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Julian Briz
Polytechnical University of Madrid
Ronald Ward
University of Florida
Isabel de Felipe
Polytechnical University of Madrid

Habit Formation and Demand System Estimates for Fluid Milk in Spain

Spain's dairy sector is of major importance to the country due to the basic demand for milk products, the nutritional aspects of milk products to the diet, and the relative large size of the dairy sector in Spain's agriculture. This sector has been particularly influenced by political policies since Spain's entrance into the European economic community. Production quotes have been imposed, placing increasing pressure on domestic production. Demand for milk products have shifted over time as have the product forms. Understanding domestic demand is essential to setting production policies and addressing equity questions relating to EEC milk production quotes.

How has the domestic demand for fluid milk changed and what are the longer terms projections? In order for the EEC to better deal with policy issues, definitive measures of fluid milk demand are needed. Modeling the demand for Spain's dairy products is the objective of this paper with the purpose to estimate short and long term demand relationships useful for policy analysis.

Between 1986 and 1992, the balance of trade in dairy products decreased from a deficit of 30 to more than 69 billion pesetas. Productivity doubled from 2.1 liters per cow in 1965 to nearly 4 liters in 1992. In this same period, Common Agricultural Policy (CAP) quotes restricted Spain's production (Rocha, 1991). Increased competition from community partners is creating downward pressure on domestic production with a maximum quote of 6.47 billion liters in 1991

Direct all correspondence to: Ronald Ward, 1125 McCarty Hall, University of Florida, Gainesville USA) 392-1845 ext. 402; Fax: (352) 392-3646; ward@fred.lfas.ufl.edu.

(Busade, 1995). CAP also places a minimum level intervention price on the sector. Given current demand for dairy products within Spain, it is generally felt that the quota system applied to the Spanish production is too restrictive and includes many administrative problems with control and distribution policies (Briz, 1995; Mercasa, 1993; Rocha, 1991).

At the center of the argument for Spain's dairy sector is the fairness of the quota system and the need for revisions in the policies. In order to make definitive arguments for bringing about allocation policies, it is essential that the demand for Spain's dairy products be fully documented. Without having a good quantitative understanding of demand, it is impossible to make consumption projections essential to setting and/or changing quota policies. Eating habits are changing in Spain, following other international patterns (Connor, 1994). In the last decade, consumption of fresh milk declined while use of sterilized milk increased. Population growth is near a zero rate. Consuming units are changing their structure with a higher proportion of couples and single person households. Regional differences in milk demand are expected given demographic differences across the country. Clearly, the first step to addressing policy issues related to the dairy sector must start with a definitive measure of fluid milk demand.

In this paper, our objective is to address the demand component of the dairy industry. Without acceptable measures of demand, it is impossible to set forth meaningful quota policies that both address Spain's concerns for its dairy sector and the broader issues for the total European community. This paper provides a better understanding of consumption patterns for whole and skim milk using a habit persistence model. Applying this expenditure allocation model, fluid milk demands are estimated and used to provide insight into Spain's fluid milk market.

Consumption and Prices Across Regions

Consumption data and prices of whole, skim, and all other milk forms were collected across 17 providences in Spain and recorded monthly starting with January, 1987. These regions listed in Table 1 extend across the entire country and, hence, should be representative for measuring Spain's demand for milk. In Table 1, means and coefficients of variation (C.V.) are shown for volumes and prices of whole and skim milk in each region. Since the C.V.'s are independent of the unit of scale, they are comparable across regions and variables (Ministerio de Agricultura, 1987-92).

The columns for whole and skim milk provide insight into how milk consumption differs within Spain. Metropolitan Madrid shows the highest average per capita consumption of whole and skim milk with the whole milk value being 6.091 *liters per capita per month*. In comparison, the Canary Islands show the lowest per capita consumption for whole milk. Consumption of skim milk is

Table 1. Whole and skim milk consumption and prices by regions in Spain, 87:1–92:9

Region Name	*Reg. No.*	*Whole Milk Volume (liters per capita)*		*Skim Milk Volume (liters per capita)*		*Whole Milk Price (Pesetas per liter)*		*Skim Milk Price (Pesetas per liter)*		*Income (Mils. Pesetas)*	
		Mean	*C.V.*[a]	*Mean*	*C.V.*	*Mean*	*C.V.*	*Mean*	*C.V.*	*Mean*	*C.V.*
MMadrid	17	6.091	0.107	1.482	0.30	77.1	0.070	74.12	0.074	1.558	0.217
MValencia	16	5.586	0.182	0.918	0.42	73.5	0.084	77.56	0.112	1.267	0.204
Rioja	14	5.283	0.158	1.404	0.29	78.2	0.073	77.74	0.080	1.444	0.121
Aragon	2	5.172	0.136	1.405	0.28	80.4	0.075	83.62	0.077	1.325	0.195
Navarra	12	4.904	0.416	1.389	0.28	79.7	0.078	76.47	0.085	1.438	0.178
Baleares	3	4.892	0.163	0.921	0.48	85.6	0.058	85.32	0.101	1.638	0.213
Vasco	11	4.800	0.212	1.112	0.35	78.5	0.071	75.91	0.085	1.379	0.145
Murcia	4	4.722	0.226	1.289	0.41	86.8	0.068	86.70	0.079	1.045	0.138
Cataluna	1	4.473	0.145	1.371	0.21	83.8	0.067	81.61	0.077	1.547	0.223
Mancha	7	4.452	0.330	1.121	0.39	79.4	0.058	83.92	0.102	0.987	0.170
Andalucia	5	4.431	0.229	0.723	0.29	85.9	0.058	88.68	0.078	1.206	0.165
Asturias	10	4.196	0.309	1.197	0.54	80.3	0.067	77.94	0.081	1.082	0.180
Cantabria	13	4.084	0.194	1.048	0.40	78.2	0.070	79.35	0.082	1.195	0.140
Leon	8	3.938	0.428	0.914	0.40	75.6	0.066	79.32	0.086	1.082	0.189
Extremadura	6	3.735	0.377	0.603	0.56	79.0	0.068	78.88	0.082	0.990	0.204
Galicia	9	2.797	0.309	0.917	0.50	75.9	0.073	78.81	0.088	0.990	0.204
Canarias	15	2.439	0.377	0.984	0.45	76.4	0.064	77.25	0.081	1.206	0.165

[a]C.V. = Coefficient of Variation (Standard Deviation/Mean). Source: MAPA, 1993.

substantially less than whole with per capita values usually in the range of .9 to 1.4 liters. Note that while skim milk consumption is quite low relative to whole, it does show substantial variations in consumption over time. For example, in Madrid the relative variation in skim milk consumption is three times that of whole milk. In some of the more rural areas (such as Galicia, Asturias, Cantabria) consumption possibly appears lower because milk is produced and consumed on the farm and may not enter the reported statistics.

Variations in whole and skim milk prices are quite similarly in contrast to what is seen for the volume results. There are minor differences in the mean levels and degree of change over time when comparing regions. While not a strong difference, skim milk prices have shown slightly more variation. Variations in volume across the regions are approximately five times the variation seen for milk prices. Variation in whole milk prices versus skim prices are almost identical. On average, one milk form does not consistently sell at a premium to the other. Also, the simple average across regions for both is nearly identical with whole milk prices averaging 79.7 pesetas per liter and skim milk being 80.2 pesetas. Finally, statistics for per capita income are presented in this table. The mean income is 1.2 million pesetas and the variation in income over time and across regions are close.

Table 1 is important because it establishes that there exist considerable variation in the consumption of fluid milk both over time and across regions. Given this variation and the monthly data from each region, information is available for measuring Spain's demand for fluid milk on average and according to differences across regions and over time.

DEMAND SYSTEMS MODELING

The economic literature is well established in mapping the relationship between utility and the demand for selected products. One frequently used approach is to estimate the demand for selected goods where the share of consumer expenditures on the selected goods is related to total expenditures on the commodity group and prices for those goods within the group. In most cases, the empirical issues focus on specifying the appropriate utility function, showing how to incorporate demographic changes into the analysis and to deal with dynamics. Pollak and Wales (1992) provide an excellent review of the more useful expenditure allocation models and give several examples and comparisons of various model forms. In Pollak and Wales' studies they show the strong performance of the Prais-Houthakker approach relative to several other specifications. Since primary concern is with the results, the demand models for Spain's milk industry are based on a modified Prais-Houthakker approach to demand modeling. Milk consumption is limited to whole fluid milk, skim milk and a class referring to all other fluid milk forms with monthly consumption recorded across the regions. Given the repeat use of fluid milk as part of most individual diets, there is likely habit persistence in the consumption of fluid milk in one or more forms and possible structural change in consumer preferences for milk products.

Let the three milk products noted above be m_1 (whole), m_2 (skim), and m_3 (other) with each m_i denoting a specific amount of each milk product.[1] We then define the consumer utility function with $U(m_1, m_2, m_3)$ measuring consumer satisfaction for the three forms of fluid milk. Given that both quantity and prices for each product are nonnegative, then consumers maximize their utility for m subject to the budget constraint that total expenditures (μ) cannot exceed the income available for expenditures on this product group (Simon and Blume, 1994). A clear implication is that consumers increase their utility with increases in consumption of each m_i, i.e., $\partial U(m)/\partial m_i > 0$ where $m = (m_1, m_2, m_3)$.

One utility form used in several demand studies is the constant elasticity of substitution (CES) function where $U(m_1, m_2, m_3) = \Sigma_{i=1}^{3}\alpha_i\ (m_i - \beta_i)^{\gamma}$. The α's correspond to proportional changes in m_i where $\Sigma_{i=1}^{3}\ \alpha_i = 1$ and the β's account for shifts in preferences or shifts in the utility mapping (see Pollak and Wales, p. 3-11). Finally, γ corresponds to an unknown parameter in the elasticity of substitution (ξ) where $\xi = 1/(1-\gamma)$ and $0 < \gamma < 1$. Following standard utility

[1] Note that the time and regional subscripts have been dropped for editorial convenience without any lose to the interpretation of the variables and estimates.

maximization procedures using this CES utility specification, the demand of m_i can be derived as developed with equation (1). Letting $w_i = p_i m_i / (\Sigma_{r=1}^{3} p_r m_r)$, then the demand function can equally be expressed in expenditure shares as set forth in equation (2) (Pollak and Wales, p. 155).

$$m_i = \beta_i + \left(\mu - \sum_{r=1}^{3} p_r \beta_r \right) \left(\frac{(p_i/\alpha_i)^{-\xi}}{\sum_{r=1}^{3} p_r^{1-\xi} \alpha_r^{\xi}} \right) \tag{1}$$

or

$$w_i = \frac{p_i \beta_i}{\mu} + \left(1 - \frac{\sum_{r=1}^{3} p_r \beta_r}{\mu} \right) \left(\frac{(p_i^{1-\xi} \alpha_i^{\xi})}{\sum_{r=1}^{3} p_r^{1-\xi} \alpha_r^{\xi}} \right) \tag{2}$$

Demographics and consumer habits can be major determinants of consumption patterns. It is essential that such determinants be directly incorporated into the demand system as set forth with equation (2). While there are several ways to include demographics in the demand systems, we have adopted the modified Prais-Houthakker procedure to account for regional differences in the demand for fluid milk products. If the original demand system was denoted by the standard form $h^i(P, \mu)$ before defining the utility function, then the modified Prais-Houthakker procedure replaces the original system with $s_i\, h(P, \mu/s_o)$ where s_i is a specific scale for the i^{th} commodity and is directly related to the demographics (η) (i.e., $s_i = S^i(\eta)$). Further, the income scale s_o is defined by the budget constraint where $\Sigma\, p_i s_i\, h(P, \mu/s_o) = \mu$ (Pollak and Wales, p. 79). Following Pollak and Wales' (p. 171) adaptation of the modified Prais-Houthakker model, equation (2) can be rewritten to explicitly relate the effects of demographics on the demand system as developed in equation (3). Note that η can be a single demographic variable or a vector of demographics impacting the demand for fluid milk.

$$w_i = \frac{p_i \beta_i (1 + \alpha_i \eta)}{\mu} + \left(1 - \frac{\sum_{r=1}^{3} p_r \beta_r (1 + \alpha_r \eta)}{\mu} \right) \left(\frac{(p_i^{1-\xi} \alpha_i^{\xi} (1 + \alpha_i \eta))}{\sum_{r=1}^{3} (p_r^{1-\xi} \alpha_r^{\xi})(1 + \alpha_r \eta)} \right) \tag{3}$$

In addition to the demographic effects, fluid milk is among a group of products that have generally well established consumption use and is a complement to the consumption of other products consumed regularly (e.g., consumption of cereal for breakfast, milk in coffee, etc.). One would expect some habit in the consumption of fluid milk products, thus the demand system should reflect habit persistence. In the context of the expenditure equation in (3), β_i is related to previous levels of milk consumption ($m_{i(t-1)}$) where one form could be $\beta_i = \delta_0 + \delta_1 m_{i(t-1)}$. If there are changes in habits over time due to exogenous effects, then the habit persistence adjustment could also include a trend variable as suggested in equation (4).

$$\beta_i = \delta_0 + \delta_1(m_{i(t-1)}) + \delta_2(t) \tag{4}$$

In equation (4), δ_0 is interpreted as the "physiological necessary" portion of β_i while δ_1 and δ_2 are the "psychologically necessary components" (Prais and Wales, p. 14). Furthermore, δ_1 is viewed as endogenous taste changes while δ_2 represents exogenous taste changes. Clearly, δ_2 and the time trend (t) represent proxy measures for factors generating these exogenous changes. Such factors could include advertising and/or major changes in product packaging, distribution, and storage methods if they were trending. Also, one would expect δ_1 to reflect only habit persistence and not inventory effects because of the highly perishable nature of fluid milk even for short time periods such as months. Thus, if δ_1 is statistically significant it must be reflecting consumption habits and not storage.

The scale adjustment in equation (3) traditionally accounts for demographics or related economic and non economic variables. Since our analysis is based on regional differences in Spain over a relative short time period, we capture demographic difference through regional dummies for each cross section in the data set. Obviously, one would prefer to have actual demographics, but data limitations make it necessary to use this approach to capture regional differences. Let the R's be regional dummies for the 17 regions identified in Table 1. Then a useful proxy way to include demographic differences in the demand system is to define $g_i = (1 + \Sigma_{r=1}^{17} \lambda_r R_r)$ where r = 1, 2,..,17. Since the inclusion of all dummies by definition creates a singular matrix, the restriction that $\Sigma_{r=1}^{17} \lambda_r = 0$ is imposed. Using region one as a base, then $\lambda_1 = -\Sigma_{r=2}^{17} \lambda_r$. Substituting this restriction into the original summation gives $g_i = (1 + \Sigma_{r=2}^{17} \lambda_r dR_r)$ where $dR_r = R_r - R_1$. This method for including the regional dummies is particularly useful when interpreting the final model results since with $g_i = 1$ implies an average value over all regions and $g_r = 1 + \lambda_r$ where $r \geq 1$ gives regional differences. Thus one can estimate the demand system fully accounting for regional differences and then discuss the average in addition to specific regions. In our analysis of Spain's dairy sector we are more interested in the overall average than for a specific region even though the model will facilitate dealing with specific regions.

FLUID MILK DEMAND ESTIMATES

Monthly data were recorded over the period 87:1 through 92:9, giving to total of 69 observations per region. Using these data, whole and skim milk expenditure share equations were estimated based on the coefficients for w_i and equation (1). Since $\Sigma_{i=1}^{3} w_i = 1$ only whole (w_1) and skim milk (w_2) were estimated since the other milk category is then predetermined. Actual variables entering the demand models are defined where:

WM_{it}	=	whole milk consumption per capita per month (liters per capita) in region i for period t.
SM_{it}	=	skim milk consumption per capita per month (liters per capita) in region i for period t.
OM_{it}	=	other milk consumption per capita per month (liters per capita) in region i for period t.
WP_{it}	=	whole milk price (pesetas per liter) in region i for period t.
SP_{it}	=	skim milk price (pesetas per liter) in region i for period t.
OP_{it}	=	other milk price (pesetas per liter) in region i for period t.
TM	=	time trend with TM = 1 when t = 87:1, etc.
$WM_{i(t-1)}$	=	whole milk consumption per capita per month (liters per capita) in region i for period t-1.
$SM_{i(t-1)}$	=	skim milk consumption per capita per month (liters per capita) in region i for period t-1.
$OM_{i(t-1)}$	=	other milk consumption per capita per month (liters per capita) in region i for period t-1.
R_{it}	=	dummy variables corresponding to the 17 cross sections.
$w_{1(it)}$	=	$WM_{(it)}\, WP_{(it)} / (WM_{(it)}WP_{(it)} + SM_{(it)}\, SP_{(it)} + OM_{(it)}\, OP_{(it)})$
$w_{2(it)}$	=	$SM_{(it)}\, SP_{(it)} / (WM_{(it)}WP_{(it)} + SM_{(it)}\, SP_{(it)} + OM_{(it)}\, OP_{(it)})$
$w_{3(it)}$	=	$1 - w_{1(it)} - w_{2(it)}$.

Note that the "i and t" subscripts for the w's can be dropped for convenience without any loss in their meaning. Using these definitions and the models from (3), empirical estimates are reported in Table 2. In this table, the λ's correspond to the regional scale adjustments discussed above (see Table 1) and the δ's reflect the structural shifts from habits and exogenous trends as defined in equation (4). Parameter estimates along with their t-statistics are presented for each milk product and other statistics are reported at the bottom of the table. Appropriate parameter restrictions consistent with demand theory have been imposed on the estimated models.

Table 2. Estimated coefficients for the modified Prais-Houthakker fluid milk expenditure models (see equation 3 with the λ's corresponding to the regions and the δ's reflecting the structural shifts set forth with equation 4).

	Whole Milk		*Skim Milk*		*Other Milk*	
	Estimate	*t-value*	*Estimate*	*t-value*	*Estimate*	*t-value*
α	0.4523	20.9101	0.2392	12.4110	0.3085	
λ2	−0.1734	−2.4287	−0.1023	−1.3531	−0.4103	−6.5897
λ3	−0.3783	−4.5915	−0.5211	−7.1669	−0.5456	−7.7862
λ4	0.2172	3.7316	0.2964	4.4803	0.0062	0.1373
λ5	0.0919	1.7643	−0.1211	−2.0278	0.0626	1.3929
λ6	−0.0722	−1.0196	−0.2914	−3.8943	0.2567	5.4222
λ7	0.1401	2.6875	0.1528	2.8092	0.1568	4.0041
λ8	0.0636	0.9562	0.0102	0.1466	0.3302	7.4960
λ9	−0.1045	−1.7560	−0.0165	−0.3040	0.2614	6.5034
λ10	−0.0104	−0.1836	0.0748	1.1697	0.2126	4.6926
λ11	−0.1353	−2.0677	−0.1828	−2.4907	0.0295	0.5477
λ12	0.2525	4.8791	0.3114	4.6598	0.2756	7.1839
λ13	−0.0933	−1.3206	−0.0725	−1.0215	0.1972	3.2811
λ14	−0.1479	−1.9641	−0.1101	−1.3506	−0.0806	−1.1259
λ15	−0.1454	−2.5533	−0.0036	−0.0718	−0.1689	−4.2200
λ16	0.2175	3.3987	0.1278	1.9008	−0.2103	−3.0978
λ17	0.1844	2.5223	0.2520	2.7580	−0.2429	−3.3643
δ0	−0.9782	−1.7628	−0.2204	−1.5155	0.5067	1.5655
δ1	0.6779	22.3136	0.5160	20.1770	0.6190	23.7413
δ2	0.0422	3.7793	0.0144	4.9176	0.0012	0.1928
ξ	2.0918	5.1923	2.0918	5.1923	2.0918	5.1923
R^2	.9089	—	.7500	—	—	—
DWW.	1.9476	—	2.1659	—	—	—
Mean w_i	.5238	—	.1316	—	—	—
σ	.0506	—	.0298	—	—	—
Obs	1132	—	1132	—	—	—
LMHet.test	11.1894		4.88266			

The t-value are based on standard errors after using the heteroscedastic-consistent matrix from the White's correction procedure.

Proportional changes (α's) in the utility mapping are statistically significant and have the correct signs and expected magnitudes. Likewise the elasticity of substitution (ξ) in the original utility is also consistent with prior expectations and is statistically significant. Regional differences are clearly seen with the λ's where the t-values provide a test of regional differences from an overall average. The δ's capture preference shifts with the habit formation (δ_1) being statistically significant for each milk product. Estimates for δ_1 are particularly interesting in that they are the most significant estimates within the models. Clearly, habit persistence as reflected initially in equation (4) is present and the implications will be shown in subsequent simulations. In contrast the exogenous preference shift estimated with δ_2 is significantly different from zero for whole and skim milk. There is strong empirical evidence of structural change reflected with the time trend set forth with equation (4). While consumer preferences have changed, the relative importance of the exogenous preference shifts compared to the other changes will be illustrated using simulation techniques.

Table 3. Price elasticities and marginal budget shares for whole, skim and other Spanish milk products.

Spain's Regions		Direct Elasticities Whole	Skim	Other	Marginal Budget Shares Whole	Skim	Other
Average	0	−0.5751	−0.1724	−0.3648	0.5616	0.1477	0.2907
Cataluna	1	−0.5502	−0.0964	−0.1642	0.5885	0.1693	0.2422
Aragon	2	−0.7776	−0.5191	−0.7258	0.6043	0.1726	0.2231
Balears	3	−0.9595	−0.8791	−1.1142	0.6326	0.1282	0.2393
Murcia	4	−0.4532	0.0862	0.1214	0.5855	0.1640	0.2505
Andalucia	5	−0.5580	−0.0738	−0.2685	0.5830	0.1234	0.2936
Extremadu	6	−0.5769	−0.1971	−0.5213	0.5258	0.1056	0.3686
Mancha	7	−0.4540	0.0406	−0.0588	0.5583	0.1485	0.2932
Leon	8	−0.4490	0.0035	−0.2145	0.5272	0.1317	0.3412
Galicia	9	−0.5242	−0.1891	−0.4666	0.4956	0.1431	0.3613
Asturias	10	−0.4919	−0.1002	−0.3138	0.5209	0.1488	0.3303
Vasco	11	−0.6447	−0.3261	−0.6023	0.5363	0.1333	0.3304
Navarra	12	−0.3527	0.2066	0.2338	0.5548	0.1528	0.2924
Cantabria	13	−0.5540	−0.2078	−0.4824	0.5122	0.1378	0.3500
Rioja	14	−0.6682	−0.3683	−0.6161	0.5455	0.1498	0.3046
Canarias	15	−0.6727	−0.3819	−0.5959	0.5525	0.1694	0.2781
MValenica	16	−0.5645	−0.0053	−0.0003	0.6332	0.1543	0.2125
MMadrid	17	−0.5545	−0.0349	−0.0038	0.6216	0.1728	0.2056
Coefficient. of Variation		−0.2371	−1.4093	−0.9887	0.07361	0.1259	0.1781

[a]All elasticities are calculated at the mean expenditure of 675 pesetas per month per capita and for the average prices (see Table 1).

The results in Table 2 include correcting for heteroscedasticity. Using a Lagrange Multiplier test (LHHET in Table 2), the test pointed to the presents of some heteroscedasticity in the whole and skim milk equations before correcting the models. LMHET in Table 2 follows a χ^2 and the corresponding Type I probabilities are shown. Given the LM values are statistically different from zero, the original milk models were corrected giving the estimates and standard errors reported in Table 2. While the corrections were made, numerically they had very minimal effect on the estimates and subsequent conclusions about milk demand.

Coefficients of determination are reported for the whole and skim milk and not for the other milk since it is predetermined once whole and skim milk shares are estimated. R^2 values are reported at the bottom of Table 2. Finally, a generalized measure of serial correlation indicated no problems with the residuals over time.

Price Elasticities

Using the estimates from Table 2, the first important dimension to understanding Spain's milk demand is to show the direct price elasticities. Table 3 includes direct price elasticities for the average across regions and for each of the 17 regions. All values are calculated at the mean expenditure level using average prices. As evident from the overall country average, there is considerable difference in the elasticities among whole, skim and other milk with the elasticities shown to be -.57, -.17 and -.36, respectfully. Since skim milk is a more differentiated product one would intuitively expect the elasticity for whole milk to exceed that of skim. Clearly, milk is very inelastic as one would hypothesize for a product that is generally considered an essential part of the nutritional intake. Also, given the perishability of milk, one would not expect increased storage with price adjustments, thus further pointing to the expectation for very inelastic demands. Studies of the U.S. dairy demand by Ward and Dixon point to similar elasticities among U.S. consumers. Williams gives elasticities for all liquid milk in the United Kingdom with values in the range of those estimated for Spain. Oskam estimates the price elasticity for milk and milk products to be -.14 for the Netherlands. Almost all U.S. dairy studies point to price elasticities in the range of -.10 to -.40 (Kilmer, 1989 ; Johnson, Eds., 1992).

Relative regional differences in elasticities are compared using the coefficient of variation reported at the bottom of Table 3. Variation in skim and other milk elasticities across regions are several times greater than seen for whole milk as show with the C.V. of -.23 for whole milk compared with -1.41 and -.99 for skim and other milk. In a few regions the sign for skim and other milk are wrong, but for the majority of regions the elasticities carry the expected signs and magnitudes. Also, the skim milk elasticities tend to be lower within the more metropolitan regions such as MValencia, MMadrid, and Cataluna (Barcelona).

Habit formation or persistence is significant for each milk product (i.e., see the δ_1 and δ_2 values in Table 2). Since whole and skim milk are our primary products of interest we have plotted the estimated demand responses for these two products to give a clearer picture for the short and longer run demands for these products. In the long-run $m_{i(t-1)}$ equals m_i^o. Substituting this value into the habit formation in equation (4) and then solving for m from equation (3), both the short and longer term demand responses can be illustrated as shown in Figures 1a and 1b for whole and skim milk. Showing the estimated demand is much more revealing than just reporting price elasticities, particularly when dealing with short and longer term changes.

Again, if there were no structural changes or habit formation, the short and long-run demand responses would be identical for each product. In Figures 1a and 1b differences in the short and long (habit formation) are evident, although the differences are not substantial. For whole milk over a price range from 68 to 88 pesetas per liter, long-run demand differs from the short run by +4% at the lower price of 68 pesetas to -2% for the higher price. Using the same price range for skim milk shown in Figure 1b, the short and long run differs by +.05% to -2.35%. For both products illustrated in these figures, habit formation due to the endogenous preference shifts is statistically significant (see Table 2) but numerically quite small. Recall that from equation (4), we are measuring the impact of the structural adjustments associated with δ_1 and not δ_2 which is the exogenous structural adjustment over time. Given the fundamental importance of milk in

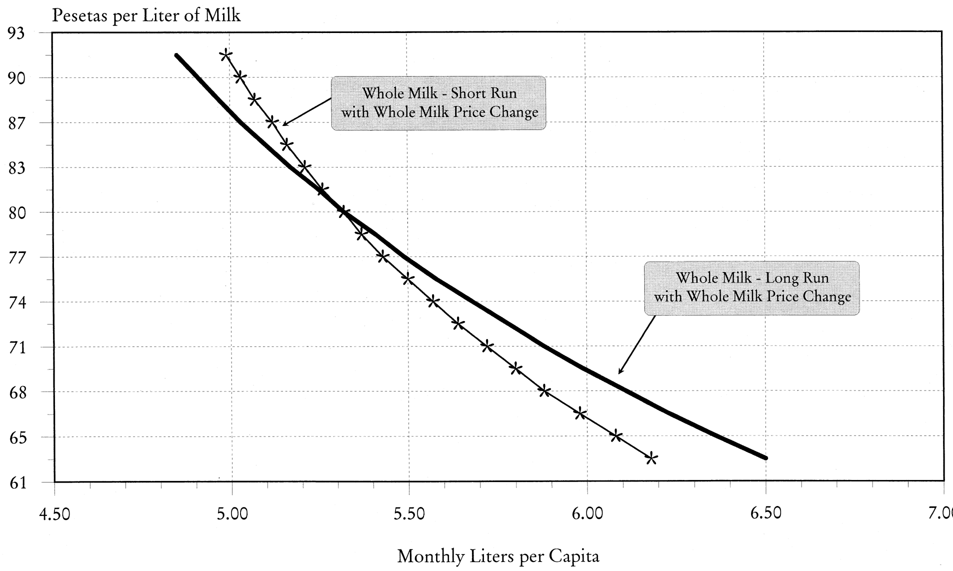

Figure 1a. Simulation of Spain's Whole Milk Demand in Response in the Short and Long Run Using the Modified Prais-Houthakker Demand Model

daily consumption patterns, the small numerical differences illustrated for both products are expected. Recall that these figures are for the average and will differ across regions depending on the λ values reported in Table 2.

These results are particularly important when addressing policy issues dependent on demand estimates. One can show the short and long-run implications of policies influencing prices but generally the differences between the short and long term will not be too large numerically. Simply, while habit persistence is statistically significant, the differences on milk demand over historical price ranges are not that large. Again such observations are best seen using the graphs rather than just reporting elasticities.

Budget Shares

What happens to milk demand and relative shares when total expenditures on milk increase? That is, what are the marginal changes associated with changes in μ from equation (2)? Marginal budget shares are also reported in Table 3 with the marginal response defined as $0 < \partial(p_i\ m_i)/\partial\mu < 1.0$. For the average (675 pesetas), whole milk captures 56% of a unit increase in expenditures and skim milk accounts for 14.7%. The marginal budget shares are close across the regions with whole milk ranging from 49% to 62% and skim milk extending from 10%

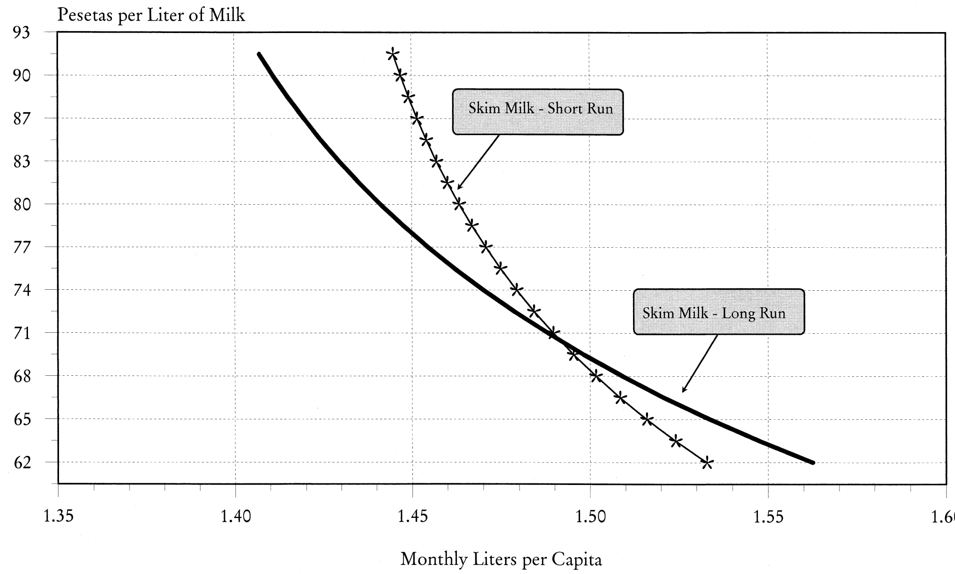

Figure 1b. Simulation of Spain's Skim Milk Demand in Response in the Short and Long Run Using the Prais-Houthakker Demand Model

to around 17%. Relative variation in marginal expenditures as measured with the coefficients of variation among the three milk categories points to a much higher degree of stability in response to expenditure changes relative to price changes. For example, the C.V. for whole milk expenditures is .0736 compared to .2371 for prices giving a factor around three. Similarly, skim milk shows the regional variation of .1259 compared to the price variation of 1.4093 or a factor nearing ten.

An interesting extension of the budget response is to show the change in demand shares over expenditure levels within a given time period. In Figure 2 we have simulated the total demand for fluid milk across per capita expenditures ranging from 400 pesetas to 1000 pesetas per month. Holding prices fixed at their means, then total demand increases as shown with the upper curve. At the lowest expenditure level, nearly 65% of the expenditures is for whole milk. As the total expenditures increase, the percentage going to whole milk declines to near 58% of the total milk volume demanded. While this figure continues to show the dominance of whole milk in the consumer diet, it also shows a growth in the use of alternative milk forms as expenditures increase. The upper level of 1,000 pesetas is approaching ranges beyond historical experiences, yet within this range the limits to demand adjustments across product forms can be easily seen. That is, whole milk demand decreases in relative terms but still remains the major component in the Spanish consumption of fluid milk. Clearly, the slope of the

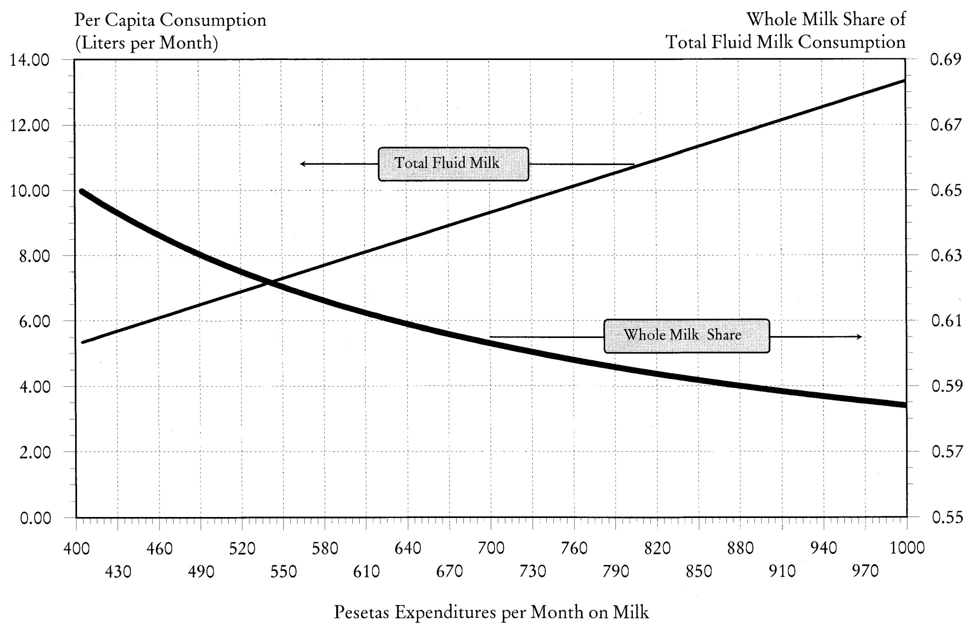

Figure 2. Simulation of Spain's Whole Milk Demand in Response to Changes in Budget Expenditures on Milk Products Using the Modified Prais-Houthakker Demand Model

whole milk share curve provides an informative picture of the demand response to potential income adjustments with consumers shifting to the more differentiated milk forms.

Dynamics of Fluid Milk Demand

Over time Spanish demand of fluid milk depends on expenditure assumptions, prices, and the preference adjustments captured with equation (4). Preference adjustments are dynamic in the sense that a prediction for m_i in one period enters the demand equation in the subsequent period through this equation. Furthermore, δ_2 adds an additional exogenous adjustment with the inclusion of time. Recall that δ_2 was significant for whole and skim milk but not for the other category (see Table 2.) Using the models set forth in Table 2 and an inflation assumption, one can gain insight into the dynamics of milk demand over time. In Figure 3, we have simulated fluid milk demand over several months using the following scenarios, recognizing that the growth assumptions are somewhat arbitrary:

Scenario (1). Fluid milk expenditures and milk prices remain at the mean starting price in 1992 while allowing for exogenous preference shifts captured with δ_2.

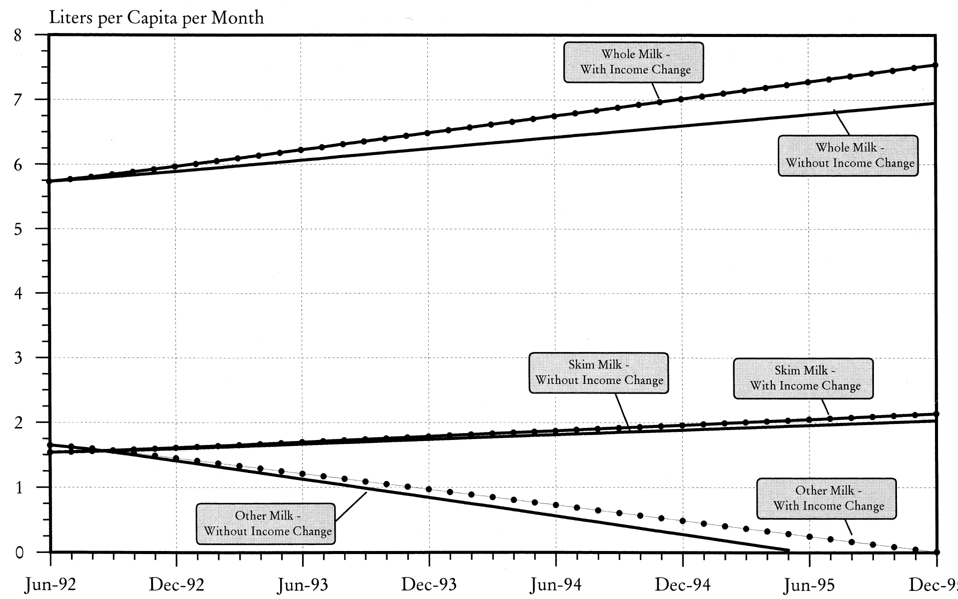

Figure 3. Simulated Changes in Milk Demand Across Time ith and without Assuming a 3% Annual Expenditure Growth Starting at a Mean of 675 Pesetas and *No Changes in Prices*

Scenario (2). Fluid milk expenditures grow at an annual rate of 3% and include the exogenous preference shifts captured with δ_2 while milk prices remain at the mean starting price in 1992.

In Figure 3, whole milk demand is shown to increase from 5.7 to 6.9 liters given the preferences shifts captured with δ_1 and δ_2 in Table 2. Likewise, skim milk increases from 1.5 to around 2.0 liters over the same period. Gains in demand for whole and skim milk in this scenario occur at the cost of declines in the demand for the other milk category. Prices will not remain fixed over time and expenditures are likely to change. Hence these plots with Figure 3 are not forecasts but a portrayal of the dynamic underlying patterns attributed to habit persistence and preference shifts estimated for the three milk forms.

In contrast to scenario (1), we have also allowed expenditures to grow at a rate of 3% annually for several years beyond the end of the data set. Again prices were held fixed at their means while recognizing that higher or lower price inflation rates over time and across the three milk categories would change the resulting demand patterns. In Figure 3, the dotted lines show the case with rising expenditures (i.e., 3% annually) and fixed prices. The expenditure increases lead to the most growth in whole milk demand with an increase to 7.5 liters. Whereas, the difference in skim milk with and without the expenditure growth is 2.13 liters compared with 2.03 liters for the same period.

What is apparent with the scenarios in Figure 3 is that the preference shifts in isolation from price adjustments will significantly change in the relative demands for milk products. Given the current preference measures, these changes can only be altered through differential pricing schemes if there is a structural reason to keep all product forms in the marketplace.

Other studies using of fluid milk demand based on non-systems approaches show mixed growth results. Williams looked at the United Kingdom dairy demand and found the income effects to be mixed from year to year and generally insignificant (Williams, p. 238). Ward and Dixon show positive and significant income elasticities for U.S. fluid milk demand (1989). Haidacher provides a review of many U.S. dairy studies and generally concludes that the income elasticity results are mixed depending on the data period and type of product (Haidacher, p. 178-210). There are often problems estimating income elasticities separate from the underlying time trends seen in many milk demand studies (Haidacher, p. 194). Oskam even shows a negative income effect for dairy consumption in the Netherlands (Oskam, 1982; 1989). Goddard shows a positive and significant income effect for Canadian milk demand (Goddard, 1988). Clearly, this habit persistence model does provide a measured difference attributed to income versus preference shifts.

From a national policy perspective, the more important issue is what happens to total demand for fluid milk under the scenarios presented. Once total demand is projected, then what are the implications for Spain's milk production quote system under the current EU (European Union) policies? For the cases presented with Figure 3, total per capita liters actually decline from 8.92 to 8.69 liters with no expenditure growth. With the 3% growth in expenditures, total milk demand increases from 8.92 to 9.69 liters over the years simulated. This represents a .75 liter increase in demand which could then be used to project to the total country. Such projections are beyond the scope of this paper since issues of estimating the appropriate growth and differential pricing issues must be carefully explored before setting forth specific demands that can be used to address the current EU milk quote problem. On the other hand, the expansion of the EU in the coming years from 15 to 25 or 30 countries may change the actual regulations. In any case, an adequate knowledge of consumer behavior and demand projections are the keystone to the policymaker.

Conclusions

Demand is one of the driving forces that ultimately dictates the success or failure of agricultural policies and firms within an industry. For Spain's dairy sector, we have measured the demand for fluid milk and then used the models to illustrate the static and dynamic dimensions to consumption of fluid milk. Milk consumption is shown to be influenced by habit patterns along with the traditional economic variables. Habit formation is measured and shown to be an important element to change. Elasticities are estimated for whole, skim, and other fluid milk forms.

As with any analysis based on econometric estimates, our conclusions are conditioned on the demand models estimated and the properties of the specification. The results from the Prais-Houthakker model were robust with slight changes to the model, thus giving us more confidence when using the estimates for simulation purposes. Clearly, one needs to always be conscious that the model properties impact subsequent simulations. While it is beyond the scope of this paper, we have compared these results to using the AIDs specification and other expenditure allocation models. Consistent with Pollak and Wales, Prais-Houthakker models seem to work quite well relative to alternatives.

In this phase of the analysis of the dairy sector, the study has been limited to measuring demand. Using this demand and the corresponding consumption projections, then it is possible to explore the economic impact for changing dairy production quotes, from allocations between whole and skim milk, and from market enhancement policies. At this stage we have limited the discussion to demand measurement, clearly recognizing its importance when addressing different supply policies. Several regions in Spain were used primarily to provide a richer data source for estimating the milk models representative of the country. Most of the differences in regions were captured with the discrete intercept shifters. A next stage to the full analysis would be to better capture the social economic, demographics, and attitudes across consumers to better explain milk demand for each region. What drives the habit persistence and can it be measured? How have attitudes about milk products changed over time and what are the implications for regional allocation of milk products? At this juncture, we have estimated a robust measure of whole and skim milk demand using the modified Prais-Houthakker model while including habit persistence and formation.

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