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The Impact of Ownership Structure on the Performance of China's Feed Mill Sector

Abstract

In the decade of the 1990s, China's feed sector became increasingly privatized, more feed mills opened, and the scale of operation expanded. Capacity utilization remained low and multi-ministerial supervision was still prevalent, but the feed mill sector showed a positive performance overall, posting a growth rate of 11 percent per year. Profit margin over sales was within allowable rates set by the government of China at 3 to 5 percent. Financial efficiency improved, with a 20 percent quicker turnover of working capital. Average technical efficiency was 0.805, as more efficient feed mills increasingly gained production shares. This study finds evidence that the increasing privatization explains the improved performance of the commercial feed mill sector.

The drivers that shaped the feed mill sector in the 1990s have changed with China's accession to the World Trade Organization. With the new policy regime in place, the study foresees that, assuming an adequate supply of soy meal and an excess capacity in the feed mill sector, it is likely that China will allow corn imports up to the tariff rate quota (TRQ) of 7.2 mmt since the in-quota rate is very low at 1 percent. However, when the TRQ is exceeded, the import duty jumps to a prohibitive out-quota rate of 65 percent. With an import duty for meat of only 10 to 12 percent, China would have a strong incentive to import meat products directly rather than bringing in expensive corn to produce meat domestically. This would be further reinforced if structural transformation in the swine sector would narrow the cost differential between domestic and imported pork.

Keywords

China, feed mill sector, privatization, trade

Disciplines

Agribusiness | Agricultural and Resource Economics | Agricultural Economics | Economics

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Abstract

In the decade of the 1990s, China's feed sector became increasingly privatized, more feed mills opened, and the scale of operation expanded. Capacity utilization remained low and multi-ministerial supervision was still prevalent, but the feed mill sector showed a positive performance overall, posting a growth rate of 11 percent per year. Profit margin over sales was within allowable rates set by the government of China at 3 to 5 percent. Financial efficiency improved, with a 20 percent quicker turnover of working capital. Average technical efficiency was 0.805, as more efficient feed mills increasingly gained production shares. This study finds evidence that the increasing privatization explains the improved performance of the commercial feed mill sector.

The drivers that shaped the feed mill sector in the 1990s have changed with China's accession to the World Trade Organization. With the new policy regime in place, the study foresees that, assuming an adequate supply of soy meal and an excess capacity in the feed mill sector, it is likely that China will allow corn imports up to the tariff rate quota (TRQ) of 7.2 mmt since the in-quota rate is very low at 1 percent. However, when the TRQ is exceeded, the import duty jumps to a prohibitive out-quota rate of 65 percent. With an import duty for meat of only 10 to 12 percent, China would have a strong incentive to import meat products directly rather than bringing in expensive corn to produce meat domestically. This would be further reinforced if structural transformation in the swine sector would narrow the cost differential between domestic and imported pork.

Keywords: China, feed mill sector, privatization, trade.

THE IMPACT OF OWNERSHIP STRUCTURE ON THE PERFORMANCE OF CHINA'S FEED MILL SECTOR

Introduction

China's food economy has always attracted attention because of its sheer size; it is currently estimated to be feeding 1.29 billion people. But a confluence of economic, demographic, and even political forces have produced dramatic changes and adjustments in China's food economy that are of even greater significance. On the demand side, China's economy has shown a record sustained economic growth at rates not seen in many developing countries, posting growth rates in real per capita income of close to 10 percent in the last five years. Moreover, urbanization is proceeding at a rate of 1 percent per annum; the proportion of China's population estimated to be living in urban areas jumps from 41 percent to 60 percent in the next 25 years. These changes, among others, have brought about both an expansion in China's consumption as well as a shift in the mix of the major consumed food groups away from the traditional grain-based staples to foods rich in animal protein. Table 1 shows per capita consumption of several food groups in the last decade alone. Grain consumption is either steady or declining, as in the cases of rice, barley, and wheat, while meat and egg consumption shows a consistent increase. On the supply side, China has introduced structural reforms through decentralization and privatization that have increased both domestic private investment as well as direct foreign investment, resulting in an expansion of its productive capacity to meet the rising demand.

These changes are particularly evident in the case of meat products: stronger demand has driven a 10.7 percent annual increase in meat production over the span of a single decade. Pork production represented 62 percent of this increase, followed by broiler production at 24 percent, and beef at 14 percent. As in the past, questions continue to be raised about whether China can continue to meet its ever-expanding food demand. In the case of meat products, a potential limiting factor is adequacy in the supply of grains.

TABLE 1. Per capita consumption of grains and meat

Items	1995	2000	2004
	Kilograms per person per year		
Animal-based			
Beef	1.89	3.67	4.59
Pork	24.02	29.99	33.74
Poultry	3.84	6.91	7.54
Eggs	5.75	8.14	9.34
Grain-based			
Corn	23.16	22.84	25.90
Barley	3.63	2.78	2.71
Rice	99.41	96.46	96.77
Wheat	87.58	83.74	77.47

Source: USDA-FAS n.d., PS&D Database.

Although China held a record 83 percent of its annual production in stocks amounting to 102.31 million tons of corn in 1999-2000, its agricultural land area is very limited, at only 0.42 hectares of arable land per person, especially when compared to the 1.43 hectares per person available in the United States. In order to avoid this constraint, China needs to exhaust all avenues to improve grain production as well as its productivity in the use of grain. One promising area is increasing feeding efficiency through balanced diets from commercially mixed feed formulations. Because of the predominance of small backyard producers in the swine sector, feeding in the form of rough grains rather than mixed feeds is commonly practiced to augment other sources of feeds such as food waste and green leaves. Among small producers, there is a difference in the feed conversion of almost half a kilo of grain per kilo of pork produced between the most efficient and least efficient backyard producers. This differential can translate into a substantial reduction in grain requirements, given that 44.1 million tons was the level for pork production in 2003. Moreover, the use of commercially mixed feeds with balanced formulations is also necessary to ensure the quality of the final meat product.

It is for this reason that the development of the feed sector is crucial in meeting the growing demand for animal-based protein by Chinese consumers. Several studies have focused on China's feed mill sector. Among the first was a comprehensive study conducted by the World Bank in 1993. Then, a U.S. Department of Agriculture (USDA) study in 1999 by Crook, Hsu, and Lopez and a University of Sydney study in 2003 by Fu and Yin covered similar aspects of the feed mill sector. The present study departs from

the last two in several ways. First, the analysis in this study focuses on the performance of the feed mill sector. More importantly, it employs an analytical framework that connects the performance of the sector with the changes in its structure. Second, this study brings together results from earlier studies in the literature to provide a clearer big picture of the main drivers in the development of the feed sector over the last decade, with the goal of identifying constraints and potential areas that may have an impact in the development of the feed sector in the future. Third, the study gives a likely scenario of the future direction of the feed mill sector given the new policy regime after China's accession to the World Trade Organization (WTO). Finally, the more recent cost structure of large pork producers is used to simulate cost-of-production impacts of policy regime changes and their implications for competitiveness. The report begins with a description of the structure and development of the feed mill sector, followed by an assessment of its performance. Then, the drivers from the derived demand for feed from the animal meat sector and the supply of grain as raw materials for feed are discussed. Next, given the information gleaned, a likely outlook of the future development of the feed mill sector is presented for the post-WTO accession period. The last section summarizes the paper and gives some concluding comments.

Feed Mill Sector Structure

This section examines several aspects of the structure of the feed mill sector, including ownership, number, size and capacity utilization, and supervision. The analytical framework in this study connects these structural characteristics of the feed mill sector to its performance.

Ownership

The major policy change that has driven the growth in the feed sector has been the opening of the sector to private and foreign ownership. Li, Li, and Zhang (1998) argue that the Deng reform in the late 1970s was primarily anchored on decentralization, which promoted the growth of community-owned enterprises controlled by township governments called Township and Village Enterprises (TVEs). This decentralizing policy resulted in local governments competing in product markets. And in this new atmosphere of competition, cost control was crucial in maintaining adequate market share. In order to

tie managers' behavior to cost control performance, many local governments provided incentives by relinquishing control and ownership to professional managers, and this in turn accelerated privatization in China. The trend toward privatization was also evident in the feed mill sector.

Feed mills can be divided into three ownership categories: state and collective; private, which includes joint ventures of private and state and collective feed mills, sole proprietorship, and other types of private ownership; and foreign-owned, which includes joint Chinese and foreign ventures, feed mills with funding from Hong Kong, Macao, and Taiwan, and wholly foreign-owned feed mills. The move toward privatization in this sector was very fast in the 1990s. Table 2 shows that the proportion of the number of feed mills owned by state or collective enterprises was almost cut in half, declining from 92 percent in 1992 to 52 percent in 1999. In contrast, the proportion of the number of privately owned feed mills jumped from 7 to 45 percent during the same period. Provinces leading in the privatization effort were Hainan, Henan, Heilongjiang, Shandong, Guanxi, and Sichuan. Of the privately owned feed mills, 69 percent were under sole proprietorship type of ownership. Feed mills with foreign ownership increased from 1 to 3 percent. It is axiomatically accepted that private ownership is better than public ownership for a number of reasons. One is that privatization improves market orientation, making feed mills sensitive to market signals in their resource allocation and product and pricing strategies. And more importantly, as feed mills become more concerned with their bottom line (i.e., profitability and solvency), market discipline will force them to control their cost. Inefficient feed mills that cannot compete will be forced out of the market, leaving the more efficient feed mills, thereby raising the overall efficiency of the sector. In contrast, publicly owned firms that regularly incur losses may continue to be sustained by additional infusion of public funds, blocking the dynamics that raise firm and sectoral efficiency under a private ownership regime. Also, it is held that private firms can be

TABLE 2. Ownership of feed mills

Type	1992	1999	Change
	Percent		Percentage Points
State-Collective	92.09	52.28	-39.81
Private	7.00	44.47	37.48
Foreign	0.92	3.25	2.33

Source: MATRIC 2004, China Project Database.

more progressive in introducing new products, production methods, and other innovations because of their incentive structure.

It should be noted that although the number of feed mills with foreign ownership relative to the total is low, the share of these firms may be higher in terms of output because foreign-owned mills are generally larger. The entrance of foreign investment in agricultural enterprises increased as a result of China's intentional effort to attract these firms. Infusion of new capital, introduction of better equipment, transfer of improved technology, and acquisition of advanced managerial expertise encouraged the government of China to pass the first law concerning foreign investment, called the Law of the Peoples Republic of China on Sino-Foreign Joint Ventures (Mai 1999). The law identified four categories for foreign investment: those under encouragement, permission, restriction, and prohibition. Agro-processing projects (e.g., feed mills) fall under the encouragement category. Foreign firms in this category are given preferential taxation treatment under the "two exemptions and three deductions" rule. That is, feed mills with foreign ownership are exempted from the 33 percent corporate income tax (30 percent central and 3 percent local) in the first two years commencing with the first profitable year. Afterwards, only one-half of the corporate income tax is paid in the third to the fifth year. Also, foreign-owned feed mills are given preferential treatment on import duties, which are normally waived or substantially reduced for imports of equipment, technology, and spare parts.

Ultimately, the increasing number of privately owned feed mills is favorable for competition, and benefits will accrue to consumers. Mixed-feed buyers will benefit from the price competition of feed suppliers as well as from the variety and quality of products made available to the market.

Supervision

Although the National Feed Industry Office under the Ministry of Agriculture is the main government agency responsible for the development of national feed industry strategies and policies, other governmental agencies supervise some of the feed mills for various reasons. There are 12 government agencies (or categories) identified in the data that have supervision control over feed mills. For example, the Ministry of Chemical Industries has supervision over some feed mills when significant premixes are involved. The Ministry of Light Industry has supervision if equipment is involved. The earlier

World Bank study (1993) of the feed sector has pointed out that the multi-ministerial involvement in the supervision of feed mills has made coordinated development planning difficult and introduced irrationalities in design capacity, product lines, market targeting, equipment design, standardization, and financial viability. The data identify four major groupings of feed mills for supervisory purposes (see Table 3). These include the areas of Business, Livestock Husbandry, TVEs, and “Others.” These four categories comprised the supervisory control of close to 90 percent of the feed mills in 1990. This proportion did not change in 1999, suggesting that multi-ministerial supervision remains an issue. What happened over 1990s was just a reassignment of some feed mills to other agencies for supervision. For example, during the 1990 to 1999 period, the proportion of feed mills under the Business and Livestock husbandry category declined by -15.59 percentage points combined, while the “Others” category increased by an almost equal amount of 14.55 percentage points. The proportion under the TVEs remained the same at 21 percent. If there was simply a reshuffling and no significant reduction in multi-ministerial involvement in supervision, this can continue to pose a problem, especially since the ownership and size of operations have changed significantly. Without detailed information about which operations the “Others” category refers to, it would seem that legitimate supervisory assignment in the Business and Livestock Husbandry category is transferred in favor of the “Others” category.

TABLE 3. Supervision of feed mills

Type	1990-94	1995-99	Change
	Percent		Percentage Points
Business	34.53	27.20	-7.34
Livestock Husbandry	26.90	18.54	-8.35
Township and Village Enterprises	21.36	21.40	0.04
Others	7.11	21.66	14.55
Agricultural Cultivation	4.61	3.87	-0.73
Fishery	4.34	4.10	-0.25
Foreign Trade	0.42	1.02	0.60
Light Industry	0.32	0.54	0.22
Chemical Industry	0.19	0.73	0.55
War Industry	0.11	0.48	0.37
Mechanical Industry	0.06	0.20	0.14
Medicine Industry	0.05	0.26	0.20

Source: MATRIC 2004, China Project Database.

Number, Size, and Capacity Utilization

Table 4 shows that over the last decade the number of feed mills doubled, from 6,045 in 1990 to 12,319 in 1999. As cited in the previous section, it is clear from the data that the increase in the number of feed mills came from privately owned mills, since the number of publicly owned mills declined. Provinces with more than 500 feed mills include Shandong, Sichuan, Hebei, Jiangsu, Shanxi, Hunan, Hubei, Liaoning, Henan, Jiangxi, Zhejiang, and Heilongjiang. Also, the size of operation of feed mills has increased. The proportion of the number of feed mills with capacity above 5 tons per hour relative to all feed mills above 1 ton per hour increased by 6.79 percentage points, from 9 percent to 16 percent. In 1999, more than half of the feed mills in Guangdong had capacity in excess of 5 tons per hour. An increase in capacity can allow feed mills to capture the benefits of economies of scale, that is, cost reduction from spreading fixed costs to a larger production base. Also, it is likely that larger feed mills can better afford to engage in quality improvement research and introduction of quality control measures.

Using a double-shift arrangement, total feed mill capacity in China increased by 1.76 percent increase in 1998 and by 23.97 percent in 1999, finally reaching 127.85 mmt by the end of the decade (see Table 5). This represents an increase in average capacity per feed mill from 8,500 tons per year in 1997 to 10,370 tons per year in 1999. What is somewhat surprising is that while capacity was expanded, capacity utilization remained rather low, at between 48.54 percent and 54.42 percent. Only Hainan, Shanghai, and Guangdong recorded capacity utilization above 50 percent in 1999. It appears that the feed mill sector is investing in expanding capacity to meet increasing demand even if there is unused capacity. Without more detailed utilization data, this phenomenon is difficult to explain, and one can only speculate. One possible reason is that state and collective feed mills might be underutilized, pulling down the average capacity utilization

TABLE 4. Number of feed mills with size of operation

Year	Capacity		Proportion
	1 ton/hour	5 tons/hour	
1990	6,045	555	9.18
1999	12,319	1,967	15.97

Source: MATRIC 2004, China Project Database.

TABLE 5. Capacity and utilization

	1997	1998	1999
Capacity (mmt)	100.55	103.01	127.85
Utilization (percent)			
Minimum	30.74	22.00	15.00
Average	52.39	53.27	52.70
Maximum	73.32	82.00	81.00
Weighted Average	54.42	53.99	48.54

Source: MATRIC 2004, China Project Database.

in the province even when new private feed mills are optimally utilized. Also, new demand might be better served with new design and equipment rather than using underutilized old mills with inefficient design and/or obsolete equipment.

Location

The location of feed milling in China has changed significantly over time. The change in location can be characterized as either structural, in which provinces lost or gained feed production share for all types of feed, or reallocative, in which provinces changed the type of feed produced. A general pattern can be observed in the structural change of location. That is, there is a movement away from the east coast provinces to the more central provinces (see Figures 1 to 4). Beijing, Shanghai, Jiangsu, and Zhejiang lost a combined total of 8.72 percentage points in their share of feed production between 1990-94 and 1995-98. On the other hand, Hebei, Henan, and Guangxi gained 6.80 percentage points. Other provinces changed the product mix of their production. For example, Shandong province moved away from layer and shrimp feed and toward broiler feed. Hubei province reduced broiler feed in favor of swine feed. Guangdong province increased production of swine and shrimp feed and reduced broiler feed. On the other hand, Sichuan province reduced swine and shrimp feed and increased broiler and layer feed. The data is presented in Table 6. The structural change in location may be driven by the fact that most big cities on the east coast are very progressive and the cost of operating in these locations has become prohibitive. Moreover, road and transport infrastructure may already be adequate enough for relocation toward the central west.

This study explores further the reasons behind the change in location of feed mills. The two main drivers identified are location of the source of the main raw materials, such as corn and soybeans, and the location of the sector driving final feed demand, such as

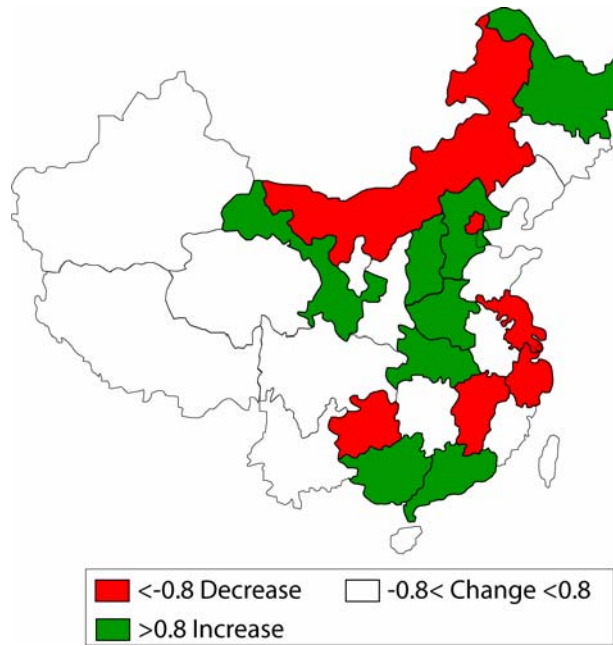


FIGURE 1. Changes in swine feed production share by province

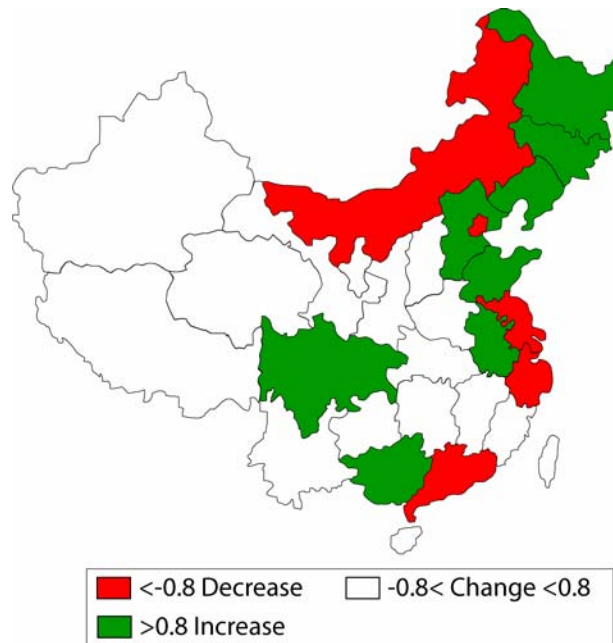


FIGURE 2. Changes in broiler feed production share by province

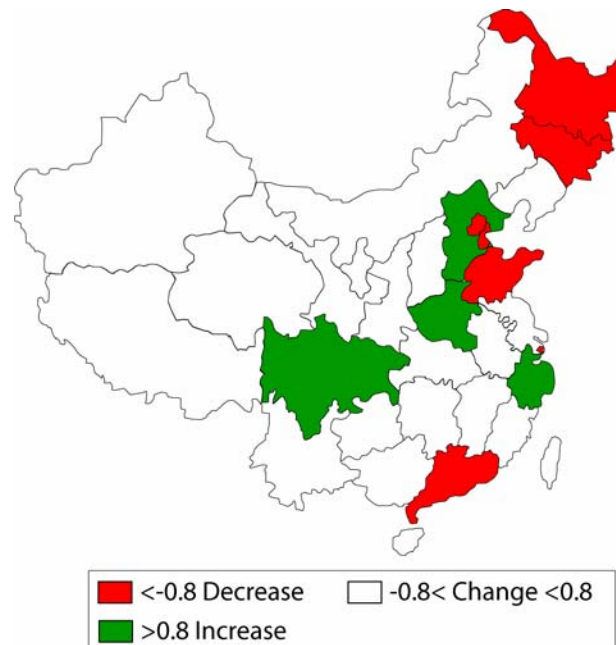


FIGURE 3. Changes in layer feed production share by province

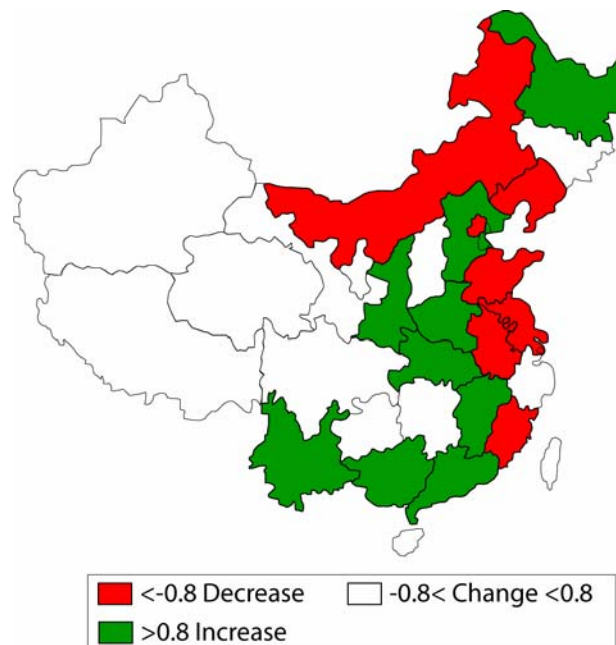


FIGURE 4. Changes in shrimp feed production share by province

TABLE 6. Share of mixed-feed production by province

Losers	Percent	Winners	Percent
Beijing	-2.763	Hebei	3.856
Shanghai	-2.620	Henan	2.007
Jiangsu	-2.210	Guangxi	0.937
Zhejiang	-1.129	Heilongjiang	0.897
Guangdong	-0.907	Gansu	0.845

Source: MATRIC 2004, China Project Database.

pork and poultry production. If transport cost is a large component of feed mills' cost structure, the mills would locate their operations to minimize total cost by balancing the cost of sourcing raw material and the distribution costs of the final product. The rule of thumb is to locate near the source of raw material if the raw material is bulky and processing would reduce its volume weight. On the other hand, locating near the market of a feed mill's final product is preferable if the processing involves expanding the volume weight from the raw material to the final product. With no data available on transport cost, feed production in China was determined to be either input-oriented (i.e., influenced more by the location of the source of raw material) or output-oriented (i.e., influenced more by the location of the final market). This was accomplished by regressing the share of feed production of each province as a function of the share of production of the major inputs in feed, that is, corn and soybeans, and the main indicator of feed demand in pork and poultry production. The data used was panel data for 30 provinces with annual observations for each province from 1992 to 1998. A fixed effects model was estimated from the panel data. The regression results are presented in Table 7.

The Hausman m-statistic suggests that a fixed-effects model is more appropriate than is the random effects model, while the null hypothesis of equality of all fixed effects is rejected using the F-statistics. The fit of the estimated model is good, having an R^2 of 0.99. Neither of the input-orientation regressors in the share of corn production and soybean production is significantly different from zero at the 1 percent level, while both of the output-orientation regressors in the share of swine and poultry production are positive and significant, with t-statistics above two. This suggests that the shares of corn and soybean production of a province do not contribute much in explaining the share in the feed production of the province, while the shares of swine and poultry production contribute in explaining the differences in the share in feed production across provinces over time.

TABLE 7. Input-orientation or output-orientation of feed mills

	Coefficient	Standard Error	t-statistic
Intercept	2.82	0.47	6.00
Input-Orientation			
Corn	-0.18	0.09	-1.87
Soybeans	-0.02	0.05	-0.44
Output-Orientation			
Swine	0.42	0.14	3.12
Poultry	0.30	0.06	4.85
Diagonstics	<i>Statistic</i>	<i>Probability</i>	
R ²	0.99		
F-statistic	17.17	<.0001	
m-statistic	19.43	0.0006	

Source: Estimated.

That is, the higher is the share of swine and poultry production of a province, the higher is the share of its feed production. It is reasonable to conclude then that feed production in China is output-oriented in terms of its location. Moreover, from the two output-oriented regressors, much of the impact is explained by the share of swine production, which has a beta coefficient of 0.41, while for poultry the beta coefficient is 0.24. In other words, for every one standard deviation change in the share of swine production, the share of feed production increases by 0.41 standard deviation, while for every one standard deviation change in the share of poultry production, the share of feed production increases by only 0.24 standard deviation. The output orientation of the feed mills may be explained by the fact that there is more significant vertical integration in feed-animal production than in grain-feed production. For example, many larger swine producers operate their own feed mills with the surplus feed production sold to other swine or poultry producers.

The results of this analysis imply that any change in the location of pork and poultry production in the future will also determine the location of feed mills.

Feed Mill Sector Performance

This section assesses the performance of the feed mill sector in terms of growth, profitability, financial efficiency, and technical efficiency. The sector's performance is then connected to its structure, particularly to the rise of private and foreign ownership.

From 1991 to 1998, the annual growth rate of commercial feed production increased by 11.14 percent, slightly higher than the 10.7 percent increase in meat production. In terms of product mix, Table 8 shows that the share of swine feed production declined by 1.80 percentage points between the 1991-94 and 1995-98 average. Shrimp feed production captured an almost equivalent increase in share of 1.86 percentage points. Feeds for other types of animals changed only slightly: layer feed increased 0.61 percentage point, broiler feed declined 0.09 percentage point, and other feed declined 0.58 percentage point.

Three measures of performance are derived from the available data. The first is a rough measure of profitability, that is, the profit margin from sales (the ratio of net income before tax to total sales). The data are aggregated by province. From 1995 to 1999, only a few of the 29 provinces reported losses. Inner Mongolia consistently reported losses in four of the five years covered at an average of -2.61 percent. The year 1998 had the most provinces reporting losses, with four provinces, including Inner Mongolia, Hainan, Ninxia Hui, and Hubei, having an average loss of 3.94 percent. Provinces reporting positive earnings had an average profit margin from sales of 3.06 to 5.38 percent. It is noted that the profit margin in the data is within the range of the allowable margin of 3 to 5 percent for compound feed producers as set by the government's Price Bureau. Also, the profit margin reported in the 1993 World Bank study was in the same range at 3 percent. There is not enough information in the available data to determine if this margin is adequate or not. However, a conditional claim can be made that the asset turnover rate (i.e., sales-to-asset ratio) of feed mills should be in the range of 1.50 to 2.81 to make the reported profit margin a remunerative enough rate given that the average cost of capital (i.e., lending rate) in China during the 1995-99 period was 8.60 percent. Considering the low capacity utilization

TABLE 8. Feed production share

Type of Feed	1991-94	1995-98	Change
	Percent		Percentage Points
Pigs	42.68	40.88	-1.80
Layer	25.33	25.94	0.61
Broiler	24.32	24.23	-0.09
Shrimp	3.70	5.56	1.86
Others	3.97	3.40	-0.58

Source: MATRIC 2004, China Project Database.

of feed mills, it is likely that the mills may not reach the minimum asset turnover rate required to make their profit margins over sales remunerative enough.

The second performance measure is on the financial efficiency of feed mills. To a certain extent feed mills may have better control of this variable than of the profit margin because of the impact of price control policy on the latter. The number of days feed mills turn over their working capital is used as the efficiency measure. The quicker the turnover, the more efficient is the use of capital. The measure reflects the turnover of feed production and inventory into sales as well as the speed of collection of sales on credit (i.e., receivables). The data show that the turnover rate has consistently declined from 116 days in 1996 to 93 days in 1999, a turnover that is quicker by 23 days, or a 20 percent improvement in financial efficiency.

The third measure of performance is technical efficiency; that is, whether feed mills in China obtained the maximum potential output given their actual use of resources, or, equivalently, whether feed mills used the least inputs to obtain the actual output level. The analysis uses one output, the actual feed output, and two inputs, working capital measured by the average balance of all the circulating funds, and the invested capital measured by plant capacity. A Data Envelopment Analysis (DEA) was used to estimate the technical efficiency of feed mills by province. In technical terms, DEA uses a programming-problem framework to maximize the ratio of outputs over inputs using solved optimal weights to aggregate both outputs and inputs. The ratio is maximized successively for each decision-making unit subject to the constraint that all ratio is less than or equal to one. The interpretation is that one less the ratio (which is a decimal) is the proportion the inputs can be scaled down without affecting the output level. A ratio of one means very efficient because there is no more room to scale down the inputs without affecting the output. Any ratio less than one suggests that either fewer inputs can be used to obtain the same output or more outputs can be obtained at the given inputs. The DEAP software by Coelli (1996) was used to estimate technical efficiency of each province for 1997. Table 9 shows that the weighted average technical efficiency of feed mills in China is 0.805, suggesting that, on average, feed mills can reduce their input use by 19.5 percent and obtain the same level of output. Hebei province, which is the second-largest feed producer in China, has a technical efficiency of 1.00. It is also the province with the largest increase in the share of production, at

TABLE 9. Technical efficiency of feed mills

Province	Technical Efficiency	Share of Production
Hebei	1.000	9.827
Gansu	1.000	1.898
Ningxia	0.992	0.367
Beijing	0.987	2.996
Shandong	0.979	9.142
Anhui	0.953	3.061
Guangxi	0.892	4.418
Inner Mongolia	0.866	0.122
Guangdong	0.855	13.101
Fujian	0.850	2.369
Shaanxi	0.841	0.833
Tianjin	0.837	2.020
Hubei	0.774	6.022
Shanghai	0.734	2.973
Jiangsu	0.729	6.450
Henan	0.724	6.363
Jilin	0.721	2.917
Yunnan	0.672	1.408
Sichuan	0.665	5.956
Shanxi	0.657	2.297
Hunan	0.649	4.244
Heilongjiang	0.641	3.706
Jiangxi	0.636	2.628
Xinjiang	0.576	1.580
Liaoning	0.463	3.302
Weighted Average	0.805	

Source: Estimated.

3.86 percentage points, between the period 1990-94 and 1995-98. The third-largest producing province, Shandong, had the fifth-highest technical efficiency, at 0.979, among 25 provinces. The largest feed producer, Guangdong, ranked ninth in technical efficiency at 0.855. Several major producing provinces had below-average technical efficiency and lost production shares. Given their measure of technical efficiency, changes in production shares by province improve China's overall technical efficiency by 1.34 percentage points. This suggests that production shares of more efficient feed mills are increasing while the shares of less efficient feed mills are declining.

Finally, the study explored the relationship between performance indicators and some structural characteristics of the feed mill sector. In particular, the performance indicators profitability and financial efficiency (i.e., working capital turnover) were regressed

as a function of the ownership structure, which in this case is measured by the proportion of feed mills that were privately owned for each province. Table 10 shows that the profitability performance of a province is positively influenced by private ownership, suggesting that provinces with proportionately more privately owned feed mills showed a higher profit margin over sales. The goodness of fit in this equation is 0.86 and the t-ratio of the ownership variable of 1.65 has a significance level of 0.11. The same result is shown for the financial efficiency performance indicator, which is also positively influenced by the private ownership variable, suggesting that provinces with proportionately more privately owned feed mills showed quicker turnover of their working capital. The equation has a goodness of fit of 0.72 and the t-ratio of 2.35 has a significance level of 0.02. The lower statistical relationship between profitability and private ownership may be because profit performance of feed mills was driven more by policy intervention such as price control than by operational decisions of feed mills. However, for financial efficiency, over which feed mills are believed to have better control, the private ownership variable was significant. Similarly, there was an attempt to relate technical efficiency (a constructed variable) and ownership structure of feed mills. Although the regression showed a positive relationship, the model did not have acceptable explanatory power, and thus these results are not reported.

Derived Mixed-Feed Demand and Supply of Raw Materials

The outlook for the mixed-feed sector is largely driven by development of the raw materials sector, such as corn and soybeans, as well as development of the final output sector, such as pork and poultry. This section reviews the factors influencing the derived demand of mixed feeds from the swine sector and the supply of grains and oil meals.

TABLE 10. Performance indicators and ownership structure

Performance Indicator	R²	Coefficient	Std. Error	t-ratio
Profitability	0.8559	0.0006	0.0003	1.6500
Working Capital Turnover	0.7247	2.4327	1.0343	2.3500

Source: Estimated.

Derived Demand of Mixed Feeds from the Swine Sector

With close to half of commercial feed production accounted for by swine feed, the demand of mixed feeds is largely driven by the development of the swine sector. The demand for swine feeds has been affected by two factors: the expansion of the swine sector and the structural transformation of the sector. Table 11 shows that over the span of a decade the share of backyard hog farms declined by 14 percentage points, from 94.6 percent to 80.7 percent. The share of specialized households increased by 12 percentage points, from 2.9 percent to 14.6 percent. The share of swine enterprises increased by only 2.2 percentage points. Since the feeding practices of these production systems are quite different from each other (especially in the proportion of purchased mixed feeds in their ration), the structural transformation has strong implications for feed demand. Table 12 shows that operations with fewer than 31 hogs have the largest share of their feed ration given as raw grain, at 56.72 percent to 66.14 percent. For the small producer category, producers with 31 to 100 swine have the highest proportion of purchased mixed feeds in their ration, at 20.45 percent. Large producers with over 500 head have half of their ration given in the form of purchased mixed feeds. The differential outcomes of these feeding practices are evident when the feed conversion ratios are compared across the size of operation. Table 12

TABLE 11. Production system

	1985	1993	1996
Back yard hog farms	94.60	88.30	80.70
Specialized hog farms	2.90	8.20	14.60
Hog enterprises	2.50	3.50	4.70

Source: Somwaru, Zhang, and Tuan 2003, 1999 RCRE Survey.

TABLE 12. Feed ration by size of operation

Feeding Practice	< 5	6-10	11-30	31-100	101-500	> 500
Fine feed	100	100	100	100	100	100
Raw grain	66.14	57.85	56.72	49.4	56.92	33.03
Mixed feed	10.12	14.33	15.86	20.13	12.37	50.12
Wheat bran and rice	22.22	18.01	22.17	20.78	20.45	8.54
Oil cakes	1.42	1.89	5.25	9.70	14.37	8.31
Performance						
Feed conversion	2.99	2.75	2.78	2.53	3.59	3.20

Source: Somwaru, Zhang, and Tuan 2003, 1999 RCRE Survey.

also shows that as size of operation increases, feed conversion declines, that is, a smaller amount of feed is needed per unit of meat produced, bottoming at 2.53 kilograms of feed per one kilogram of meat for the 31 to 100 hog size, and increasing again with larger operations. For size of operation below 100 swine, there are opposing impacts of increasing size on the consumption of commercial mixed feeds. On the one hand, the proportion of mixed feeds in the ration increases, positively affecting feed demand. However, on the other hand, the feed conversion improves, thereby adversely affecting the demand for feed per output. In contrast, for operations with more than 100 swine, as size increases, the positive impact on feed demand due to the higher proportion of purchased mixed feeds is further positively reinforced by the lower feed conversion ratio of larger operations. The actual trend in the aggregate feed use data suggests that mixed-feed use per unit of meat output increased by 7.11 percent annually during the last decade. This is further corroborated by the increasing share of feed consumption of corn as mixed feed rather than as raw grain. Corn use in mixed feed increased its share from 41 to 55 percent relative to total corn feed use.

The higher mixed-feed demand over the study period is driven by pork production, which increased by 7.56 percent annually. This increase is, in turn, partly driven by the rise in per capita income, at 9.72 percent per year. Pork income elasticity is reported by Zhang and Wang (2003) to be 0.23, giving an annual growth in per capita demand of 2.13 percent from income alone. During the same period, growth in population contributed a 1.10 percent increase in total pork consumption. This increase in demand was met by an increase in domestic supply rather than by imports. A study by Fang and Fabiosa (2002) claimed that swine production in China is competitive in feed cost relative to U.S. producers only among backyard producers (see Table 13). Among specialized households and large-scale swine producers, feed cost in China is higher than that of the United States. However, whatever cost disadvantage Chinese swine producers have in feed cost is more than offset by their lower cost in the remaining components such as the costs of feeder pigs, labor, and others. Furthermore, even with its lower cost, the swine sector was protected during this period (see positive protection rate for pork in Table 14).

TABLE 13. Cost comparison of U.S. and Chinese hog production, 1996-2000

	China	NE	North	East	Pastoral	South	West
China to U.S. Cost Ratio							
Backyard							
Feed	0.97	0.95	0.93	0.99	0.95	1.08	0.85
Feeder Pig	0.42	0.33	0.40	0.53	0.22	0.60	0.34
Labor	1.83	0.93	1.48	1.88	1.47	2.11	2.27
Other	0.17	0.17	0.12	0.16	0.17	0.18	0.20
Specialized							
Feed	1.10	0.97	1.10	1.41	0.96	1.30	1.13
Feeder Pig	0.50	0.35	0.52	1.01	0.26	0.70	0.44
Labor	0.80	0.60	0.57	1.41	0.76	0.74	0.96
Other	0.19	0.17	0.16	0.18	0.23	0.15	0.12
Large Scale							
Feed	1.32	1.06	1.21	1.40	1.23	1.69	1.41
Feeder Pig	0.33	0.22	0.33	0.38	0.24	0.43	0.35
Labor	0.59	0.44	0.52	0.33	0.53	0.47	1.01
Other	0.25	0.32	0.27	0.11	0.18	0.16	0.20

Source: Fang and Fabiosa 2002.

TABLE 14. Measures of comparative advantage and protection

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Degrees of Comparative Advantage									
Hogs	0.45	0.36	0.55	0.61	0.58	0.47	0.39	0.37	0.55
Broiler	0.43	0.41	0.24	0.49	0.47	0.51	0.45	0.39	0.60
Corn	0.54	0.64	0.49	0.51	0.38	0.02	-0.09	-0.17	-0.20
Soybeans	0.48	0.40	0.39	0.37	0.47	-0.03	0.00	-0.10	-0.03
Protection									
Hogs	0.57	0.06	0.30	0.15	0.47	0.42	0.73	0.65	0.68
Broiler	-0.27	-0.34	-0.10	-0.43	-0.36	-0.49	-0.32	-0.43	-0.55
Corn	-0.31	-0.46	-0.23	-0.24	-0.35	-0.81	0.52	0.40	0.71
Soybeans	0.26	0.04	0.23	0.30	0.08	0.33	0.59	0.46	0.65

Source: Tuan, Cheng, and Peng 2001.

The import duty for meat imports was 45 percent during this period. Fast income growth, a competitive cost structure, and protection of the local market combined to create incentives for domestic meat production to expand and as a result increased the demand for mixed feeds. The question of whether the same derived demand drivers will shape the feed mill sector in the future will be addressed in the next section.

Sources of Grains

Table 13 shows that China's degrees of comparative advantage for corn and soybeans are negative, suggesting that China has a relative disadvantage in producing these commodities. Given these adverse fundamentals, how did China provide an adequate supply of grains for its livestock sector? Prior to 1997, China followed a low-price policy. The domestic market price was lower than the world price and the procurement price was below the domestic market price. Grain surplus was primarily produced through the production quota and the Governor's Responsibility System. Later, the procurement price was increased (by 40 percent in 1996) and record surpluses in several successive periods drove the domestic market price down to the procurement price level. A more recent cost comparison by Fang and Fabiosa (2002), given in Table 15, also shows a higher cost of production of corn and beans in China compared with that in the United States. In the latter part of the last decade, corn prices in China exceeded the world price as the protection rate became positive for corn (see Table 14). The domestic markets for corn and soybeans were protected by more than 50 percent on average from 1996 to 1998. During this period, China's grain exports slowed down but continued to carry a large stock of corn, representing 83 percent of the production. The next section addresses what may happen if grains become a limiting factor in China.

TABLE 15. Cost comparison of U.S. and Chinese corn and soybean production, 1996-2000

Year	China	NE	North	East	Pastoral	South	West
China to U.S. Cost Ratio							
Corn							
1996	1.15	0.87	0.95	1.23	1.00	2.31	1.67
1997	1.41	1.12	1.21	1.20	1.32	1.93	1.82
1998	1.23	0.82	1.06	1.26	1.33	2.15	1.79
1999	1.21	0.90	1.31	1.35	1.31	1.72	1.57
2000	1.28	1.13	0.97	1.19	1.24	1.59	1.11
96-00	1.26	0.97	1.10	1.25	1.24	1.94	1.59
Soybeans							
1997	1.20	0.80	1.15	0.97	1.71	1.88	2.66
1998	1.12	0.85	0.89	0.84	1.90	1.25	1.30
1999	0.93	0.70	0.79	0.77	1.33	1.34	1.35
2000	0.98	0.93	0.76	1.09	1.12	1.16	1.17
97-00	1.06	0.82	0.90	0.92	1.52	1.41	1.62

Source: Fang and Fabiosa 2002.

Future Prospects of the Feed Mill Sector

The long-term development of the feed mill sector will be largely shaped by the fundamentals in China's meat, grain, and oil meal sectors. It is expected that the demand for meat products will continue to grow with continued expansion in income and population.

But how will this growing demand be supplied? On the one hand, there is strong evidence in the literature that China does not have comparative advantage in grains and oil meals. On the other hand, China has a cost advantage in pork production, especially among backyard producers. Given these fundamentals, what path of development will China follow in meeting its growing demand for meat products? There are three likely alternatives:

- continue to protect its grain and oil meal sectors to produce domestically the feed grain and oil meal requirements of the meat sector; or,
- import the grains and oil meals required by the meat sector; or,
- import meat products directly.

Recent policy developments in China will have a large impact on the course taken. Foremost of these developments is China's accession to the WTO in December 2001 and the implications for the country's commitment on border duties, export subsidies, and domestic support. For the oilseed complex sector, China has chosen a policy direction that supports its domestic crushing sector by importing a substantial amount of soybeans. This is reflected by the tariff escalation in the oilseed complex, whereby the import duty for soybeans is low at 3 percent, (the same level as before China's accession), that for soy meal is 5 percent, and that for soy oil is 9 percent (see Table 16). This duty differential

TABLE 16. Border regime

Commodity	Pre-accession	WTO Commitment		
	Tariff (%)	Tariff/In (%)	Out (%)	TRQ (mmt)
Corn	14	1	65	7.2
Soybean	3	3		
Soy meal	5	5		
Soy Oil	13	9	74	3.3 ^a
Beef	45	12		
Pork	20	12		
Poultry	20	10		

Source: World Trade Organization schedule.

^aTariff-only regime at in-quota rate starting 2007/08.

avored imports of soybeans rather than soy products, pushing the soybean import level from 9.8 mmt in 1999-2000 to 22.8 mmt in 2003-04. As a result, China has enough soy meal, a by-product of the crushing industry, for its domestic mixed-feed sector, with even a small surplus (750 tmt in 2003-04) available for export. Even with the large import of soybeans, China's soybean price is still 33 percent higher than the world price.

The case of corn is somewhat different, as it is under a tariff rate quota (TRQ) regime in China's WTO commitment. Although China has an in-quota rate of only 1 percent in corn, the out-quota rate is prohibitive at 65 percent, which is several times higher than the pre-accession import duty of 14.13 percent. The TRQ level is 7.2 mmt. It is not highly unlikely for a scenario to exist whereby corn becomes a limiting factor in the future development of the feed sector. There are already signs of a shortfall in the corn market in China, with its stock of corn dramatically declining from 79.87 percent of production (equivalent to 102.31 mmt) in 1999 to only 17.53 percent (19.99 mmt) in 2003. The domestic corn price in China has been 35 percent higher than the world price in the last decade.

The question then is, when China is short of corn, will it import more corn for the feed mill sector, or will it just import the final meat products? It is argued in this study that a reasonable path of development for China will have two phases. In the first phase, China will import corn for its mixed-feed sector for as long as this is within its TRQ so that the feed mill sector can take advantage of the low 1 percent in-quota rate for corn. The main reason for this is that China has enough excess capacity in its feed mill sector to absorb an increase of its production using the 7.2 mmt corn TRQ. Assuming an 80 percent share of the mixed-feed ration for corn, the 7.2 mmt corn TRQ is only 9 mmt in terms of mixed-feed production. This is only 13.47 percent of the 65.79 mmt excess capacity of the feed mill sector in 1999. This would also make economic sense since there is enough supply of the other important ingredient—soy meal. The second phase commences when the TRQ is exceeded because it might be too prohibitive to bring expensive corn into China at the out-quota rate of 65 percent. Given that the duty for pork is only 12 percent and that for poultry is only 10 percent, directly importing meat products will become increasingly more attractive. Based on the border duty alone, at the in-quota rate, pork is cheaper to import than is corn if the ratio of the price of pork to the price of corn is less than 0.239. However, at the

out-quota rate, it is cheaper to import pork rather than corn if the ratio of the price of pork to the price of corn is less than 15.55. Since 2001, the ratio of the price of pork to the price of corn has moved in the range of 7.35 to 10.92.

Moreover, with the growth in the demand for meat products concentrated mostly in the big coastal cities, which are easily accessible to ocean freight, it might be easier and less costly to bring in imported meat, rather than importing corn, trucking it to the location of feed mills in the more central-west region of China, and then transporting the finished meat products to the coastal cities. However, the full development of the second phase would also depend on the situation in the meat sector, especially in pork production. If structural transformation proceeds in the swine sector such that larger farms continue to gain an increasing share in pork production, the cost disadvantage of larger farms may narrow the cost differential between domestic and imported pork to make importation of pork an attractive option. A preliminary analysis showed that a higher cost of corn when imported outside the quota translates into a 12.11 and 15.93 percent rise in the cost of feeder and finished pigs, respectively, in China, which is enough to offset any initial cost advantage it may have over imports.

Summary and Conclusion

China's food economy has gone through dramatic transformation driven by both demand and supply forces. Sustained economic growth and fast urbanization have expanded demand and shifted China's consumption basket away from the traditional grain-based staples to more animal-protein rich products. At the same time, major policy reforms emphasizing decentralization and privatization have increased investments and expanded productive capacity to meet this growing demand.

Nowhere is this change better illustrated than in the grains-feeds-meat complex. Driven by stronger demand, meat production in China increased by 10.7 percent annually over the 1990s, with 62 percent of this production in pork, 24 percent in poultry, and 14 percent in beef. To better meet the growing demand in the swine sector, production shifted to more specialized households and even to larger-scale operations. These producers not only increased their scale of operation but also had a higher proportion of purchased mixed feeds in their ration, increasing the demand for mixed feeds. Hence,

during the same period, the increase in mixed-feed production mirrored the increase in meat production at a slightly higher rate of 11 percent.

The feed mill sector also experienced its own structural transformation. The number of feed mills increased, doubling in a decade, from 6,045 to 12,319. Domestic private investors and foreign investors gained an increasing share of production as new laws providing incentives for this type of ownership were put into place. The performance of the feed mill sector has been positive. Profitability of feed mills was within the set allowable profit margin of 3 to 5 percent, with only a few provinces reporting losses. The sector also showed progress in its financial efficiency, with the turnover of its working capital quicker by 23 days, a 20 percent improvement. The average technical efficiency of feed mills is 0.805, suggesting that inputs can be scaled down by 19.5 percent without affecting output. More-efficient feed mills increasingly gained production shares while less-efficient feed mills lost production shares. It was shown that provinces with proportionately more privately owned feed mills also had a higher profit margin over sales and quicker turnover of working capital.

The size of operation also increased, with the proportion of feed mills having capacity above 5 tons per hour rising from 9.18 percent to 15.97 percent. Total capacity increased by 27 percent in two years, reaching 127.85 mmt in 1999. However, capacity utilization remained low, in the range of 48.54 to 54.42 percent. Also, the multi-ministerial supervision of feed mills, found by an earlier study to be the source of a lack of coordinated development, has changed little, with only a reallocation of supervisory control.

Location of mixed-feed production shifted away from the progressive coastal provinces, where the cost of operation may have become prohibitive, to provinces in the middle and western part of the country. This was largely driven by the change in the location of final markets—pork and poultry production—suggesting more vertical integration in the feed-to-meat rather than the grains-to-feed operations.

Despite not being competitive in corn and soybeans, China had an adequate supply of grains, as domestic production was encouraged by some level of protection, especially in the latter part of the decade. Moreover, by policy choice China maintained a substantial stock of corn, at 83 percent of production. Later in the decade, also by policy choice, China protected its domestic crushing sector by importing soybeans rather than the prod-

ucts through tariff escalation. Soybean imports grew from 9.8 mmt to 22.8 mmt in a matter of three years. As a result, China met its soy meal requirement and even had a small exportable surplus.

The case of corn is different. The market shortfall is becoming evident, as China's corn stock dropped from 79.87 percent of production to only 17.53 percent. This tightening of supply is evident from the fact that the domestic corn price has consistently exceeded the world price over the last decade. There is a strong possibility that corn will become a limiting factor in the future. When this point is reached, the question as to whether China will import corn for domestic meat production or import meat products directly becomes an important choice of interest to many stakeholders. Given the fact that there is an adequate supply of soy meal and that there is excess capacity in the feed mill sector, this study points to the likelihood that China will allow corn imports up to the TRQ of 7.2 mmt since the in-quota rate is very low at 1 percent. However, when the TRQ is exceeded, the duty jumps to the prohibitive out-quota rate of 65 percent. At this point, given that the duties for pork and poultry imports are only 12 and 10 percent, respectively, there would be a strong incentive for China to import meat products directly rather than importing expensive corn to produce meat domestically. Moreover, since the growth in meat demand is mostly in the large coastal cities, which are easily accessible to ocean freight, meat imports will be an attractive option, rather than importing expensive corn that must be trucked to feed mills concentrated in the central-west region and transporting final meat products back to the coastal cities. Finally, the cost disadvantage of foreign producers may be narrowed, with large-scale swine operations increasingly substituting for backyard producers, providing yet another reason to favor meat imports. The out-quota rate of corn will raise the cost of production in China by 9.82 percent, which is enough to close the cost gap.

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