Changing Dairy Consumption in an Emerging Economy:

An Application of a Multivariate Two-part Model

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Abstract

This article examines the choices of Polish households in their decision to consume and the amount spent on four dairy products, i.e., whole milk, skim milk, butter and yogurt. A random utility framework leads to the specification of a system of four participation and four level (expenditure) equations. With the strong substitution effect between the consumption of whole milk and low-fat milk and possible correlation among the purchase decisions of other dairy products, the specification allows for correlation between the consumption decisions among different dairy products. Therefore, the selection of a system approach leads to constructing a multivariate two-part model. A pooled cross-sectional sample used in model estimation has 77,043 observations with non-missing values for the period from 2005 to 2008.

Key words: Random utility, maximum likelihood, outmigration, household consumption, dairy, Poland, multivariate two-part model, whole milk, skim milk, yogurt, butter

JEL classification: D12, Q13

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1 Introduction

Dairying is among the most important farm enterprises across Europe (Wilczynski, 2013) and Poland is the fourth largest milk producer in the European Union-28 (European Commission, 2016). The dairy sector is one of Poland's most important food industries (Sznajder, 2012), representing about 16% of sales revenues of the food processing industry in 2012 (Sznajder, 2012). Dairy products, especially milk, plays an essential role in the diet of consumers in Poland. Food consumption and nutrition literature pay attention to dairy products because of the importance of dairy consumption for disease prevention and health maintenance (for example, Lana et al. 2015). Dairy products are a major source of essential nutrients including calcium, vitamin D, potassium and others.

The change in the economic system and the adjustment to market conditions during the transition period in the 1990s influenced milk producers in Poland drastically. Poland's accession to the EU has accelerated this change, primarily through the execution of EU standards and the implementation of the Common Agricultural Policy (CAP) (Wilkin et al. 2006). Since then, the milk quota system was abolished, removing the penalties for excess production and leaving room for exportation (Sobczynski et al. 2015). Shifts in milk production and retailing along with changes in other factors such as household income level also induced fluctuation in the demand of dairy products. With the drastic change in Poland's dairy sector, and given the importance of dairy production, processing and retailing, and milk's essential role in the diet of consumers in Poland, factors responsible for consumption deserve a closer scrutiny. Such findings provide important insights for producers, retailers, and public health policymakers.

Market observations suggest that Polish consumers are increasing their consumption of dairy products, including yogurt which has a high proportion of added value. Personal income level is suggested to play a significant role (Wilkin et al. 2006). In terms of traditionally important milk consumption, there has been an increase in the purchase of skim milk as compared to whole milk. The consumption quantities of butter have been rather stable. It appears that consumers have diversified their purchases of dairy products and their choices include a wider variety than in the initial transition to a market economy. However, larger fluctuations seem to emerge in purchase amount and the consumption of specific dairy products has been less predictable than in the past. Moreover, as Polish society ages, dairy product choices and amounts purchased can be expected to change, reflecting the shift away from high fat content products to products with less fat. With the drastic changes in milk production as well as a possible structural change in demand, it is meaningful to investigate factors responsible for milk consumption.

This article examines the decision to purchase and the amount spent on four dairy products: whole milk, skim milk, yogurt, and butter. These products are consumed almost daily in the vast majority of Polish households. Food demand literature has identified a variety of socio-economic and demographic factors as consumption determinants, including household income, household size and structure, region of residence, and individual characteristics such as age, education level, and employment status (for example, Davis et al. 2010). A special factor in Poland is worker migration and depopulation, especially after Poland's accession to the EU in 2004, coupled with free job market entry to other EU countries.

With macroeconomic development and demographic changes particularly associated with worker migration and depopulation, the dietary patterns are expected to have substantially changed. Migration often leads to changes in age structure and gender composition, which in return contributes to different consumption features. The resulting difference in food consumption can contribute to insufficient or unbalanced nutrition intake and thus result in a less healthy population. The combination of relatively low incomes, unfavorable population changes and dietary insufficiency creates conditions for the emergence of persistently underdeveloped areas. Previous studies focused on the dampening effect of depopulation on economic growth (for example, Yea, 2004); however, less attention has been paid at a micro/household level to the dietary welfare of people living in the depopulating regions. This article investigates factors affecting household dairy product consumption in Poland, accounting for the effect of outmigration. Despite the attention paid to dairy products in literature on food consumption and nutrition, to our best knowledge, studies that examined the consumption patterns of multiple dairy products in Poland have been lacking. This paper attempts to fill this gap in literature.

The investigation of demographic, socio-economic and location factors, and their connection to milk consumption are important because of milk's dietary benefits. Furthermore, the Poland's dairy sector has undergone a drastic re-construction and thus has affected local job opportunities and consumption patterns. Therefore, an analysis of factors influencing the consumption of dairy products will offer insights applicable in milk processing and distribution, and, even in assessment of potential public health threats resulting from permanent decline in fluid milk consumption. Lastly, expanding milk production in regions with suitable natural conditions could provide job opportunities in rural areas (Klepacka et al., 2013). Insights about household dairy consumption decisions are helpful to that effort.

The remainder of this article is organized as follows: Section 2 describes the methodology, including economic theory and statistical modeling. Section 3 introduces data source and variable definitions. Section 4 reports estimation results. Finally, Section 5 concludes with discussion.

2 Method

Researchers have long hypothesized a two-stage choice process where consumers first decide whether to buy a commodity, and then choose the amount to purchase (e.g. Wright and Barbour 1977; Bettman 1979; Gensch 1987; Shocker et al. 1991). This article follows that well-accepted hypothesis. These two stages of decision-making process are referred as the *participation decision* and *level decision*.

2.1 Economic Theory

A qualitative choice model based on a random utility maximization developed by McFadden (1980) provides the theoretical foundation for model specification. Our empirical model is derived by extending the discrete choice model (Pudney, 1989). A household maximizes the random utility function subject to a budget constraint. The household random utility function is given by:

$$V(y,q;\boldsymbol{w}) = d \cdot U(y,q;\boldsymbol{w}) + (1-d) \cdot U^{*}(q;\boldsymbol{w}) \qquad (1)$$

where U is the utility for buyers and U* for non-purchasers, y is the quantity of dairy product with price p, q is a composite commodity for other goods with price normalized to 1, w is a vector of demographic variables, and d is a binary variable that equals one if the household buys milk and zero otherwise.

Assume the outcome for dairy purchase, the participation decision, is generated by a binary choice structure:

$$d = 1 \; if \; \boldsymbol{z}'\boldsymbol{\alpha} + u > 0 \qquad (2)$$
$$= 0 \; if \; \boldsymbol{z}'\boldsymbol{\alpha} + u \leq 0$$

where $\mathbf{z}$ and $\boldsymbol{\alpha}$ are vectors of variables and parameters affecting binary purchase decision, and u is a random error. In cross-sectional demand modeling, zero observations are often treated as the result of economic non-consumption (i.e., corner solution). In some cases, however, zero purchase might be caused by behavioral factors other than prices. Because y does not enter the purchasers' utility function $U^*(q; \boldsymbol{w})$ as described in equation (1) and p > 0, the optimal level is y = 0 for a non-eater. This optimal zero purchase could be corner solution or the result of opting out of the market. For a buyer, the optimal level of y results from a solution to the constrained utility maximization problem with a fixed budget I:

$$\max_{y,q} \{U(y, q; \boldsymbol{w}) | \; py + q = I\} \qquad (3).$$

Assume that the utility function $U(y, q; \boldsymbol{w})$ is regular strictly quasi-concave and has positive first partial derivatives with respect to y and q. Furthermore, assume an interior solution for y and q. Then, solving Equation (3) yields the notional (latent) demand for dairy product, y*. Denote as $\boldsymbol{x}$ the vector of income and demographic variables (with corresponding parameter vector $\boldsymbol{\beta}$) affecting the quantity demanded.

Further, assume latent quantity y* is expressed by the lognormal distribution, which accommodates right-skewness and ensures positive purchase amount:

$$y^* = \boldsymbol{x}'\boldsymbol{\beta} + v \qquad (4)$$

where $\boldsymbol{x}$ and $\boldsymbol{\beta}$ are variables and corresponding parameters affecting quantity decision and v is a random error.

2.2 Econometric Modeling

The occurrence of excessive percentage of zeros in micro-data sets mandates a proper treatment for the censoring of the dependent variables. Cragg's two-part model (1971) accommodates for censoring by separately modeling the probability of a limit observation and the density of observations. With the strong substitution effect between the consumption of whole milk and low-fat milk (Fu et al., 2015), and possible correlation among the purchase decisions of other dairy products, it is important to allow correlation between the consumption decisions among different dairy products. Therefore, we take a system approach by constructing a multivariate two-part model. Specifically, a 4-variate probit regression models the binary decisions of purchase and allows the decisions to be correlated among the four dairy products. And, a 4-variate lognormal regression is used to analyze positive expenditure. The 4-variate two-part model can be viewed as an extension of the regular two-part model, where the consumption of four dairy products are allowed to correlate with each other.

Each outcome variable y_i (dairy expenditure) is governed by a binary selection rule of whether to consume; and the nonzero expenditures are assumed to follow lognormal distributions (observation subscription omitted):

$$\begin{cases} \log(y_i) = \mathbf{x}'\boldsymbol{\beta}_i + v_i & \text{if } \mathbf{z}'\boldsymbol{\alpha}_i + u_i > 0 \\ y_i = 0 & \text{if } \mathbf{z}'\boldsymbol{\alpha}_i + u_i \leq 0, \quad i = 1, 2, 3, 4 \end{cases} \tag{5}$$

where $\mathbf{z}$ and $\mathbf{x}$ are vectors affecting binary purchase decision and level decision, respectively; $\boldsymbol{\alpha}_i$ and $\boldsymbol{\beta}_i$ are vectors of parameters; $\boldsymbol{u}_i$ and $\boldsymbol{v}_i$ are random error in the participation and level equation, respectively. To facilitate presentation of the likelihood function, define a diagonal matrix **S**=diag[σ_1, ..., σ_4] as standard deviation of $\boldsymbol{\upsilon}$. Also, let $\mathbf{R}_{uu}$=[ρ_{ij}^{uu}], and $\mathbf{R}_{vv}$=[ρ_{ij}^{vv}] be 4 x 4 correlation matrices among elements of **u** and **u**, and $\boldsymbol{\upsilon}$ and $\boldsymbol{\upsilon}$, respectively.

Assume the error vector $\mathbf{u} \equiv [u_1, u_2, u_3, u_4]'$ of the participation equation is distributed as 4-variate normal with zero mean and covariance matrix Σ_1 = E(**uu**') = $\mathbf{R}_{uu}$. The standard deviations of **u** are set at unity, and therefore the covariance matrix Σ_1 and correlation matrix $\mathbf{R}_{uu}$ of **u** are identical. The error vector $\boldsymbol{\upsilon} \equiv [\upsilon_1, \upsilon_2, \upsilon_3, \upsilon_4]'$ of the level equation is assumed to be distributed as 4-variate normal with zero mean and covariance matrix Σ_1 = E($\boldsymbol{\upsilon\upsilon}'$) = $\mathbf{S}'\mathbf{R}_{\upsilon\upsilon}\mathbf{S}$.

To construct the log likelihood function for the bivariate probit regression, the whole sample is decomposed into three regimes. The likelihood for positive regime (where $\mathrm{d}_1 = 1\,, d_2 = 1, d_3 = 1,\ \mathrm{d}_4 = 1$) is:

$$\mathrm{L1}_1 = \int_{\boldsymbol{u}>-\mathbf{r}}^{\infty} \phi_4(\boldsymbol{u})\mathrm{d}\boldsymbol{u} \qquad (6).$$

where the joint probability density function (pdf) $\phi_4(\boldsymbol{u}) = (2\pi)^{-4}|\Sigma_1|^{-1/2}\mathrm{e}^{-\frac{1}{2}\boldsymbol{u}'\boldsymbol{\Sigma_1}^{-1}\boldsymbol{u}}$ and $\mathbf{r} = [\boldsymbol{z}'\boldsymbol{\alpha_1}, \dots, \boldsymbol{z}'\boldsymbol{\alpha_4}]'$. The likelihood for negative regime (where $\mathrm{d}_1 = 0\,, \dots, \mathrm{d}_4 = 0$) is:

$$\mathrm{L1}_2 = \int_{-\infty}^{\boldsymbol{u}\leq-\mathrm{r}} \phi_4(\boldsymbol{u})\mathrm{d}\boldsymbol{u} \qquad (7).$$

For mixed regime, without loss of generality, denote $\mathbf{u_i}$ as the vector of error term associated with the non-censored variable and $\mathbf{u_j}$ associated with the zero-valued variable. The length of vector $\mathbf{u_i}$ ranges from 1 to 3, depending on the number of zero-valued variables. Therefore, there are $\sum_{i=1}^{3}\binom{4}{i} = 14$ cases for the mixed regimes. The likelihood function for the mixed regime is:

$$\mathrm{L1}_3 = \sum \int_{\boldsymbol{u_i}>\boldsymbol{r_i}}^{\infty} \int_{-\infty}^{\boldsymbol{u_j}\leq\boldsymbol{r_j}} \phi_4(\boldsymbol{u})\mathrm{d}\boldsymbol{u_j}\mathrm{d}\boldsymbol{u_i} \qquad (8).$$

The sample likelihood function is the product of $\mathrm{L1}_1$, $\mathrm{L1}_2$ or $\mathrm{L1}_3$ across observations, depending on the regimes of each observation.

For the bivariate lognormal regression, the likelihood function is:

$$\mathrm{L2} = \phi_4(\boldsymbol{u}) \prod_{i=1}^{4} \frac{1}{y_i} \quad (9).$$

Products across observations produce the likelihood function for the whole sample of positive expenditure. Logarithm transformation of the sample likelihood function gives the log likelihood function. Maximum likelihood estimation of the model is performed in MATLAB (MATLAB, 2014).

3 Data, Sample and Variables

The data are from the Polish household panel of about 20,000 households annually surveyed by Poland's Main Statistics Office (GUS). A pooled cross-sectional sample has 77,043 observations with non-missing values for the period from 2005 to 2008.

Table 1 presents summary of statistics of sample variables. An “average” respondent is 51 years old. Two thirds of them are married, and nearly three out of five household heads are male. Rural residents account for 37.5% of all observed households. On average, there is 0.72 child, 1.80 adults, and 0.45 elder per household. Household size averages at 2.98 persons. Elders and children are present in 33.7% and 42.1% households, respectively. About 40 percent had at least secondary education and little more than one quarter was fully employed. The average household income was about 2781 Polish zloty (PLN). About 25% households are observed in each of the four-year period of observation.

Two variables are reported as measure of depopulation. First, net domestic migration measures the net outflow of population from a region to other regions within Poland. Second, net international migration measures the net outflow of population from a region to other countries.

Average inflow from a domestic region is 1352 persons, and the outflow from a Polish region to other countries averages at 1565 persons per region.

The dependent variables are expenditures in the month preceding survey on four dairy products, namely whole milk, low-fat milk, yogurt and butter. Positive expenditures are logarithm transformed to mitigate deviation from normality and heteroscedasticity. Binary variables, with value one indicating purchase and zero non-purchase, are induced from expenditures. The percent of households who bought whole milk, low-fat milk, yogurt, and butter in the month preceding survey is 62.6%, 61.0%, 65.2%, and 73.3%, respectively. Conditional on purchase, households on average spend PLN 13.70, 9.89, 8.68, and 13.417 on each of above four dairy products. Equations for whole and skim milk include expenditures on soft drinks to account for possible substitution because of the observed changes in eating choices. The average spending on soft drink, a substitute for milk, is PLN169.76.

4 Results

As shown in Table 2, the decisions of purchase are indeed correlated among four dairy products. The correlation coefficient between whole milk and skim milk purchase is estimated to be -0.554 with a *p*-value less than 5%. This indicates a strong substitute effect among the purchase decisions of whole milk and skim milk. Except for milk products, the purchase decisions between any two dairy products are positively correlated. The correlation coefficient estimates are relatively larger (>0.1) between skim milk and yogurt, whole milk and butter, and between yogurt and butter. Above result confirms the necessity of accommodating for interrelatedness in the specified model.

The result also shows that almost all explanatory variables are statistically significant in the participation decisions of all four dairy products. The following interpretations are given for the latent consumption. Income level is positively related to latent consumption of low-fat milk, yogurt, and butter, which has higher added value through additional processing, compared to whole milk. Larger households are more likely to buy whole milk, but less likely to buy the remaining three products. The presence of an elder is associated with larger consumption of whole milk, yogurt and butter by a household, but not skim milk. The presence of a child increases the latent consumption of all four dairy products. Rural residence is positively related to the consumption of whole milk, but inversely to that of the other three dairy products. Market observation suggests that the once-common homemaking of butter in rural areas has virtually ceased and rural households now depend on commercially manufactured butter. Higher level of education attainment shows a positive effect on the consumption of high value-added products, namely low-fat milk, yogurt, and butter. As comparison, higher education level negatively affects the latent consumption of whole milk. The effect of education in the case of Polish consumers appears to be similar to that of other EU members reflecting the effect of knowledge on choice of nutritionally recommended food choices. The positive effect of education on butter consumption is likely associated with the fact that people consider butter as a natural, unaltered product as compared to other fat spreads like margarine. Males are less likely to consume skim milk, yogurt, or butter. Males have been found to prefer whole milk and tend to eat less yogurt as compared to females. But lower butter consumption by male may be explained by males' less likelihood of cooking. Married household heads report higher expenditure on all four dairy products. This is quite plausible because married households are more likely to eat home-cooked meals and entertain at home, an activity involves the serve of hot or cold dishes in the Polish tradition. More stable employment as compared with other employment status is associated with higher expenditure on low-fat milk, but less on the other three dairy products. It is plausible that the interaction with other full-time employed consumers leads to similar lifestyle including more frequent consumption of meals away from home and resulting the respective expenditures to be lower than in the case of households of respondents with alternative employment status.

The effects of migration vary, depending whether it is domestic migration or foreign migration. As domestic migration increases, consumption of whole milk and butter decreases, but skim milk and yogurt consumption increases. Because domestic migrants tend to be young and well educated, it appears they tend to have different overall preferences regarding the type of milk consumed and their food choices influence the choices of those left behind. The choices appear to be healthier suggesting that internal migration contributes to possible improvement of diet along the recommendations of public health nutritionists. Those migrating to other countries tend to be less educated, leaving behind families that tend to consume more whole milk and butter, but less skim milk and yogurt. Such families appear to have a potentially less healthy diet than families of domestic migrants. The contrasting effects of domestic versus foreign migration requires special attention because families of foreign migrants left in the country often receive transfers that increase their purchasing power and the choice of specific dairy product is associated with potentially adverse effects on health maintenance and disease prevention. In particular, butter and whole milk consumption may contribute to already prevalent circulatory heart diseases in Poland.

However, the interpretation of the coefficients in multivariate probit regression is not as straightforward as those in linear regression. Instead, a more meaningful measure is marginal effect. This marginal effect is obtained by taking differential (difference) of purchase likelihood with respect to a continuous (discrete) explanatory variable. The derivation of marginal effect is complicated because of the multivariate setting. See Mullahy (2011) for a general analytic formula. For convenience, however, this article computes marginal effects through numerical iteration. Average marginal effects over data sample will be reported in later version of this manuscript.

Table 3 reports MLE estimates for level decisions. Since level decisions are modelled by multivariate log normal regression, the coefficients are semi-elasticity, indicating marginal expenditure change in percent. Similarly to the participation decisions, the consumption of soft drinks is positively associated with whole milk expenditure, but inversely related to skim milk consumption. Higher income is associated with lower expenditure on whole milk, but larger expenditure on the other three dairy products, which have higher added values through additional processing. Not surprisingly, more family members increase expenditure on all products. Households located in rural areas, on average, spend more on all products except for yogurt. Household heads with higher education level chose to spend less on whole milk, but more on skim milk. This confirms findings in literature about the positive effect of education on healthy diet choices. Older household heads spend more on milk and butter, but less on yogurt. Married household heads spend more on all four products. Households with a fully employed household heads, on average, spend less on all four dairy products, reflecting possible lifestyle difference. Households from regions with high domestic outmigration tend to spend less on yogurt and butter, but slightly more on skim milk, than those in regions with low outmigration. However, higher international outmigration is associated with lower expenditure on all four products.

5 Conclusion and Discussion

Poland is the fourth largest milk producer in EU-28. Poland's dairy sector has undergone a drastic change since the transition period in the 1990s and Poland's accession to the EU in 2004. Changes in demand factors such as aging society and increased personal income also contributes to changing consumption patterns of dairy products. Given the importance of dairy sector in Poland and milk's essential role in the diet of consumers in Poland, factors responsible for consumption deserve closer scrutiny. This article examines the decision to purchase and the amount spent on four dairy products, whole milk, skim milk, yogurt, and butter. The decision of whether to buy, and if yes, how much to spend, are considered as occurring sequentially and therefore are modelled by two-part model. The traditional two-part model is extended to its multivariate version to accommodate for likely interrelatedness of the consumption decisions among different dairy products. In addition to conventionally important determinants of food consumption, this article also looks for possible effects of migration, an important factor in Poland because accession to the EU liberalized the movement of workers.

Model estimation by MLE confirms the necessity of censored system. The substitution effect among whole and skim milk as well as the interrelatedness among the consumption of other dairy products are confirmed. It is encouraging to see the positive effect of higher education on the healthy food choices of consuming more skim milk and yogurt. The presence of child increases the probability of purchase and expenditure on all four dairy products. This pattern is beneficial to children's nutrition status. The presence of elder(s), however, has mixed effect. For the participation decision, the presence of an elder is positively associated with the consumption of whole milk, yogurt, and butter, but negatively related to the consumption of yogurt. Migration has contrasting effects, depending whether it is domestic migration or foreign migration. The domestic migration seems to lead to desirable changes in dairy product consumption reflected as increased expenditures on skim milk and yogurt, but the foreign migration increases consumption of products high in saturated fatty acids, namely the expenditure on whole milk and butter.

In summary, the multivariate two-part model enables a close scrutiny on the demographic and socio-economic factors affecting household dairy consumption in Poland. The resulted findings revealed the direction of each variable’s effect as well as its magnitude. The gained knowledge is important allowing to learn about factors associated with healthy (unhealthy) dairy product choice and directly contributes to the formulation of economic and public health policies.

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Table 1. Summary of Descriptive Statistics of Sample Variables

Variable	Description/Unit	Mean	Std Dev
Demographic, Socio-Economic Factors / Explanatory variables			
Village	1, if a household residents in village, 0 otherwise	0.375	0.484
Income	Household income in the month preceding survey, in 1000 Polish Zloty (PLN)	2.781	2.205
Male	1, if the household head is male, 0 otherwise	0.593	0.491
Married	1, if the household head is married, 0 otherwise	0.674	0.469
HighEduc	1,if the household head has secondary or higher education, 0 otherwise	0.407	0.491
Age	Household head's age, in years	51.146	15.210
Employed	1 if household head is permanently employed or contract employee, 0 otherwise	0.266	0.442
Children	Number of children (under 18)	0.723	1.040
Adult	Number of adults 60 or under 60 years old	1.804	1.191
Elder	Number of elders above 60	0.453	0.696
hhsize	Household size (number of family members)	2.981	1.531
Delder	1 if there is elder(s) above 60, 0 otherwise	0.337	0.473
Dchild	1 if there is child(ren) (under 18), 0 otherwise	0.421	0.494
OUTD	Net migration domestically to other regions in Poland, in 1000	-1.352	5.714
OUTF	Net migration international to other countries, in 1000	1.565	2.108
Year2005	Baseline, 1 if observed in 2005, 0 otherwise		
Year2006	1 if observed in 2006, 0 otherwise	0.251	0.434
Year2007	1 if observed in 2007, 0 otherwise	0.249	0.432
Year2008	1 if observed in 2008, 0 otherwise	0.249	0.432
SoftDrink	Expenditure on soft drink in the month preceding survey, in PLN	169.760	328.328
Food Expenditures / Dependent variables			
b_{wmlk}	1, if household buys whole milk, 0 otherwise	0.626	-
b_{lmlk}	1, if household buys low fat milk, 0 otherwise	0.610	-
b_{yogurt}	1, if household buys yogurt, 0 otherwise	0.652	-
b_{butter}	1, if household buys butter, 0 otherwise	0.733	-
wmlk	Expenditure on whole milk in the month preceding survey, in PLN	13.699	22.318
lmlk	Expenditure on low fat milk, in PLN	9.801	15.069
yogurt	Expenditure on yogurt, in PLN	8.686	13.225
butter	Expenditure on butter, in PLN	13.417	16.606

Note: N=77,043

Table 2. Maximum-likelihood Estimates of Multivariate Probit Model for Dairy Consumption

Variable	Whole milk Estimate (se)	Low-fat milk Estimate (se)	Yogurt Estimate (se)	Butter Estimate (se)
Intercept	-0.255 (0.028)**	0.223 (0.028)**	0.390 (0.029)**	-0.269 (0.03)**
SoftDrink	0.537 (0.159)** (x10e-4)	-0.327 (0.153)** (x10e-4)		
Income	-0.002 (0.003)	0.021 (0.003)**	0.087 (0.003)**	0.075 (0.003)**
Hhsize	0.071 (0.005)**	-0.018 (0.005)**	-0.004 (0.005)	-0.021 (0.005)**
Delder	0.063 (0.014)**	-0.055 (0.013)**	0.029 (0.014)**	0.134 (0.014)**
Dchild	0.108 (0.014)**	0.068 (0.014)**	0.306 (0.015)**	0.025 (0.015)*
village	0.306 (0.011)**	-0.433 (0.011)**	-0.187 (0.011)**	-0.096 (0.011)**
HighEduc	-0.042 (0.011)**	0.029 (0.011)**	0.165 (0.011)**	0.206 (0.012)**
Age	0.001 (0.000)	0.005 (0.00)**	-0.009 (0.000)**	0.009 (0.000)**
Male	0.001 (0.011)	-0.094 (0.011)**	-0.132 (0.011)**	-0.059 (0.012)**
Married	0.106 (0.013)**	0.120 (0.013)**	0.158 (0.013)**	0.258 (0.013)**
Employed	-0.078 (0.012)**	0.113 (0.012)**	-0.056 (0.012)**	-0.108 (0.012)**
OUTD	-0.015 (0.001)**	0.013 (0.001)**	0.002 (0.001)*	-0.013 (0.001)**
OUTF	0.026 (0.003)**	-0.013 (0.003)**	-0.017 (0.003)**	0.075 (0.003)**
Year2006	0.042 (0.014)**	0.005 (0.014)	0.097 (0.014)**	-0.099 (0.015)**
Year2007	0.099 (0.013)**	-0.059 (0.013)**	0.199 (0.014)**	-0.042 (0.014)**
Year2008	0.128 (0.013)**	-0.134 (0.013)**	0.205 (0.014)**	-0.010 (0.014)

Correlation estimates			
$b_{wmlk}.b_{mllk}$	-0.554 (0.005)**	$b_{lmlk}.b_{yogurt}$	0.122 (0.006)**
$b_{wmlk}.b_{yogurt}$	0.038 (0.006)**	$b_{lmlk}.b_{butter}$	0.027 (0.006)**
$b_{wmlk}.b_{butter}$	0.102 (0.006)**	$b_{yogurt}.b_{butter}$	0.121 (0.006)**

** Significant at 5% level.
* Significant at 10% level.

Table 3. Maximum-likelihood Estimates of Multivariate lognormal Model for Dairy Consumption

Variable	**Whole milk** Estimate (se)	**Low-fat milk** Estimate (se)	**Yogurt** Estimate (se)	**Butter** Estimate (se)
Intercept	1.716(2.721)**	1.612(2.648)**	1.657(2.559)**	1.684(1.98)**
SoftDrink	0.0004(0.002)**	-0.000(0.002)**		
Income	-0.007(0.342)**	0.012(0.233)**	0.061(0.681)**	0.050(0.444)**
N1960	0.166(0.543)**	0.111(0.582)**	0.076(0.626)**	0.150(0.444)**
N60above	0.262(0.938)**	0.174(1.069)**	0.056(0.993)**	0.211(0.725)**
Nkid	0.220(0.491)**	0.176(0.556)**	0.108(0.472)**	0.122(0.371)**
village	0.470(1.008)**	0.092(1.039)**	-0.084(1.052)**	0.039(0.761)**
HighEduc	-0.067(1.041)**	0.016(0.990)*	0.156(1.174)**	0.177(0.826)**
Age	0.002(0.040)**	0.005(0.042)**	-0.003(0.039)**	0.003(0.030)**
Male	0.072(1.031)**	0.018(1.040)**	0.011(1.000)	-0.018(0.737)**
Married	0.027(1.220)**	0.093(1.237)**	0.089(1.248)**	0.167(0.904)**
Employed	-0.130(1.111)**	-0.036(1.166)**	-0.112(1.059)**	-0.131(0.814)**
OUTD	0.0004(0.081)	0.009(0.089)**	-0.004(0.086)**	-0.004(0.062)**
OUTF	-0.015(0.240)**	-0.032(0.246)**	-0.007(0.242)**	-0.020(0.176)**
Year2006	-0.013(1.338)	-0.003(1.348)	0.048(1.306)**	0.006(0.944)
Year2007	-0.007(1.264)	-0.034(1.267)**	0.120(1.217)**	-0.004(0.897)
Year2008	0.026(1.260)**	-0.039(1.269)**	0.140(1.268)**	0.009(0.918)

Correlation estimates			
$b_{wmlk}.b_{mllk}$	-0.013(0.349)**	$b_{lmlk}.b_{yogurt}$	0.064(0.375)**
$b_{wmlk}.b_{yogurt}$	0.044(0.371)**	$b_{lmlk}.b_{butter}$	0.079(0.362)**
$b_{wmlk}.b_{butter}$	0.107(0.373)**	$b_{yogurt}.b_{butter}$	0.120(0.382)**

Standard deviation estimates			
σ_{wmlk}	0.760(0.239)**	σ_{yogurt}	0.762(0.248)**
σ_{lmlk}	0.755(0.231)**	σ_{butter}	0.823(0.215)**

** Significant at 5% level.
* Significant at 10% level.
Standard errors were multiplied by 100.