



## Got milk? The rapid rise of China's dairy sector and its future prospects

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### Abstract

This paper synthesizes recent research and new empirical findings to build a more comprehensive understanding of developments in China's dairy sector. China's tremendous rise in dairy demand has been driven by several mutually reinforcing factors: including rapid income growth, promotion by the government and dairy industry, changes in urban lifestyles, and the development of new, more sophisticated marketing channels. Domestic milk output has grown to satisfy rising demand largely by increasing the dairy herd. Substantial increases in productivity have been achieved through technology adoption, but there is evidence that the torrid growth has created inefficiencies because adaptations to marketing rules, infrastructure, and institutions have not kept pace with the changing environment. These results suggest there is ample room for future growth in both domestic milk production and dairy demand, but multinational firms and imported products will likely play an increasing role as China's dairy market continues to develop.

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## Introduction

In the 1990s, during the second decade after China's emergence from its period of Socialist isolation, [Garnaut and Ma \(1993\)](#) noted that the nation's food consumption patterns were emerging in ways that were largely consistent with other East Asian nations – with one notable exception. Given China's income level, the demand for grain, most meat commodities, aquaculture products, fruits and vegetables were at or exceeded the expected levels of consumption. There was only one major commodity that China's consumers were under consuming: dairy. The average urban resident in 1992 only consumed a milk equivalent of 9.07 kg per capita of dairy products, only a fraction of level in many other nations.<sup>2</sup> While [Garnaut and Ma \(1993\)](#) postulated that “different tastes associated with historical contact with international consumption patterns” was the cause for the unusually low consumption of milk in China, we suggest below that historical preferences are only one of the factors influencing dairy demand.

Since the mid-1990s the lethargy of China's dairy sector has disappeared and a large literature has appeared trying to understand it. Demand, especially in urban areas, has exploded ([Zhou et al., 2002](#)). Dairy production has risen sharply. Internationally there is a scramble to understand the implications China's emerging dairy sector for world trade. While many papers have appeared recently that address the supply and demand for dairy products in China ([Zhou et al., 2002](#); [Fuller et al., 2004a,b](#)), we believe that the literature still lacks research that systematically explains the recent emergence of China's dairy industry and its future demand and supply trends.

This paper sketches a more comprehensive picture of China's dairy sector and assesses the nature of the sector's development in the coming decades. In the first two sections, we draw upon the growing number of empirical studies to identify the factors underlying the explosion in China's dairy consumption and analyze milk supply by assessing the relative importance of herd expansion and improvements in efficiency to the overall growth of milk output. Based our analysis of both supply and demand, we conclude with our perspective on the future path of dairy supply, demand and trade in China.

## Dairy demand

Urban consumers in China have greatly altered their diets in the last 20 years, increasing the share of calories derived from animal fats and proteins, decreasing their intake of carbohydrates from grains, and increasing consumption of sugar and vegetable oils ([Hsu et al., 2001](#); [Guo et al., 2000](#)). Despite rapid income growth throughout the late 1980s and early 1990s, fluid milk consumption in urban areas remained strangely stagnant from 1987

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<sup>2</sup> Fluid milk equivalent of fluid milk consumption reported in the CNBS Urban Household Income and Expenditure Survey and total dairy consumption data reported in [Zhou \(2001\)](#). Total dairy consumption of 6.32 kg contains 5.52 kg of fluid milk and an estimated 0.43 kg milk powder and 0.37 kg yogurt. Milk powder is converted at a rate of 7.4:1 to fluid milk and yogurt is converted at a rate of 1:1. Rural per capita consumption is estimated by subtracting urban consumption from total milk production. [Zhou \(2001\)](#) cites an average of 1.46 kg of dairy products for rural residents in 1992, which is equivalent to 1.25 kg of fluid products and 0.21 kg of milk powder.

Table 1  
Annual urban dairy product consumption (kg per person) per capita by income group

	1996	1997	1998	1999	2000	2001	2002	2003
<i>Fresh products</i>								
Lowest 10%	2.52	2.62	2.87	3.34	4.59	5.61	4.83	6.71
Third Quintile	4.84	4.97	6.17	7.62	9.83	11.78	15.79	18.94
Top 10%	7.91	9.02	10.66	13.78	17.52	19.60	26.46	28.29
Average	4.83	5.07	6.18	7.88	9.94	11.90	15.72	18.62
<i>Yogurt</i>								
Lowest 10%	0.11	0.15	0.28	0.39	0.51	0.55	0.51	0.68
Third Quintile	0.33	0.44	0.57	0.80	1.09	1.30	1.76	2.57
Top 10%	0.56	0.78	1.16	1.47	1.47	2.27	3.31	4.33
Average	0.32	0.44	0.64	0.87	1.12	1.36	1.80	2.53
<i>Milk powder</i>								
Lowest 10%	0.22	0.23	0.24	0.25	0.26	0.29	0.34	0.31
Third Quintile	0.42	0.40	0.43	0.47	0.52	0.52	0.58	0.61
Top 10%	0.59	0.61	0.6	0.62	0.7	0.74	0.65	0.63
Average	0.41	0.41	0.43	0.44	0.49	0.50	0.60	0.56
Average total	8.18	8.54	10.00	12.00	14.67	16.96	21.96	25.29

Source: CNBS. Milk powder converted to milk equivalent at a rate of 7.4:1.

to 1997 at an average of 4.81 kg per person.<sup>3</sup> Since 1998, however, fluid milk consumption in urban China has grown annually at double digit rates.

According to data from official sources, Table 1 shows that dairy product consumption has increased at all income levels for the three product categories reported. On average, urban milk demand in China was roughly half of the level in Taiwan in 2003. Even households in the lowest 10% of the income distribution more than doubled their milk consumption in 7 years. Fresh product (primarily fluid milk) consumption increased nearly 300% or more for higher income groups. Although yogurt consumption was lower than milk powder consumption in 1996, yogurt purchases grew roughly 29–37% annually, while milk powder consumption grew less than 7% annually. The growth rate for milk powder consumption decreased from low income to high, and milk powder consumption per capita for the highest income group grew just 6.7% over the entire 7-year period and actually declined in 2002 and 2003.

The growth in household incomes has played a major role in the rapid increase in dairy product consumption, but it cannot fully explain the changes that have occurred. The growth in dairy product consumption only loosely corresponds to growth in real incomes. While increases in real income generally match the pattern of dairy product consumption growth across incomes groups (i.e., larger changes in income generate greater growth in consumption), the increases in consumption for the lower income groups are much bigger than one would expect, even from a luxury food item.

Several recent studies using cross-sectional household data have attempted to estimate price and income elasticities for dairy products. One of the most striking observations is that all of the studies suggest that milk and other dairy products are not elastic with respect to total household income (Fuller et al., 2004a; Wang et al., 2004; Liu and Chern,

<sup>3</sup> Fluid milk consumption does not include the milk equivalent of other dairy product consumption.

2003). However, with respect to the household's allocation of food expenditures, dairy products typically represent one of the most elastic categories in the food basket (Liu and Chern, 2003; Gould and Dong, 2004). The income elasticity estimates in the studies were computed using data for single year, so the impacts of shifts in preferences over time on income elasticities are not captured.

Using panel data, Guo et al. (2000) found evidence that income elasticities in urban China changed from year to year, with elasticities for livestock products increasing and elasticities for grains decreasing. Similarly, Huang and Bouis (2001) found empirical support for the idea that dietary changes in Taiwan in the 1980s were driven by changing lifestyles, occupations and marketing systems, as well as price and income factors. Without doubt, the rapid growth in household incomes has been necessary to make dairy products affordable for Chinese households, but the development of China's economy and the opening of society to the West over the last two decades have prompted several other transformations that facilitated growth in dairy product consumption. Although we are not able to precisely quantify the source of demand change, we believe the current literature and our observations in the field show that there are at least three important drivers for changes in urban dairy consumption: changes in (a) consumer perceptions of dairy products; (b) food purchasing behavior; and (c) dairy product marketing.

Historically, the majority of Chinese viewed milk as a nutrition supplement, particularly for infants and the elderly (Zhou et al., 2002), but it was not perceived as a food for regular consumption by the general populous. These traditional perceptions are being challenged on several fronts. Current government guidelines for food and nutrition include regular milk consumption in its dietary recommendations. In a survey conducted in 2001, Fuller et al. (2004b) found that more than 25% of sample households in Beijing, Shanghai, and Guangzhou reported that a healthcare professional had recommended regular milk consumption. The expansion of television ownership has greatly increased the influence of the mass media and advertising on consumer perceptions. Advertisements extolling the convenience, good taste, and healthiness of regular milk and yogurt consumption have become commonplace on China's networks. In the same survey 93% of the sample reported seeing television advertisements for milk products, and 73% had seen billboards with dairy ads. Finally, the adoption of school milk programs in several large cities sends the message to families with young children that milk consumption is important for the health of China's youth. In short, inasmuch as the growing awareness of dairy products fosters a culture of dairy consumption, we can expect a growing percentage of households in China to integrate dairy products into their daily diets.

Economic prosperity in China also is gradually changing lifestyles among urban households, and this, in turn, is affecting purchasing behaviors. Social policies to slow population growth have reduced the number of children in modern urban families. With greater opportunities to find employment outside the home, the cost of spending time shopping and preparing food has risen, and an increasing number of China's households are willing to pay for prepared foods and packaging that increases shelf life and reduces shopping frequency. Young, educated, and wealthy consumers shop less frequently, eat outside the home more often, and frequently purchase processed and packaged foods (Veck and Veck, 2000). Most dairy products require refrigeration until they are consumed, and greater refrigerator ownership is having a positive impact

on dairy product consumption (Lyon and Durham, 1999). There is also some evidence that shoppers with higher education levels tend to buy dairy products more frequently at supermarkets and purchase more ultra-high temperature pasteurized (UHT) milk (Fuller and Hu, 2005).

Studies of purchasing behaviors are interesting because they highlight the connection between income, education, product choices, and the variety of retail outlets in which China's consumers are shopping. These relationships are closely tied to the changes that can be observed in marketing of dairy products. Throughout the 1980s and into the 1990s, pasteurized milk was principally marketed through home distribution networks and specialized milk stores operated by the dominant local milk company (usually a state-owned processor). This situation began to change in the early 1990s, as foreign dairy processors began investing in production facilities near key cities and as UHT technology was adopted by dairy processors. Both of these developments prompted the introduction of new brands and products in urban dairy markets, sharpening the competition faced by incumbent firms.

New entrants into local dairy markets could not use the established distribution networks because they were owned and operated by the local dairy company. Consequently, entering firms channeled their products to consumers through other food retail outlets: street vendors, small grocery stores, and the newly emerging supermarkets and convenience stores. While home delivery networks still play an important role in pasteurized milk markets, surveys indicate that supermarket sales account for the majority of yogurt and UHT milk sales and a growing proportion of pasteurized milk sales (Fuller et al., 2004a; Fuller and Hu, 2005). Consumers benefit from the expanded selection of products and brands available at supermarkets and from the frequent promotional discounts (Fuller and Hu, 2005).

Also important has been the creation of nationally recognized brands. When China's dairy products markets were local and segregated, branding was not important because only one or two companies existed in the market. Farmers or small processors that sold their products directly to consumers could develop a relationship with their customers, and the relationship substituted for brand identification. As dairy companies expanded beyond their historical marketing regions into new markets, they needed to differentiate themselves from the local milk companies and to provide assurances of product quality and safety to consumers in the new markets. Unreliable quality and food safety concerns deterred some of China's consumers from purchasing milk in the past. Marketing through supermarkets and convenience store chains can reinforce brand equity to the extent that consumers believe supermarkets choose the brands they carry based on product quality and value.

In sum, the recent growth of dairy product consumption in China is driven by the convergence of several, mutually reinforcing factors. Rising incomes have prompted a shift in consumer preferences towards meat, vegetable oils, fruits, and dairy products. Information regarding the benefits of regular dairy product consumption provided by the government, the healthcare sector, and the dairy industry is convincing a growing number of China's consumers to integrate dairy products into their daily diets. At the same time, the hectic pace of the modern urban life promotes the consumption of prepared and packaged foods, including dairy products. Competition in China's dairy industry has forced dairy processors to adapt to the changing consumer environment by developing high-quality, branded dairy products that are made available to consumers in a wide array of retail

outlets, including supermarkets and convenience stores. The development of nationally recognized brands and ubiquitous use of mass media advertising reduces the search cost for new consumers interested in adopting regular dairy consumption.

How will dairy product demand in China develop in the future? Consumption will likely continue to rise rapidly for a number of years, but much of the growth in milk and yogurt consumption in urban areas will come from the low and middle income segments of the population. As incomes continue to rise, consumption levels for these consumers should approach those of consumers in higher income brackets. High income urban consumers are rapidly approaching consumption levels for milk and yogurt that are comparable to other medium and high income Asian countries. Consequently, growth of milk demand in these consumer segments will likely slow. At the same, there is still room for those in the highest income categories to expand total dairy product consumption. For example, wealthy households in China consume much less cheese than consumers in Japan, Taiwan, or Korea; from this perspective, cheese demand still has substantial growth potential. Cheese consumption in China occurs chiefly through consumption of western-style foods in restaurants (Fuller et al., 2004a), and further development of cheese consumption will likely follow the sales trends of pizza and other cheese-intensive restaurant foods.

In smaller cities and rural areas, many of the same factors that contributed to the explosion of dairy consumption in large urban areas are relevant. School milk programs are being promoted in a greater number of regions each year. While the dairy revolution has not even begun or is just beginning for many demographic groups, consumers' diets in small cities and in rural areas are expected to shift toward greater consumption of livestock products as incomes rise (Huang and Bouis, 2001). Supermarkets and convenience stores are gradually moving from large to medium and small cities (Reardon et al., 2004). When these retail venues arrive, among other things, they bring with them the national dairy product brands, making quality dairy products accessible. The commercialization of the media as well as rising refrigerator and television ownership are giving households the ability and incentive to increase dairy consumption.

Finally, continued rural to urban migration will put upward pressure on the demand for all livestock commodities, including dairy. Although one of the greatest factors limiting growth of dairy product demand in China in the future will be income levels, as rural households begin to move into urban areas, dairy consumption will summarily rise. Even when their income is held constant, Huang and Bouis (2001) and Huang and Rozelle (1998) have shown that the newly arriving migrants begin to adopt the consumption patterns of their urban counterparts, including dairy demand.

Recent projections of China's dairy product consumption reported by Dong (2006) are generally consistent with these expectations of future growth. Assuming 7.0% annual growth in real per capita expenditures in urban China, Dong (2006) projects average urban fluid milk consumption will reach 32.04 kg per person in 2014, an annual rise of 5.1%. Total dairy product demand in China is anticipated to grow by 50% in milk equivalent terms. Meeting the additional demand projected by Dong (2006) with domestic milk would require production in China to increase 11.2 million metric tons over the 2003 level. In the next section, we seek to understand the dynamics of how producers have been able to satisfy rising consumption in the past and how well China's dairy sector is positioned to meet the expected rise in demand.

## Producing dairy products in China

China's dairy production was only about 1 million tons per year in 1980. During the following 15 years, output increased steadily by about 14% annually. However, because China was starting from such a low base, total dairy production was only 6–7 million tons by the mid-1990s, a level that placed China about 20th in overall milk production internationally. After the mid-1990s, however, there was structural break (Fig. 1). Between 1997 and 2003, the growth of dairy production accelerated to nearly 20% annually. Aggregate production rose to more than 18 million tons in 2003, a level that ranked China 7th in the world.

## Expanding production, expanding herd size

Milk production is implicitly the product of the number of dairy cows and the productivity per cow, so growth in milk production is the result of changes in these two components. By far, the most prominent source of growth of milk production in China has been the expansion the dairy herd. In 1980, there were only about 640,000 dairy cows in China. Between 1980 and 2000, China's dairy cow herd grew at a rate of about 11% annually, just under that of milk production. By 2000, there were 4.88 million dairy cows in China. China's dairy cow herd also increased 20% annually after 2000, matching the growth of milk production. By 2004, there were 8.93 million dairy cows in China.

## Productivity gains: technology and/or efficiencies or not?

Productivity per cow is the second component of milk production. The analysis and data required to study the productivity of China's dairy sector, however, is not trivial,

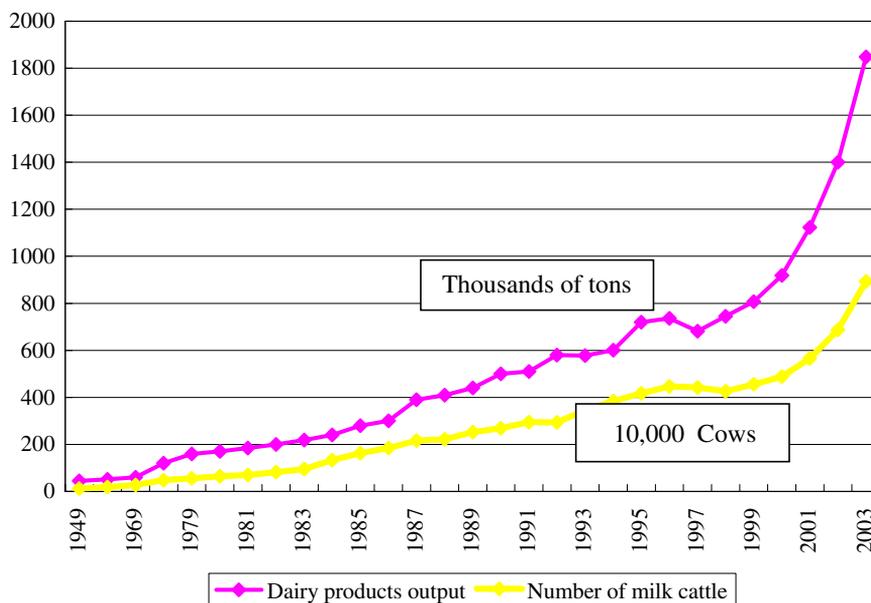


Fig. 1. The growth of China's milk sector, 1949–2003. Data sources: Wang (2002) for data before 2003 and CNBS for 2003 and 2004.

Table 2  
Milk yield, output per man-day of labor and production costs in China, 1992–2003

Year	Yield (kg/cow)	Milk output of per labor man-day (kg)	Cost (Yuan/ton)
<i>Specialized household dairy farms</i>			
1992	4335	42.2	680
1993	4234	32.4	837
1994	5159	48.5	924
1995	4998	41.1	1236
1996	4705	64.9	1292
1997	5071	60.4	1559
1998	4602	65.7	1304
1999	4421	67.1	1261
2000	5032	64.4	1186
2001	5121	78.4	1244
2002	5226	68.4	1349
2003	5342	88.4	1329
1992–97	4750	48.3	1103
1998–03	4957	72.1	1280
<i>State and collective dairy farms</i>			
1992	4744	35.9	844
1993	4736	49.0	983
1994	4477	47.8	1348
1995	4757	60.9	1726
1996	5139	55.1	1917
1997	5155	63.8	1816
1998	5435	86.9	1718
1999	5889	89.9	1619
2000	6019	92.9	1674
2001	6000	93.5	1671
2002	6032	93.7	1665
2003	6091	97.6	1774
1992–97	4835	52.1	1452
1998–03	5911	92.4	1687

*Data source:* National Agricultural Production Cost and Return Survey.

*Note:* Total revenue is equal to total milk output multiplied by the farm gate sale price. All value terms are calculated at present price.

and relying on standard indicators can create an ambiguous picture. The sector is dynamic and constantly changing. Milk production technology is extremely heterogeneous, ranging from farmers in remote, mountainous villages with one or two dairy cows to state-of-the-art dairy operations with hundreds of cows. New technologies and high quality genetics are increasingly available, but it is unclear to what extent China's small farmers have been able and willing to use them. Complicating matters further, the [China National Bureau of Statistics](#) does not collect information on many key statistics that are critical to understanding some of the sector's most fundamental elements.

Based on information available to the authors, the partial productivity and cost data shown in [Table 2](#) also fail to provide clear results.<sup>4</sup> Milk output per cow in both the spe-

<sup>4</sup> The cost data are collected by the Price Bureau and the National Economic Development Commission and were provided to the authors for use in this paper. Available upon request to the authors.

cialized household and commercial/collective/state-owned farm sectors rose. Although low by international standards, milk yields for specialized dairy households rose steadily during the 1990s and are above the national average of roughly 2600 kg/cow. Output per man-day also has risen, partly due to rising yields and partly to a reduction in annual man-days/cow. At the same time, the total cost per ton of milk has risen. Hence, until a multivariate analysis is performed, it is unclear whether productivity has increased. Moreover, even if we could ascertain that productivity growth has occurred, it is important to understand whether the growth was generated by adoption of new technologies or increased efficiency in the use of current technologies. The answer to that question has bearing on expectations of potential for future growth.

### **Potential for gains from technical change**

There is little doubt that China's dairy technology has improved since the pre-reform era. Before 1980 there were almost no genetically improved dairy cows, and most of the dairy cows were owned and managed by state farms and collectives that used extremely labor intensive methods and poor quality rations. Feed mixes rarely included any concentrates, vitamins or other supplements.

Since 1980 improved genetic material, feeding regimes, and milking and handling equipment have become available, partly as a result of several large and sustained government-to-government development aid efforts. More recently China's government has relaxed restrictions on the import of dairy technology, and greater numbers of private and quasi-private enterprises are introducing new genetics and feeding technologies. Since 1995 the number of imported breeding cows and amount of bull semen have risen sharply ([China Customs Statistics Yearbook, 2003](#)). With such an effort, it is likely that productivity should have increased due to technological change.

However, an industry that is characterized by hundreds of thousands of small producers, there are many possible barriers to the adoption of new technologies. For example, credit constraints arising from a banking system that is unfriendly to producers could prevent farmers from investing in new technologies ([Findlay et al., 2003](#)). The lack of either a strong extension or viable cooperative system hinders the spread of new technologies, especially among a poorly educated farm population.

### **Changes in efficiency**

Possession of advanced technology does not imply efficient production. Efficiencies can be achieved through specialization along lines of comparative advantage or through exploitation of scale economies. However, these gains can be offset by market and information inefficiencies associated with a swiftly changing market environment and institutions that struggle to adjust. There is anecdotal evidence that China's dairy sector may be experiencing both efficiency gains and losses.

#### *Specialization and concentration of dairy production*

National production data are clear that the rise of milk production from 1996 to 2003 has not occurred evenly across China. In fact, the data show a tendency for production to specialize in two dimensions. First, the bulk of the rise in milk production during this

period took place in North China (including all provinces that are north of the Yangtze River). Second, within north China, there has been substantial geographic concentration of dairy cows at the provincial level in Xinjiang and in the dairy belt that runs from Heilongjiang and eastern Inner Mongolia in the north to Hebei and Shandong on the North China Plain. Xinjiang and the four emerging dairy belt provinces fully account for 70% of the rise in China's dairy herd.

### *Scale effects*

Even through the mid-1990s the scale of the average Chinese dairy producer was extremely small. According to the 1997 census of agriculture, more than three-quarters of the dairy herd was owned by individual farmers; the average dairy farmer in 1996 owned only 3 cows (Zhou et al., 2002). At that time a commercial dairy sector was emerging, but in many cases the firms were state- or collective-owned. Given the lack of systematic data, it is difficult to gauge what has happened to the average dairy herd size since the mid-1990s, but some evidence suggests there has been little change. Small-scale household production in other livestock sectors thrived in the late 1990s, as improvements in transportation infrastructure lowered the costs of moving feedstuffs into and products out of poorer inland areas (Chen, 2002). In addition, many regionally supported dairy programs established in recent years use small bank loans to help farmers that are new to the dairy industry purchase one to three dairy cows. A survey conducted in 2000 by the Center for Chinese Agricultural Policy found that sample households raising dairy cows owned an average of four cows, a level that was statistically indistinguishable from the three cows per household found in the 1997 census.

Despite the apparent small scale of production, there are strong incentives for processing firms to promote larger scale dairies that make effective use of technologies which increase the quality of the milk and reduce costs. Indeed, there is some evidence that the commercial sector may be expanding and that a healthy "specialized household" sector is increasing its share of the national herd (Wang, 2002). More importantly, dairy processors are playing a strategic role in developing unique institutional structures in some regions to capture scale economies with household production. For example, in Inner Mongolia we observed several processor-run milking stations where farmers can bring their cows to be milked using the processor's milking machine. The milk goes directly into the processor's bulk cooling tank, and farmers receive the market price. In Yunnan and Sichuan, farmers can buy or rent stalls in a commercial milking shed, where they house and milk their cows. The farmer is responsible for feeding and providing care for the cow, while the milking shed manager keeps the milking and cooling equipment operating and coordinates deliveries and payments with the processors. It is unclear how common such arrangements are; nevertheless, their existence demonstrates the importance that processors place on increasing the scale and sophistication of milk production.

### *Disequilibria from expansion and institutional change*

While increasing concentration and scale expansion may be generating efficiency gains, it is certainly possible that the torrid pace of development in the dairy industry is creating so much change and disequilibria that measured efficiency (at least temporarily) is falling on aggregate. With the herd size growing by 20% per year, the number of cows in China

doubles every four years. New producers are entering. Experienced producers are changing their genetics and upgrading their milking facilities. Commercial operations are changing management incentive plans and control-rights regimes, and they are altering the way they interact with small producers, processors, and local governments. It is well recognized in the economics literature that high adjustment costs often leads to inefficiencies as firms and whole industries make new investments.

Our observations in production areas reveal that there may be inefficiencies related to industry growth, especially in the ways that processors interact with producers during periods of supply expansion in a locality. According to one major Shanghai dairy processor, more processing plant capacity has been built in China during the past 5 years than during the entire history of milk production in China. Successfully establishing a new plant requires the processor to develop reliable links with raw milk suppliers and to provide a set of production, collection, and pricing rules. However, industry participants make it clear that establishing raw milk supplies for a new processing plant entails more than simply providing an orderly marketing structure for farmers. In many locations the construction of a new processing plant has sparked a series of local dairy wars. As soon as a new plant becomes operational, there is immediate pressure to operate at full capacity to reduce average costs. In most cases, the new plants are unwilling to invest the time and effort to fully develop their raw milk supply base from scratch. Instead, they often opt, at least in part, to induce producers in the area to switch from their current buyer to the new processing firm. Even when milk producers are bound by a written contract to supply a particular processor (which is rare), processors have few legal remedies to prevent another firm from poaching its raw milk supplies. We have encountered producers that have switched buyers every several months for a period of years. This confusion and uncertainty can prompt temporary declines in the industry's efficiency.

### **An empirical analysis of productivity, technical change and efficiency shifts**

It is clear from the discussion above that a large share of the rise of China's dairy production can be attributed to the increase in the dairy herd; however, empirical evidence is lacking concerning the direction, magnitude, and source of any changes in productivity. In this section, we briefly present results from estimation of a stochastic production frontier for China's dairy sector. The model provides estimates of total factor productivity (TFP) growth from 1991 to 2001 for a panel data set. We decompose the estimated productivity growth into components resulting from technical change and from shifts in productive efficiency. The methods, data and empirical approach used for this analysis are discussed in detail in [Rae et al. \(2005\)](#).

### **Results**

Due to the unbalanced nature of our panel data, some clarification of the procedures used in constructing the results reported in [Table 3](#) is required. First, while average productivity growth rates are presented for the entire 1991–2001 period, there are insufficient degrees of freedom to allow us to present results for the early 1990s and the 2000–2001 period. Second, individual provincial results are included in growth rate calculations, provided that at least six provincial observations were available within the relevant time period. Third, provincial results are averaged to the regional level using output shares as

Table 3

Annual growth (%) in milk total factor productivity (TFP) and decomposition into technical efficiency (TE) and technical change (TC)

Region <sup>a</sup>	Specialized households				Commercial operations			
	Output	TFP	TE	TC	Output	TFP	TE	TC
1990s								
North	4.75	2.87	-5.25	8.13	2.84	-0.60	-5.60	5.01
Central	14.82	0.02	-7.31	7.33	12.18	-0.87	-6.99	6.12
South	-4.55	8.93	-7.99	16.92	-1.99	6.37	-0.58	6.96
Southwest	n.a.	n.a.	n.a.	n.a.	-2.73	9.05	-8.83	17.88
West	11.48	-2.50	-6.45	3.95	10.47	1.15	-0.35	1.50
Mean	8.81	0.48	-6.09	6.58	5.25	1.31	-3.26	4.57

For commercial operations: North: Beijing, Tianjin, Mongolia, Liaoning and Jilin; Central: Hebei, Shandong, Henan and Hubei; South: Shanghai, Jiangsu, Anhui, Fujian, Hunan, Guangdong; Southwest: Guangxi and Chongqing; West: Shaanxi, Gansu and Xinjiang.

In total, these provinces accounted for 59% and 57% of specialized household and commercial farm output in 1999–2001.

n.a. = Data unavailable.

<sup>a</sup> For specialized households: North: Tianjin, Mongolia, Liaoning, Jilin and Heilongjiang; Central: Hebei, Shandong and Henan; South: Anhui and Fujian; West: Shaanxi and Xinjiang.

weights. Finally, overall average productivity results are obtained by averaging the output-weighted regional results.<sup>5</sup>

Milk production over the 1990s on specialized and commercial farms grew annually around 9% and 5%, respectively. Hence, compared with the overall production rates of growth reported in official statistics for the entire 1990 to 2001 period, the rates in Table 3 are somewhat lower. Adjustments made to output levels in preparing the data preparation for analysis are partially responsible for the difference; however, it may also indicate that small-scale producers have contributed more to output growth than specialized households and commercial operators.

Rising TFP accounts for only a portion of the robust output growth. Just 0.48% of growth in the specialized household sector and 1.31% of growth in the commercial sector stems from rising TFP. Thus, input augmentation – heifer purchases, feed concentrates, equipment, and other inputs – generates much of the output growth. Compared to a similar decomposition of China's other livestock sectors reported in Rae et al. (2005), TFP's contribution to output growth is lower for milk production than all other livestock sectors, except backyard hog production.

Interestingly, while TFP growth for dairy was low compared to other livestock sectors, the contribution of technology is among the highest. Overall, technical change (TC) generated a 6.58% annually increase in productivity in the specialized household sector and 4.57% increase in the commercial sector. Indeed, most of the productivity growth in the specialized and commercial dairy sectors appears to be the result of adopting improved genetics, better milking processes, and superior management practices. Following this

<sup>5</sup> In the TFP decompositions we do not present the scale effects as they were minor compared with the technical change and efficiency components. We also do not calculate the allocative inefficiency components due to incomplete price data. To save space, we do not report the stochastic frontier production parameter estimates. They are available upon request to the authors.

logic, the backyard household sector accounts for the bulk of the dairy cows added to the herd in recent years.

Modest TFP growth and high TC implies that there has been a decline in efficiency of the sector during the 1990–2001 study period. Columns 3 and 7 in [Table 3](#) show that, had it not been for the decline in efficiency, output growth would have risen by 6.09% more in the specialized household sector and 3.26% in the commercial sector. Falling scale economies are not responsible for the loss of efficiency. Although the results are not reported, our analysis did find very small gains in scale economies. Likewise, rising concentration in the industry suggests that a lack of specialization at the regional level is not the cause. Assuming specialization at the community level has not declined, the main cause of the fall in efficiency may be a disequilibria effect arising from the very high rates of growth during the study period. If this inference is correct, the future of China's milk production may be fairly bright, assuming industry growth moderates and processors begin to rationalize their supply bases.

### Looking ahead

Looking back, the story of China's dairy industry over the past decade has been a simple one: Demand has risen rapidly. In addition to greater purchasing power, shifting preferences prompted by a new awareness of the health benefits of milk have greatly increased demand. Indeed, in recent years milk is being consumed by a broad cross-section of China's population. Where did most of the supply come to meet the new demand? By far the greatest fraction has come from China's emerging domestic dairy industry. Driven primarily by increases in the dairy herd and adoption of new technologies, domestic supply has risen as fast as demand. There is evidence that considerable inefficiencies remain in the dairy sector, and there is potential for future improvements in productivity per cow. Consequently, there is good reason to believe that production can continue to rise in the future.

Looking ahead, there are many reasons to believe the rapid growth in demand for dairy products will continue unabated in China. Incomes are forecast to continue to rise. If China is successful in modernizing, there will be hundreds of millions of new urban residents. As the dairy processing industry matures and becomes even more competent, it is likely the media attention, advertising and promotion of dairy products will accelerate. All of these factors will contribute to a growing number of households that adopt regular dairy consumption. Most importantly, as today's generation grows up in an environment that increasingly accepts dairy products, these attitudes become entrenched and are passed from parent to child. It is likely that the growth in dairy demand observed in the last decade is just the start of long, sustained expansion of China's dairy consumption.

With more consumers seeking to buy dairy products in the future, who will ensure that they can get milk? Will China's dairy industry be able to satisfy the growing demand or will imports play a greater role? The answer to that question hinges critically on the ability of China's dairy sector to continue to increase productivity and begin to improve efficiency over time. Certainly, China's dairy herd will continue to expand. However, if the domestic dairy industry is to be successful at keeping pace with rising consumption, it will have to actualize the tremendous potential for scale economies in milk production, collection, and processing through innovative organizational structures of rural households. Likewise, output per cow must rise. With appropriate investments, milk production could double

at the current herd size. Of course, expanding cow numbers and raising productivity may significantly increase the dairy industry's competition with other livestock sectors for feed grains, quality forages, and protein feeds. Finally, institutions within the industry or within the government need to develop constructive methods for coordinating expansion of raw milk production and processing. The inefficiencies and confusion induced by struggles over milk supplies are symptoms of larger problems associated with inadequacies in contract law and enforcement, agricultural lending and capital markets, and market information channels.

China's role in international dairy markets has grown significantly in the last 15 years and has accelerated recently. In 1990, China ranked 14th in volume and 15th in value terms in world dairy trade. Although it did not change from 1990 to 1995, since 1995, China's dairy import volume has grown at roughly double the rate of global trade, and China ranked 7th in the world in volume terms in 2003. With the domestic processing industry focusing on increasing production of fluid and fresh products, most of the imports have been powders and processed products. Multinational firms have already entered dairy markets in China, and with the relaxation of import barriers and constraints on foreign investment under China's WTO commitments, competition from abroad will only increase. In the last year, a number of large multinational dairy companies have increased or made plans to increase their investments in Chinese dairy companies. These investments are likely to facilitate the technology transfer and adoption needed for the domestic industry to meet the supply challenges that lay ahead.

Dong (2006) projects a short-term rise in milk powder imports, but a gradual decline as domestic milk production rises. Cheese imports are projected to double over the next decade, but volumes remain under 50 thousand metric tons. These are plausible outcomes that are consistent with the analysis in this paper. In particular, the greatest growth in dairy demand is expected to continue to be in fluid and fresh products; though, cheese demand will rise among high income consumers, leading to some additional imports. Thus, the actual product mix and trade volumes will ultimately depend on the ability of China's domestic dairy suppliers to answer the growing number of consumers asking, "Got milk?"

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## References

- Chen, J., 2002. Three essays on China's livestock market. Unpublished dissertation, Department of Agricultural and Resource Economics, University of California, Davis.
- China Customs Statistics Yearbook, 2003. 2004 Customs General Administration of the People's Republic of China, Beijing, China.
- China National Bureau of Statistics (CNBS), Various Years. China Statistical Yearbook. China Statistical Press, Beijing, China.
- Dong, F., 2006. The outlook for Asian dairy markets: the role of demographics, income, and prices. *Food Policy*, in press, doi:10.1016/j.foodpol.2006.02.007.

- Findlay, C., Watson, A., Enjiang, C., Gang, Z., 2003. *Rural Financial Markets in China*. Asia Pacific Press, Canberra.
- Fuller, F., Hu, D., 2005. Dairy products in southwestern China: anecdotal evidence from Kunming. In: *China's Agri-Food Value Chain: Opportunities and Challenges*, Proceedings of the WERA-101, April 25–26.
- Fuller, F., Beghin, J., Rozelle, S., 2004a. Urban demand for dairy products: evidence from new survey data. Center for Agricultural Development, Iowa State University, Working Paper No. 04-WP 380, November.
- Fuller, F., Rozelle, S., Beghin, J., Hu, D., 2004b. China's dairy market: survey results for consumer demand and supply characteristics. Center for Agricultural Development, Iowa State University, Staff Paper No. 04-SR 99, September.
- Garnaut, R., Ma, G., 1993. How rich is China: evidence from the food economy. *The Australian Journal of Chinese Affairs* 30, 121–146.
- Gould, B.W., Dong, D., 2004. Product quality and the demand for food: the case of urban China. In: Paper presented at the Annual Meeting of the American Agricultural Economic Association, Denver, CO, 1–4 August.
- Guo, X., Mroz, T., Popkin, B., 2000. Structural change in the impact of income on food consumption in China, 1989–1993. *Economic Development and Cultural Change* 48, 737–760.
- Hsu, H., Chern, W., Gale, F., 2001. How will rising income affect the structure of food demand? In *China's Food and Agriculture: Issues for the 21st Century*, US Department of Agriculture, Economic Research Service, Agricultural Information Bulletin no. 775, pp. 10–13.
- Huang, J., Bouis, H., 2001. Structural change in the demand for food in Asia: empirical evidence from Taiwan. *Agricultural Economics* 26, 57–69.
- Huang, J., Rozelle, S., 1998. Market development and food demand in rural China. *China Economic Review* 9 (1), 25–45.
- Liu, K.E., Chern, W.S., 2003. Food demand in urban China: an application of a multi-stage censored demand system. In: Paper presented at the Annual Meeting of the American Agricultural Economic Association, Montreal, Canada, 27–30 July.
- Lyon, C., Durham, C., 1999. Refrigeration and food demand in China: can refrigerator ownership help predict consumption of food products in China? In: *Chinese Agriculture and the WTO*, Proceedings of the WCC-101, 2–3 December.
- Rae, A., Ma, H., Huang, J., Rozelle, S., 2005. Livestock in China: commodity-specific total factor productivity decomposition using new panel data. Working Paper, Center for Chinese Agricultural Policy, Institute of Geographical Science and Natural Resource Research, Chinese Academy Science.
- Reardon, T., Hu, D., Timmer, P., Rozelle, S., Wang, H., 2004. The emergence of supermarkets with Chinese characteristics: challenges and opportunities for China's agricultural development. *Development Policy Review* 22 (4), 557–586.
- Veeck, A., Veeck, G., 2000. Consumer segmentation and changing food purchasing patterns in Nanjing, PRC. *World Development* 28 (3), 457–471.
- Wang, H., 2002. *Guide to China's Dairy Industry*. China Agriculture Press, Beijing, China.
- Wang, J., Zhou, Z., Yang, J., 2004. How much animal product do the Chinese consume: empirical evidence from household surveys. *Australasian Agribusiness Review* 12: Paper 4.
- Zhou, J., 2001. *A Study of Chinese Dairy Consumption*. In: Forum of China Dairy Industry & WTO. China Dairy Association, Shanghai (in Chinese).
- Zhou, Z., Tian, W., Zhou, J., 2002. The emerging dairy economy in China: production, consumption and trade prospects. *Australasian Agribusiness Review* 10: Paper 8.