Urban Demand for Dairy Products in China: Evidence from New Survey Data

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Abstract

In this paper we use 2001-2002 urban survey data we collected to analyze demographics, cultural factors, and purchasing behaviors influencing the consumption of fresh milk, yogurt, ice cream, and powered milk in urban areas of China. The data include frequency of consumption by product, location of consumption and purchase, exposure to advertising and foreign culture, and school milk programs. The variables serve as regressors in a double-hurdle model that examines the decision to consume or not to consume and the level of consumption. We also estimate consumption levels and participation equations with tobit and probit models.

Keywords: China, dairy products, demand analysis, limited dependent variable models, survey data.

URBAN DEMAND FOR DAIRY PRODUCTS IN CHINA: EVIDENCE FROM NEW SURVEY DATA

Introduction

China has one of the lowest levels of per capita milk consumption in the world, averaging 5 kg per year from 1998 to 2001 (FAPRI 2003). This statistic hides the fact that there is great variation in milk consumption levels across regions and from rural to urban areas. In many regions of the country, milk and dairy products have not been part of the local diet (particularly in southern China), while in other regions there is a longer history of milk production and consumption (such as in Inner Mongolia, Shanghai, Beijing, Tianjin). Historically, milk consumption in China was promoted for its health benefits as the "key to Darwinian success" (Glosser 1999). To some extent, this perception of milk's nutritious benefits persists in modern China (Wu 2003). However, until China's economic reforms accelerated growth in agricultural output, limited supplies, high prices and lack of refrigeration prevented widespread consumption of milk and dairy products.

In the last decade, China's dairy industry has rapidly emerged. Milk production nearly doubled between 1990 and 2000. Fluid milk consumption rose by 39 percent over the last five years, largely in urban areas. Despite the rapid growth, supply constraints almost certainly limit the availability of milk. In response, China's government recently announced plans to boost milk production by an additional 15 to 20 percent by 2007 through improvement of dairy herd genetics and better management practices (Bean and Zhang 2003). School milk programs have also emerged in recent years. Further, several scholars have noted the leading role of supermarkets in the expansion of the feasible set of urban consumers (Reardon et al. 2003). Finally, fast-food outlets are now present in China, and travel outside the nation is increasing; both developments may also have a role in a westernization of the Chinese urban diet and the availability of new goods intensive in dairy products.

Despite the rapid growth, relatively few studies have examined milk demand in China. A number of demand studies have noted that consumption patterns in China are shifting toward diets with a greater share of animal products (Shono, Suzuki, and Kaiser 2000; Rutherford 1999; Rae 1997; Zhang and Wang 2003). Though relatively few estimates are available, expenditure and income elasticities for milk and dairy products for China's consumers tend to be among the highest for aggregate food categories (Zhang and Wang 2003; Huang and Bouis 1996). These findings suggest that the recent rapid growth in dairy consumption in China is likely to continue well into the future as household incomes rise. China's dairy markets only recently attracted international attention. Beyond aggregate price and income responses, limited knowledge is available regarding the purchasing behavior and the consumption profile of Chinese consumers of dairy products. Other economic, demographic, and cultural forces likely influence dairy consumption, as do changes in government policies and food retailing.

International scholars visiting China are making conjectures about dairy consumption based on casual observations, but a rigorous investigation is still missing. Our paper is a first step toward filling this gap. It contributes new knowledge on dairy consumption patterns in China based on an analysis of survey data collected from households in Beijing, Shanghai, and Guangzhou. The survey questions were directed toward household consumption behavior, with a specific emphasis on disaggregated dairy products. We confirm many conjectures about consumption patterns for dairy products. For example, we establish the importance of Western cultural influences, such as the consumption of cheese and ice cream in fast-food outlets and the exposure to international food through foreign travel. Education seems to increase dairy consumption, independently of the additional income it brings. The demographic structure of the household is also important. Households with younger parents and children purchase ice cream more often than do other households but in smaller quantities per purchase. Structural change is already happening within China's dairy consumption. Milk powder consumption is associated with older household members, in poorer households following medical advice, and living away from city centers, whereas yogurt consumption is associated with younger and better-educated consumers.

With respect to supply constraints, we find that distribution channels matter a lot. Supermarkets have become the principal channel for yogurt purchases, delivering three-

quarters of the purchases in the surveyed cities. Supermarkets are also important for access to fluid milk; although, a variety of outlets bring fluid milk to consumers, such as home delivery, delivery points to designated locations, and smaller grocery stores. Finally, we also find that ice cream consumption is positively related to the household's proximity of fast-food outlets.

The next section provides a summary of the household characteristics, dairy product information, and purchasing behavior. We use our data to establish a set of stylized facts on patterns of dairy products consumption for large urban areas in China. Then we present our formal econometric investigation of dairy consumption, focusing on regression results intended to isolate factors important to the market participation and purchasing decisions for selected disaggregated dairy products. The paper concludes with a summary of the findings and discussion of the implications of the analysis.

Description of the Survey Data

The data set used for this analysis was collected in the fall of 2001. Centering exclusively on dairy product consumption, the survey was administered to 100 households in Beijing, 100 households in Shanghai, and 114 households in Guangzhou, generating a total sample size of 314. Enumerators elicited information on household expenditures for a broader set of dairy products than those currently covered in the urban consumption survey of the National Bureau of Statistics of China (NBS). Different sections of the survey instrument included questions about purchasing behavior—such as the location of purchase, package size, preferred brand, and frequency of purchase—as well as changes in dairy product consumption over time, the relative importance of various factors in the purchasing decision, consumption of imported dairy products, and the prevalence of dairy product advertisements in a variety of media.[1]

The demographic data collected in the first block of survey questions are summarized in Table 1. The median household size was three in all three of the cities surveyed. Just fewer than 20 percent of the households had four or more members, 46 percent of which were reported in Guangzhou. The data suggest that household sizes tend to be larger in Guangzhou and smaller in Shanghai. Chi-squared tests of these differences are significant at the 5 percent level. Household composition data reported in

TABLE 1. Household demographic information: Sample average or median

	Units	Beijing	Shanghai	Guangzhou	Entire Sample
Household size	Number	3	3	3	3
Children < 14	Number	0	0	1	0
Adults > 60	Number	0	0	0	0
Household income	Yuan/Mo.	2,954	2,803	3,250	3,013
Wages of male household head	Yuan/Mo.	1,382	1,204	1,387	1,327
Spouse's wages	Yuan/Mo.	996	1,007	1,201	1,074
Other income	Yuan/Mo.	481	591	615	564
Age of household head	Years	48	52	46	49
Spouse's age	Years	48	50	43	47
Education of household head	Years	12	12	10	11
Spouse's education	Years	11	11	10	10

the 2003 China Statistical Yearbook indicate that 77 percent of households in Beijing, 70 percent of households in Shanghai, and 49 percent of households in Guangdong provinces[2] have three or fewer members. The average household size for urban China was 3.04 people in 2002.

Similar differences among three city samples were also evident in the number of young children and older adults. Only 28 percent of the households have children under the age of 14, and 54 percent of those are located in Guangzhou. In contrast, 46 percent of the households with adults over the age of 60 were in Shanghai. Fifty-two households in Shanghai contained at least one member who was retired, while only 24 households (21 percent) in Guangzhou had a retired member. Beijing was in the middle with 36 percent. NBS-based data shows similar differences in the age distribution of the populations in Beijing, Shanghai, and Guangdong. Roughly 11 percent of the population in Beijing and Shanghai is under the age of 15, while 25 percent of the population in Guangdong is in the same age category. Likewise, the shares of the populations over the age of 65 in the three provinces are 11 percent, 13 percent, and 8 percent, respectively. These statistics, coupled with the information on household size, indicate that, on average, the households surveyed in Shanghai are more mature in the sense that household members are older and children are grown.

The larger number of retired individuals in the Shanghai sample has an impact on average monthly household income in the survey sample. There is a statistically significant difference in household income levels across cities, and the likely source of the variation appears to be in the number of retired females in the city samples. More than 75 percent of the retired individuals in each city sample are females, and monthly incomes for retired females are an average of 176 yuan lower than for working females. In general, income levels reported in the survey are somewhat lower than the average disposable income of urban residents in Beijing and Shanghai (5.2 percent and 15.4 percent lower, respectively) and somewhat higher (16.7 percent) than those reported for urban residents in Guangdong province.

One of the most surprisingly findings from the survey data was the breadth of consumption of dairy products in China's main metropolises. All but five households reported purchases of one or more dairy products. All five of the households with zero dairy product purchases were located in Guangzhou. Table 2 displays the percentage of households in each city sample indicating purchases of dairy products. All of the households in the sample owned refrigerators, which contributes to the prevalence of dairy product consumption. Fluid milk purchases do not vary substantially by city, but yogurt purchases are significantly higher in Beijing. Likewise, a significantly higher percentage

TABLE 2. Household dairy product purchasing behavior

	Fluid Milk	Yogurt	Milk Powder	Ice Cream
Households reporting purchases		*(Percent of Sample)*		
Beijing	91.0	78.0	25.0	59.0
Guangzhou	86.8	50.0	32.5	58.8
Shanghai	94.0	50.0	26.0	43.0
Total Sample	90.4	58.9	28.0	53.8
Average purchases per week		*(Number of Purchases)*		
Beijing	3.13	1.02	0.07	0.35
Guangzhou	2.19	0.70	0.11	0.41
Shanghai	4.07	0.58	0.08	0.11
Total Sample	3.09	0.76	0.09	0.30
Average annual quantity purchased per capita		*(Kg)*		
Beijing	56.83	17.08	0.84	4.08
Guangzhou	27.35	7.06	1.14	2.41
Shanghai	51.45	7.64	0.68	0.59
Total Sample	44.41	10.43	0.90	2.36

of households in Guangzhou indicated purchases of ice cream and exhibit the highest frequency of purchase. Beijing consumers eat larger quantities of ice cream overall but purchase ice cream less frequently.

Table 2 also displays the average number of dairy product purchases made each week and the associated annual per capita consumption levels. The combination of the number of purchases, packages per purchase, and package size determines the total quantity purchased by the household. Significant differences in each of these variables are observed in the data. For example, households in Shanghai purchase milk more frequently than do households in Beijing but purchase fewer packages per purchase. However, the amount of milk purchased per household member is virtually the same in the two cities. Milk consumption per person in Guangzhou is just over half the level of the other two cities. China's urban consumers appear to prefer individual portions, with 250 ml being the most frequent package size for milk. Yogurt consumption comes second in terms of quantity purchased per capita, followed by ice cream and milk powder. With access to refrigeration and greater consumption of fresh dairy products, most urban households surveyed are moving away from milk powder, as indicated by the low frequency of milk powder purchases.

Annual consumption averages for the survey sample initially appear substantially higher than the national averages in urban areas reported by the NBS. However, they do not appear unbelievable when one considers that incomes in Beijing, Shanghai, and Guangzhou are some of the highest in the country. NBS-based data suggest that per capita fresh milk consumption increases from 15.72 kg on average to 20–26.5 kg for households in the top half of the income distribution. Yogurt consumption by upper income households averages 2.3–3.3 kg per person. Moreover, per capita expenditures on milk and dairy products in Beijing and Shanghai were more than double the national average for urban households in 2002. While certainly not representative of China as a whole, the reported consumption levels in our survey are consistent with broader samples for the survey areas.

Table 3 shows the breakdown of household purchases by marketing venue. From these figures we can see that the greater frequency of milk purchases in Shanghai is due to more frequent use of daily home delivery services and dedicated delivery points for

TABLE 3. Location of milk and yogurt purchases

Location	Beijing	Guangzhou	Shanghai	Entire Sample
	(Percentage of Households Reporting Purchases)			
Milk				
Home delivery	15.38	18.09	32.32	22.18
Delivery point	0.00	7.45	21.21	9.86
Supermarket	56.04	71.28	48.48	58.45
Grocery store[a]	23.08	21.28	2.02	15.14
School	1.10	13.83	6.06	7.04
Street vendor	6.59	7.45	2.02	5.28
Other	10.99	5.32	2.02	5.99
Yogurt				
Home delivery	1.28	8.00	7.02	4.86
Delivery point	1.28	12.00	8.77	6.49
Supermarket	82.05	78.00	80.70	80.54
Grocery store[a]	14.10	28.00	0.00	13.51
School	0.00	6.00	1.75	2.16
Street vendor	3.85	6.00	0.00	3.24
Other	6.41	6.00	0.00	4.32

[a] Grocery store refers to smaller retail outlets such as corner shops.

procuring fluid milk than is the case for households in the other two cities. Home delivery and dedicated delivery services in Shanghai appear to substitute largely for milk purchases from grocery stores. Indeed, fluid milk and yogurt consumers in Shanghai depend less on grocery stores than do consumers in the other cities but depend more on home delivery and delivery points. Only 20 percent of the sample's 88 households that reported purchasing milk through delivery services also reported purchasing milk from supermarkets or grocery stores.

The leading role of supermarkets as the source for dairy products is striking in the three cities. This rise in importance of large retail outlets as a place where dairy products are purchased almost certainly has alleviated supply constraints for urban consumers and expanded their choice set, particularly for dairy products other than fluid milk. The majority of households in all three locations purchases milk from supermarkets, but 25 percent of those households also purchases milk from other outlets. Likewise, more than 80 percent of households that purchase yogurt bought their yogurt at a supermarket. Just over 9 percent of those households also purchased yogurt from other locations, primarily smaller grocery stores. While of interest for those studying China's food economy, it should be noted that such a pattern of supermarkets as a force of transformation is consis-

tent with what has been observed by others in many countries and food markets (Hu, Fuller, and Reardon 2004; Hu et al. 2004; Reardon et al. 2003).

Another interesting difference in consumption patterns in the three cities is the breakdown of dairy product consumption within the household. On average, the household head and spouse consume 65 percent of the dairy products in Beijing, and children account for just 32 percent of household consumption. This is in direct contrast to the intuition of many who believe that the recent rise in dairy demand can be attributed to consumption by children. Such expectations, however, appear to be true in Guangzhou, where children consume 55 percent of the dairy products in the household, while the household head and spouse consume only 35 percent on average. These differences are statistically significant at the 1 percent level.

Finally, reported changes in dairy product consumption over time reveal that growth in milk and yogurt purchases has been greatest among consumers in Beijing. Over 46 percent of the respondents (147 households) indicated that they had increased their milk consumption in the last two years, and 45 percent of those households were in Beijing, representing 67 percent of the Beijing sample. In contrast, 49 percent of the households surveyed in Shanghai reported that their milk consumption had been stable over the last two years, and 17 percent of the households in Guangzhou had decreased milk consumption. One contributing factor to these differences may be differences in the availability of higher-quality, more affordable domestic dairy products. Nearly 66 percent of Guangzhou respondents reported purchases of imported dairy products compared with 40 percent in Beijing and 36 percent in Shanghai. More than 70 percent of the Guangzhou households that purchase imported dairy products indicated that lack of domestic products was an important or very important factor in their decision. Likewise, a large majority of these households stated that the safety and lower cost of imported products were important factors. Similar patterns were reported for changes in yogurt consumption over the last two years. Beijing residents also reported purchasing imported milk and yogurt less often than households in the other two cities.

While the appearance of school milk programs has coincided with the take-off of China's milk demand, in fact, school milk programs account for only a fraction of milk consumption in our sample, especially in Beijing. For example, only 29 respondents indi-

cated that their child's school had a school milk program. There were no significant differences in the frequency of responses across cities. Among these 29 respondents, 19 have young children under 14 years of age in the household; all but 4 of these 19 households reported purchases of milk at school. A total of 20 households reported milk purchases at school, and 13 of the 20 households are located in Guangzhou. Thus, while school milk programs are not more common in Guangzhou than in the other cities, a significantly greater share of milk purchases at school can be attributed to Guangzhou households. Only 9 of the 13 households (69 percent) reporting availability of school milk in Guangzhou actually purchased milk at school; thus, 4 households purchase milk at school despite the lack of a school milk program. The percentage of households with access to school milk programs that actually purchase milk at school is slightly lower at 66.7 in Shanghai, but only 1 of the 7 households in Beijing reporting access to a school milk program actually purchased milk at school. Our survey was conducted in the early stages of implementing school milk programs in China, so the future influence of these programs on dairy product consumption is likely to be larger than that suggested by our sample.

The impacts of exposure to international influences are evident in the data. For example, for households living near a MacDonald's outlet (1.5 miles or closer), the average per capita consumption of milk, yogurt, milk powder, and ice cream is 17 percent higher than for individuals in households further away from these outlets. For ice cream alone, this difference rises to 78 percent. Also, for households in which an individual has had an opportunity to travel abroad and consume dairy products while abroad (7 percent of the sample), fresh dairy product consumption is much higher, and the difference increases with the level of processing of the dairy product consumed (27 percent higher for milk, 61 percent higher for yogurt, and 81 percent higher for ice cream).

Empirical Analysis

Just over 91 percent of the households surveyed purchase milk, but less than 60 percent purchase yogurt or ice cream. With a large number of households indicating no purchases of particular dairy products, it is not possible to apply standard demand analysis using flexible functional forms, such as the almost ideal demand system (AIDS). Zero consumption observations can be the result of a corner solution in the utility maximization process, perhaps

because dairy prices are too high, but they can also be caused by factors that limit market participation, such as supply constraints, high transaction costs, or consumer characteristics (lactose intolerance, for example). A third possibility is that consumers make infrequent purchases of dairy products, and the timing of the survey did not capture their consumption (Blundell and Meghir 1987; Angulo, Gil, and Gracia 2001). This third reason is not relevant for the present data set because questions were asked in a way that implied average purchasing behavior throughout the year. Consequently, respondents often reported infrequent purchases in terms of the number of times per year when the time frame indicated in the question was shorter than the average period between purchases.

Several empirical models have been developed to handle censored or truncated data. Historically, the tobit model (Tobin 1958) has been widely used to estimate demand equations for survey data with zero consumption observations. The tobit model assumes observed consumption of a good by household i, y_i, is determined by a latent variable, y^*_i, that can be modeled as a linear function of a vector of independent variables $\boldsymbol{X}_i$, a vector of coefficients β, and an error ε_i, which has a normal distribution N(0, σ^2). Observed consumption can be described as follows:

$$\left.\begin{aligned} y_i = y_i^* = X_i'\beta + \varepsilon_i \qquad & if\ X_i'\beta > -\varepsilon_i \\ y_i = 0 \qquad & if\ X_i'\beta \le -\varepsilon_i \end{aligned}\right\}. \tag{1}$$

With both market participation and consumption levels determined by the same equation, zero consumption observations in the tobit model are assumed to result from a corner solution to the utility maximization problem. This may not be desirable if there is reason to believe that some factors affecting market participation do not impact consumption levels directly. Likewise, some independent variables may have opposite impacts on the participation and consumption decisions. In either one of these circumstances, it is beneficial to separate the two decisions into a double-hurdle model as described by Cragg (1971).

In the double-hurdle model, the household's decision to participate in the market is modeled as a binary variable, D_i, that is a linear function of a vector of independent variables, Z_i, a vector of coefficients, γ, and an error, μ_i. The variable D has a censored distribution, similar to the tobit model. However, the observed consumption variable has

a truncated distribution because it is only non-zero when consumers decide to participate in the market and when economic conditions are favorable for actually purchasing dairy products. The equations for the double-hurdle model are given in system (2):

$$\left.\begin{array}{ll} D_i = Z_i'\gamma + \mu_i & \text{if } Z_i'\gamma > -\mu_i \\ D_i = 0 & \text{if } Z_i'\gamma \le -\mu_i \\ y_i = X_i'\beta + \varepsilon_i & \text{if } X_i'\beta > -\varepsilon_i \text{ and } D_i > 0 \\ y_i = 0 & \text{Otherwise} \end{array}\right\}. \tag{2}$$

The errors μ_i and ε_i are assumed to have a bivariate normal distribution with mean zero and variance-covariance matrix Σ. The variance structure has the general form shown in equation (3), where ρ is the correlation coefficient between the errors:

$$\Sigma = \begin{bmatrix} \sigma_\mu^2 & \rho\sigma_\mu\sigma_\varepsilon \\ \rho\sigma_\mu\sigma_\varepsilon & \sigma_\varepsilon^2 \end{bmatrix}. \tag{3}$$

Both the tobit and double-hurdle models were applied to the survey data for the consumption of fluid milk, yogurt, milk powder, and ice cream. The tobit models were estimated over the entire survey sample using the maximum likelihood estimator (MLE) routine in TSP version 4.5. Descriptions of the dependent and independent variables included in the regressions are given in Table 4. The list of explanatory variables does not include prices because price data were not collected, and unit values cannot be derived for households that do not report consumption. Assigning a regional average price to households that do not report consumption significantly reduces sample price variation when censoring is significant. Other demand studies of this type that have omitted price variables from their demand specification include Yen and Jensen (1996), Gould (1992), Jensen (1995), and Blisard and Blaylock (1993).[3]

Estimation results for fluid milk consumption, yogurt, milk powder, and ice cream are shown in Tables 5 to 8, respectively. Given that survey data frequently exhibit heteroskedastic behavior, the conditional moments of the tobit estimates of all four dairy products were tested (Greene 1993, pp. 917-919). The null hypothesis of homoskedasticity was rejected at the 1 percent level for all goods. Consequently, the Eicker-White

TABLE 4. Variable description for limited dependent variable regressions

Variable	Type/Units	Description
D	Binary	1 = Participation in the product market
Y	Kg/person	Per capita consumption level
ADINTENS	Number	Number of different media through which the household has been exposed to milk advertisements (1-6)
AGE	Number	Average age of household head and spouse
BJ	Binary	1 = Beijing resident
CCDIST	Kilometers	Distance from the household to the city center
CHILD	Number	Number of children under 14 in household
DCABROAD	Binary	1 = Consumed dairy products while abroad
DEL	Binary	1 = Purchases product through home delivery or at designated delivery point
DOCTOR	Binary	1 = A health care professional has suggested that a family member drink milk
EDUC	Years	Average education of the household head and spouse (number of years)
SUPER	Binary	1 = Purchases product at a supermarket
GD	Binary	1= Guangzhou resident
HHSIZE	Number	Number of people in household
INCPC	Yuan/person	Per capita household monthly income
INSTORE	Index (0 to 1)	Frequency of in-store advertisements for dairy products
MCDIST	Kilometers	Distance to the nearest McDonald's restaurant
SCHMILK	Binary	1 = Child has school milk program available
SENIOR	Number	Number of people over 60 in household
TRAVEL	Binary	1 = A household member has traveled abroad in last decade
OTHER	Binary	1 = Purchases product from a street vendor or other location

covariance matrix (White 1980) was used to compute standard errors and t-statistics as reported in Tables 5-8.

Table 5 shows that many of the coefficients in our analysis are of the expected sign and are consistent with the descriptive data. The consumption of fluid milk is positively related to income per capita (INCPC variable). As seen in the descriptive statistics, the influence of Western culture is noticeable. For example, households with members that have consumed dairy products while being abroad (DCABROAD) tend to demand more

TABLE 5. Regression results for fluid milk consumption

	Model			
Dependent/Independent Variable	**Tobit** *y*	**Probit** *D*	**Double-Hurdle** *y*	*D*
INCPC	0.020***	0.0004	0.020***	0.0001
	(3.07)	(1.59)	(2.95)	(1.41)
HHSIZE	-2.436		0.056	
	(-0.56)		(0.05)	
AGE	-0.369	-0.0141		-0.0018
	(-1.07)	(-1.33)		(-0.96)
CHILD	5.317		0.778	
	(0.93)		(0.54)	
SENIOR	10.269**		3.770*	
	(1.98)		(1.84)	
EDUC	0.022	0.0467	0.852	0.0090
	(0.02)	(1.13)	(0.98)	(1.11)
ADINTENS	-2.571	0.1176		0.0197
	(-1.38)	(1.40)		(1.45)
DOCTOR	-8.466*	0.2692		0.0411
	(-1.87)	(1.05)		(1.19)
SCHMILK	-1.471	0.4925	0.233	0.0613
	(-0.17)	(1.04)	(0.21)	(1.20)
TRAVEL	-6.625	0.3590	-0.307	0.0448
	(-1.02)	(1.32)	(-0.15)	(0.98)
DCABROAD	23.615**		3.730	
	(2.37)		(1.51)	
CCDIST	-0.477	-0.0304		-0.0047
	(-0.93)	(-1.40)		(-0.99)
INSTORE	5.421		0.253	
	(0.42)		(0.09)	
DEL			3.673***	
			(2.53)	
SUPER			2.126	
			(1.24)	
OTHER			3.432**	
			(2.10)	
BJ	-0.022	-0.3590	8.637	-0.0512
	(-0.00)	(-1.23)	(1.60)	(-1.18)

TABLE 5. Continued

Dependent/Independent Variable	Model			
	Tobit	Probit	Double-Hurdle	
	y	*D*	*y*	*D*
GD	-29.390***	-0.7684***	-17.733***	-0.1171**
	(-4.77)	(-2.59)	(-5.39)	(-2.27)
CONSTANT	64.606***	1.2549	14.182**	0.8393***
	(2.74)	(1.40)	(2.05)	(5.92)
SIGMA	39.266		37.015	
Rho (Correlation)			0.350	
RMSE	35.950	0.286	36.859	0.286

Note: t-statistics are given in parentheses. *** denotes significance at the 1% level. ** denotes significance at the 5% level. * denotes significance at the 10% level.

dairy than do other households. In fact, every household that reported dairy product consumption abroad also reported milk consumption at home. These households consumed nearly 12 kg per person more than the sample average, despite the fact that the city with the largest share of households consuming dairy products abroad is Guangzhou. The presence of household members over age 60 also has a strong positive influence on consumption. While somewhat unexpected, this may be a reflection of the fact that both Beijing and Shanghai have a greater number of households with senior citizens than does the Guangzhou sample.

Although a number of the estimated coefficients in the tobit model are statistically significant, some coefficients appear to have the wrong sign. For example, a recommendation from a doctor or healthcare professional should have a positive impact on consumption, but the coefficient of the DOCTOR variable is negative. Given that many doctors have been urging their patients to drink milk, this result is unexpected. In addition, increased exposure to advertising through a wide variety of media might be expected to increase milk consumption. However, the coefficient for advertising intensity (ADINTENS) is negative. It is possible that some unobservable factor that is correlated with advertising intensity is omitted from the analysis.

In fact, in examining these unexpected signs more closely, two possible causes for the unexpected signs may be the presence of heteroskedasticity and the possibility of errors with non-normal distributions. The tobit MLE is inconsistent when either assumption

is violated (Greene 1993, pp. 912-916); however, the low degree of censoring in the milk consumption data should reduce the degree of inconsistency due to heteroskedasticity. Tests for normal skewness and kurtosis of the tobit residuals rejected the null hypothesis at the 1 percent level, indicating that the error term in equation (1) is not normally distributed. A third possible explanation for the unexpected signs is that advertising and doctor recommendations may have a greater impact on the decision to purchase milk than on the actual quantity purchased.

Table 5 displays the results of estimating a probit model of the purchase decision. Given the low degree of censoring, it is not surprising that most of the estimated coefficients from the probit model are not significant. Nevertheless, a joint test reveals that the hypothesis that all of the parameters except the intercept are zero is rejected at the 1 percent level. Moreover, the signs on all of the coefficients are more consistent with a priori expectations. For example, the average education level of the household head and spouse, advertising intensity, physician recommendations, presence of school milk programs, and travel abroad all have a positive influence on the probability of purchasing milk.

Thus, modeling the participation and consumption decisions separately, as in the double-hurdle model, may produce more sensible results. Attempts to estimate the double-hurdle model using the Heckman two-step estimator and the MLE were unsuccessful because both estimators had problems isolating a local maximum with a covariance structure for the errors that was amenable to an estimate of $|\rho| < 1$. This is a common problem in double-hurdle models because elements of the likelihood function can act as a perfect classifier for some data sets (Ruud 2000; Golan, Moretti, and Perloff 2000). Consequently, a generalized maximum entropy (GME) estimator (Golan, Judge, and Miller 1996) was used to jointly estimate the parameters of the participation and consumption equations. Wu's (1986) weighted jackknife estimator was employed to compute the covariance matrix for the estimated coefficients because of its consistency properties in the presence of heteroskedasticity.

The results of the double-hurdle estimation are also displayed in Table 5. The estimates for the coefficients of the participation equation are similar in sign to the probit estimates, but the magnitudes of the coefficients are substantially smaller in absolute value for most variables. Despite the smaller coefficient values, significance levels of the

GME estimates are similar to the probit estimates. An added benefit of separating the consumption decision from the participation equation is that we can include some variables in the consumption equation that might be considered endogenous to the participation decision. For example, binary variables indicating the location where consumers typically purchase milk (DEL, SUPER, VEND) were included in the consumption equation of the double-hurdle model. We also dropped some variables that appeared to have a greater influence on the participation decision than on actual consumption levels. The estimation results indicate that income, presence of senior citizens, home delivery services, and purchases from vendors have significant positive impacts on the level of fluid milk consumption. Per-capita fluid milk consumption for households using home delivery or delivery points is 21 percent higher on average than for all households. Similarly, more than half of the households that purchased milk from vendors or in other locations also purchased milk from supermarkets or grocery stores. These supplemental purchases raise their milk consumption 20 percent above the survey average. Finally, we could not identify any significant effect of school milk programs (SCHMILK) on the milk consumption decision or level.

Table 6 presents yogurt consumption results. The tobit equation shows that education and travel abroad positively influence the level of yogurt consumption, as does the demographic structure of the household. Younger households with children (SENIOR=0 and CHILD=1) consume more yogurt than do childless older households. However, larger households consume less per person, suggesting that yogurt consumption may be less evenly spread across household members than is milk consumption. The double-hurdle results reveal that education, in-store advertising, and the presence of children in the household have a more significant impact on the decision to participate in the market than on the actual consumption level. Households that purchase yogurt in supermarkets tend to consume at higher levels than do those that make purchases through home delivery or other channels. Again, school milk programs do not seem to influence the level of consumption of yogurt in households having access to these programs.

Table 7 presents the regression results for the milk powder equations. Both market participation and consumption levels are positively associated with the households distance from the city center. This result may reflect the implicit costs of transportation or

TABLE 6. Regression results for yogurt consumption

Dependent/Independent Variable	Model			
	Tobit	**Probit**	**Double-Hurdle**	
	y	*D*	*y*	*D*
INCPC	0.002	-0.0001	0.003	-0.0000
	(0.34)	(-0.32)	(0.85)	(-0.23)
HHSIZE	-5.798*		-1.465**	
	(-1.89)		(-2.17)	
CHILD	5.041	0.3604**	0.455	0.1153**
	(1.59)	(2.22)	(0.61)	(2.15)
SENIOR	0.133	-0.1120	0.043	-0.0354
	(0.05)	(-0.94)	(0.19)	(-0.83)
EDUC	1.323*	0.0655*	0.216	0.0253**
	(1.80)	(1.90)	(1.20)	(2.00)
ADINTENS	-0.434	0.0772		0.0280
	(-0.32)	(1.28)		(1.31)
SCHMILK	8.409		0.805	
	(1.38)		(1.27)	
TRAVEL	6.359		0.718	
	(1.27)		(1.13)	
INSTORE	9.957	0.7752**	1.540	0.2225**
	(1.26)	(2.15)	(0.46)	(2.04)
DEL			3.642**	
			(2.37)	
SUPER			5.722***	
			(5.69)	
OTHER			0.154	
			(0.25)	
BJ	12.901***	0.5516***	7.392***	0.1927**
	(3.05)	(2.58)	(2.97)	(2.54)
GD	-4.056	-0.2215	-0.583	-0.0700
	(-0.88)	(2.19)	(-0.31)	(-0.97)
CONSTANT	-2.970	-0.9453**	3.829	0.1407
	(-0.21)	(-2.19)	(0.76)	(0.92)

TABLE 6. Continued

Dependent/Independent Variable	Model: Tobit *y*	Model: Probit *D*	Model: Double-Hurdle *y*	Model: Double-Hurdle *D*
SIGMA	24.530		16.564	
Rho (Correlation)			0.340	
RMSE	24.304	0.458	20.645	0.458

Note: t-statistics are given in parentheses. *** denotes significance at the 1% level. ** denotes significance at the 5% level. * denotes significance at the 10% level.

TABLE 7. Regression results for milk powder consumption

Dependent/Independent Variable	Model: Tobit *y*	Model: Probit *D*	Model: Double-Hurdle *y*	Model: Double-Hurdle *D*
INCPC	-0.002	-0.0003	-0.000	-0.0001
	(-1.45)	(-1.49)	(-1.32)	(-1.40)
HHSIZE	0.050		0.000	
	(0.09)		(0.02)	
CHILD	-0.584	-0.0869	-0.006	-0.0271
	(-0.60)	(-0.53)	(-0.56)	(-0.50)
SENIOR	0.942	0.1756	0.049	0.0568
	(1.40)	(1.47)	(1.03)	(1.32)
EDUC	-0.007		-0.009	
	(-0.04)		(-0.66)	
ADINTENS	0.178	0.0691	-0.013	0.0222
	(0.52)	(1.11)	(-0.61)	(1.06)
DOCTOR	2.685	0.5559***	0.260	0.1814***
	(2.81)	(3.26)	(1.41)	(2.98)
TRAVEL	0.314		-0.025	
	(0.26)		(-0.94)	
DCABROAD	-2.209		-0.002	
	(-1.01)		(-0.38)	
CCDIST	0.226**	0.0371**	0.019**	0.0124*
	(2.35)	(1.97)	(2.06)	(1.68)

TABLE 7. Continued

Dependent/Independent Variable	Model			
	Tobit	**Probit**	**Double-Hurdle**	
	y	*D*	*y*	*D*
INSTORE	-0.780		-0.007	
	(-0.47)		(-1.32)	
BJ	1.514	0.1599	0.254	0.0533
	(1.10)	(0.76)	(0.70)	(0.79)
GD	2.334*	0.3049	0.535*	0.1003
	(1.92)	(1.52)	(1.85)	(1.49)
CONSTANT	-6.141**	-1.0913***	1.021**	0.1201
	(-2.03)	(-3.20)	(2.41)	(1.08)
SIGMA	5.946		2.500	
Rho (Correlation)			0.555	
RMSE	7.658	0.434	4.497	0.433

Note: t-statistics are given in parentheses. *** denotes significance at the 1% level. ** denotes significance at the 5% level. * denotes significance at the 10% level.

that households in suburbs and outlying areas have limited access to delivery services or supermarkets. Medical advice promoting milk consumption has a significant positive impact on the market participation decision for milk powder. Older and poorer households (SENIOR, INCPC) tend to consume more but the statistical significance for these variables is weaker. In sum, a clear pattern emerged for milk powder consumption. It is an inferior good consumed by older and poorer households located away from city centers and following medical advice to consume dairy products.

Table 8 shows the results for the ice cream equations. The tobit equation suggests that ice cream consumption levels are positively influenced by the intensity of advertisements, medical advice, and proximity of fast-food outlets (MCDIST). The probit results also point to the proximity of fast-food outlets and the intensity of advertisements. Income has no significant influence on ice cream consumption. The striking result here is the clear positive effect of the proximity of fast-food outlets. The survey results indicate that households in the sample typically purchased ice cream in single-serving quantities (50 grams). Similar to yogurt consumption, household size has a significant negative impact on consumption levels. This may also reflect the fact that ice cream consumption

TABLE 8. Regression results for ice cream consumption

	Model			
Dependent/Independent Variable	**Tobit** *y*	**Probit** *D*	**Double-Hurdle** *y*	*D*
INCPC	0.000	-0.0003	0.001	-0.0001
	(0.02)	(-1.59)	(1.03)	(-1.42)
HHSIZE	-0.698		-0.009*	
	(-1.11)		(-1.81)	
CHILD	0.717	0.1608	0.068	0.0578
	(0.76)	(1.03)	(0.42)	(0.97)
SENIOR	-0.262	-0.0115	-0.010	-0.0032
	(-0.31)	(-0.10)	(-0.80)	(-0.07)
EDUC	-0.014	0.0461	-0.046	0.0188
	(-0.05)	(1.45)	(-0.63)	(1.56)
ADINTENS	0.749	0.0790	0.204	0.0300
	(1.57)	(1.36)	(1.60)	(1.32)
DOCTOR	2.703**		0.075**	
	(2.01)		(2.24)	
MCDIST	-0.876**	-0.0987	-0.225**	-0.0328*
	(-2.56)	(-2.35)	(-2.43)	(-1.88)
INSTORE	0.357		0.001	
	(0.17)		(0.18)	
BJ	5.426***	0.3405	3.174***	0.1272*
	(3.40)	(1.82)	(3.76)	(1.77)
GD	3.002***	0.3257	1.404***	0.1215*
	(2.77)	(1.71)	(3.15)	(1.65)
CONSTANT	-3.438	-0.4617	-0.066	0.2984**
	(-0.97)	(-1.15)	(-0.06)	(2.07)
SIGMA	7.984		5.465	
Rho (Correlation)			0.370	
RMSE	8.061	0.484	7.026	0.482

Note: t-statistics are given in parentheses. *** denotes significance at the 1% level. ** denotes significance at the 5% level. * denotes significance at the 10% level.

appears to be associated with children and younger households, though these results are not statistically significant.

We undertook extensive influential data analysis to identify outliers in the collected data based on the usual statistics (DFITS, DFBETA, H-STAT, etc.) (see Belsley, Kuh,

and Welsh 1980). Nine data points were influential in three equations or more, either influencing the value of the regression coefficients and/or having large residuals or other forms of influence. Several data points were corrected for inconsistencies in demographic values by cross-referencing with additional data available from the households. None of these influences was strong enough to change the qualitative results of our analysis and no data points were deleted. We also tested the sensitivity of our GME estimates to the range of coefficient and error supports. The potential sensitivity of GME estimates to support variation can be damaging, as shown by Paris and Caputo (2001). Parameter values did respond to a 50 percent increase in coefficient supports and a 100 percent increase in error supports. On average, the absolute value of the coefficients changed by 24.3 percent, with the greatest changes occurring in the consumption equations. No clear patterns could be identified in the changes. However, increasing the support bounds decreased the coefficient standard errors for five of the eight equations. Despite the differences in the two sets of estimates, only three coefficients changed sign,[4] and one coefficient changed its statistical significance. The results reported in Tables 5-8 are the estimates using the broadest support bounds.

Unconditional elasticities of consumption were computed from the GME results and are displayed in Table 9. The unconditional consumption elasticity (η_{ij}) measures the effect of an exogenous variable (X_j) on the actual consumption level for good *i*, including the impacts of the change in values on the probability of positive consumption. The general form for the elasticity evaluated at the sample mean is given in equation (4):

$$\eta_{ij} = \frac{\partial P[y_i > 0]}{\partial X_j} \frac{\overline{X}_j}{P[\overline{y}_i > 0]} E[y_i \mid y_i > 0] + \frac{\partial E[y_i \mid y_i > 0]}{\partial X_j} \frac{\overline{X}_j}{\overline{y}_i} P[\overline{y}_i > 0]. \qquad (4)$$

Elasticities for changes in discrete variables were computed using the difference in the probability or expectation following a unit change in the exogenous variable.

The interesting feature revealed by the elasticity calculations is that income, education, purchase location (or method, in the case of delivery services), and regional factors have, by far, the greatest impacts on dairy product consumption. Table 9 also reveals that the aggregate effects of income are positive for three of the four dairy products, despite some negative signs in the market participation equations.

TABLE 9. Double-hurdle unconditional consumption elasticities

	Milk	Yogurt	Milk Powder	Ice Cream
ADINTENS	-0.001	-0.006	-0.020	0.103
AGE	0.001			
BJ	0.155	0.289	0.044	0.440
CCDIST	0.000		0.012	0.000
CHILD	0.015	0.000	0.005	-0.003
DCABROAD	0.069		0.000	
DOCTOR	-0.003		0.006	0.014
EDUC	0.171	0.084	-0.020	-0.091
GD	-0.349	-0.017	0.089	0.207
HHSIZE	0.001	-0.076	0.000	-0.002
INCPC	0.366	0.136	-0.084	0.190
INSTORE	0.001	0.009	0.000	0.000
MCDIST				-0.058
DEL	0.068	0.179		
OTHER	0.063	0.008		
SUP	0.039	0.273		
SCHMILK	0.003	0.041		
SENIOR	0.069	0.009	-0.004	-0.001
TRAVEL	-0.007	0.036	-0.006	

Concluding Comments

Using our new urban survey data, in this paper we analyze demographics, cultural factors, and policies influencing dairy consumption in China. Using information about a set of four dairy products, our data included the frequency of consumption by product, location of consumption and purchase, exposure to advertising and foreign culture, and availability of school milk programs. We used these variables as regressors in tobit and double-hurdle models of consumption. Results from the two approaches are quite consistent with each other.

While income, as expected, positively affects demand, there are a number of other factors. Western/foreign culture influences dairy consumption in urban China. Cheese and ice cream products in fast-food outlets are well received by consumers. The household's proximity to McDonald's restaurants (our proxy for fast-food availability)

increases the consumption of ice cream for the households we surveyed. Information available about the brands purchased by households reveal that only a handful of households in the sample (all located in Guangzhou) actually preferred to purchase ice cream at McDonald's. Thus, the MCDIST variable captures the impacts of proximity to major shopping districts where vendors selling ice cream novelties are more likely to concentrate. The exposure to international food (foreign travel and or exposure to dairy products while abroad) induces more consumption of dairy products. However, in the econometric estimation, we could not verify the conjecture that households with children and younger parents tend to consume ice cream more often than do other households.

Household characteristics also affect dairy demand. For example, educational achievements within the household, independently of the additional income it brings, increase dairy consumption of fluid milk and yogurt, the two main sources of dairy consumption in our survey. The significant, positive influence of education on dairy product consumption is consistent with findings by Bhandari and Smith (2000).

Distribution channels also matter a lot. One general finding is that certain products tend to flow through particular marketing venues but not through others. For example, supermarkets are the principal channel for yogurt deliveries. To a lesser extent, fluid milk moves through supermarkets. However, in some cases, there is more than one main marketing channel. Fluid-milk consumers use a variety of alternative outlets with an important role for home delivery and delivery points. Cheese purchases occur indirectly through consumption of restaurant food containing cheese. Overall, supermarkets appear to be a leading force in the evolution and diversification of urban dairy consumption.

Interestingly, in the regression analysis we could not identify any significant effect of school milk programs in the three urban areas we surveyed. Although households with children reported using them (more frequently in Guangzhou than in the other cities), there just may be too few of the households with children in our data. Moreover, the large number of other sources available to households may diminish the impacts of school milk programs in our sample. These patterns suggest that school programs may have some role in introducing dairy consumption to new consumers, especially in less-affluent households and those constrained by lack of availability, but their effectiveness may fade away

quickly as income rises, other sources become available, and consumers become more accustomed to purchasing dairy products.

A clear pattern emerged for milk powder consumption in the three cities we studied. It is an inferior good consumed by older and poorer households located away from city centers and following medical advice to consume dairy products. By contrast, fluid milk is on the rise and so are the other dairy products we investigated. In the future, we would expect a greater payoff from investigating consumption patterns associated with new dairy products and high-value-added dairy products such as cheese.

When considering China's future dairy industry, it appears clear that demand is going to continue to grow and may accelerate over time. Policies that promote production and marketing of both domestic and imported products need to be strengthened to reduce the supply constraints that currently limit consumption. Increased opening to the outside world, rapidly rising incomes, and shifting retail-marketing channels will undoubtedly continue to increase demand. Many of China's dairy commodities are and will continue to be produced domestically (e.g., fluid milk and much of the yogurt and ice cream), necessitating further development of an efficient dairy sector that provides a sufficient quantity of high-quality and safe milk.

Endnotes

1. Additional information about the survey instrument and data may be obtained from the authors upon request.

2. Statistics from the *China Statistical Yearbook* are for the entire province-level municipalities of Beijing and Shanghai and for the entire province of Guangdong, so rural and outlying areas are included. Data excluding the rural areas were not available.

3. Although in theory prices should be used when estimating a demand function, in practice when using cross-sectional data, since prices do not vary (much) within a region (e.g., a municipality), applied econometricians do not (should not) include price in cross-sectional demand regressions (Deaton 1997).

4. All three coefficients were insignificant in both sets of regressions. T-statistics were less than 0.6 in all cases. The diagnostic results previously discussed are available from the authors upon request.

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