

## Chapter 2 Pork Price and Mixed Oligopoly Market, Firm's Behavior -Data and Theoretical Analysis-

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## **Chapter 2**

### **Pork price and Mixed Oligopoly Market, Corporate Behavior**

#### **- Data and Theoretical Analysis -**

#### **1. Outline of the Hog Slaughtering and Processing Industry**

##### **1.1 Industrial Organization and Pricing by Firms**

Increases in pork prices are generally brought about by a shortage of hog production, but prices are not set uniformly all over the nation by one entity. Pork is produced by the hog slaughtering and processing industry and it is firms in this industry who set the market prices of pork. These firms are operating in a market where there exist several types of competition. In order to understand the firms' pricing strategy, it is very useful to employ techniques of industrial organization theory to analyze market outcomes such as price or quantity.

Pricing strategy is a key part of a firm's decision making and is strongly influenced by the competition environment. If all suppliers are small and have no room for exercising bargaining power, firms are faced with an identical price level. If competition is oligopolistic, price is set by the supplier and in a strategic way. In theory, an efficient industrial organization can supply sufficient volumes with the rationally lowest price. If something irrational happens in reality, an industrial organization might encounter some problems.

We will build our hypothesis around what has caused current market outcomes to arise, including pork price increases in China. In this paper we are primarily addressing the questions of, "What is the pricing policy of hog slaughtering and pork processing company", "Whether the nature of industrial organization matters in pricing behavior", and "How does their sale pricing policy influence procurement policy in regards to selection of procurement channels and procurement prices". In this chapter, we will determine the mechanisms working in the market through observation of the market outcomes, from our original survey data, and through examining theoretical model.

##### **1.2 Regulations by "Qualified Slaughtering Spot" System**

Prior to going through the data in detail, we reviewed the institutional setting of the

industry. In 1998, the “Hog Slaughtering Controlling Ordinance” was endorsed. This ordinance provided that each town and village might establish a “Qualified Hog Slaughtering Spot Factory” so as to maintain certain hygiene conditions and quality of pork. The ordinance also obliged purchasers of hog who supply restaurants, schools, hotel, and other public dining areas use only hogs slaughtered at qualified factories.

In the mid 1990s, water-injected pork or perished meats were often sold on the market disguised as good quality products. In order to eliminate bad meat, a “Qualified Slaughtering Spot” system was started. However, when pork price started increasing around the middle of 2000, problems with bad meat problem again became a social issue.

### **1.3 Organization of the Industry**

The regulation dubbed the “Qualified Slaughtering Spot” system provides the industry with a certain feature where numerous hog slaughtering and pork processing companies were set up all over the country. The intention of this measure was to try to preserve the quality of pork and provide a convenient slaughtering spot for even the small villages. The firms were set up not purely to maximize profit, but also to secure the welfare of countryside consumers. Along with development of the industry and with economic growth in China, a few companies have grown out of this primary welfare stage to become very large corporations, even compared to the international counterparts in the 2000s.

Due to this institutional setting and historical development, the industry currently consists of numerous small-scaled hog slaughtering factories and a few larger operations. However, the growth of large companies may have changed the competition environment in the industry. Starting from a geographically local monopoly, the big firms have stepped out into the realm of nationwide competition. Small and locally monopolistic factories are dropping out of the market due to fiercer competition conditions in facing the large, nation-wide developed counterparts.

## **2. Observations from the Hog Slaughtering Firms Survey**

In order to understand the behavior of hog slaughtering and processing firms in China, we conducted an original survey in Henan Province, the largest hog production base, and Jilin Province, an emerging hog production base, in 2008. Chapter 5 details the contents of the survey.

### **2.1 Main Findings**

After conducting this firm-level survey, we were able to summarize a number of main findings gained through the observations and data on market outcomes of the industry. We found that traditional channels, such as wet markets, indirect transactions via wholesalers and middlemen, remain the main channels. We also observed that selling prices almost converged to the same level, but procurement prices were diversified among various channels or provinces. Gross margins between selling price per head and procurement price per head were almost zero or negative, except for sales to supermarkets. Additionally, we were able to determine that product types were less differentiated and no clear differences existed between big and small firms in terms of product differentiation. Big firms, however, operated under more competitive environments and in a wider area market. These firms were more dependent on middleman and enjoyed lower procurement prices. Smaller and medium-sized firms tended to operate in localized and monopolized markets and are becoming more involved in contract farming.

## **2.2 Profile of the Surveyed Firms**

The sample of our survey consisted of 103 and 105 firms for Jilin and Henan, respectively. The basic profile of the surveyed firms was that most firms were relatively young and had a history of only around ten years (year of establishment was 1997 on average, 2000 median). Also, firms were relatively small with the median amount of sales being RMB 1.037 million and assets at RMB 0.58 million. Because our sample contained information of Shuanghui, Henan, which is the largest hog slaughtering processing company in China, perhaps in the world, averaged data becomes very large.

The firms were also small in terms of labor, where at the median and average, firms had 10 and 173 employees, respectively. The share size of controlling owners tended to be concentrated, reflecting small size of the firms. The number of hogs of hogs per firm averaged around 59,000, with 4,000 at the median and pork production volumes were 300 tons at the median and averaged 4,640 tons. The large difference between median and average values showed that the industry was diversified, consisting of numerous small and a few very large firms.

### **Table 2-1: Basic Information on the Surveyed Firms**

	Obs	Mean	Std. Dev.	Min	Median	Max
Year of firm establishment	208	1997	12.6	1954	2000	2008
Sale (0000RMB:2007)	208	15,608	152,628	0	103.7	2,184,458
Asset (0000 RMB:2007)	208	5,304	31,299	0	58	402,412
Share of controlling owner(%)	199	90.1%	19%	11%	100%	100%
# of employee	207	173	910.4	1	10	12,428
# of hog procured(=slaughtered:head)	204	58,987	230,665	21	4,000	2,267,888
Pork production volumem (ton)	200	4,638	17,736	1	300	153,563

(Source) CAAS-IDE Jilin Henan Hog Industry Survey

Comparing Jilin and Henan provinces, we can see that Jilin's firms tended to be smaller in all of the indices examined and were generally younger than those in Henan.

**Table 2-2: Jilin and Henan**

	Jilin		Henan	
	Obs	Mean	Obs	Mean
Year of firm establishment	103	2001	105	1992
Sale (0000RMB:2007)	103	2,649	105	28,321
Asset (0000 RMB:2007)	103	3,310	105	7,259
Share of controlling owner(%)	103	92.5%	96	87.4%
# of employee	103	75	104	270
# of hog procured(=slaughtered:head)	102	28,751	102	89,222
Pork production volumem (ton)	101	2,301	99	7,023

(Source) CAAS-IDE Jilin Henan Hog Industry Survey

## 2.3 Marketing and Procurement Channels and Prices

### 2.3.1 Transaction Channels

In order to gain a rough picture of who traded with whom, we went through the share of marketing and procurement channels of pork and hogs. A review of these channels showed that the market still maintains traditional characteristics. The main marketing channels are the wet market and wholesalers where the procurement of hogs primarily depends on middlemen. Sales to restaurants or supermarket, 2% and 5%, respectively, by which the firm can expect higher profit via product differentiation with high grade meat or stable procurement via contract farming, is very limited and averaged 6.6% in the pork production industry in China.

The wet market is a marketing channel that has less product differentiation, but is spatially monopolized. Technology requirements of this channel are lower than those of restaurants or supermarkets. The substantial share of wet market utilization by the

surveyed firms implies that though the firms have enjoyed monopoly status at local markets, their technology levels, including such things as freezing or cold chain, is not high. The prevalence of transactions with middlemen implies that transaction costs with numerous hog raising farmers is much larger than agency costs to control the middlemen for the most of slaughtering and processing firms.

Although the government has stressed upgrading the industry, average institutions functioning in the Chinese hog industry have a very traditional look, having not yet undertaken modernization or structural transformation processes.

**Table 2-3 Shares of Marketing Channels and Procurement Sources**

	Obs	Mean		Obs	Mean
Sales ('0000 RMB)	206	5,860	Procured hogs (head)	204	58,987
Share of sales(%)			Share of procurement source(%)		
Wetmarket	206	58.1%	Middleman	204	59.4%
Wholesaler	207	31.6%	Own procurement team collect	204	15.4%
Supermarket	206	5.1%	Independetn farmer transport	203	13.3%
Brand outlet	206	4.0%	Contract farmer	204	6.6%
Restaurant	206	2.0%	Others	203	3.5%
Export	206	0.3%	Own farm	204	1.9%

(Source) CAAS-IDE Jilin Henan Hog Industry Survey

### 2.3.2 Price Development

Next, we will take a look at various price data obtained through our survey. Sales price by the marketing channels are listed in Table 2-4 below. Here, we can see that price level does not change much between the different marketing channels. Tests of significance for the equality of prices were not rejected except in the case of restaurant and wet market prices in 2006. On average, firms in the industry were faced with identical prices.

**Table 2-4: Sales Price by Marketing Channels**

price/ KG	2007				2006				2005			
	restaurant	supermark	wholesale	wetmarket	restaurant	supermarke	wholesale	wetmarket	restaurant	supermarke	wholesale	wetmarket
Mean	20.9	21.1	20.2	19.9	20.5	13.7	13.7	12.7	11.9	11.0	10.8	10.5
Std. Dev	3.2	3.1	3.2	3.4	23.7	3.9	3.0	3.2	3.0	2.9	2.4	2.3
Min	14	14	12	10	11.5	4.8	4.8	4.8	8	5.4	5.2	5.4
Max	29	29	28	34	120	27	26	27	21	21	20	21
Obs	23	47	132	156	20	41	117	141	19	38	108	136

t-value to test on the mean equality for paired sample (number in parenthesis is # of observation)

wholesaler>restaurant	-1.94 (19)				-1.10 (17)							-1.63 (16)
wholesaler>wetmarke	1.25 (85)				0.98 (75)							0.32 (72)
wholesaller>superma	0.27 (36)				-0.66 (35)							-0.25 (29)
restaurant>supermark	-0.12 (18)				1.00 (15)							-1.00 (14)
restaurant>wetmarket	-0.22 (14)				<b>2.21</b> (13)							1.81 (13)
supermarket>wetmarl	0.81 (3)				0.08 1							1.76 (28)

(Source) CAAS-IDE Jilin Henan Hog Industry Survey

Procurement prices, however, show a different feature in 2007, where prices from middlemen became higher than contracted farmers or independent farmers. Tests of significance here on the equality of prices were rejected for prices between middlemen and independent farmers and also between middlemen and contracted farmers in 2007. The tests on price equality were not rejected for all relationships in 2005 and 2006. In 2007, procurement prices from the middlemen rose more rapidly than from contracted or independent farmers.

**Table 2-5: Purchase Price by Procurement Channels**

Price/ head	2007			2006			2005		
	Procurement source	Middleman	Independen nt farmer	Contracte d farmer	Middleman	Independen nt farmer	Contracte d farmer	Middleman	Independen nt farmer
Mean	1570.4	1512.1	1531.5	1018.1	960.5	1030.6	879.1	817.1	801.6
Std. Deviation	348.1	304.5	338.9	306.5	264.4	309.3	270.1	161.8	198.6
Min	760	730	1000	450	500	580	400	430	450
Max	2800	2500	2500	1980	1800	1800	1980	1250	1250
Obs	157	67	33	143	64	30	135	60	28

t-value to test on the mean equality for paired sample (number in parenthesis is # of observation)

middleman > independent	<b>1.75</b> (4)				-0.64 (43)				-0.58 (40)
middleman> contracted	<b>2.41</b> (24)				-0.31 (24)				1.18 (21)
independent>contracted	0.75 (16)				0.58 (16)				0.67 (15)

(Source) CAAS-IDE Jilin Henan Hog Industry Survey

### 2.3.3 Price Difference Between Jilin and Henan

This procurement price diversification was confirmed by in each of the different provinces. Sales prices showed little differences between Jilin and Henan provinces, but procurement prices showed more diversity. Henan procurement prices were significantly higher than Jilin's. Tests of significance for mean equality of prices among marketing channels were not rejected, but the tests on procurement prices

showed significant differences among all pairs of the three procurement sources.

**Table 2-6: Price Differences between Jilin and Henan**

	2007	Sales price (per KG)				Hog purchase price (per head)		
		restaurant	supermarket	wholesaler	wetmarket	Middleman	Independent farmer	Contracted farmer
<b>Henan</b>								
	Mean	21.0	21.6	20.7	20.1	1,718	1,576	1,620
	Std. Dev	3.5	3.5	3.4	3.6	404	318	322
	Obs	19	22	70	65	72	45	26
<b>Jilin</b>								
	Mean	20.4	20.6	19.7	19.7	1,445	1,382	1,202
	Std. Dev	1.3	2.6	2.9	3.3	229	230	139
	Obs	4	25	62	91	85	22	22
<b>Mean price difference</b>								
	Henan-Jilin	0.62	0.95	1.00	0.39	273	193	418

(Source) CAAS-IDE Jilin Henan Hog Industry Survey

Price data showed that the selling prices of pork were almost the same among different marketing channels and provinces and that procurement prices were diversified among different procurement sources and provinces. This implies that firms in the Chinese hog industry are being faced with a perfect competitive market and identical prices, thus profit is mainly generated from differences in procurement costs.

## 2.4 Demand: Poorly Differentiated Product and Localized Demand

Demand for products of the hog slaughtering and processing firms can be classified according to “types of products” and “market area”.

### 2.4.1 Product Types

In our survey, hog processing firm products were classified into the following four types: (1) fresh cleaned hog body; (2) frozen split meat; (3) chilled split meat; and (4) processed or cooked pork. Generally speaking, fresh cleaned hog bodies are the simplest products, just having slaughtered, cleansed the hog body, and then sold them directly. Freezing meat requires relatively simple technology, but consumers regard it as lower grade meat compared to chilled or fresh products. Chilled meat requires the highest level of technology among these four types in terms of storage or distribution. Finally, processed or cooked meat is regarded as a different product from the “pork”



products above.

Among sales to wet markets and wholesalers, the largest marketing channels of our surveyed firms, the share of fresh cleaned hog body took up more than 60 and 90%. Chilled pork's share was around 20% (3. plus 3+others in Table 2-7), excluding the wet market. Restaurants were the customers who needed the highest grade of meat and half of them bought chilled meats. As a whole, product types of the hog slaughtering and processing industry are still poorly differentiated, though technological innovation is now progressing.

**Table 2-7: Type of Products Sold to Customers**

	Wholesaler		Restaurant		Supermarket		Wet market	
	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
1. Fresh cleaned bod	86	57%	6	25%	24	67%	133	90%
2. Frozon split body	30	20%	2	8%	2	6%	3	2%
3. Chilled split body	17	11%	11	46%	6	17%	4	3%
4. Processed meat	2	1%	1	4%	0	0%	1	1%
1+2 or 1+2+4	3	2%	1	4%	1	3%	0	0%
3+others	12	8%	3	13%	2	6%	8	5%
Total	150	100%	24	100%	36	100%	147	100%

(Source) CAAS-IDE Jilin Henan Hog Industry Survey

#### **2.4.2 Distance From the Customer**

Along with product differentiation by product type as addressed in the section above, spatial differentiation might influence competition in the industry. This survey has also obtained information on firms' distance from each customer. Here, we can see that transactions with wet markets were particularly spatially localized. Around 70% of customers were located within 3 km from the slaughtering and processing firms. On the contrary, wholesalers distribute the products to a wider range of markets. Around half of the wholesalers were located within 3 km from the firms, but 17% of them were located from 500km to 5000km away from the firms. As a whole, wet markets cover local markets and wholesalers distribute to wider areas.

**Table 2-8: Distance From Customers**

Wholesaler			Restaurant			Supermarket			Wet market		
KM	cum #	cum%	KM	cum #	cum%	KM	cum #	cum%	KM	cum #	cum%
1	24	19%	1	3	13%	1	8	17%	1	39	26%
3	59	46%	3	6	25%	3	20	42%	3	104	68%
10	75	59%	15	12	50%	10	30	63%	10	135	89%
50	87	69%	40	20	83%	50	43	90%	50	147	97%
540	105	83%	500	23	96%	500	47	98%	500	151	99%
5000	127	100%	600	24	100%	1006	48	100%	1006	152	100%

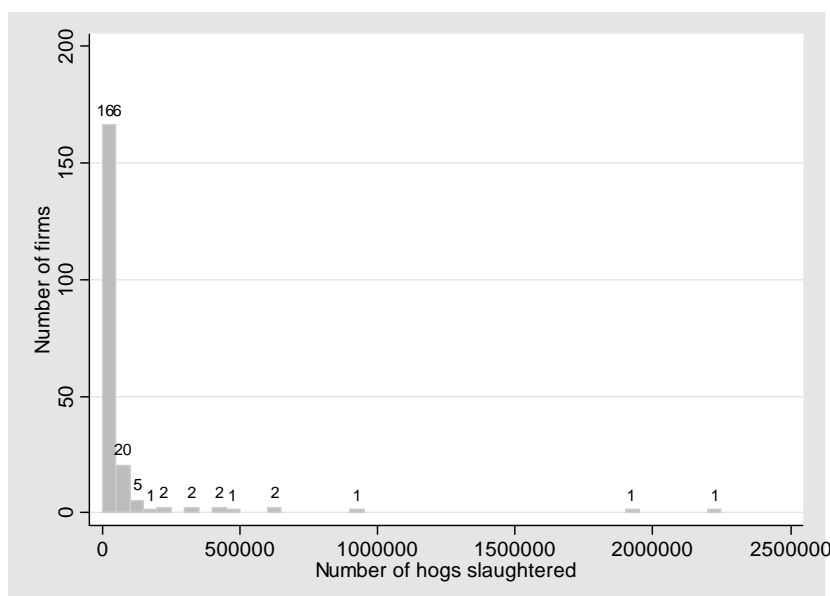
(Source) CAAS-IDE Jilin Henan Hog Industry Survey

The data above in Table 2-8 shows inter-regional transactions. We can see that the products have just begun to be differentiated, but this is currently very limited. The production of hogs by the surveyed firms is very homogenous and spatially oligopolized.

### 2.5 Supply: Very Few Big Processors and Numerous “Policy Qualified Factories”

Profiles of the surveyed firms showed that the industry consists of a few big processors and numerous small factories. Figure 2-1 shows the distribution of the surveyed firms by number of hogs slaughtered. The larger sized firms belong to “tail” part of the distribution with smaller firms belonging to “peak” part of the distribution.

**Figure 2- 1: Distribution of the Surveyed Firms by Number of Hogs Slaughtered**



(Source) CAAS-IDE Jilin Henan Hog Industry Survey

(Note) Width of a bin is 50,000 head.

We have taken a look at the firms’ strategies by comparing those of top firms and those

of the whole sample. “Top firms” are defined as the top 15 firms in terms of number of hog procured and slaughtered in the surveyed sample.

### 2.5.1 Firms’ Strategies

Under this section we will take a look at price, product type, and shares of marketing and procurement channels.

#### (1) Price

Are review of industry prices yielded an interesting result in that the selling price was almost the same between the top 10 firms and the whole sample. However, the procurement prices turned out to be different and prices for the top 15 firms was lower than the whole sample or smaller firms.

**Table 2-9: Prices of Top 15 firms**

	Top 15 firms		Total	
Selling price				
	Obs	Mean	Obs	Mean
Wholesaler	15	20.7	132	20.2
Restaurant	5	21.9	23	20.9
Supermarket	9	21.8	47	21.1
Wetmarket	8	18.9	156	19.9
Procurement price				
	Obs	Mean	Obs	Mean
Contract farmer	9	1,422	36	1,522
Independent farmer	9	1,448	71	1,492
Middleman	12	1,316	191	1,561

(Source) CAAS-IDE Jilin Henan Hog Industry Survey

#### (2) Product Type

Configurations of product types by marketing channels showed no significant differences in the sample as a whole. Chilled and fresh meats are sold to restaurants and supermarkets and fresh meat is sold to the wet markets. The wholesalers buy more diversified products, fresh meat, frozen meat, chilled meat, and combinations of all. All types of firms have the configuration as above and in this regard, product are less differentiated.

#### (3) Procurement and Marketing Sources’ Share

Shares of procurement sources were different throughout the whole sample. In order to

remove the impacts of large sized firms, we split the sample into two parts consisting of the top 15 in terms of hog slaughtered and then the rest.

An interesting point here was that on average, smaller groups depended more on contract farmers for their hog sources. The top 15 firms depended on middleman twice more than contract farmers. Among the top 15 firms, the smaller firms depended more on contract farmers with the smaller sized firms in the larger group being more actively involved in contract farming, probably in order to secure their hogs under competition with the larger firms.

**Table 2-10: Shares of Marketing and Procurement Channels**

	Top 15		No.16 and below	
<b>Marketing channels</b>				
	Obs	Mean	Obs	Mean
Wholesaler	15	5,553,761	115	305,114
Restaurant	5	68,439	18	74,100
Supermarket	9	479,163	38	79,622
Wetmarket	8	564,887	148	282,845
<b>Procurement sources</b>				
	Obs	Mean	Obs	Mean
Contract farmer	9	47,641	27	5,789
Independent farmer	9	10,442	62	2,134
Middleman	12	82,977	151	2,438

(Source) CAAS-IDE Jilin Henan Hog Industry Survey

#### **(4) Number of competitor**

Another interesting point was the difference in competition environments. The survey had information about the number of competitors as classified into seven grades (1 - no competitors, 2 - 1 to 5 competitors, 3 - 5 to 10 competitors, 4 - 10 to 30 competitors, and 7 - 100+ competitors). As Table 2-11 shows, larger firms had more competitors than smaller groups, averaging 5 to 30 and 1 to 10 competitors, respectively. Other than this, data on distances from customers shows that larger groups' customers are located farther away than for smaller firms. Larger firms were operating under a more competitive environment and in a wider market area. On the contrary, the smaller firms were operating in a localized and monopolized market.

**Table 2-11: Competition in Marketing and Procurement**

	Top 15 firms		Total	
Number of competitor to the customers				
	Obs	Mean	Obs	Mean
Wholesaler	11	3.3	129	2.3
Restaurant	5	3.4	22	2.3
Supermarket	5	3.2	47	2.3
Wetmarket	8	3.0	155	1.7
Number of potential competitor				
	Obs	Mean	Obs	Mean
Contract farmer	9	3.1	34	3.3
Independent farmer	9	3.3	71	2.5
Middleman	11	3.2	191	2.1

(Source) CAAS-IDE Jilin Henan Hog Industry Survey

### (5) Margins for processing firms

The question we must now consider is, “under the competitive environment above, are the surveyed firms able to make a profit?” We calculated information for gross margins by taking the selling price minus the procurement price per head of livestock. Profits for slaughtering one head of livestock by each of the marketing channels are listed in Table 2-12. Strikingly, only sale to supermarkets was profitable at gross margins in the whole sample in 2007. The hog processing industry was operating under severe conditions. The top 15 firms were remaining profitable thanks to low procurement costs.

**Table 2-12: Profit per Head of Hogs**

	Top 15		Whole sample	
	Obs	Mean	Obs	Mean
Sales price per head				
Wholesaler	13	1,539	108	1,506
Wetmarket	7	1,328	138	1,521
Supermarket	7	1,643	38	1,637
Restaurant	4	1,806	19	1,476
Average procurement price per head*				
P_avg	14	1,380	166	1,571
Profit per head				
Wholesaler	12	129	101	-1.4
Wetmarket	7	21	135	-19.5
Supermarket	6	258	36	98.6
Restaurant	3	355	18	-41.9

(Source) CAAS Jilin and Henan Hog Industry Survey.

(Note) The survey obtained information on sales price per KG and procurement price per head. Sales price per head was obtained by sales price per KG multiplied by meat ratio (pork sales volume / number of head procured). The data above is limited to those with a meat ratio that ranges from 40 to 150. The survey also included information regarding source channels of hogs for each marketing counterpart. The margin is obtained by taking the difference between sales price to each customer and paired procurement source.

### **3. Hog Price and Mixed Oligopoly: A Theoretical Analysis**

#### **3.1 Mixed Oligopoly**

As described in the previous sections, the hog slaughtering and processing industries were set up with a purpose to improve social welfare in the 1990s under the “Qualified Factory” system. Thus, firms were motivated to pursue improving social welfare as well as profit. The mixed oligopoly approach has studied what the industrial organization will look like with heterogeneous types of firms, a profit maximizer and a social welfare maximizer. Matsushima and Matsumura (2004) and Kumar and Saha (2007) analyzed spatial and price competition with homogenous goods. Matsumura and Matsushima (1998) and Kumar et al (2007) also analyzed the impact of partial privatization of price levels, quantity, and social welfare in industry.

Though most firms in the industry being set up with as social welfare maximizing, the pork production industry in China is facing a dynamic structural transformation. A mixed oligopoly approach is therefore very suitable for describing the current hog industry in China. In addition, this analysis focuses on spatial competition of homogenous goods based on features observed in our survey above. We will describe a mixed oligopoly, duopoly in this case, model by re-interpreting Matsushima and Matsumura (2004).

#### **3.2 The Model**

For our analysis, we considered a linear city model with a length of 1 and consumers that are uniformly distributed with density 1 along this line. A location of Firm  $i$  is set as  $l_i \in [0, 1]$ , which is a point on the line at a distance from the left end of the line. Here we assume  $l_0 < l_1$ , as the opposite relationship only generates symmetric results. We also assume that Firm 0 is a social welfare maximizer and Firm 1 is a profit maximizer.

##### **3.2.1 The Consumer**

The consumer living at  $y \in [0, 1]$  buys a product from Firm 0 if  $c_0 < c_1$ , where  $c_i$  is cost

to buy a product of Firm  $i$  and  $c_i = p_i + t(l_i - y)^2$ . Cost to buy a product of Firm  $i$  consists of the price of the product,  $p_i$ , and the transportation cost of the consumer to travel to an outlet of Firm  $i$ ,  $t(l_i - y)^2$  ( $t > 0$ ). Following the literature of location choice theory, we assumed that transportation cost was a function of the square of the distance<sup>1</sup>. The consumer enjoys their utility and surplus from the consumption was  $U_i = s - c_i$ .

The consumer at point  $x$  on the line is where utility from Firm 0 products and Firm 1 products is the same and the consumer will be indifferent between the products from either. The consumer located between point 0 and point  $x$  will buy the product of Firm 0 and the consumer who is located between point  $x$  and point 1 will buy the product of Firm 1. Thus, demand for the product of Firm  $i$  will be given by follows:

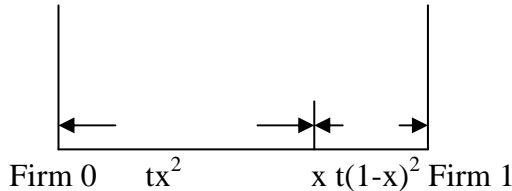
$$D_0 = \min\{\max(x, 0), 1\},$$

$$D_1 = 1 - D_0.$$

From  $U_1 = U_0$ , the indifferent location  $x$  is derived as follows:

$$x = (l_0 + l_1)/2 + (v_1 - v_0)/2t(l_1 - l_0) \quad (1)$$

**Figure 2-2: Cost of Consumers and Distance from Firms**



(Source) Author

### 3.2.2 The Firm

In this market, we consider a welfare-maximizing firm (Firm 0) is competing with a profit-maximizing firm (Firm 1). Firm 0 and Firm 1 produce a homogenous good. The unit cost of production for each firm is  $p_i$ , which is subject to cost reduction efforts by the firms at cost  $I_i$ . For simplicity, we assume  $I_i = (p - p_i)^2$  ( $> 0$ ). The cost of this reduction is common between Firm 0 and Firm 1 and there are no ex ante cost differences between the two.

The game runs in following manner. In the first stage each Firm  $i$  choose their production cost level,  $p_i$  simultaneously, in the second stage firms choose their

<sup>1</sup> Distance from the locations of consumers and firms is lower than  $1/2$ , as we only consider cases when  $l_0 < l_1$ .

locations, and in the third stage the firms set their price  $v_i \in [0, \infty)$  simultaneously. The difference of Firm 0 and Firm 1 comes from their objective functions. Firm 1's objective is to maximize profit. Thus, its objective function is:

$$\pi_1 = (v_1 - p_1)(1 - D_1) - I_1.$$

On the other hand, Firm 0 is motivated to maximize social welfare as long as its profit plus initial asset,  $A_0$ , is positive. The objective function of the social welfare-maximizing firm is,

$$W = s - p_0 D_0 - p_1(1 - D_1) - I_0 - I_1 - t \left( \int_0^{D_0} (y - l_0)^2 dy + \int_{D_0}^1 (y - l_1)^2 dy \right),$$

$$\text{subject to } \pi_0 + A_0 = (v_0 - p_0)(1 - D_0) - I_0 + A_0 \geq 0.$$

### 3.2.3 The Equilibrium

This section discusses the equilibrium outcome in the mixed market as formulated above with the game being solved through backward induction.

#### (1) Pricing

First, we consider the third stage sub-game. Firm 0 will set  $p_0$  so as to maximize social welfare  $W$ , and Firm 1 will set price  $v_1$  to maximize its profit  $\pi_1$ . First order conditions for the two firms reduces the price functions as follows:

$$\begin{aligned} v_0 &= 2p_0 - p_1 + t(l_1 - l_0)(2 - l_0 - l_1), \\ v_1 &= p_0 + t(l_1 - l_0)(2 - l_0 - l_1) \end{aligned} \quad (2).$$

Here,

$$v_0 - v_1 = p_0 - p_1 \text{ holds.}$$

*Proposition on Pricing Behavior:* The pricing principle is asymmetry. Firm 1 sets its price based on Firm 0's costs. Firm 1 will set price so as to keep a selling price difference,  $v_0 - v_1$ , as the same as cost difference  $p_0 - p_1$ .

#### (2) Location Choice

Next, we will consider the second stage, location choice. Substituting (1) into the objective functions  $W$  and  $\pi_1$ , we can derive first order conditions for Firm 0 and Firm 1. First, when (1) holds, demand for Firm 0 and Firm 1 is divided as follows by substituting (2) into (1):



$$x = (t(l_1^2 - l_0^2) + p_1 - p_0) / 2t(l_1 - l_0). \quad (1)'$$

Location choice depends on the efficiency difference of Firm 0 and Firm 1. Firm 0 is motivated to make decisions to maximize social welfare and its location choice will determine the configuration of location choice in the industry. Thus, if Firm 0 is more efficient than Firm 1 for all consumers, that is  $c_0 < c_1$  or  $(c_0 - c_1) / \{(1 - l_0)^2 - (1 - l_1)^2\} < t$ , Firm 0 will choose:

$$l_0 = 1/2, l_1 = 1,$$

and set a low price so as to induce an efficient outcome. Given this strategy, Firm 1 will stay as far away as possible from Firm 0.

On the other hand, if Firm 1 is more efficient than Firm 0 for all consumers, that is  $c_1 < c_0$  or  $t < (p_0 - p_1) / (l_1^2 - l_0^2)$ , Firm 0 and 1 will choose:

$$l_0 = 0, l_1 = 1/2,$$

where firm 0 will set a high price so as to induce a monopoly by Firm 1.

If neither case is chosen, that is  $(p_0 - p_1) / (l_1^2 - l_0^2) > t > (p_0 - p_1) / \{(1 - l_0)^2 - (1 - l_1)^2\}$  when a mixed oligopoly is taking place, Firm 0 will choose a location so as to maximize  $W$ , and Firm 1 will choose to maximize its profit. With the first order conditions of these two objectives, we can derive best response functions on location choice:

$$\begin{aligned} l_0 &= (4p_1 - 4p_0 + t) / 4t, \\ l_1 &= (4p_1 - 4p_0 + 3t) / 4t \end{aligned} \quad (3).$$

*Proposition on Location Choice:* In the case where the cost difference between the social welfare maximizer and the profit maximizer is large enough, a monopoly of either will take place. If efficiency differences are not large enough to overcome transportation costs, Firms 0 and 1 will choose locations by keeping a distance of  $1/2^2$ .

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<sup>2</sup> In case of a circular city model where we can analyze endogenously the entry of firms, profit maximizer firms will be located at the maximal differences. In this setting, social maximizing firms are operating monopolistically at one point, profit maximizer firms are located at the opposite point of the circle, and several numbers of firms will be agglomerated (Matsushima and Matsuura (2004: Concluding Remarks). This is consistent with an observation from the survey in Table 2-11 that big firms were faced with competition, but small firms enjoyed a local monopoly.

### (3) Cost Reduction Level at Full Game

Finally, we will discuss decisions on investment for production cost reduction. We will see the results for the three cases above.

If the cost of the social welfare-maximizing firm is absolutely lower than the private firm, that is  $(p_0-p_1)/\{(1-l_0)^2-(1-l_1)^2\} < t$ , then Firm 0 will monopolize the market and set price  $v_0$  as low as possible. The objective of Firm 0 is to maximize  $W$  via product cost reduction. The first order condition is given as:

$$p_0^* = p - 1/2, \quad p_1^* = p.$$

Here,  $v_0^* = p - 1/2 + t/4$ ,  $v_1^* = p + t/4$ ,  $l_0 = t/4 - 3/4$ ,  $l_1 = 0$ .

As Firm 1 is not interested in taking a market share here, Firm 1 does not invest in cost reductions and sets a price higher than Firm 0.

If  $c_1 < c_0$  or  $t < (p_0-p_1)/(l_1^2-l_0^2)$ , then a monopoly by the profit maximizing firm will occur. The firm will set a monopolized, high price with the other result being symmetry with the social welfare maximizer's monopoly:

$$p_1^* = p - 1/2, \quad p_0^* = p,$$

$$v_0^* = p + 1/2 + 3t/4, \quad v_1^* = p + 3t/4, \quad l_0 = 0, \quad l_1 = t/4 + 3/4.$$

If  $(p_0-p_1)/(l_1^2-l_0^2) > t > (p_0-p_1)/\{(1-l_0)^2-(1-l_1)^2\}$ , when neither production cost difference or difference in transportation cost by location choice is dominant, a mixed oligopoly takes place. In this case, location, selling price, cost, and profits of the firms are as follows:

$$l_0 = (4p_1 - 4p_0 + t)/4t = \frac{1}{4} - \frac{3}{2(t\gamma - 5)}, \quad l_1 = (4p_1 - 4p_0 + 3t)/4t = \frac{3}{4} - \frac{3}{2(t\gamma - 5)}$$

$$p_0^* = p - \frac{t\gamma - 8}{4\gamma(t\gamma - 5)} > p_1^* = p - \frac{t\gamma - 2}{\gamma(t\gamma - 5)},$$

$$v_0^* = p_0 + 2(p_0 - p_1) + t/2 = p + \frac{(t\gamma - 4)}{2\gamma(t\gamma - 5)} + \frac{t}{2} > v_1^* = p_0 + (p_0 - p_1) + t/2 = p - \frac{2}{\gamma(t\gamma - 5)} + \frac{t}{2}.$$

$$D_0^* = \frac{1}{2} - \frac{3}{2(t\gamma - 5)}.$$

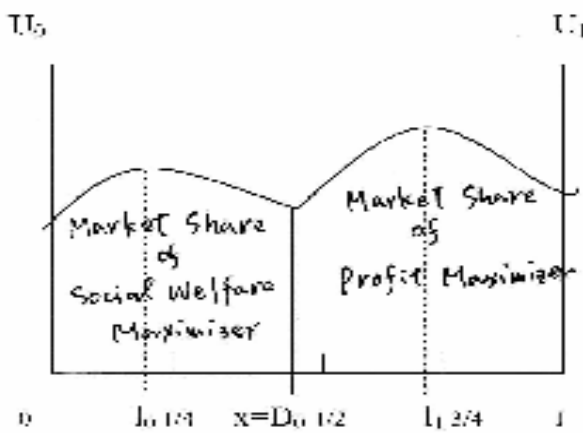
$$l_0^* = \frac{(t\gamma - 8)}{(t\gamma - 5)^2} \left\{ \frac{t(t\lambda - 2)}{4} - \frac{(t\lambda - 8)}{16\lambda} \right\} < \quad l_1^* = \frac{(t\gamma - 2)^2}{(t\gamma - 5)^2} \left( \frac{t}{4} - \frac{1}{\lambda} \right) \quad (4)^3.$$

<sup>3</sup>When we assume  $(p_0-p_1)/(l_1^2-l_0^2) > t > (p_0-p_1)/\{(1-l_0)^2-(1-l_1)^2\}$ , monopoly by either the profit maximization firm or social welfare-maximizing firm does not happen,  $t > 8$  holds, from

Both production cost and selling price of the profit-maximizing firm are lower than the social welfare-maximizing firm. The profit-maximizing firm invests more in cost reduction and then generates larger cost differences with social welfare maximizer. The social welfare-maximizing firm may respond by locating itself as far as possible from profit-maximizing firm and setting a higher price in order to increase social welfare. Thus, the profit maximizer has an incentive to strategically lower production cost and to reduce the investment by the public firm, which is a strategically substitutive commitment. Matsushima and Matsuura (2004) assert that the profit-maximizing firm's cost reduction is excessive compared to that of the social planner's.

*Proposition on Cost Reduction:* If either Firm 0 or 1 is the monopolist, only a monopolist will make cost reduction investments. Ex post production cost level is the same regardless who is the monopolist. When monopolies are taking place, the profit-maximizing firm will set a higher selling price when he monopolizes the market. When both of them stay in a market, the profit-maximizing firm reduces costs more than social welfare firms.

**Figure 2-3: Locations, consumer utility and market share at equilibrium**



(Source) Author

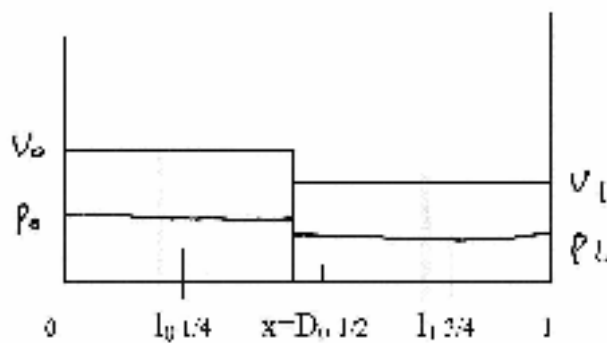
In this paper, we are interested in how prices of products and procurement are set by the firms. We can summarize the model prediction on pricing as the following

$$D_0 = \frac{1}{2} - \frac{3}{2(t\gamma - 5)} > 0 \text{ and } t > 2 \text{ from } D_0 = \frac{1}{2} - \frac{3}{2(t\gamma - 5)} < 1.$$

propositions.

*Proposition on Selling and Production Cost at Equilibrium:* The selling price of the social welfare maximizer and profit maximizer is diversified if a difference in production cost exists. The social welfare maximization firm will set a higher price than the profit maximizer within the extent of production cost differences, though he chooses a location so as to minimize the transportation cost of the consumer and improving consumer welfare<sup>4</sup>.

**Figure 2-4 Selling price and distance**



(Source) Author

Comparing monopoly equilibriums, the selling price of products in a mixed oligopoly is higher than the price at equilibrium of a monopoly by the social welfare-maximizing firm, but lower than the profit maximizer's monopoly. Competition is desirable to lower the expenditure of the consumer and monopoly by the profit maximizer will induce a higher product price.

$$\begin{aligned}
 v_0^{\text{profit maximizer monopoly}} &= p + 1/4 + 3t/4 \\
 > v_0^{\text{mixed oligopoly}} &= p + \frac{(t\gamma - 4)}{2\gamma(t\gamma - 5)} + \frac{t}{2} \\
 > v_0^{\text{social welfare maximizer monopoly}} &= p - 1/4 + t/4 \quad (5)^5.
 \end{aligned}$$

For production cost, the cost level of the social welfare maximizer in a mixed

<sup>4</sup> A mixed oligopoly analysis (Kumar and Saha, 2007) stated that the presence of a social welfare-maximizing firm brought about a low consumer price.

<sup>5</sup> The latter relationship hold when  $t > 8$ .

oligopoly is higher than that of two monopoly equilibriums, but the production cost of the profit maximizer is lower than in the monopoly case. Competition is good to reduce production costs and increase the efficiency of the industry even in a mixed oligopoly concept.

$$p_0^* = p - \frac{t\gamma - 8}{4\gamma(t\gamma - 5)} > p - 1/2 > p_1^* = p - \frac{t\gamma - 2}{\gamma(t\gamma - 5)} \quad (6).$$

#### **(4) Financial Sustainability of a Social Welfare Maximizer**

The profit level of a social welfare maximizer stays lower than a profit maximizer in the mixed oligopoly from (4). Though the unit margin  $v_0 - p_0 = v_1 - p_1$  holds the same, the lower the production cost of the profit maximizer, the larger the market share of the profit maximizer as the social welfare gives up the market. The more aggressive the profit maximizer is in terms of cost reduction investment, the smaller the market share and the higher the selling price of social welfare maximizer. This mechanism is progressive and if the game is repeated in multiple periods, the social welfare maximizer may exit the market except in a market where transportation costs are substantially high.

If production cost  $p_0$  increases due to an exogenous reason such as a labor cost increase, then the selling price of a social welfare maximizer products' will increase rapidly, as the cost difference is exaggerated due to the firm's own exogenous reasons. This implies that the price of pork supplied by a social welfare maximizer is more vulnerable to increasing labor costs, which is what is currently happening.

### **3.3 Data on Selling Price Dispersion**

The model above predicted that if the social welfare maximizer and the profit maximizer are operating in a market, the social welfare maximizer will choose the location so as to minimize the transportation cost that the consumer bears, but will set selling prices higher if there is a cost difference between the two firms. When this mixed oligopoly takes place, the product price level is diversified where the social welfare-maximizing firm, who sells products close to its location, sets a higher price and the profit maximizer, who enters farther away from the initial location of the former, sets lower prices.

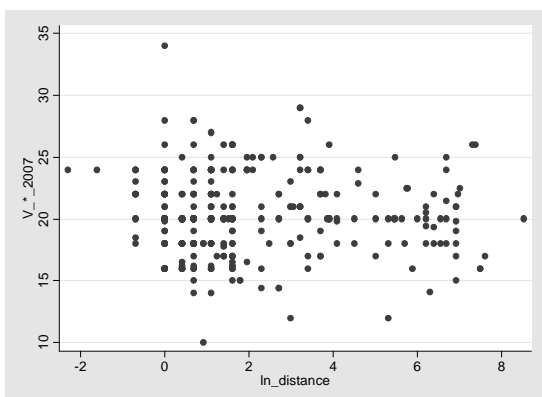
This result implies that price is diversified according to the distance from the firm to the customers. Figure 2-5 shows the dispersion of prices of the whole sample, and sub-samples within; completely homogenous goods, here fresh pork; and the type of customer, in this case wet markets. We can observe here that there exist a correlation between selling price and distance. Selling price is lower the longer the distance to the

customer within completely homogenous products or the same customer type (Figure 2-5b, 2-5c), though price is independent to the distance in the whole sample (Figure 2-5a or previous sections).

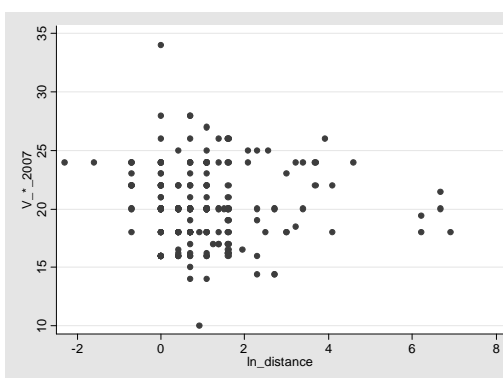
The model describes an interaction between the social welfare maximizer and the profit maximizer. Our survey does not have information to directly distinguish this heterogeneity of firms' motivation, but we assume "big firms" are profit maximizers who have grown out of the initial purpose and currently pursue the maximization of profits and "small firms" are social welfare maximizers that maintain the motivation instilled during their establishment. Figure 2-5d and 2-5e show the price dispersion of two sub-samples split into the top 15 and below as we did in the previous section. Small firms' prices are relatively more scattered including higher levels and the prices of big firm have converged to a lower level, though mean prices are almost the same.

## Figure 2-5: Price Dispersion

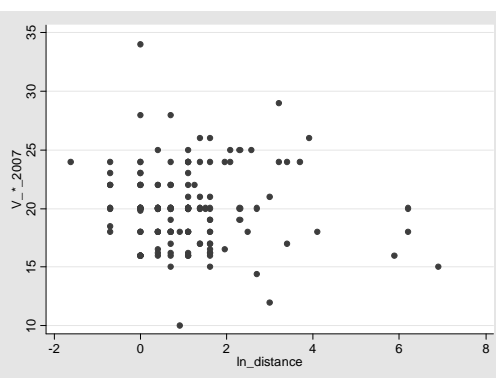
### Figure 2-5a: Whole Sample



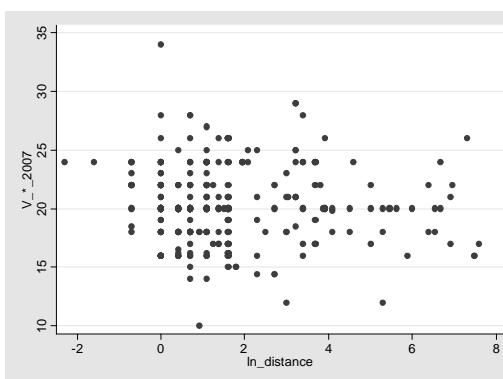
### Figure 2-5b: Fresh Cleaned Body



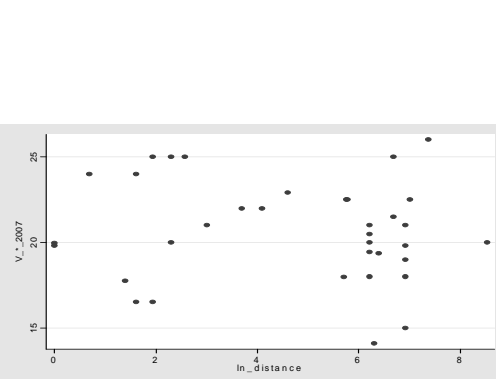
### Figure 2-5c: To Wet Markets



### Figure 2-5d: No. 16th and below



### 2-5e: Top 15



(Source) CAAS Jilin and Henan hog industry survey.

The figures above look consistent with the prediction of a mixed oligopoly and location choice model in this section. A rigorous statistical test is necessary to fully examine the hypothesis.

#### **4. Summary and Conclusion**

In order to explore the mechanism that brought about the increase of pork prices, we focused on and analyzed the pricing behavior of hog slaughtering and processing firms based on an industrial organization approach.

Observation of the data and the institutions in the previous section indicated that the hog slaughtering and processing industry produced less differentiated products and has developed a spatial competition. Also, most of the firms were established to secure the social welfare of the consumers in rural areas in the 1990s. The objective of some firms, particularly part of the small firms, still remains as to consider primarily social welfare, though the big firms appear to behave as purely pursuing profit. There are firms with heterogeneous objectives operating in a hog slaughtering and processing market.

Based on this basic observation, we referred to a mixed oligopoly analysis on the spatial competition of homogenous goods as a theory to analyze the market. The model predicted that social welfare-motivated firms will reduced their market share and will set a higher product-selling price in response to aggressive cost reduction investment. Thus, cost differences between profit maximizers and social welfare maximizers have emerged. This endogenous cost difference may be brought about the financial distress of social welfare-maximizing firms.

Our data showed that the selling price of the products was less dispersed, but the procurement price of hogs shares a substantial part of production costs and is apparently significantly different between bigger and smaller firms. Big firms, who are more strongly motivated to maximize profits, looked more aggressive in reducing costs, which is consistent with model prediction above. Small firms are now operating at a deficit even at a gross margin per head of hogs. The social welfare-maximizing principle of the “Qualified Slaughtering Factory” system now seems to be eroding.

The model also predicted selling prices and distance between supplier and consumer where the closer to the social welfare maximizer, the higher the price is set compared to a neighborhood producer or the profit maximizers. Though product price dispersion was not so apparent as the procurement price, it showed a correlation with the distance between suppliers and consumers. “Small firms” prices were more dispersed and included higher levels than “big firms”.



As a whole, the data observations and model predictions may explain current pork price increase. Other than labor cost increases, the nature of the mixed oligopoly market accelerated price increases, particularly in the rural areas. Also, the larger firms, the profit maximizers, aggressively pursued cost reductions, but the smaller firm, social welfare maximizers with smaller market shares, had higher products prices. If a monopolistic system by the big firms, or the profit maximizers, becomes prevalent, the selling price of pork may increase even more, as the profit maximizer will set an equally high price. A sustainable competitive environment is necessary for the efficient development of the industry.

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