supermarkets, and online shopping stores.

5.2 Policy implication

5.2.1 General implication

We observe the imbalance of power in today's Chinese agricultural sector. We believe the undergoing market transformation, if we turn a blind eye on it, would jeopardize the original design of our policy implements. Some special tools that the government has executed via regulations or industrial support plans seem not to be effective especially well these days either.

Reasons are probably several, including market power might have important redistributive consequence. The regulation policy is perhaps one of the best examples to explain it. Unless the counterpart sector has strong enough bargaining power, the oligopolistic/oligopsonistic firms could alter the cost burden to the upstream or downstream partners. Or in the subsidies case, marketing intermediaries may be able to capture policy rents intended for farmers/consumers. It would eventually distance the policy implements from the designed goals. In other words, the policymakers should recognize the link between these vertical stages matter, and policies will affect the competitiveness of the food chain as a whole.

Also, policies could become the new barrier for the exit and entry decision. In the traditional competitive market analysis, we usually measure the policy impacts without considering the entry or exit decisions too much. Because each atomistic, independent market participant might not own strong enough power to take advantage of the industrial policies. But nowadays, barriers to entry and exit are regarded as an important structural characteristic of the agri-food system. Some are explicit such as the economics of scales or food safety control, and some are implicit such as goodwill, reputation, or brand loyalty. We observe that some agricultural intermediaries execute the policy (e.g., sanitary standards) to deter potential competitors. Therefore, we argue that the government should avoid the strategic actions taken by incumbent firms of utilizing the agricultural and food policies to hold their market power. This issue could be more severe if we include our research scope with the competition between the domestic firms and international exporters.

Last but not least, in setting of where market power matters less or imperfectly competition is not an issue, the competitors or the policymakers might not have strong motivations to perform the product strategies or operating strategies such as advertising, R&D investment,

mergers, etc. These improvements would generate very marginal effects on the final outputs in the perfectly competitive setting. However, agricultural market throughout China is undergoing a rather dramatic consolidation. If agricultural policy could acknowledge the positive sides of these non-price strategies and promote the firms invest more funds into quality improvement and differentiated products, it would eventually expand and update the whole industry output and consumption instead of attacking other competitors with respect to market share.

In all, more inclusive and scientific industrial policies should be planed and stipulated in the context of concentrated market share, growing market power, and less competitive market. The government tools should guide the agri-food system towards production differentiation, food safety, and competitiveness, rather than empower the incumbents holding more privileged rights or oligopolistic/oligopsonistic powers.

5.2.2 Policy implication for each chapter

The results of this dissertation are relevant to future decisions. From the policy perspective, chapter two indicates the Chinese government made efforts to consolidate the slaughtering industry and reduce the number of existing small firms. This policy reduces regulation costs for food safety and quality control. But it also generates low efficiency and welfare transfer and loss due to the creation of market power. The high barriers induce incumbent slaughtering firms to get markup profits from upstream hog farms. Therefore, the Chinese government should give more attention to hog producers since they stay in a disadvantaged position within the pork supply chain.

Chapter three verifies the positive impact of subsidies on the final competition degree, but the implications of subsidies should be divided into long-term and short-term, respectively. In the near term, subsidies promote the dairy processors to have a larger production or execute a low- price strategy. But there is still a potential risk that the low-price strategy (advanced by the subsidies support) would squeeze out small competitors and create a less competitive market in the long term. Therefore, the competitiveness of the fluid milk industry should be kept under constant surveillance.

Chapter four demonstrates the market power of imported fluid milk products, but considering the limited sales value, the extra profits of the imported are modest. However, we observe the imported volume is growing sharply along with time, and the supernormal profits would increase correspondingly. To minimize the impact of imperfect competition, the Chinese government should promote a more competitive environment for both domestic and imported competitors such as dispersing the exporters or applying the tariff more equally and homogeneously.

5.3 Limitations and future research

Rather than concluding the dissertation with a summary of the main points, I propose to highlight the limitations for a future research agenda. Both topics and methodological issues are raised.

(1) Cost function estimation. It is a consensus that cost information is extremely hard, if not impossible, to obtain. In our research, we resort to using the proxy data at the provincial level, where the headquarter of the firm is located. Data quality and accuracy could be reasonably

improved if we could access to the corresponding cost information from our sampled firms directly.

(2) Heterogeneity of the import competitors. To estimate the market power of the import, we employ a constructed, artificial player who is an aggregated variable involving all the imported. It might lose the heterogeneity information within the exporter countries and brands. With more specific data, we could obtain more consistent estimation results.

(3) We should admit the existence of the market power is more like a by-product of the industry updated process. Along with stricter food safety standards or new technology enforcement, the entry and exit barrier would increase naturally. For instance, the players need invest more sunk costs to operate their business. In the future, policymakers should delicately weigh the multiple goals of their interventions. They might need to decide the give-and-take between food safety regulation, competitive productivity, and competition.

Absolutely, there would be a few topics on market power we could explore in the next. For instance, (1) the non-price decisions' impacts on the market power of firms such as advertising, R&D investment, product differentiations, etc., (2) measures the exporters' market power at the country level, and (3) regional monopoly issues.