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THE CENTER FOR AGRICULTURAL ECONOMIC RESEARCH

Working Paper No. 9606

HOUSEHOLD DEMAND FOR TOBACCO: IDENTIFYING REASONS FOR NON-PURCHASES

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Household Demand for Tobacco: Identifying Reasons for Non-Purchases

A Paper Prepared for Presentation at the 1996 Meeting of the European Society for Population Economics

by

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Abstract

This paper provides a framework for identifying reasons for non-purchase of a commodity on statistical grounds without having explicit information about these reasons. The traditional corner solution has frequently been modeled in the literature using the Tobit model. Two generalizations of the Tobit model are the double-hurdle model and the purchase-infrequency model. This study proposes an integrated approach which nests both double-hurdle and purchase-infrequency as special cases, and hence enables a distinction between these reasons for non-purchase. Although previous studies have compared the performance of these models by a non-nested test, the integrated approach enables a simple and probably stronger nested test. A set of Monte-Carlo simulations shows that the integrated model is much more robust to mis-specification than any of the two simpler models, and that the non-nested test has relatively low power.

In the empirical application, an Engel curve for tobacco is estimated using Israeli family expenditure data, utilizing all of the above methods. The results confirm the usefulness of the integrated approach: whereas both the double-hurdle and purchase-infrequency models were rejected in favor of the integrated model using the nested likelihood-ratio test, the non-nested test was not able to reject either one of the nested models in favor of the other. The findings show that 9% of the sample households are censored due to the second hurdle and another 7% due to infrequency of purchase. The conventional corner solution (Tobit-type censoring) occurs in 40% of the households. A total of 60% of the sample households did not purchase tobacco during the survey's 2-week period, and this was predicted correctly by the integrated model for 60% of these.

The coefficients of log total expenditure in the tobacco-share equation estimated by the different models are all negative. However, relative to the integrated model, the Tobit coefficient is largely underestimated and the double-hurdle coefficient is largely overestimated (both in absolute values). Other socioeconomic explanatory variables are shown to affect the different equations (second-hurdle, purchase, and consumption) in different ways.

1. Introduction

Estimates of commodity-demand functions with micro-data most often require a correction for selection bias, since a zero quantity of the good is demanded by a non-trivial fraction of the population. While the Tobit model introduced by James Tobin (1958) almost four decades ago remains the most popular method to deal with this issue, researchers are gradually adopting more general selection models, most of which nest the Tobit model as a special case. The motivation for this trend is the recognition that zero values of demand could very well stem from reasons other than the "pure" neoclassical corner solution assumed by the Tobit specification.

The most common generalization of the Tobit model is the double-hurdle model presented by Cragg (1971). It has been used in labor supply analyses when labor-market rationing was assumed to be in effect (Blundell, Ham, and Meghir 1987; Lacroix and Frechette 1994). It has also been used in commodity-demand analyses when it was assumed that specific sentiments against the commodity exist. Blisard and Blaylock (1993) applied this method to the demand for butter, whereas Burton, Tomlinson and Young (1994) applied it to the demand for meat. The model is also useful in estimating the demand for certain commodities for which there exist incentives not to report their consumption, such as cigarettes (Jones 1989) and alcohol.

The double-hurdle model has also been applied to the demand for durable goods, since individuals presumably consume the goods continuously while purchasing them at only a few discrete intervals which might be missed during the survey period (Cragg 1971; Deaton and Irish 1984). This argument also holds for nondurable but storable goods when the survey period is relatively short (Blisard and Blaylock 1993). However, for such cases a different model, termed the infrequency of purchase model, may better characterize behavior (Kay, Keen, and Morris 1984).

In essence, the difference between the double-hurdle model and the purchase-infrequency model stems from distributional assumptions which cannot be directly verified unless one has direct information as to the reasons for reporting zero purchases. Hence, when dealing with the demand for a commodity with some degree of durability (as most commodities have) and with some perceived constraint or sentiment affecting its purchase or reporting, both models should be given equal opportunity. Blisard and Blaylock (1993) justifiably followed this approach when estimating the demand for butter. They estimated each of the models and then applied a non-nested test to select the model that best fit the data. In their application, the two models gave very different parameter estimates, although both predicted the zero observations with equal degrees of success (65%). The model selection test chose one model over the other with a decent level of significance. In other words, one arbitrary set of distributional assumptions was chosen over the other. Would it not be wise to allow a combined, less restrictive set of assumptions that encompasses both models? Blisard and Blaylock (1993) correctly cited the more general specification derived by Blundell and Meghir (1987), but claimed that it cannot be estimated without direct information regarding the reason for zero reporting. This is in fact not accurate: the Blundell and Meghir (1987) model does not require sample separation. Given sample separation, the model is perhaps easier to implement and the results are supposed to be more robust, as shown by Jones (1989) and by Lacroix and Frechette (1994), but even without it the full model should be preferred to each of the two competing models. In fact, as shown further on, if either of the two explanations for zero value of the dependent variable is not relevant, the full model will not produce finite estimates. This may serve as an informal indication that each model should be estimated separately and in such a case, the Blisard and Blaylock (1993) approach may be justified.

The purpose of this paper is to show the appropriateness of an integrated model which accounts for both double hurdles and infrequency of purchases. The three models are described in the following section. Then, a simple Monte-Carlo analysis is conducted to compare the performance of the integrated model to that of each of the two simpler models. Since both the double-hurdle and the purchase-infrequency models are nested in the integrated model, a simple likelihood-ratio test is applied to test each of the nested specifications. The results of the test are compared to those of Voung's (1989) non-nested test used by Blisard and Blaylock (1993) to distinguish between the double-hurdle and purchase-infrequency models. Finally, the models are applied to an estimation of Engel curves for tobacco using Israeli family expenditure data.

2. The Models

The Tobit model assumes a linear equation describing the dependence of a latent demand variable on a set of explanatory variables, $y^{*}=\beta' x+u$, and an observed demand of the form $y^{**}=\max(y^{*},0)$. The double-hurdle model adds a selection equation, $w=\alpha' z+v$, and a dummy selection variable, d, which equals one if $w>0$, zero otherwise. The dependent variable y is observed only when $d=1$, hence: $y=dy^{**}$. Assuming that u and v are jointly distributed as $N(0,\Sigma)$ where Σ is a diagonal matrix with a diagonal of $(\sigma,1)$, the log likelihood function of this model is:

$$(1)\quad \log L = \sum\nolimits_0 \log(1-\Phi(\alpha' z)\Phi(\beta' x/\sigma)) + \sum\nolimits_+ [\log\phi((y-\beta' x)/\sigma)+\log\Phi(\alpha' z)-\log\sigma]$$

where Φ and ϕ are the cumulative probability function and the density function, respectively, of a standard normal random variable. The subscripts 0 and + mean that summation is performed over the subsample in which the dependent variable is zero and positive, respectively.

The full derivation of the purchase-infrequency model is more complicated and can be found in Blundell and Meghir (1987). The log likelihood function of this model is:

$$(2)\quad \log L = \sum\nolimits_0 \log(1-\Phi(\gamma' r)\Phi(\beta' x/\sigma)) + \sum\nolimits_+ [\log\phi((\Phi(\gamma' r)y-\beta' x)/\sigma)+ 2\log\Phi(\gamma' r)-\log\sigma]$$

where it is assumed that a positive purchase is observed only if $\gamma'r+\tau>0$, and τ is a standard normal random variable independent of u and v.[1]

Using (1) and (2), it can be shown (Blundell and Meghir 1987) that the log likelihood function of a combined model is:[2]

$$(3)\quad \log L = \sum_0 \log(1-\Phi(\alpha'z)\Phi(\gamma'r)\Phi(\beta'x/\sigma)) + \sum_+ [\log\phi((\Phi(\gamma'r)y-\beta'x)/\sigma) + 2\log\Phi(\gamma'r) + \log\Phi(\alpha'z) - \log\sigma]$$

It is clear that (3) becomes the log likelihood function of the double-hurdle model (1) if $\gamma'r$ goes to infinity. Similarly, (3) becomes the log likelihood function of the purchase-infrequency model (2) if $\alpha'z$ goes to infinity. Hence, it is concluded that the full model cannot be estimated if in fact only one of the selection mechanisms is in effect. Moreover, both the double-hurdle (1) and the purchase-infrequency (2) models are nested within the integrated model (3), and hence the conventional likelihood-ratio test can be applied to each of the two simpler models. This is an alternative to the non-nested testing approach used by Blisard and Blaylock (1993). These two testing approaches will be examined and compared in the Monte-Carlo analysis.

3. Monte-Carlo Analysis

In this section I report the results of several simulation experiments conducted to compare the performances of the aforedescribed competing models in alternative situations. All the simulations were conducted on artificial samples of 1000 observations each, with 100 repetitions.

In the first stage, the samples were generated under the assumption that both the double-hurdle and the purchase-infrequency factors are in effect, which means that the integrated model is the correct specification. The two factors, as well as the regression equation itself, are affected by four random explanatory variables $\{x_1, x_2, x_3, x_4\}$, each drawn from an independent u(0,1) distribution, and by random disturbances $\{u_1, u_2, u_3\}$, each drawn from an independent $n(0, \sigma_i)$ distribution. The double-hurdle effect was specified as $a_0+a_1x_1+a_4x_4+u_1$; the purchase-infrequency effect was specified as $b_0+b_2x_2+b_4x_4+u_2$; and the regression equation was specified as $c_0+c_3x_3+c_4x_4+u_3$. Since the standard deviations of the double-hurdle and purchase-infrequency models cannot be identified in this framework, both σ_1 and σ_2 were maintained to be one throughout the analysis.

At this stage, the only correlations between the two effects and the regression equation are those related to the common explanatory variable x_4. The following results will show that this indeed has a notable effect on the different estimators. Other types of correlations will be dealt with in future research.

The parameters chosen for the simulations were (0,1,1) for each of the hurdle and frequency effects, and (5,1,1) for the regression equation, with σ_3=1.5 as the standard deviation. Each of the three models was estimated given these artificial data, and this was repeated 100 times with both the variables and the disturbances being redrawn each time.

The mean parameter estimates over the 100 repetitions are compared in Figure 1 (note that the parameters are normalized and their true values appear on the vertical axis). Not surprisingly, the coefficients of the integrated model were very close to the true parameters. The hurdle coefficients were somewhat underestimated by the double-hurdle model, as were the frequency coefficients in the purchase-infrequency estimation. In the regression equation, the double-hurdle model overestimated the first two parameters and the standard deviation, but strongly underestimated the third parameter. The purchase-infrequency model revealed exactly the opposite picture.

The nested likelihood-ratio tests rejected the double-hurdle specification in favor of the integrated model in 100% of the cases at the 1% significance level. The purchase-infrequency specification, on the other hand, was rejected in favor of the integrated model in only 10% of the cases. Regarding the parameter estimates, it is worth noting the coefficients of x_4, the variable which appears in all of the equations. Both the double-hurdle and purchase-infrequency models produced fairly good estimates of the coefficients of x_4 in the hurdle equation and the purchase equation, respectively. On the other hand, they were both way off the mark with respect to the coefficient of x_4 in the regression equation. The coefficient produced by the purchase-infrequency model was almost twice as large as the true parameter, whereas the coefficient produced by the double-hurdle model had the correct magnitude but the opposite sign, on average.

Given these observations, it is not surprising that when applying Voung's (1989) non-nested test procedure to the double-hurdle and purchase-infrequency models, one cannot conclude that one model is significantly better than the other. Both test statistics are far from being significant at any reasonable significance level.

Next, I repeated the previous set of simulations, this time generating the samples according to the double-hurdle specification only. The means of the estimated coefficients are compared in Figure 2. It is clear that both the double-hurdle model and the integrated model are very close to the true parameters, on average, and of course to each other.[3] The nested likelihood-ratio test could not reject the double-hurdle specification in favor of the integrated model in any of the cases. The estimated regression coefficients of the purchase-infrequency model, however, were not so close to the true parameters. The first two parameters were underestimated by about 25%, and so was the standard deviation. The regression coefficient of x_4 was again greatly overestimated, reaching a value of almost twice that of the true parameter. The estimated frequency coefficients were not large enough to guarantee a zero probability of censoring due to purchase infrequency. However, the purchase-infrequency specification was rejected in favor of the integrated specification in only 3% of the cases, using the nested likelihood-ratio test with a 1% significance level. Not surprisingly in this case, Voung's (1989) non-nested test could not reject the purchase-infrequency model in favor of the (true) double-hurdle model in even one of the repetitions.

Finally, this Monte-Carlo experiment was repeated given that the purchase-infrequency model is the correct one (Figure 3). This time, all the coefficients of the purchase-infrequency model and of the integrated model were very close to each other and to the true parameters, and the purchase-infrequency specification was not rejected in favor of the integrated specification in any of the cases. The double-hurdle model produced coefficients that were quite different from the true parameters. The first two regression coefficients were overestimated, as well as the standard deviation. Again, the regression coefficient of x_4 was about the size of the true parameter but with an opposite sign. The hurdle coefficients as estimated by the double-hurdle model were not large enough to guarantee a zero probability of censoring due to the second hurdle, whereas those estimated by the integrated model were.

Overall, the double-hurdle model was rejected in favor of the integrated model in 100% of the cases using the nested likelihood-ratio test, whereas Voung's (1989) non-nested test failed to reject it in favor of the purchase-infrequency model in even one of the cases.

To summarize this experiment, a comparison of the coefficient estimates of the different models showed that the double-hurdle and purchase-infrequency models cause qualitatively similar biases on average. However, it was much harder to reject the purchase-infrequency model using the likelihood-ratio test than it was to reject the double-hurdle model. In particular, the double-hurdle model was rejected in favor of the true integrated model and the true purchase-infrequency model in 100% of the cases, whereas the purchase-infrequency model was rejected in favor of the true integrated model and the true double-hurdle model in only 6% and 39% of the cases, respectively. This implies that there is a potential danger in using the purchase-infrequency model on the basis of failing to reject it in favor of the integrated model, while getting biased coefficients in the case of a type-II error. The double-hurdle model does not seem to suffer from this deficiency. The non-nested test failed to reject one of the models in favor of the other, even when the other was true. This test probably lacks power, but does not lead to a potential type-II error in favor of the purchase-infrequency model as the likelihood-ratio test does. Perhaps the best recommendation one can derive from this experiment is to always use the integrated model.

4. Application: the Demand for Tobacco

In this section, the different models are used to estimate household demand for tobacco, using data from the 1992-3 Family Expenditure Survey in Israel. The double-hurdle specification is justified for tobacco since the decision to smoke may be affected by factors other than own preferences, such as preferences of others in the immediate environment.[4] The purchase-infrequency model is justified because tobacco products are heavily taxed in Israel, so one may purchase large stocks if a black market opportunity arises.[5]

The functional form chosen for the analysis is the PIGLOG Engel curve (Deaton 1986, p. 1775), in which expenditure share is a function of the log of total expenditures and other socioeconomic characteristics, given that prices are unknown. The survey included 5212 households, of which 5193 had complete records and were included in the analysis. Only 40% of the households had positive tobacco expenditures during the 2-week survey period. The raw data shows that having positive tobacco expenditures seems to be affected by age and sex, marital status, work status, education, ethnic origin, and locality, as well as household composition and total consumption. Table I includes definitions and descriptions of the variables used in the estimation.

Table II compares the performances of the four different models. The bottom part of the table presents the results of the likelihood-ratio tests. It shows that each nested model specification is rejected, i.e., the hypothesis that the double-hurdle model is true is rejected in favor of the alternative integrated model, and the same is true for the purchase-infrequency model, although the latter is only marginally rejected. The Tobit model is rejected in favor of all the other models. It seems that the purchase-infrequency model has a better predictive ability than the double-hurdle model. Voung's (1989) non-nested test statistic is only about 0.07, which means that one cannot reject the double-hurdle specification in favor of the purchase-infrequency model.

The top part of Table II compares the ability of the different models to correctly account for censoring. The Tobit model is way off the mark, predicting that almost 75% of the households are censored, relative to 60% in reality. The integrated, purchase-infrequency, and double-hurdle models predict 49%, 54%, and 57% censoring, respectively. Without direct information on the reason for not purchasing tobacco, one cannot say much more about the predictive power of these models, taking into account that the predicted tobacco expenditures of the different models (other than Tobit) are not much different.

Tables III-V include the coefficient estimates of the hurdle equation, frequency equation, and consumption equation, respectively. Looking at the hurdle coefficients of the integrated model in Table III, one can see that only a few coefficients are statistically significant. These include age, which has a negative effect on the probability of purchasing tobacco, and number of adults and total consumption, both having a positive effect. The estimated coefficients of the double-hurdle model are quite different from those of the integrated model, probably picking up the effects of the omitted purchase-infrequency equation. Similar differences in coefficients are observed in the frequency equation results in Table IV, although they seem to be smaller in magnitude. Fewer coefficients of the frequency equation are significant when using the purchase-infrequency model rather than the integrated one.

There are more significant coefficients in the consumption equation (Table V), and they are more similar across the different models. Again, the coefficients of the purchase-infrequency model are closer to those of the integrated model than the coefficients of the double-hurdle and Tobit models. Consumption of tobacco decreases with age and with total consumption, and increases with the number of adults. Consumption is higher among unmarried males and among female-headed households. It is higher among non-Jews, those whose parents were born in Asia or Africa, and those with elementary education, and lower among those with post-secondary schooling. Several occupational and location-specific effects also have significant impacts on the tendency to consume tobacco products.

The importance of correctly accounting for the source of censoring is demonstrated by the different coefficients of total consumption (Table V). According to the integrated model, a 10% rise in total consumption increases the share of tobacco in total expenditures by 7.8 percentage points. The relevant numbers for the purchase-infrequency, double-hurdle, and Tobit models are 7.2%, 18%, and 4.5%, respectively. The conclusion is that the purchase-infrequency model, although marginally rejected by the data, does pretty well in estimating the expenditure elasticity of tobacco, whereas the double-hurdle model overestimates it and the Tobit model underestimates it by a great deal. This conclusion is in contrast with the results of the Monte-Carlo analysis which showed a bias in the coefficients estimated by the purchase-infrequency model when the integrated model was true.

5. Summary and Conclusions

This paper demonstrates the usefulness of combining the double-hurdle and purchase-infrequency models into an integrated model which includes both simpler models as special cases, to explain zero purchases in commodity-demand analyses. In a limited Monte-Carlo analysis, the integrated model performed better than either of the two simpler models in all cases. In particular, the double-hurdle model produced fairly biased estimates when the purchase-infrequency model was the true model, and vice versa. When the integrated model was correct, such that the zero observations were in part a result of the second hurdle and in part a result of purchase infrequency, both simpler models performed significantly worse than the integrated model. The fact that both simpler models are nested within the integrated model enables straightforward testing of either of the constrained formulations by a standard likelihood-ratio test. In contrast, when comparing the double-hurdle and purchase-infrequency models using the non-nested test suggested by Voung (1989), as has been done previously in other applications, neither model was preferred over the other even when it was in fact the true model. This suggests that the non-nested test has low power in this context relative to the likelihood-ratio test, and for this reason as well the integrated model is preferred. It should also be emphasized that the integrated model is not much more difficult to implement than the simpler models using a software package such as Gauss.

When applied to the demand for tobacco products in Israel, both double-hurdle and purchase-infrequency models were rejected against the integrated model using the likelihood-ratio test. Although the purchase-infrequency model produced coefficients that were much closer than those produced by the double-hurdle model to those produced by the integrated model, Voung's (1989) non-nested test was not able to reject the double-hurdle specification in favor of the alternative purchase-infrequency specification.

Several of the findings suggest possible directions for further research. The Monte-Carlo simulations showed that the bias of the two simpler models is sometimes systematic. For example, one model tends to overestimate certain parameters and the other tends to underestimate the same parameters. Also, it seems that multicollinearities between the regression equation, the hurdle equation, and the purchase equation markedly increase the bias. This was true in the empirical application with respect to the double-hurdle model but not to the purchase-infrequency model. This deserves further investigation.

Other directions for investigation include relaxing the assumption of independence between the three disturbances, and allowing for other forms of mis-specification in the integrated model.

Notes

1. This is a bit different from the Blundell and Meghir (1987) specification since they assumed that all consumers actually consume the commodity continuously.

2. Both the Blundell and Meghir (1987) and the Blisard and Blaylock (1993) papers have errors in the likelihood function of the full model. These errors have been corrected here.

3. The coefficients of the frequency parameters in the integrated specification are not shown in the figure, since they are all quite large meaning that the probability of a zero observation due to purchase infrequency is essentially zero.

4. Using household expenditures as the dependent variable reduces the applicability of this argument, of course, but I will ignore this drawback here.

5. This is especially true for imported brands.

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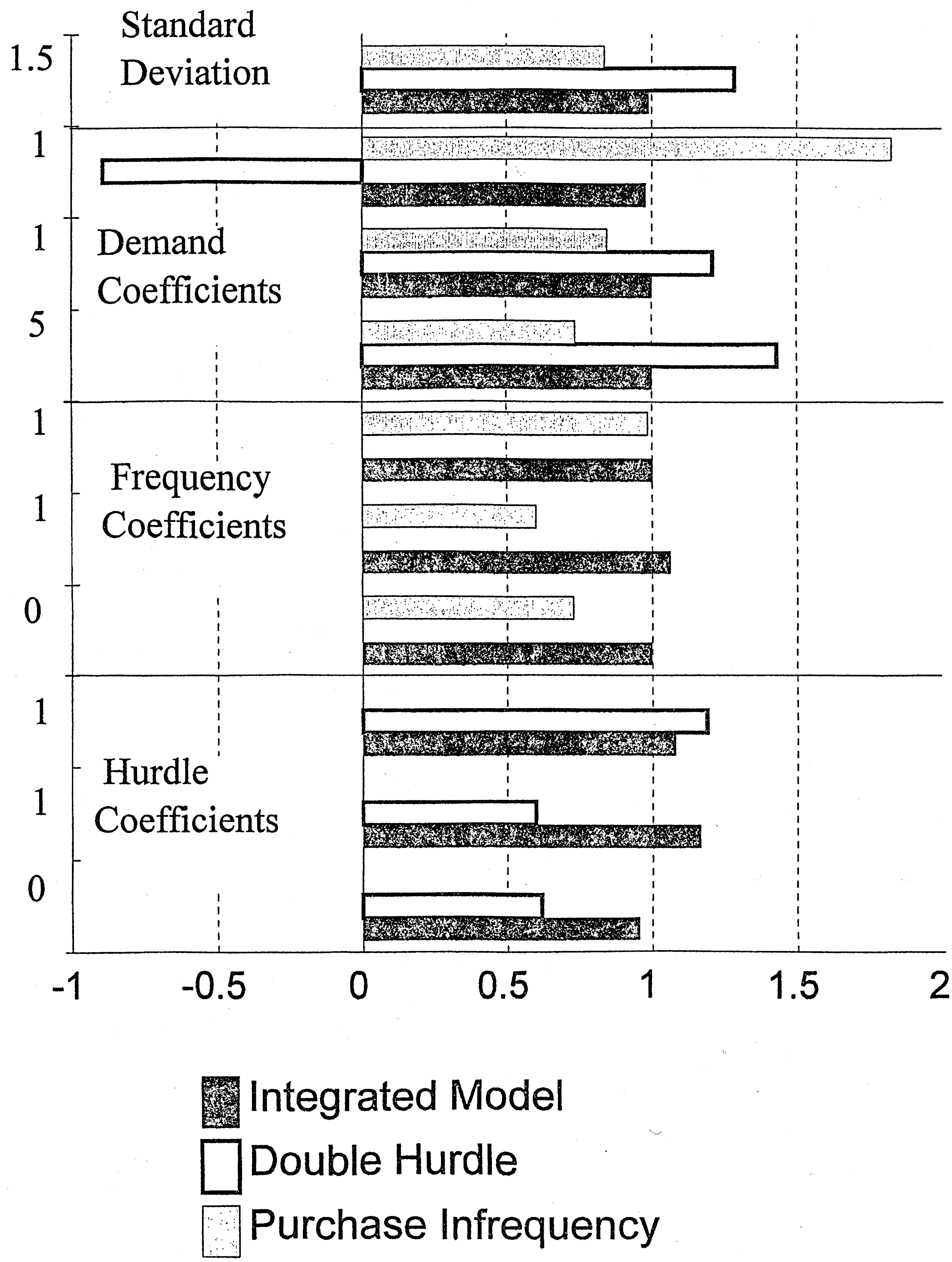

Figure 1. Comparison of means of estimators from simulations when data are generated by the integrated model.

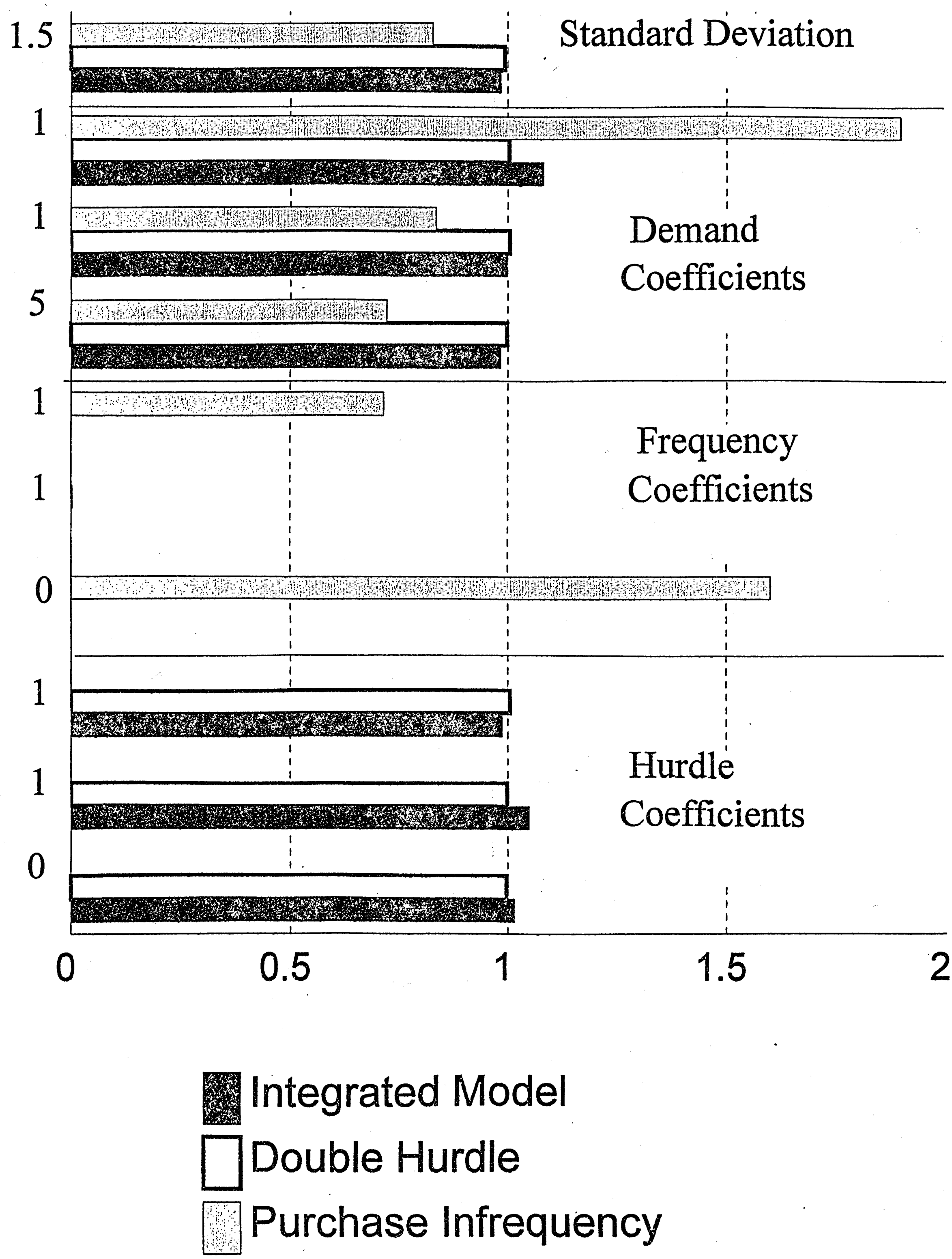

Figure 2. Comparison of means of estimators from simulations when data are generated by the double-hurdle model.

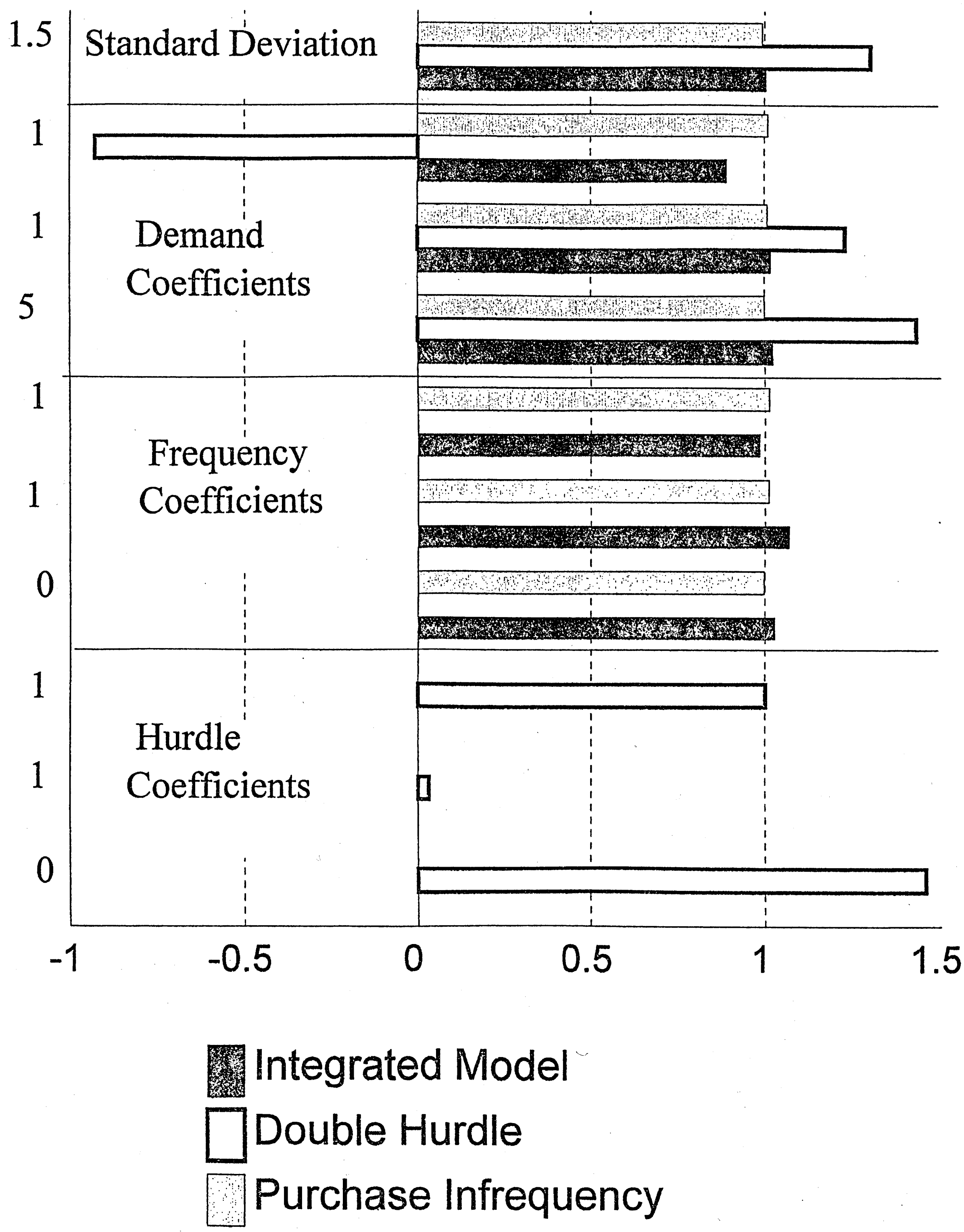

Figure 3. Comparison of means of estimators from simulations when data are generated by the purchase-infrequency model.

Table I. Variable definitions and descriptive statistics

Variable	Definition	Sample mean
Household head characteristics		
Age	Age	49 years
Female	Female	0.1791
Unmarmal	Unmarried male	0.0703
Moza0[a]	Non-Jewish	0.0953
Moza47[a]	Jewish born in Asia or Africa	0.2241
Moza813[a]	Jewish born in Israel, father born in Europe or America	0.1244
Moza847[a]	Jewish born in Israel, father born in Asia or Africa	0.1450
Moza88[a]	Jewish born in Israel, father born in Israel	0.0547
Yrs0[b]	No schooling	0.0383
Yrsel[b]	Elementary schooling	0.1918
Yrshigh[b]	High school graduate	0.1845
Yrscol[b]	College education	0.1835
Yrsuni[b]	Post-college education	0.2072
Selfemp	Self-employed	0.1165
Notwork[c]	Not working	0.3251
Occup0[c]	Scientific/academic professional	0.0657
Occup1[c]	Free professional, technician	0.0851
Occup2[c]	Manager	0.0587
Occup3[c]	Clerk	0.0716
Occup4[c]	Sales worker, agent	0.0712
Occup5[c]	Service worker	0.0670
Occup689[c]	Farm worker or unskilled worker in industry/transport/mining	0.0564
Local1[d]	Lives in Jerusalem	0.0880
Local2[d]	Lives in Tel-Aviv	0.0971
Local3[d]	Lives in Haifa	0.0682
Local5[d]	Lives in a town of 50-100 thousand	0.1204
Local6[d]	Lives in a town of 20-50 thousand	0.1704
Local7[d]	Lives in a town of 10-20 thousand	0.0624
Local8[d]	Lives in a town of 2-10 thousand	0.0381
Household characteristics		
Adult	Number of adults	2.25
Child	Number of children	1.42
Consump	Total consumption	5319

[a] Excluded group: Jewish born in Europe or America.
[b] Excluded group: some high school education.
[c] Excluded group: skilled workers in industry, transportation, construction, or mining.
[d] Excluded group: lives in a town of 100-200 thousand.

Table II. Comparison of model performances

	Integrated	D-H[a]	P-I[b]	Tobit
% censored by D-H	8.99	19.18		
% censored by P-I	6.62		11.65	
% censored by D-H or P-I	13.82	19.18	11.65	
% censored by Tobit	37.57	38.96	45.93	74.56
% censored (total)	49.39	56.52	53.84	74.56
% censored in sample	59.95	59.95	59.95	59.95
% correctly censored	60.26	66.85	65.40	83.75
% correctly uncensored	66.88	58.94	63.46	39.18
L-R[c] statistic against D-H				298
degrees of freedom				5193
critical value at 1%				73.7
L-R[c] statistic against P-I				616
degrees of freedom				5193
critical value at 1%				73.7
L-R[c] statistic against Integr.		404	86	702
degrees of freedom		5193	5193	10386
critical value at 1%		73.7	73.7	103.6

[a] double-hurdle.
[b] purchase-infrequency.
[c] likelihood-ratio.

Table III. Hurdle coefficient estimates

	Integrated model		Double-hurdle model	
Variable	Coefficient	t-ratio	Coefficient	t-ratio
Intercept	2.5894	1.21	-4.8432	-5.48**
Age	-0.0543	-5.56**	-0.0257	-6.17**
Female	-0.3410	-0.96	-0.1315	-1.06
Moza0	0.9343	1.37	0.1887	0.85
Moza47	0.6332	1.66*	-0.0133	-0.10
Moza813[a]	1.1395	1.27	0.1482	0.88
Moza847[a]	1.1395	1.27	0.1482	0.88
Moza88[a]	1.1395	1.27	0.1482	0.88
Yrs0	0.1775	0.22	-0.0087	-0.03
Yrsel	-0.8095	-2.21*	-0.2533	-1.51
Yrshigh	-0.9659	-2.87**	-0.1524	-0.81
Yrscol	-0.3591	-0.81	-0.5130	-3.00**
Yrsuni	0.1944	0.35	-0.2669	-1.14
Local1[b]	0.1239	0.41	-0.0114	-0.08
Local2[b]	0.1239	0.41	-0.0114	-0.08
Local3	-0.4825	-1.32	-0.2814	-1.68*
Local5	-0.4004	-1.06	-0.1564	-1.11
Local6	0.5881	1.20	0.0571	0.40
Local7	-0.2097	-0.60	-0.0387	-0.21
Local8	0.0018	0.00	0.1165	0.50
Adult	0.7891	3.63**	0.4206	3.40**
ln(Cons.)	0.0631	0.27	0.7348	7.46**

The variables Unmarmal, Selfemp, and Child were excluded for identification. Including these variables would result in a group of households having a zero or one probability of crossing the hurdle. The occupational dummies were found insignificant as a group and hence dropped. The other groups of dummies were each found significant as a group.

* coefficient significant at the 5% level.
** coefficient significant at the 1% level.

[a,b] The coefficients of these variables were forced to be equal for identification.

Table IV. Frequency coefficient estimates

	Integrated model		Purchase-infrequency model	
Variable	Coefficient	t-ratio	Coefficient	t-ratio
Intercept	-6.2171	-10.8**	-5.7811	-11.7**
Age	-0.0016	-0.45	-0.0081	-3.32**
Female	-0.0488	-0.43	-0.1069	-1.19
Unmarmal	-0.1890	-1.38	-0.1832	-1.55
Moza0	-0.3039	-1.91*	-0.1276	-1.00
Moza47	-0.4095	-3.46**	-0.2082	-2.38**
Moza813	-0.3353	-2.08*	-0.1855	-1.33
Moza847	-0.2447	-1.92*	-0.0887	-0.83
Moza88	-0.4193	-2.44**	-0.2724	-1.77*
Yrs0	-0.1663	-0.84	-0.1303	-0.76
Yrsel	-0.0169	-0.14	-0.1226	-1.25
Yrshigh	0.0979	0.79	-0.0010	-0.01
Yrscol	-0.2325	-1.78*	-0.1860	-1.57
Yrsuni	-0.2440	-1.69*	-0.1560	-1.13
Notwork	-0.0212	-0.19	-0.0376	-0.38
Occup0[a]	-0.0878	-0.54	-0.1230	-0.81
Occup1[a]	-0.0878	-0.54	-0.1230	-0.81
Occup2[a]	-0.0878	-0.54	-0.1230	-0.81
Occup3[b]	0.0823	0.73	0.0780	0.75
Occup4[b]	0.0823	0.73	0.0780	0.75
Occup5[b]	0.0823	0.73	0.0780	0.75
Occup689	-0.1748	-1.38	-0.1774	1.45
Local1	-0.2496	-1.78*	-0.1859	-1.46
Local2	0.0295	0.16	0.0080	0.05
Local3	-0.0175	-0.13	-0.0707	-0.68
Local5	-0.0200	-0.14	-0.0554	-0.51
Local6	-0.2033	-1.96*	-0.1288	-1.42
Local7	-0.2174	-1.64	-0.2122	-1.83*
Local8	0.1734	0.98	0.2151	1.41
Adult	0.0220	0.38	0.1010	1.84*
ln(Cons.)	0.9033	12.76**	0.8400	13.42**

The variables Selfemp and Child were excluded for identification. Including these variables would result in a group of households having a zero or one purchase probability.

* coefficient significant at the 5% level.
** coefficient significant at the 1% level.

[a,b] The coefficients of these variables were forced to be equal for identification.

Table V. Consumption share equation coefficient estimates

Variable	Integrated	D-H	P-I	Tobit
Intercept	0.0767 (8.55)**	0.1610 (7.11)**	0.0738 (9.28)**	0.0480 (4.35)**
Age	-0.0003 (-3.95)**	-0.0002 (-2.28)*	-0.0004 (-8.33)**	-0.0007 (-11.6)**
Female	0.0079 (4.21)**	0.0126 (4.33)**	0.0055 (3.59)**	0.0046 (2.30)*
Unmarmal	0.0126 (4.95)**	0.0186 (4.93)**	0.0113 (4.73)**	0.0129 (4.92)**
Moza0	0.0143 (7.00)**	0.0177 (5.81)**	0.0160 (8.24)**	0.0129 (7.23)**
Moza47	0.0010 (0.66)	0.0041 (1.74)*	0.0032 (2.50)**	0.0042 (2.30)*
Moza813	-0.0029 (-1.79)*	-0.0030 (-1.18)	-0.0014 (-0.89)	-0.0034 (-1.48)
Moza847	0.0036 (2.44)**	0.0049 (2.11)*	0.0050 (3.44)**	0.0071 (3.31)**
Moza88	-0.0007 (-0.34)	-0.0014 (-0.45)	0.0004 (0.20)	-0.0015 (-0.51)
Yrs0	0.0020 (0.59)	0.0073 (1.07)	0.0037 (1.28)	0.0063 (1.70)*
Yrsel	0.0053 (2.92)**	0.0084 (3.16)**	0.0032 (2.06)*	0.0037 (1.74)*
Yrshigh	0.0034 (2.27)*	0.0040 (1.81)*	0.0018 (1.41)	0.0027 (1.41)
Yrscol	-0.0050 (-3.25)**	-0.0027 (-1.17)	-0.0048 (-3.30)**	-0.0089 (-4.33)**
Yrsuni	-0.0095 (-5.61)**	-0.0108 (-3.55)**	-0.0085 (-5.22)**	-0.0135 (-5.97)**
Selfemp	-0.0014 (-1.02)	-0.0014 (-0.76)	-0.0014 (-1.03)	-0.0022 (-1.07)
Notwork	-0.0022 (-1.41)	-0.0030 (-1.41)	-0.0032 (-2.16)*	-0.0039 (-1.84)*
Occup0	-0.0085 (-3.73)**	-0.0106 (-3.44)**	-0.0084 (-3.74)**	-0.0122 (-3.51)**
Occup1	-0.0080 (-4.06)**	-0.0105 (-4.07)**	-0.0080 (-4.17)**	-0.0106 (-3.85)**

Continued on next page

Table V. (*continued*)

Variable	Integrated	D-H	P-I	Tobit
Occup2	-0.0021 (-1.10)	-0.0013 (-0.54)	-0.0021 (-1.16)	-0.0025 (-0.83)
Occup3	-0.0051 (-2.91)**	-0.0069 (-2.95)**	-0.0046 (-2.70)**	-0.0054 (-1.97)*
Occup4	-0.0048 (-2.77)**	-0.0060 (-2.66)**	-0.0050 (-2.91)**	-0.0066 (-2.47)**
Occup5	-0.0035 (-1.80)*	-0.0048 (-1.82)*	-0.0032 (-1.67)*	-0.0042 (-1.58)
Occup689	-0.0009 (-0.45)	-0.0024 (-0.87)	-0.0012 (-0.62)	-0.0039 (-1.41)
Local1	-0.0029 (-1.54)	-0.0037 (-1.27)	-0.0026 (-1.41)	-0.0050 (-1.92)*
Local2	0.0005 (0.29)	0.0005 (0.17)	0.0009 (0.51)	0.0019 (0.81)
Local3	0.0015 (0.70)	0.0052 (1.72)*	-0.0003 (-0.19)	-0.0004 (-0.14)
Local5	0.0011 (0.73)	0.0021 (0.95)	0.0002 (0.17)	-0.0008 (-0.36)
Local6	0.0023 (1.65)*	0.0043 (1.98)*	0.0031 (2.39)**	0.0044 (2.33)**
Local7	0.0054 (2.93)**	0.0079 (2.43)**	0.0050 (2.81)**	0.0069 (2.61)**
Local8	0.0023 (1.14)	0.0044 (1.49)	0.0020 (1.06)	0.0043 (1.26)
Child	-0.0005 (-1.41)	-0.0006 (-1.39)	-0.0005 (-1.51)	-0.0006 (-1.23)
Adult	0.0022 (3.33)**	0.0008 (0.97)	0.0035 (5.79)**	0.0058 (8.32)**
ln(Cons.)	-0.0078 (-7.03)**	-0.0180 (-7.04)**	-0.0072 (-7.51)**	-0.0045 (-3.34)**
Sigma	0.0221	0.0310	0.0217	0.0374
ln(L)	2608	2406	2565	2257

* coefficient significant at the 5% level.
** coefficient significant at the 1% level.

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