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China as Dairy Importer: Rising Milk Prices and Production Costs

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Abstract

China's emergence as a major importer of dairy products corresponds to rapid increases in its domestic milk prices. Allocating growth in China's milk prices from 2006 to 2014 to production cost categories shows that feed concentrates and fodder account for about half of the price increases. While labor productivity grew rapidly, there was only moderate growth in milk per cow and no improvement in milk output per unit of feed. Scarcity of feed resources, particularly forage, is likely to constrain growth of China's milk production and maintain the country's demand for dairy imports.

Keywords: China, dairy, productivity

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Introduction

Seven years after the melamine crisis, China's Agriculture Minister said that consumers still lacked confidence in Chinese dairy products (Han 2015). He also raised concerns that resource scarcity and pressure from low-priced imports constrained the industry's development. Industry analysts also stressed the importance of supply-side issues. Li (2015) cited low productivity of cows, feed conversion, and disease control as major problems facing the industry. Gai and Gao (2015) emphasized the need to improve competitiveness by increasing the scale of producers and strengthening their linkages with processors. Li (2015) also observed that imported alfalfa had become a key input for China's large-scale dairy farms, given the scarcity of forage resources in China.[1]

While it is apparent that supply-side factors are important determinants of China's demand for imported dairy products, there is little recent analysis of these factors. Zhou, et al. (2010) warned that the expansion of large-scale dairy farms had outpaced feed supplies, improvements in manure disposal, and disease control. Wang and Li (2014) found only modest differences in milk yield per cow across different sizes of dairy farms and concluded that rising labor and feed costs were the main factors driving the exit of small-scale farms. More investigation of the changing cost structure of China's dairy industry is needed to assess the country's prospects for meeting its growing consumption of milk products.

This article analyzes the cost structure and measures of partial productivity for different sizes of dairy operations to gain insight about the international competitiveness of dairy production in China. The analysis assesses the contribution of various components of production costs to rapid growth in Chinese milk prices. Growth in input prices and partial productivity measures is considered to evaluate the role of input scarcity in constraining growth of China's dairy sector.

The next section describes the analytical approach and cost of production data used for the study. The analysis that follows profiles recent growth in Chinese milk prices and key input prices. It then reports changes in cost components and partial productivity measures for different types of farms. A final section summarizes the findings.

Analytical Framework and Data

This analysis investigates recent trends in milk prices, unit milk production costs and partial productivity measures of Chinese dairy farms to gain insight about how the industry is evolving. In view of the rapid structural shift from small "backyard" farms to large-scale farms in China's dairy industry, the analysis is conducted for farms of varying scale.

The demand for imports of a commodity by a country is driven by growth in the commodities consumption and the capacity of domestic producers to supply it. Domestic prices tend to rise when consumption growth outpaces growth in domestic supply, prompting increased demand for imports when domestic price exceeds the price of imported supplies. Limited supplies of inputs

[1] According to China's customs statistics, imports of alfalfa (Harmonized System code 121409) rose from 77,000 metric tons in 2009 to 1.36 million metric tons in 2015.

may drive input prices higher, contributing to growth in a commodity's output price. However, the effect of rising input prices on output price may be offset by increases in the productivity of inputs.

The relationships of input prices and partial productivity to output price are implied in the basic identity that revenues to producers are fully distributed to input costs and net returns:

$$1)\quad PQ = \sum_{i=1}^{K} w_i x_i + NR$$

where P and Q are the price received and the quantity produced of output (milk), w_i and x_i represent the prices and quantities of each of K inputs such as labor and feed, and NR is the value of net returns to management.

The change in the output price over time equals the sum of changes in per-unit input costs and net returns per unit of output:

$$(2)\ \Delta P = \sum_{i=1}^{K} \Delta\left(\frac{w_i x_i}{Q}\right) + \frac{\Delta NR}{Q}$$

Changes in output price could be influenced by both changes in input prices and productivity of inputs. If a competitive industry with low barriers to entry and exit maintains a given level of net returns (ΔNR=0) in the long run, and the average product is represented by $AP_i = Q/x_i$, then equation 3 results:

$$(3)\quad \Delta P = \sum_{i=1}^{K} \frac{\Delta w_i}{\Delta AP_i}.$$

An increase in input prices—wages, land rents, feed and input prices—could be offset by increases in average output of milk per unit of input. If input prices rise faster than productivity, China's milk price will have to rise to maintain profitability.

The data for the empirical analysis is obtained from a cost of production survey conducted by China's National Development and Reform Commission (NDRC). The survey was developed during the 1970s as a tool to aid officials in setting farm prices, and it is still conducted annually. The data is widely used by analysts in China, and it was the basis for research by Fuller et al. (2006), Rae et al. (2006), and Wang and Li (2014).

The NDRC survey is conducted by a hierarchy of planning commission offices and statistical bureaus at the national, provincial, and county level. Participating farms are chosen at the discretion of county officials under guidelines issued by administrators. Officials are instructed to choose farms from representative townships in their jurisdiction that represent various sizes and types, but there does not appear to be a rigorous standard procedure for selecting sample farms. Farmers record data on expenses, production, sales and input use, and submit the report form to the office. The data are compiled and reported to provincial and national offices. NDRC publishes an annual compilation of tables showing average expenses and quantities for dairy and other commodities. No sample sizes or standard errors are published, so the reliability of the data is hard to assess.

While the survey design does not appear to be rigorous, the data are a unique compilation of information useful for tracking changes in income and expenses of farms in China over time. Examination of the data bolstered our confidence in the reliability of data for 2006–2014 which was tabulated in a manner consistent with other data sources and market reports.[2]

Each year from 2006 to 2014, the NDRC published a table showing average expenses for four types of dairy operations: "backyard" (1–10 head), "small scale" (11–50 head), "medium scale" (51–499 head), and "large scale" (500 head or more). NDRC reported physical quantities of milk per cow, labor input, and feed concentrates (referred to by NDRC as "fine" feed) and expenses for other items. NDRC also reported the average producer price for milk. The analysis is based on a compilation of data reported in these tables. A weighted average of small scale and medium scale data is calculated to reduce the number of categories.

Rapid structural change in China's dairy industry is evident from Ministry of Agriculture data showing shares of dairy cattle by size. The share of cows held by smallholders with less than 5 head fell by more than half, from 44.8% in 2002 to 21.8% in 2013. Small-scale farms holding 5–19 head increased their share slightly from 2002 to 2008, but their share of cattle fell by 10 percentage points from 2008 to 2013. The changes in shares reflect a large decline in the number of backyard smallholders and rapid increase in the number of large-scale farms. The data reveal rapid consolidation that is important to consider when analyzing farm costs and productivity.

Table 1. Share of dairy cattle by farm size, 2002–2013.

Size of Farm	**2002**	**2008**	**2013**
Number of Cows		*Percent*	
1 – 4	44.8	32.4	21.8
5 – 19	29.3	31.5	21.2
20 – 199	17.6	20.5	21.7
200 or more	8.3	15.5	35.3
Total	100.0	100.0	100.0

Source. China Ministry of Agriculture

Trends in Chinese and US Dairy Prices

The analysis begins by comparing trends in milk prices using cost of production survey data for China and the US over 2006–2014 to provide context for the analysis of costs. The average price reported by the NDRC data was converted to dollars per cwt at the official exchange rate for each year. The US milk price, reported by US dairy farm cost-of-production estimates, is reported annually by the USDA (McBride 2016).[3]

[2] NDRC data from the early 1990s and 1980s was reported in varying tabulations, and some indicators displayed large year-to-year fluctuations that undermined confidence in the data's quality for those years.

[3] China's dairy imports consist mainly of powdered milk and other products, but in this analysis we compared farm prices from similar production cost surveys in China and the United States to capture differing cross-country trends in farm-level prices. We also compared imported milk powder prices converted to a fluid milk equivalent with Chinese milk prices and found patterns similar to the comparison reported here.

China's milk price rose faster than the US milk price, suggesting a decline in competitiveness for milk producers in China. In 2006, the China price ($11.09/cwt) was about 15% less than the US price ($12.99/cwt) (Figure 2). The China price rose each year thereafter to reach $29.46/cwt in 2014—about 24% higher than the US price that year. The US price rose in some years and fell during others. The China price exceeded the US price each year from 2009 to 2014, and the difference was as large as 46% during 2013. The rise in the dollar price of China's milk reflects a doubling of the price in local currency plus a cumulative 30% appreciation of the currency against the dollar from 2006 to 2014. The increase in the China price above the US price during 2009–2014 corresponds to the increase in China's milk imports during those years shown in Figure 1.

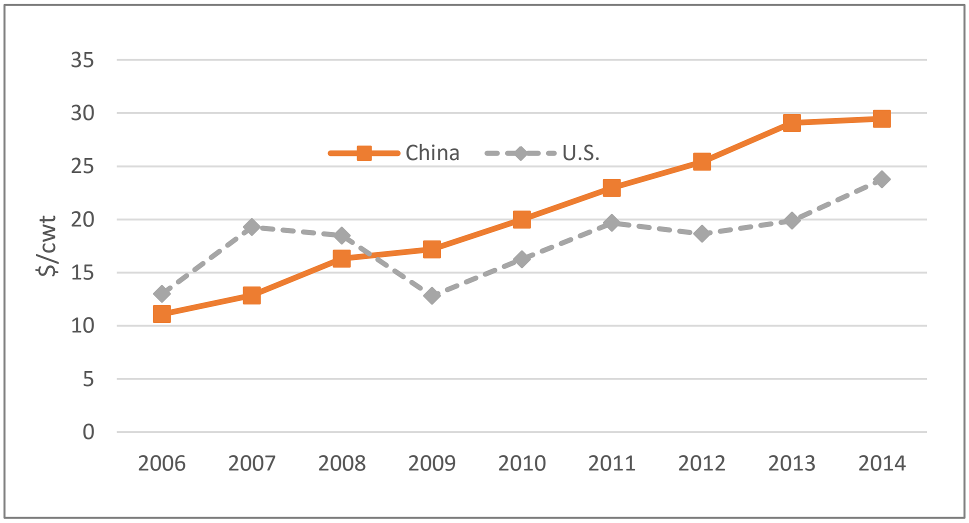

Figure 2. China–US farm prices for milk, 2006–2014.
Note. China milk price is average reported by NDRC. US price is from McBride (2016).

The increases in the Chinese milk price reflect rising costs of production in the country. Indexes were calculated to assess the rise in overall costs and the role of several key input prices. An index reflecting production cost was calculated as the ratio of total cost per kg of milk output reported by the NDRC data to its value in 2009. Similar price indexes were calculated for feed concentrates, hired labor, and imported alfalfa. The average price of feed concentrate was calculated as the ratio of feed expense to quantity of feed used. The average daily wage for hired laborers was obtained directly from NDRC reports. Chinese customs data (Harmonized System code 121490) was used to calculate the unit value of imported alfalfa as a proxy for its price since the NDRC data do not provide quantity information to calculate prices of forage and hay.[4] The alfalfa unit value was converted to Chinese currency at the official exchange rate for each year.[5] The hired labor wage is a cash expense recorded by farms.

[4] Imported alfalfa is a key input for large-scale dairy farms (Li, 2015). Imports rose from 77,000 metric tons in 2009 to 1.4 million metric tons in 2015.
[5] No data on unit values for 2006-08 are available because China did not import significant volumes of alfalfa before 2009.

A simple index with a base year of 2009 was calculated for each value in Chinese currency with no adjustment for inflation. The indexes for total production cost and prices of feed concentrate price, imported alfalfa, and labor are displayed in Figure 3. The total cost index rose each year from 2006 to 2014, with cumulative growth of 91% from 2006 to 2014. Growth in the production cost and the milk price was about three times the general rate of inflation in China—cumulative growth in China's CPI from 2006 to 2014 was 30%. The wage was the fastest-growing input price, with daily wages growing 190% during 2006–2014. The feed concentrate price rose 96%, roughly the same rate as growth in total cost. The price of imported alfalfa rose during 2011, 2012, and 2014 but it declined during 2010 and 2013. The cumulative increase in alfalfa price from 2009 to 2014 was 22%, less than a fourth of the growth in the feed concentrate price. Thus, imported alfalfa became cheaper relative to feed concentrates, consistent with the surge of China's alfalfa imports during those years.

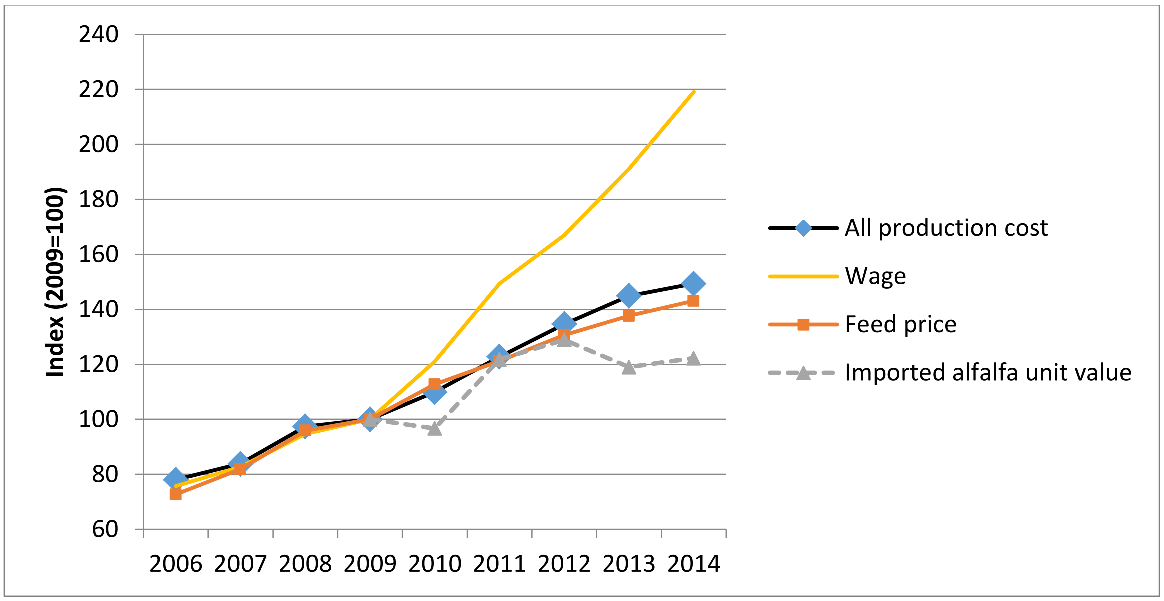

Figure 3. Indexes of China diary input prices and cost.
Note. Production cost is average reported by NDRC. Wage is daily wage for hired workers. Feed price is expense for feed concentrate divided by volume consumed. Imported alfalfa unit value calculated from customs data converted to Chinese currency.

Contribution to Milk Price Growth

The growth in Chinese dairy farms' gross revenue was allocated to expense categories to assess cost factors driving the growth in China's milk prices. Milk sales consistently accounted for 90% to 93% of gross revenue in the NDRC data. Thus, the gross revenue per kilogram of milk output largely reflects the milk price. The source of the remaining 7% to 9% of revenue for dairy producers is not identified, but may include sales of calves, cull cows, and manure.

The per-cow expenses reported by NDRC were converted to expenses per unit of milk output for five categories:

- feed concentrates (referred to as “fine feed”: grains, oilseed meals, beans, bran, commercial feed)[6]
- fodder (“green coarse feed”: hay, grass, corn stalks, and other forages valued at market prices)
- labor (hired labor expense and imputed value of unpaid family labor)
- fixed asset depreciation (dairy cattle and structures)
- Other expenses (total production cost less the four categories above)

The net return to management was calculated as a residual between gross revenue and the sum of the five expense categories.

The cost of both hired and family labor was estimated using the average wage for hired labor. NDRC imputes the value of family labor based on local per capita income statistics. The hired labor wage exceeded the imputed family labor wage by 87% in 2006 and by 27% in 2014, suggesting that the wage imputed for family labor might not reflect the level or the trend in rural wages. Therefore, the wage for hired labor was used to impute the expense of both hired and family labor.[7]

The analysis was conducted for three dairy operations: backyard (1-9 cows), small-medium scale (10-499) and large scale (500 or more cows) farms to provide perspective on the structural shift from small- to large-scale farms. Table 2 displays the increases in gross revenue, five categories of expenses, and returns to management from 2006 to 2014 for each of the three operations. Consistent with the increase in price observed previously in Figure 2, the gross revenue per unit of output increased each year from 2006 to 2014 for each type of producer. The cumulative increase in gross revenue was 2.20 yuan/KG for backyard farms, 2.22 yuan/KG for small-medium farms, and 2.49 yuan/KG for large-scale farms. Expenses and net returns also increased each year to varying degrees. However, revenue grew faster than overall expenses, so the residual net returns grew for each type of operation. The increase in net returns is inconsistent with anecdotal accounts of low profitability in the sector. This could reflect under-reporting of some expenses, as discussed below.

Feed concentrate was the leading contributor of expense growth for both backyard and large-scale farms. The feed concentrate expense absorbed 36.3% of the increase in revenue of backyard farms, 33.5% for small-medium farms, and a 30% share for large farms. In contrast, fodder expenses were more important for large farms (20.6%) than for small-medium (16.4%) and backyard farms (11.8%). The greater fodder share for large farms likely reflects the greater propensity of farms with large numbers of cows to purchase high-quality fodder and transport it to a fixed location. Backyard farmers often gather fodder locally or graze their few cows near their farmstead.

[6] According to NDRC documentation, feed expense does not include that used for calves and replacements.
[7] “Backyard” farms use almost exclusively unpaid family labor while large scale farms use mainly hired labor, so using the same wage for both types of labor also removes a potential bias in evaluating labor costs of different sizes of farms.

Table 2. Contribution of expenses and net returns to 2006–2014 milk price increase, by farm type.

	Backyard Farms (1–9 Cows)		Small-Medium Farms (10–499 Cows)		Large Scale Farms (500 or more Cows)	
	2006–2014	Share of Increase	2006–2014	Share of Increase	2006–2014	Share of Increase
Item	*Yuan*	*Percent*	*Yuan*	*Percent*	*Yuan*	*Percent*
Gross income	**2.20**	**100.0**	**2.22**	**100.0**	**2.49**	**100.0**
Feed concentrate	0.80	36.3	0.74	33.5	0.75	29.9
Fodder	0.26	11.8	0.36	16.4	0.51	20.6
Labor	0.44	20.0	0.34	15.2	0.20	8.0
Depreciation	0.07	3.1	0.16	7.4	0.20	7.9
Other expense	0.03	1.3	0.03	1.5	0.13	5.0
Returns to management	0.61	27.6	0.58	26.0	0.71	28.6

Note. Table shows change in each value from 2006 to 2014 with no adjustment for inflation. The sum of increases in expenses and returns to management equal the increase in gross revenue.

Conversely, labor expense was more important for backyard operations than it was for large-scale farms. Labor expense absorbed 20% of revenue growth for backyard farms, 15.2% for small-medium farms, and only 8% for large-scale farms. This pattern reflects greater labor intensity of small-scale production.

Depreciation was a more important expense for large farms (7.9% of revenue growth) and small-medium farms (7.4%) than it was for backyard farms (3.1%). This may reflect minimal investment in facilities and high-quality cows by backyard farms. Depreciation of fixed assets may be understated since many Chinese farms have benefited from subsidies for construction of "scale" farms or "dairy-farming communities" (known in Chinese as *yang zhi xiao qu*). Higher expenses for other items like veterinary fees, manure disposal, and energy may be reflected in the greater share of other expenses (5%) for large-scale farms versus small-medium farms (1.5%) and backyard farms (1.3%).

Residual returns to management accounted for a surprisingly large share of the increase in milk prices—26%-28% for the three types of farms. This result is at odds with phenomena that indicate low profitability such as exit of backyard farmers and reports of "milk dumping." The apparent increase in net returns shown by the NDRC data may be an artifact of undervaluing unpaid family labor, self-supplied forage resources, or understating land cost. Depreciation expense could be understated by NDRC's assumption of a relatively long six-year productive life of cows.

Partial Productivity Measures

Increases in input prices can potentially be offset by increases in productivity to maintain price- and cost-competitiveness. In the second part of the analysis, growth in partial productivity is assessed for three main inputs for which physical quantity data published by NDRC: the number of cows, feed concentrate use, and days of labor input. Growth in milk output per unit of input was calculated for each input from 2006 to 2014 for an (unweighted) average over all farms reported by NDRC.[8]

Indexes of milk output per cow, milk per unit of feed concentrate, and milk per day of labor were calculated with the 2006 value set equal to 100 as the base year. Calculations were performed for each of four farm size classes which displayed similar trends. The results are summarized two tables showing how productivity grew over time and differences across farm size classes.

Table 3. Partial milk productivity indexes for Chinese dairy farms, 2006–2014.

Year	Cows	Feed Concentrate	Labor
		2006=100	
2006	100.0	100.0	100.0
2007	101.7	100.0	106.6
2008	103.1	100.3	109.7
2009	105.6	101.4	122.1
2010	103.9	100.0	121.3
2011	104.1	103.7	122.2
2012	105.1	100.7	125.6
2013	106.1	100.9	129.7
2014	106.4	99.3	130.3

Note. Table shows indexes calculated based on milk output per cow, per kg of feed, and per day of labor reported in NDRC data for all dairy farms.

Labor was clearly the input with the greatest improvement in productivity over time (Table 3). Output per labor-day rose a cumulative 30% from 2006 to 2014. However, the growth in labor productivity was uneven, as most of the increase occurred during 2006–09. Milk per cow grew only marginally—a cumulative 6.1% from 2006 to 2013, or less than 1% annually. There was essentially no change in milk per unit of feed concentrate during 2006–2013 and feed productivity dropped in 2014.

The dominance in labor productivity growth is consistent with adoption of labor-saving technology or business models induced by the rapid rise in wages. The 30% improvement in labor productivity only partially offsets the 90% increase in wages reported earlier in Figure 3. While improvement in labor productivity was not fast enough to fully offset the rise in wages, it did mute the impact of rapid wage growth on the rise in labor cost. The analysis of costs presented above found that labor accounted for 20% of revenue increase for backyard farms and just 8% for large-scale farms.

The comparison of productivity by type of farm suggests that the Chinese dairy industry improved productivity by shifting from backyard farms to large-scale farms. The differences in

[8] Data on output by size class were not available to calculate weighted averages. The Ministry of Agriculture’s Livestock Industry Yearbook reported cow inventories by size for 2008 but not for more recent years.

productivity across farms is summarized by calculating partial productivity indicators for each farm type using averages for 2006–2014 and calculating an index with backyard farms equal to 100 (Table 4).[9] The indexes show that productivity of each input increases with farm size. Small, medium, and large-scale farms all have more productive laborers and cows than backyard farms (Table 4). Milk-per-cow of large-scale farms is 23.2% higher than that of backyard farms, while the advantage over backyard farms is 8.4% for medium-scale farms and less than 1% for small-scale farms. There is little difference in milk-feed ratios across farm types. Feed productivity was about 2–4% higher for small, medium and large farms compared with backyard producers. Labor productivity differs dramatically across farm types. Labor productivity on large farms is more than double that of backyard farms. Small-scale farms labor productivity is 35.7% higher than that of backyard operations. For medium-scale farms the labor productivity advantage is 63.4% and for large scale farms it is 116.7%.

Table 4. Partial productivity comparisons by type of dairy farm, 2006–2014.

	Type of Farm			
Input	**Backyard**	**Small**	**Medium**	**Large**
		Backyard farm = 100		
Cows	100.0	100.9	108.4	123.2
Feed	100.0	102.5	103.5	104.2
Labor	100.0	135.7	163.4	216.7

Note. Table shows indexes based on average milk output per cow, per kg of feed, per day of labor. For each input, the index shows the productivity compared with backyard producers. Indexes are averages over 2006–2014.

Conclusions

China's dairy industry is encountering obstacles to growth as it expands to meet the country's growing demand for dairy products. Inputs are becoming scarce and their prices are rising rapidly as demand grows. Cost pressure from rising input prices and an appreciating currency have contributed to higher milk prices in China which corresponds to rising wholesale prices for dairy products in China. The rise in milk prices during 2009–2014 corresponded to China's emergence as a significant importer of dairy products. China is likely to remain a significant importer if cost pressures continue to push its milk prices above international prices.

Based on analysis of the cost structure of Chinese dairy producers, scarcity of feed resources may be a key obstacle to expansion of China's dairy industry. China's high cost of corn and other feed grains is an impediment to expansion of its dairy sector. The analysis also reveals the importance of fodder in the cost structure of large scale farms. Large concentrations of cows cannot easily be grazed given the large land requirements. Instead, large farms tend to rely on purchasing hay and other forages.

Transition to larger-scale farms may achieve greater technical efficiency, but higher costs of fodder and scarcity of skilled laborers and farm managers may impede competitiveness and

[9] There were no discernible differences in trends in the productivity measures across farm types, so we only report the index by farm type for the average over 2006-2013.

expansion of domestic dairy output. Large-scale farms also require higher investment in fixed assets and expenses for veterinary services and manure disposal.

China's trade policy sets low tariffs for imports of scarce high-protein feed ingredients like soybeans and alfalfa which has allowed livestock producers to circumvent resource constraints to some degree by importing those scarce feed resources (Gale 2015). The shift to large-scale farms coincided with China's rising imports of alfalfa which may have been encouraged by low import prices compared to local feed prices. In contrast, China's grain prices were kept artificially high by a price support program and an import quota for corn during 2006–2014. The elimination of China's corn price support program announced in 2016 could relieve some cost pressure if corn prices fall, but the import quota for corn is likely to continue. A Ministry of Agriculture plan to shift land from corn for grain to corn silage, alfalfa and other fodder crops may also support dairy production by adding to domestic feed supplies.

While the corn policy adjustments may slow the growth of feed costs, the across-the-board increase in production costs observed in this study suggests scarcity of other inputs may also constrain the dairy industry's growth. In view of continuing constraints on domestic output growth, China's rising consumption of dairy products is likely to be satisfied to a significant degree by imports. Thus, China is likely to grow as an export market for dairy products.

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