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Projections of Dairy Product Consumption and Trade Opportunities in China

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Abstract

China has been rapidly increasing its consumption and imports of dairy products in recent years. A two-stage demand system was estimated for livestock product consumption in urban China over the 1990s. Total expenditure elasticities for the livestock commodity group and expenditure elasticities for dairy products within the livestock commodity group were calculated. The results suggest that dairy products, even in urban areas, remain luxury goods because of a high expenditure elasticity (1.14). Due to rapidly increasing consumption and the likelihood of inadequate supply growth, China will continue to increase its imports of dairy products to meet its domestic demand. Projections imply that China�s imports of dairy products may range between 13-30 percent of its total domestic consumption by 2006. Due to differences in regional income and population growth rates, increases in dairy products consumption may occur especially in the Coastal, South and North areas, where potential trade opportunities may exist.

Introduction

Understanding food consumption patterns is essential to the continuing growth of international trade, in particular for major exporter nations (Halbrendt *et al*., 1994). This is particularly so in a large country like China where, due to its large population base, even small increases in per capita consumption may produce a significant impact on world food trade (Brown, 1995). Enhanced knowledge about livestock products consumption can provide valuable information for both domestic and overseas producers, traders and policy-makers.[2]

According to Zhou *et al*. (2002), increased food supplies and consumer incomes have resulted in a shift towards high quality and healthy food products, such as dairy products, particularly in urban areas of China. Although per capita consumption of dairy products in China is far lower than in many other countries, the potential exists for further increases in consumption as more consumers, especially the younger generation, develop a taste for dairy foods. In fact, dairy products consumption has become very popular in cities where younger consumers are gradually adopting westernized diets, and many dairy products (e.g. fermented milk, yogurt and ice cream) that used to be consumed mostly during warm seasons are now being consumed in large quantities year-round (FAS, 2001).

As a result, China rapidly increased its dairy imports during the 1990s. Between 1995 and 2002, China�s dairy product imports rose from US$62 million to US$274 million, with milk powders the dominant product imported (Table 1). With China�s dairy exports relatively minor and static, her net imports rose from US$28 million to US$213 million over the same period. China�s share of total Asian dairy product imports was only around 2.3 percent in 1990, but had more than doubled by 2002 (5.2 percent). Therefore China has become one of the larger importers of dairy products in Asia. This raises the question �what role might China play in global dairy markets in the future?�

Table 1. China�s Dairy Products Trade, 1995-2002 (US$ million)

Year	Exports				Imports			
	Drinking Milk	Milk Powder	Other [a]	Total	Drinking Milk	Milk Powder	Other [a]	Total
1995	17.1	9.0	8.2	34.3	5.4	28.1	28.5	62.0
1996	19.0	7.5	3.7	30.2	3.6	18.1	31.7	53.9
1997	19.2	14.9	10.5	44.6	3.9	19.2	40.9	64.0
1998	18.2	13.7	15.2	47.1	3.3	39.0	46.7	89.0
1999	18.2	19.5	8.8	46.5	8.5	80.1	76.1	164.7
2000	20.1	20.9	20.2	61.2	8.9	115.3	97.1	221.3
2001	19.1	10.4	15.3	44.7	4.9	114.4	102.4	221.7
2002	20.4	23.7	16.5	60.6	3.1	160.7	110.2	273.9

Source: FAOSTAT in Chinese version.

a Including yogurt, cheese, butter and whey. Note that whey accounts for a significant share of China�s dairy products imports, for example over 80 percent of �other dairy products� imports between 1999 and 2002.

Given the substantial recent increase in dairy product demand, China�s future participation in world dairy products markets may be expected to have a significant impact on some dairy product net exporter nations. While there exist a few studies on China�s dairy consumption (Rae, 1997; Wei and Viney, 1999; Shono *et al*., 2000; Zhou *et al*. 2002), they tend to be rather general and some do not provide any econometric parameters (such as elasticities) for dairy products consumption. For example, in this Journal Zhou *et al*. presented descriptive information on dairy production, consumption and trade and discussed factors affecting future development of China�s dairy market, but attempted no quantitative analyses or projections.

This study focuses on dairy products consumption in urban areas[3], estimates expenditure elasticities for dairy product consumption and uses them to make projections of China�s future dairy product demand and trade. Production and consumption projections are also formulated on a regional basis to identify those urban locations where trade opportunities may be greatest. The following section will discuss changes in dairy product consumption in urban China over the past two decades. The model and data to be used will then be discussed, followed by the empirical results, projections and conclusions.

Trends in Dairy Products Consumption in China

China�s reforms have resulted in significant increases in urban incomes and living standards and dramatic changes in food consumption patterns for both urban and rural economies (Huang and Rozelle, 1998). Some of the more pronounced changes in food consumption patterns include the declining share of food in total expenditure (Fan *et al*., 1995) and the shift from staple foods (such as rice and wheat) to relatively expensive livestock products (Cai *et al*., 1998). Of six different types of livestock products (pork, beef, mutton, poultry, eggs and dairy products), consumption of dairy products has increased the most. For example, its expenditure share in total livestock products consumption was only about 1.5 percent in 1980 but then rose dramatically, doubling twice by 2000 to more than 6 percent.

Table 2 gives the levels, composition and annual growth of dairy products consumption in urban China.[4] In the mid-1980s, total dairy products consumption (in liquid milk equivalents) was only 7.2 kilograms, but then almost tripled over the following 16 years to 18.1 kilograms in 2001. Along with this rapid increase in dairy products consumption, the composition of dairy products consumption also changed significantly over time. For example, in the mid-1980s drinking milk consumption accounted for about 55 percent of total consumption, but rose to 68 percent of total consumption by 2001. In contrast, the share of powdered milk consumption declined over time, from nearly 40 percent to 24 percent over the same period. The average annual growth rate of consumption over the past 16 years was faster for drinking milk (7.8 percent) and other dairy products (8.7 percent) than for dairy products in the aggregate (6.3 percent).

Table 2. Dairy Products Consumption, Structure and Growth in Urban China

Period	Total Dairy Products [a]	Of Total Dairy Products		
		Drinking Milk	Powdered Milk	Others
Per Capita Dairy Products Consumption (kg):				
1985 [b]	7.2	4.0	2.8	0.4
1990	9.3	5.2	3.7	0.4
1995	10.7	6.5	3.6	0.6
2000	16.8	11.6	4.3	0.8
2001	18.1	12.3	4.4	1.4
Structure of Dairy Products Consumption (%):				
1985	100	55.0	39.3	5.7
1990	100	56.1	39.6	4.4
1995	100	62.5	34.5	3.1
2000	100	69.1	25.9	5.0
2001	100	70.4	22.6	7.1
Annual Growth Rates (%):				
1985-2001	6.3	7.8	3.1	8.7

Source: Consumption data are from the Household Income and Expenditure Survey (HIES), State Statistical Bureau of China.

a Liquid milk equivalent (LME) includes drinking milk, powdered milk and other types of dairy products (e.g., yogurt, cheese and butter). The conversion coefficient of powdered milk into drinking milk used in this paper is 8.85; the conversion coefficient of cheese and butter into drinking milk is 28.

b In order to obtain a stable base, we used three-year averages centered on the years listed in the table as the consumption levels to calculate consumption structure and annual growth.

The Demand Models

Many studies of animal food consumption have used single equation models to estimate expenditure elasticities (Atkins *et al*., 1989; Rae, 1997; Stroppiana *et al*., 1998; Song and Sumner, 1999; Stroppiana and Riethmuller, 2000). To be consistent with consumption behaviour, however, this paper will use a two-stage LES-AIDS model that assumes the consumer�s utility maximization decision can be decomposed into two separate steps (see Fan *et al*., 1995 for discussion of the advantages of using this particular two-stage model). The functional form chosen for the first stage is the linear expenditure system (LES):

(1)��� $P_I Q_I = P_I R_I + B_I (E - \sum_J P_J R_J)$

where P_I and Q_I are aggregated price and quantity indices for commodities within group *I*, *E* is total household expenditure, and R_I and B_I are parameters to be estimated. An intuitive economic interpretation of LES is possible provided $R_I > 0$, with a two-stage budgeting process implied. The consumer initially buys subsistence quantities (R_I) and associated subsistence expenditures are $P_I R_I$. After those initial purchases are made, the consumer has an amount remaining equal to $E - \sum_J P_J R_J$. This amount, the discretionary expenditure, is allocated over all commodity groups according to the marginal budget shares (B_I). We estimate the LES model in its shares formulation:

(1a)� $w_I = P_I \theta_I + B_I (1 - \sum_J P_J \theta_J)$

where $w_I = P_I Q_I / E$ is the share of the *I*th commodity group in total expenditure and� $\theta_I = R_I / E$ �are the new threshold parameters. This linear share formulation implies a threshold level that grows proportionally with total expenditure (Parks and Barten, 1973) and is also less likely to suffer from heteroskedasticity (Pollak and Wales, 1978)

As in Fan *et al*. (1995) and Chern and Wang (1994), the uncompensated own-price (η_{II}) and expenditure elasticities (e_I) associated with equation (1a) are defined as:

(2)��� $\eta_{II} = (1 - B_I) \cdot P_I \theta_I / w_I - 1$

(3)��� $e_I = B_I / w_I$

The functional form chosen for the second stage of the demand system is the Almost Ideal Demand System (AIDS) developed by Deaton and Muellbauer (1980). As in much empirical work using the AIDS, the price index *P* is approximated with Stone�s index ($\ln P^* = \sum w_k \ln P_k$). Hence the resulting linear approximate AIDS (LA/AIDS) model can be defined as:

(4)��� $w_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln(X / P^*)$

where w_i �is the expenditure share of livestock commodity *i*; p_j �is the price of livestock commodity *j*; and *X* is total expenditure within the livestock commodities system.

Following Green and Alston (1990), the correct formula for estimating conditional uncompensated price elasticities (η_{ij}) from the LA/AIDS model, and that for the conditional expenditure elasticities (e_i) are:

(5)�� $\eta_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} - \frac{\beta_i}{w_i}[w_j + \sum_k w_k \ln P_k (\eta_{kj} + \delta_{kj})]$

(6)�� $e_i = 1 + \frac{\beta_i}{w_i}$

where δ_{ij} �is equal to one when *i* = *j*, and zero otherwise. Note that the $\beta_i s$ �in equation 5 will be equal to zero only if preferences are homothetic at stage two. The unconditional price elasticities within the livestock commodity group and the unconditional expenditure elasticities can be defined as (Fan *et al*., 1995):

(7)�� $\eta^*_{ij} = \eta_{ij} + e_i w_j (1 + \eta_{II})$

(8)�� $e^*_i = e_i e_I$

Fan *et al*. (1994) modified this model to incorporate consumer habit formation over time, and Huang and Bouis (2001) allowed food consumption behaviour to change geographically. In this paper, we permit consumption behaviour to vary both over time and across geographic regions. Therefore we specify the two parameters in the first-stage equation (1a) and the three parameters in the second-stage equation (4) as:

(9) $\theta_I = \theta_{I0} + \theta_{I1} T_t + \sum_k \theta_{I2\,k} D_k$

(10) $B_I = B_{I0} + B_{I1} T_t + \sum_k B_{I2\,k} D_k$

(11) $\alpha_i = \alpha_{i0} + \alpha_{i1} T_t + \sum_k \alpha_{i2\,k} D_k$

(12) $\gamma_{ij} = \gamma_{ij0} + \gamma_{ij1} T_t + \sum_k \gamma_{ij2\,k} D_k$

(13) $\beta_i = \beta_{i0} + \beta_{i1} T_t + \sum_k \beta_{i2\,k} D_k$

where T_t �denotes a time variable and D_k �are regional dummy variables. These modifications add a large number of parameters to the equations to be estimated. We therefore conduct tests of various null hypotheses of all parameters on the right-hand-sides of equations (9) � (13) before making final choice of models.

Data

We use the Household Expenditure and Income Survey (HIES) annual data aggregated to the provincial level and covering 28 provinces (autonomous regions or municipalities) for the period 1990-2001. Two provinces (Hainan and Chongqing) and one autonomous region (Tibet) were excluded due to incomplete data.[5] Further explanation of this data source can be found in Chern and Wang (1994), Wu *et al*. (1995) and Cai *et al*. (1998). For the first stage LES model, all commodities were aggregated into three broad groups: livestock products (excluding fish), all other food and a non-food group. The livestock products group was further disaggregated into pork, beef, dairy products, poultry, eggs and mutton for the second-stage LA/AIDS model. Dairy products (measured in milk equivalent) included fresh milk, milk powder, yogurts, cheese and butter.

Lack of a full set of provincial price data for soymilk prevented us from including this product in the demand system. We believe, however, that there are good reasons to suspect that this product and cows milk may not be strong substitutes in China. For example, neither young mothers who use milk powder or fresh cow milk to feed their babies, nor older people who appear to drink cow milk for breakfast and dinner for health reasons, appear willing to accept soymilk as a substitute. In recent years, too, it has become fashionable for many Chinese to drink cow milk rather than soymilk during the summer and even during the winter seasons.[6]

Unlike other studies based on HIES data (e.g. Wu *et al*., 1995; Chern and Wang, 1994; Cai *et al*., 1998; Gao 1996), this study augmented that traditional data set with the adjusted livestock commodity expenditure data of Ma *et al*. (2004). The reason for this is that the HIES data on food consumption away-from-home is not dissaggregted across food products. We took the �food expenditure away from home� category in the HIES and apportioned it among the various livestock and other food commodities based on the procedure and estimates of Ma *et al* (2004). This is an important data improvement because consumption of livestock products away-from-home has increased substantially in China, especially over the 1990s. The proportions of livestock product consumption that occurs away-from-home differ substantially across livestock products. For example, the proportion of pork consumed away-from-home is substantial, but that for dairy products is almost zero.

Provincial price indices for the three commodity groups represented in the first-stage model came from China�s Commodity Price Statistical Yearbooks. As is common in the linear expenditure system literature (Fan *et al*., 1995; Lewis and Andrews, 1989; Halbrendt *et al*., 1994), price indices were used for the first-stage analysis. These were calculated for each of the commodity groups using geometric means with expenditure shares and population as weights. Ideally, data on price parity across provinces for at least one year should be used to adjust the provincial price indices so that they reflect differences among provinces and over time. However, such data were unavailable.

Price series for individual foods within the livestock products group required for the second-stage LA/AIDS analysis were obtained from the database of the National Price Bureau of China (NPB). The NPB gathers price data from major urban free markets every ten days and uses an average of them as the monthly price. We used such monthly price data and took the average of the 12 monthly prices within each year to generate an annual price series from 1990 to 2001. Since free market fresh milk retail price data are not available from the NPB�s database, an implicit price series for fresh milk was derived from the purchased quantity and expenditure data. Households consumed milk powder as well as fresh milk. Since milk powder prices were also unavailable, we used the sum of fresh milk and milk powder expenditures from the HIES to generate an expenditure share for dairy products, while we retained the fresh milk price in the demand system.

The provincial data for both stages of the analysis were aggregated up to seven regions. Dietary composition, as well as the level of consumption of dairy products, varies substantially across regions in China due to variations in social and economic factors. For example, in some regions (e.g., Shanghai, Xinjiang, Beijing and Qinghai), urban dairy consumption per capita exceeded 40 kilograms, but averaged less than 15 kg in the Northeast, South and Southwest areas. We decided upon an appropriate aggregation on our understanding of China�s food culture across regions. Provinces included in each of the regional groups exhibit similar consumption levels and food consumption cultures.[7]

Estimation and Results

We first estimated equations (1a) and (4), with parameters defined as in equations (9) � (13), simultaneously using iterative SUR techniques with symmetry and homogeneity restrictions imposed. We then conducted various hypothesis tests regarding the behaviour of the price and expenditure parameters over time and across regions. These involved tests of whether the coefficients of the time trend and regional dummy variables in equations (9)-(13), either as a group or individually, were equal to zero. The test results and maximum likelihood ratio statistics are presented in Appendices 1 and 2 for the first-stage and second-stage models, respectively. Variables whose parameters were not significantly different from zero at the 5 percent level or better were excluded. The system was then re-estimated including all remaining trend and regional dummy variables.

Results from the first-stage estimation are presented in Table 3. All tabulated parameters are significant at the 1 percent level except for other food prices. The time trend variables and most of the regional dummy variables related to price indices and total expenditure (not reported in Table 3) are also significant, indicating that the consumption patterns for all three commodity groups significantly changed over time and across regions. Own-price elasticities for livestock products, other food and non-food groups are different, ranging from �0.71 for non-food to �1.39 for other food (cross-price elasticities are not reported). Demand is almost price elastic for livestock products. Of the three commodity groups, livestock products have the lowest expenditure elasticity (0.65) in 2001, whereas the non-food group has the highest expenditure elasticity (1.18). We note the negativity of the θ_{I0} �parameters for the two food groups. Their popular interpretation as subsistence quantities is not appropriate here as this would require complete evaluation of equation (9), but we observe that such negative values can imply and be implied by elastic own-price behaviour for these goods (Parks and Barten 1973).

Table 3. Estimated Major Parameters and Elasticities for Commodity Groups (Stage One)

Commodity Groups	Major Parameters				Elasticities [a]	
	θ_{I0}	θ_{I1}	B_{I0}	B_{I1}	Own-Price	Expenditure
Livestock Products	-0.1148 (6.65)	0.0107 (5.01)	0.2219 (26.29)	-0.0127 (6.16)	-0.9582	0.6459
Other Food	-0.0038 (0.22)	-0.0054 (2.63)	0.4683 (39.89)	-0.0230 (7.62)	-1.3923	0.7807
Non Food [b]	0.2659 (13.80)	-[c]	0.3098 (23.76)	0.3571 (9.96)	-0.7123	1.1765

Note: Numbers in parentheses are *t* values. For brevity, the estimated parameters were not reported for regional dummy variables related to prices and total expenditure.

[a] The elasticities are calculated using the year 2001 values.

[b] These coefficients were derived from the adding-up condition of demand parameters in the linear expenditure system.

[c] Dropped due to insignificance after maximum likelihood test.

The second-stage parameter estimates for the disaggregated products within the livestock products group are presented in Table 4. Adding-up, homogeneity and symmetry restrictions (specified appropriately to incorporate time and regional dummy variables) were imposed (the mutton demand equation was dropped from system) using the SUR technique. Except for some cross-price parameters, all of the own-price coefficients with the exception of poultry are significant at the 5 percent level as are all expenditure parameters except those for beef and eggs. Except for dairy products, the own-price parameters did not change significantly over time.

Table 4. Estimated Parameters for Livestock Products (Stage Two)

Commodity (j)	Parameters										
	$\ln p1$	$\ln p2$	$\ln p3$	$\ln p4$	$\ln p5$	$\ln p6$	$\ln(X/P^*)$	$\ln p1*T$	$\ln p3*T$	$\ln p5*T$	$\ln p6*T$

Pork (1)	0.2458 (5.20)	-0.0339 (1.76)	-0.0436 (2.53)	-0.0182 (1.35)	-0.1139 (4.13)	-0.0362 (1.50)	-0.1438 (5.54)	-0.0086 (1.34)	0.0027 (0.68)	0.0098 (2.78)	0.0015 (0.30)
Beef (2)	-0.0339 (1.76)	0.0717 (4.66)	-0.0347 (3.23)	-0.0035 (0.60)	0.0282 (2.01)	-0.0279 (2.04)	-0.0167 (1.50)	0.0011 (0.42)	-0.0029 (1.63)	0.0009 (0.56)	0.0012 (0.55)
Dairy Products (3)	-0.0436 (2.53)	-0.0347 (3.23)	0.0370 (2.47)	0.0239 (4.71)	0.0331 (2.36)	-0.0158 (1.29)	0.0911 (9.15)	0.0056 (2.45)	-0.0043 (2.27)	-0.0102 (7.44)	0.0037 (1.99)
Poultry (4)	-0.0181 (1.35)	-0.0035 (0.60)	0.0239 (4.71)	0.0111 (1.23)	-0.0051 (0.57)	-0.0082 (1.08)	0.0964 (5.91)	-0.0041 (1.67)	0.0104 (4.78)	-0.0004 (0.17)	-0.0010 (0.43)
Eggs (5)	-0.1139 (4.13)	0.0282 (2.01)	0.0331 (2.36)	-0.0051 (0.57)	0.0774 (2.94)	-0.0198 (1.15)	0.0189 (1.11)	0.0077 (2.02)	-0.0019 (0.69)	-0.0031 (1.30)	-0.0063 (2.09)
Mutton [a] (6)	�-0.0362 (1.57)	-0.0279 (2.04)	�-0.0158 (1.61)	�-0.0082 (1.08)	�-0.0198 (0.97)	�0.0270 (5.51)	-0.0459 (3.12)	-0.0017 (0.51)	-0.0040 (1.69)	0.0031 (1.53)	0.0009 (0.06)

Note: Parameters related to the constant terms and regional variables are not reported. Numbers in parentheses are t-values.

[a] These coefficients were derived from the imposed adding-up restrictions.

Own-price and expenditure elasticities, calculated at year 2001 consumption levels, are presented in Table 5. As regards the unconditional own-price elasticities, we can see that dairy products and poultry demands are elastic and that for mutton the most inelastic. Dairy products have the highest unconditional expenditure elasticity (1.14), implying that dairy products remain luxury goods even in urban China. Mutton also exhibits the lowest expenditure elasticity (0.29). Remaining unconditional expenditure elasticities range from 0.44 to 0.96. In addition, we found that the expenditure elasticities declined over time. For example, expenditure elasticities for the livestock products group decreased from 1.36 in 1990 to 0.65 in 2001 (from the first stage LES estimation), and the conditional expenditure elasticity for dairy products within the livestock commodity group decreased from 2.72 in 1990 to 1.77 in 2001 (from the second stage LA/AIDS estimation).

Table 5. The Estimated Own-Price and Expenditure Elasticities (Stage Two)

Commodity	Conditional Elasticity		Unconditional Elasticity	
	Own-price	Expenditure	Own-Price	Expenditure
Pork	-0.5148	0.6759	-0.5023	0.4366
Beef	-0.4635	0.7389	-0.4615	0.4773
Dairy Products	-1.1735	1.7706	-1.1647	1.1436
Poultry	-1.0403	1.4891	-1.0281	0.9618
Egg	-0.7020	1.1390	-0.6956	0.7356
Mutton	-0.2872	0.4486	-0.2864	0.2897

Note: Unconditional expenditure elasticities with respect to total expenditure are equal to conditional expenditure elasticities with respect to livestock product expenditure multiplied by the total expenditure elasticity for the livestock products group estimated by the first-stage model (0.6459, see Table 3). Both conditional and unconditional expenditure elasticities are estimated at the year 2001 consumption levels.

The expenditure elasticities for the seven regions are presented in Table 6. From the first-stage, the expenditure elasticities for the livestock products commodity group are somewhat similar and range from 0.65 to 0.98. However, the expenditure elasticities for specific livestock products (from the second-stage analysis) vary substantially across regions. For example, the unconditional expenditure elasticities for dairy products are 0.88 in the North, range between 1.12 and 1.37 in the Central, Northeast, Northwest and Southwest regions, and are highest at 1.61 and 2.32 in the Coastal and South regions. The reasons for such large regional variations in dairy expenditure elasticities are unclear, although consumption levels and consumer preferences may be two of the more important. For example, dairy consumption is already high in the Coastal, North and Northwest areas (over 25 kg during 1999-2001), but is very low in Central, South and Southwest regions (about 15 kg during the same period). Besides, perhaps due to taste preferences, Southern consumption of dairy products is low even though incomes are relatively high. For example in urban Guangdong, dairy products expenditure per capita was only 37.3 percent of that in urban Beijing in 2001 even though Guangdong per capita food expenditure was the same as in Beijing.

Table 6. Estimated Expenditure Elasticities by Regions (2001)

Regions	Total Expenditure Elasticities for Livestock Products Group ���(Stage One)	Expenditure Elasticities for Dairy Products (Stage Two)	
		Conditional	Unconditional [a]
Central	0.6857	1.9283	1.3222
Coastal	0.7336	2.1965	1.6113
North	0.7869	1.1149	0.8773
Northeast	0.6493	1.7309	1.1239
Northwest	0.7578	1.8033	1.3665
South	0.9775	2.3762	2.3227
Southwest	0.8398	1.4142	1.1877

Note: Regions are defined as in footnote 6.

[a] The numbers in column 3 are the products of the numbers in column 1 and column 2.

Projections of Dairy Products Consumption and Production

In this section we make constant-price[8] projections of China�s dairy products consumption and milk production to the year 2006, to indicate the possible change in China�s net imports of these products.

Since total consumption in any year is equal to the product of consumption per capita and total population, projections must be made of both these elements. To project per capita consumption, expenditure elasticities and projections of per capita expenditure are required. The relationships between per capita consumption and expenditure, as estimated above, are used to provide the relevant elasticities. Finally, the projected level of consumption per capita is multiplied by the projected population size.

The relevant expenditure elasticities (equations 3 and 6) were estimated for each year in our sample period. Linear extrapolations were then made to project these elasticities to the year 2006. To make extrapolations of per capita urban expenditure and total urban population, we assumed that growth rates of the past ten years will continue until 2006. Two three-year averages centered on 1990 and 2000 were used to calculate annual growth rates over the intervening years for each of these variables. The projected levels of per capita dairy products consumption were estimated as:

(9)� $q_{it} = q_0 \prod_{s=2002}^{t} (1 + e_{Bs} e_{is} g)$; t = 2002, � ,2006.

where q_0 is base year (2001) consumption (18.1 kg per person), and g is the projected growth rate of total expenditure per person (5.32 percent). The e_{Bs} �are the estimated total expenditure elasticities for the livestock products group.[9] The e_{is} �are the estimated conditional expenditure elasticities for dairy products within the livestock products group.[10]

We have made projections for the years from 2002 to 2006, but we only present the projections for 2006 (Table 7). The projected 33 percent increase in urban per capita expenditure over the projection period combines with a 27 percent increase in the total urban population to result in total urban consumption of dairy products increasing from 8.72 million tonnes in the base period to 14.01 million tonnes in 2006, or an increase of 61 percent. This projected increase in consumption may be decomposed into that portion due to the increase in the urban population (45 percent of the total increase) and that due to the rise in per capita expenditure (55 percent). Though rural per capita dairy consumption is very low, it can be estimated that approximate 10 percent of total dairy products was consumed in rural areas based on recent three-year rural population and dairy product consumption levels. Since rural demand has not been explicitly modeled here, we obtain national aggregated dairy consumption by simply multiplying urban total consumption by a coefficient[11] of 1.11.

Table 7. Constant-Price Projections of Dairy Products Consumption and Production Deficits

	Actual level 2001	Projected Levels for 2006 [c]	
		Moderate Domestic Supply Growth	High Domestic Supply Growth
Urban total expenditure (yuan per capita)[a]	5272	7012	7012
Urban population (million)[a]	480.6	608.5	608.5
Urban consumption			
�- per capita (kg LME)	18.1	24.0	24.0
�- total (mmt LME)	8.72	14.01	14.01
Total consumption (mmt LME)[b]	9.69	15.57	15.57
Total production (mmt)[c]	8.17	11.00	13.61
Production as percent consumption (%)	84.3	70.6	87.4
Production deficit (mmt)	1.52	4.57	1.96

Note: mmt = million metric tonnes and LME=liquid milk equivalents

[a] Assumed annual growth rates of these exogenous variables were 5.87% (total expenditure) and 4.01% (urban population).

[b] This study did not explicitly model the largely-static rural milk consumption. Given its current consumption of around 1.2 kg per capita, the rural population accounts for approximately 10 percent of national total dairy consumption. Therefore the projections of urban consumption have been increased by 11.1 percent to derive consumption for mainland China as a whole.

[c] Moderate and high annual supply growth rates were 6.14% and 10.76% respectively (see text for explanation).

Milk production in China was projected using recent average growth rates. In common with several other livestock products, milk production has been over-reported in the official statistics (Ma *et al*. 2004). We adjusted the official data by taking the total milk cow numbers from the Chinese agricultural census of 1996, and multiplied that number by average yield per cow. This gave a total production volume equal to 87 percent of the official published volume for that year. The same percentage was then used to adjust all other supply data over our sample period. Using these adjusted data, milk production grew at the annual rate of 6.14 percent over the period 1991 to 2001, but at the more rapid of 10.76 percent between 1997 and 2001. Therefore we chose to make �moderate� and �high� production projections, using the above annual growth rates, to help indicate the sensitivity of China�s import dependency to variation in the level of future domestic supply.

China�s total milk production is projected to increase by 34.6 percent, or from 8.17 million tonnes in the base period to 11.00 million tonnes in 2006 under the �moderate� supply growth. As a result, the domestic milk production shortfall of 1.52 million tonnes in the base period is projected to rise to 4.57 million tonnes by 2006. China�s milk self-sufficiency rate is projected to fall from 84 percent in the base year to 71 percent by the year 2006. Alternatively, China�s milk production could reach 13.61 million tonnes by 2006 under our �high� supply growth scenario. Then, the total milk deficit is projected to be 1.96 million tonnes by 2006 and the self-sufficiency rate 87 percent. So even under this high supply growth scenario, the production deficit is larger than in the base period. We project total consumption to increase by 5.88 million tonnes, while domestic production increases somewhat less at 5.44 million tonnes

Constant-price projections of dairy products consumption and production were also made for each region, based on the estimated expenditure elasticities (Table

6) and projected expenditure and population growth rates for each region. Some results are summarized in Table 8. Although not shown in the Table, projected per capita consumption levels are very different across regions in China. These vary from 15 kg in the Central region, 22-25 kg in the Northwest, South and Southwest, 37 kg in the North and Northwest, and up to 50 kg in the Coastal region. Growth rates in regional milk production also vary considerably being greatest in the Northwest and Coastal regions (more than 10 percent), but virtually stagnant in the Central, South and Southwest regions. Total consumption levels are projected to grow the most rapidly in the South and Coastal regions (by more than 85 percent) and projected increases of between 50-80 percent are found for the other regions. But the largest absolute consumption increase is projected to take place in the Coastal area, where total dairy consumption may increase from 2.44 million tonnes in the base year to 4.52 million tonnes in 2006.

Table 8. Projections of Urban Dairy Product Consumption, Milk Production, and Dairy Product Production Deficits By Region

Region	Actual levels in2001 �����(�000 mt LME)		Projected levels 2006 �������������� (�000 mt LME)			Production as percent consumption (%)			Production deficit a�������������� (�000 mt LME)		
	Consumption	Production	Consumption	Production [b]	Production [c]	2001	2006 [b]	2006 [c]	2001	2006 [b]	2006 [c]
Central	1494	438	2470	482	555	29	20	22	1056	1988	1915
Coastal	2436	1293	4515	1797	2115	53	40	47	1143	2718	2400
North	1515	1138	2309	1579	1810	75	68	78	377	730	499
Northeast	1055	1469	1576	1805	2069	139	115	131	-414	-229	-493
Northwest	865	3299	1577	5306	6311	381	336	400	-2434	-3729	-4734
South	686	134	1424	137	157	19	10	11	553	1287	1267
Southwest	855	394	1329	427	492	46	32	37	461	902	837

Note: Regions are defined as in Table 6. Major projection parameter assumptions in the order as in the table are follow: 1) Population growth rates: 4.32%, 3.95%, 3.70%, 2.31%, 4.56%, 4.14% and 3.60%; 2) Per capita total living expenditure growth rates: 5.21%, 5.92%, 5.67%, 5.29%, 5.54%, 5.73% and 4.33%.

The projected aggregate output for 2006 in the table does not necessarily equal to total output in Table 7 because growth rates were estimated using regional data.

[a] Negative values indicate a regional surplus of production over consumption.

[b] Calculated based on moderate production growth.

[c] Calculated based on high production growth.

Decomposition of the projected increases in dairy consumption shows that living expenditure growth accounts for more than half of the total increase in dairy consumption. For example, expenditure growth accounts for approximately 70 percent of the total increase in dairy consumption in the Coastal, Northeast and South areas.

Self-sufficiency rates are projected to decline in all regions (with the possible exception of the Northwest), and (as in the base period) only the Northwest and Northeast regions show a surplus of milk production over consumption in 2006. Under either supply growth scenario, only the Northwest shows a higher surplus in 2006 than in 2001. Other regions run large production deficits, with self-sufficiency rates well below 50 percent in most cases.

Based on the above analysis, the greatest opportunities for dairy exporters to China may occur in the Coastal, South and North areas considering current processing and transportation facilities. In fact, according to China Dairy Association data, Shanghai and Jiangsu (in the Coastal region) imported US$63.79 million of dairy products during the first 11 months of 2002, accounting for 26.5 percent of national total imports, while Guangdong (in the South) imported US$67.12 million dairy products during the same period (27.9 percent of national total imports). and Beijing and Tianjin (in the North) imported US$48.99 million dairy products (20.4 percent of national total dairy imports) in the first 11 months in 2002. In contrast, both Central and Southwest regions are projected to still have large production deficits by 2006, although they may be partly met by domestic supply that can be transported from the Northwest. In fact, few imports occurred in these two regions during recent years.

Conclusions

A livestock product demand system for urban China was estimated using LES and LA/AIDS models, with a particular focus on dairy products. Based on the estimated econometric parameters, constant-price projections of dairy products consumption were made. Coupled with production projections, potential deficits were estimated at the national level as well as for major regions within China. Results should be of interest to dairy market traders, farm producers and policy makers.

Many livestock products consumed in China can be classified as necessities, since their unconditional expenditure elasticities are typically less than one. Dairy products do not appear to fall into this classification, however, as their consumption is at an early stage of development. Of the six major livestock products studied here, only for dairy products is the unconditional expenditure elasticity greater than one, allowing such products to be classified as luxury goods in urban China. This suggests that future growth of China�s dairy market will depend heavily upon the growth of incomes.

China will most likely continue to import increasing amounts of dairy products into the foreseeable future due to increases in demand outstripping growth in domestic milk supply. The estimated shortfall in production may reach 4.6 million tonnes by 2006, implying a self-sufficiency rate of 70 percent compared with 84 percent five years earlier. This deficit assumes that milk-surplus regions in China will be able to supply milk and dairy products to those regions in deficit. The extent to which this can occur in future depends in part upon further developments in transportation, especially the availability of suitable refrigerated food chains. At a regional level, the greatest opportunities for dairy exporters may occur in the Coastal, South and North areas.

Finally, a few cautionary points can be noted, that may influence the future evolution of China�s dairy imports. First, our assumption of constant prices will almost certainly not hold. As observed above, China�s accession to the WTO in December 2001 required tariffs on imports of dairy products (and many other foods including meats) to be reduced. Applied tariffs on various dairy products were in the range of 23 percent to 44 percent in 2001, and these are to be reduced to between 10 percent and 20 percent by 2004. The price elasticity of demand for dairy products was estimated to be �1.16 in 2001 and is projected at -1.22 in 2006, meaning that demand for dairy products is elastic. Since dairy imports could comprise from 13-30 percent of total domestic consumption in 2006, China�s tariff reduction commitments have the potential to lower domestic prices of, and boost demand for, dairy products. To the extent that this occurs, consumption could exceed our projection for 2006 which in turn would amplify the imports of dairy products beyond that projected above. However, it is also important to realize that China�s tariff reduction commitments apply to a wide range of food products, including other livestock products. Hence the relative decline in dairy prices may be somewhat less than the absolute decline. Given the range of food and non-food products into which these dairy imports flow,� a much more detailed modeling approach than that used here would be required to estimate impacts on prices of drinking milk and other dairy foods. This remains, however, an important issue for future research.

Second, counteracting any downward pressure such tariff cuts might have on domestic Chinese prices, international dairy prices might rise in future should the current WTO Round of trade negotiations in agriculture result in significant market liberalization, and global dairy prices may rise by more than for many other foods due to the high protection currently afforded milk production in many developed countries. Although such reforms would not be implemented until after 2005, to the extent that these price rises would be transmitted to the domestic Chinese market then demand growth could be inhibited somewhat as dairy products increase in price relative to other foods, and domestic production could be boosted.

Finally, our milk supply projections implied extrapolation of past growth in cow numbers and yields per cow. Up till now, growth in China�s milk output has been driven by increases in the number of cows, rather than by yield per cow. Milk yields per cow remain low in China relative to many other countries (Rae and Hertel 2000) and improvements in the rate of new technology development and adoption, and increased scale of production in China could lead to more rapid supply growth than projected here. Yields vary substantially across regions, and demonstrate how increased scale and use of high-quality breeds, for example, in certain regions can increase productivity.

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Appendix 1. Maximum Likelihood Ratio Tests in the First Stage

Variables	Critical Values 5%	Critical Values 1%	# Restrictions	χ^2 Statistics
The Tests Over Time:				
Livestock Food Price Index	7.81	11.34	3	105.3***
Other Food Price Index	7.81	11.34	3	90.9***

Non-Food Price Index	7.81	11.34	3	1.9
Total Living Expenditure	7.81	11.34	3	132.7***
The Tests Across Regions:				
Livestock Food Price Index	32.67	38.93	21	138.9***
Other Food Index	32.67	38.93	21	163.9***
Non-Food Price Index	32.67	38.93	21	67.1***
Total Living Expenditure	32.67	38.93	21	49.5***
Special Tests Over regions:				
Livestock Food Price Index�Region 1	7.81	11.34	3	8.3**
Livestock Food Price Index�Region 2	7.81	11.34	3	11.9***
Livestock Food Price Index�Region 3	7.81	11.34	3	37.9***
Livestock Food Price Index�Region 4	7.81	11.34	3	55.6***
Livestock Food Price Index�Region 5	7.81	11.34	3	4.4
Livestock Food Price Index�Region 6	7.81	11.34	3	9.1**
Livestock Food Price Index�Region 7	7.81	11.34	3	42.1***
Other Food Price Index�Region 1	7.81	11.34	3	31.6***
Other Food Price Index�Region 2	7.81	11.34	3	7.5
Other Food Price Index�Region 3	7.81	11.34	3	47.2***
Other Food Price Index�Region 4	7.81	11.34	3	56.1***
Other Food Price Index�Region 5	7.81	11.34	3	3.8
Other Food Price Index�Region 6	7.81	11.34	3	14.1***
Other Food Price Index�Region 7	7.81	11.34	3	68.4***
Non-Food Price Index�Region 1	7.81	11.34	3	32.6***
Non-Food Price Index�Region 2	7.81	11.34	3	3.6
Non-Food Price Index�Region 3	7.81	11.34	3	7.3
Non-Food Price Index�Region 4	7.81	11.34	3	7.9**
Non-Food Price Index�Region 5	7.81	11.34	3	21.6***
Non-Food Price Index�Region 6	7.81	11.34	3	7.5
Non-Food Price Index�Region 7	7.81	11.34	3	18.9***

Note: There are no intercept terms in the first stage according to the model specification.

*** and ** stand for 1% and 5% significant levels.

Appendix 2. Maximum Likelihood Ratio Tests in the Second Stage

Variables	Critical Values		# Restrictions	χ^2 Statistics
	5%	1%		
The Tests Over Time:				
Intercept	12.59	16.81	6	8.2
Pork Price	12.59	16.81	6	15.4**
� Beef Price	12.59	16.81	6	4.0
� Dairy Price	12.59	16.81	6	15.7**
� Poultry Price	12.59	16.81	6	10.3
� Egg Price	12.59	16.81	6	44.9***
� Mutton Price	12.59	16.81	6	15.9**
Livestock Food Expenditure	12.59	16.81	6	10.6
The Tests Across Regions:				

Intercept	61.66	69.96	42	213.6***
Pork Price	61.66	69.96	42	80.6***
� Beef Price	61.66	69.96	42	180.8***
� Dairy Price	61.66	69.96	42	132.6***
� Poultry Price	61.66	69.96	42	71.9***
� Egg Price	61.66	69.96	42	107.6***
� Mutton Price	61.66	69.96	42	177.8***
Livestock Food Expenditure	61.66	69.96	42	263.3***
Special Tests Across regions: [a]				
Beef Price�Region 6	12.59	16.81	6	13.9**
Beef Price�Region 7	12.59	16.81	6	13.5**
Dairy Price�Region 2	12.59	16.81	6	23.8***
Dairy Price�Region 5	12.59	16.81	6	14.3**
Dairy Price�Region 6	12.59	16.81	6	35.4***
Dairy Price�Region 7	12.59	16.81	6	13.0**
� Egg Price�Region 5	12.59	16.81	6	15.9**
� Egg Price�Region 6	12.59	16.81	6	20.3***
� Egg Price�Region 7	12.59	16.81	6	27.3***
� Mutton Price�Region 1	12.59	16.81	6	20.8***
� Mutton Price�Region 3	12.59	16.81	6	45.5***

[a] Although prices as a whole change significantly across regions, there are many combinations of prices and regions that are insignificant. Too many price-related variables can cause many price variables to be insignificant. Therefore, we tested the changes of livestock prices across regions one by one and dropped those that are not significant. Only the significant cases are presented here.

*** and ** stand for 1% and 5% significant levels.

Appendix 3. Urban Per Capita Total Living Expenditure and Shares: 1990-2001

Year	Total Living Expenditure� (yuan)	Shares of Total Living Expenditure		
		Livestock Products [a]	Other Foods	Non-Foods
1990	1278.89	0.1629	0.3907	0.4464
1991	1453.81	0.1605	0.3994	0.4401
1992	1671.73	0.1616	0.3703	0.4681
1993	2110.81	0.1681	0.3510	0.4809
1994	2851.34	0.1637	0.3510	0.4853
1995	3537.57	0.1633	0.3530	0.4837
1996	3919.47	0.1660	0.3446	0.4894
1997	4185.64	0.1585	0.3268	0.5147
1998	4331.61	0.1573	0.3187	0.5240
1999	4615.91	0.1430	0.3037	0.5533
2000	4998.00	0.1340	0.2845	0.5815
2001	5309.00	0.1270	0.2757	0.5973

Source: Urban Household Income and Expenditure Survey.

[a] The shares of livestock products include away from home consumption, following the adjustments of Ma et al. 2004.

Appendix 4. Urban Per Capita Livestock Products Expenditure and Shares: 1990-2001 [a]

Year	Total Expenditure (yuan)	Livestock Product Shares					
		Pork	Beef	Milk.	Poultry	Eggs	Mutton

1990	208.33	0.5048	0.0561	0.0507	0.0709	0.2693	0.0481
1991	233.34	0.5231	0.0543	0.0514	0.0802	0.2425	0.0484
1992	270.15	0.5070	0.0627	0.0539	0.0975	0.2310	0.0480
1993	354.83	0.5011	0.0630	0.0503	0.1111	0.2256	0.0489
1994	466.76	0.5399	0.0707	0.0488	0.1052	0.1864	0.0490
1995	577.69	0.5338	0.0730	0.0544	0.1143	0.1739	0.0506
1996	650.63	0.5231	0.0661	0.0562	0.1300	0.1806	0.0439
1997	663.42	0.5684	0.0710	0.0624	0.1133	0.1411	0.0438
1998	681.36	0.5351	0.0609	0.0705	0.1363	0.1542	0.0429
1999	660.08	0.5149	0.0660	0.0851	0.1575	0.1417	0.0348
2000	669.73	0.5100	0.0618	0.1024	0.1576	0.1225	0.0457
2001	674.24	0.4436	0.0639	0.1182	0.1971	0.1357	0.0416

Source: Urban Household Income and Expenditure Survey and Ma et al. 2004.

[a] Total expenditure of livestock products include away-from-home consumption (Ma et al. 2004).

Appendix 5. Price Indices of Commodity Groups: 1990-2001

Year	Livestock Products	Other Foods	Non-Foods
1990	1.0000	1.0000	1.0000
1991	1.0806	1.1101	1.1324
1992	1.1269	1.2405	1.2463
1993	1.2856	1.5020	1.4630
1994	1.7078	1.9661	1.6910
1995	2.1298	2.4943	18684
1996	2.2777	2.6972	2.0372
1997	2.3249	2.5146	2.1422
1998	2.1910	2.4985	2.1564
1999	2.0419	2.3692	2.1493
2000	1.9940	2.2317	2.1524
2001	2.0035	2.1866	2.1744

Source: China Statistical Yearbook, 1989-2002.

Note: All price indices in the table are weighted by the relevant food expenditure.

Appendix 6. Prices of Major Livestock Products in Urban Areas (yuan/kg): 1990-2001

Year	Pork	Beef	Milk	Poultry	Eggs	Mutton
1990	5.30	6.38	1.31	3.23	5.03	6.15
1991	5.94	6.43	1.32	3.95	4.92	7.24
1992	6.49	6.95	1.37	4.54	4.87	8.35
1993	7.29	7.88	1.51	5.74	5.64	10.41
1994	11.2	13.30	2.06	7.55	6.33	14.90
1995	13.17	15.75	2.56	9.35	7.10	18.23
1996	13.82	15.21	2.74	10.75	8.15	17.22
1997	16.32	14.43	2.85	8.70	6.15	16.76
1998	14.87	13.38	2.86	10.31	6.47	17.29
1999	12.88	13.18	2.84	10.64	5.59	16.60
2000	12.47	12.74	2.84	10.09	4.66	15.93
2001	10.54	12.84	3.93	9.46	5.28	14.73

Source: see data section.

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[2] This study covers Mainland China only.

[3] Rural residents consume less than 6 percent of urban per capita consumption volumes.

[4] To save space, we did not provide the data for other livestock commodities. However, all data, including prices and shares, used in this study are available upon request.

[5] Before 1996, Sichuan includes Chongqing.

[6] We thank reviewers for pointing out this issue.

[7] Regions are defined as follows � Coastal: Shanghai, Jiangsu, Zhejiang and Shandong; North: Beijing, Tianjin, Hebei and Shanxi; Northwest: Mongolia, Gansu, Qinghai, Ningxia and Xinjiang; Northeast: Liaoning, Jilin and Heilongjiang; South: Fujian, Guangdong and Guangxi; Southwest: Sichuan, Guizhou and Yunnan; Central: Anhui, Jiangsu, Henan, Hubei, Hunan, Shaanxi.

[8] Under China�s accession to the WTO, tariffs on dairy products, that ranged from 23% to 44% in 2001, are to be reduced to 10% to 20% by 2005. While incorporating these changes in import policy in the projections would add realism, we decided against this. The impacts of these tariff reductions on the domestic prices of liquid milk and other dairy products are complex and unclear. Only very small amounts of liquid milk are imported into China, and while the major import items are milk powder and whey they are used in a number of end-uses (infant feeding, ice cream and yogurt manufacture in the case of milk powder) and animal feed and bakery industries in the case of whey (Yang and MacAulay, 2004).��

[9] They are 0.6323, 0.6089, 0.5915, 0.5801 and 0.5747 for the years 2002-2006.

[10] They are 1.6746, 1.5787, 1.4828, 1.3869 and 1.2910 for the years 2002-2006.

[11] This assumes rural consumption remains at its current level of about 1.2 kg per capita over the projection period.