Life-cycle Effects on Household Expenditures: A Latent-variable Approach

Eva Ventura and Albert Satorra[1]

Universitat Pompeu Fabra

October 1998

---

[1] Address for corresponding author: Eva Ventura, Departament d'Economia i Empresa, UPF, Ramon Trias Fargas, 25-27, 08005 Barcelona, Spain, Phone: 34-935421760, Fax: 34-935421746, e-mail: eva.ventura@econ.upf.es.

Abstract

Using data from the Spanish household budget survey, we investigate life-cycle effects on several product expenditures. A latent-variable model approach is adopted to evaluate the impact of income on expenditures, controlling for the number of members in the family. Two latent factors underlying repeated measures of monetary and non-monetary income are used as explanatory variables in the expenditure regression equations, thus avoiding possible bias associated to the measurement error in income. The proposed methodology also takes care of the case in which product expenditures exhibit a pattern of infrequent purchases. Multiple-group analysis is used to assess the variation of key parameters of the model across various household life-cycle typologies. The analysis discloses significant life-cycle effects on the mean levels of expenditures; it also detects significant life-cycle effects on the way expenditures are affected by income and family size. Asymptotic robust methods are used to account for possible non-normality of the data.

Keywords: Structural Equations; Multi-group analysis; Life cycle effects; Product Expenditures

JEL classification: M31, C31, C51, D12

1. INTRODUCTION

Consumption is a multidimensional concept that varies with income, family composition, and life-cycle behavior. Differences in the pattern followed by expenditures are brought about by family role transitions from one to other stage of life, with the stage of life being usually determined by the age of the head (sometimes the age of the wife is used instead), the marital status and the number and age of children. Schaninger and Danko (1993) compared a number of alternative family cycle models, with families ranging from “traditional” to “modernized”. The common feature in these models is the classification of families into several categories related to particular life-cycle stages; however the types of families to consider and the stages of life they go through have changed with time to account for recent cultural and institutional developments. In a more recent paper Wilkes (1995) used cross-section data on family budgets and provided empirical verification of changes in household spending across a wide variety of products as households pass from one stage of life to another. In this type of work it is assumed that a series of status-changing events produce a series of predictable stages or categories that are associated with systematic patterns of expenditures by consumers. Then the different categories are introduced in the analysis of the expenditure system of equations by means of dummy variables in a linear regression, thus allowing to test for life-cycle effects on the mean level of expenditures. In our paper we also follow the approach of classifying families into different categories according to a combination of variables that we consider to be indicators of a particular stage of life; however, we also allow for life-cycle effects on the covariance structure of all the observable variables, and in particular on the way that income and family size affect expenditures.

The issue of measurement error on the explanatory variables arises when assessing the effect that income has on expenditures. This type of problem has been treated by several authors (see Summers (1959), Liviatan (1961), Biørn (1992) or Aasness, Biørn and Skjerpen (1993) and (1995)). To circumvent the issue of measurement error in income we adopt a latent-variable model approach. Two of the explanatory variables in our model will be unobservable factors underlying the various measures of income.

The analysis of products which exhibit a pattern of infrequent purchases requires a specific treatment. In this paper infrequent purchases are treated as censored variables. In a first stage of the analysis we estimate the covariance between the underlying uncensored variable and the rest of the variables of the model. The estimated covariance is integrated then into the standard analysis. This allows us to work with any type of expenditure while keeping the same model framework.

The paper is organized as follows. Section 2 describes the data, model and the statistical analysis. The results are presented in section 3. Section 4 concludes.

2. METHOD

2.1 Data and life-cycle typology

The data set is taken from the Spanish Continuous Survey of Family Budgets (ECPF, 1996) . The sample consists of about 3,200 households per quarter and is rotated in a 12% every quarter. This data has already been used by some authors (see for example Labeaga and López (1994)) in the context of demand system estimation.

The survey asks the families to keep a detailed record of all kind of expenditures for a period of one week [2]. For some of the more infrequent purchases the survey ask the families to write down the expenditures realized during the last three months. There are two hundred and fifty eight categories of expenditure. We aggregate some of these categories to build the four types of expenditures that we use in the present analysis: transportation, food, durable and medical expenditures. We select those families which remain in the survey for the last two quarters of data consecutively. A few (less than a 3% of the data) outlier observations have been dropped from the data set using the multiple-outliers detection method of Hadi (1992) implemented in the program Stata (1997). The resulting sample size is around 2,600 households.

The survey also collects information on income perceived during the last tree months by every member of the household. This income is both monetary and non-monetary (mainly due to imputations of home owned rent, which is also considered as part of consumption expenditures). Note that the various measures of income can only be regarded as "proxy" of the "true" value of income.

---

[2] The weeks are chosen randomly over the quarter.

Two main issues of inaccuracy of the reported income can be distinguished. The first one has to do with the systematic bias of income and it is known as underreporting. In fact, in our survey families consistently seem to underreport income. The second problem has to do with the *reliability* of reported income; i.e. the fraction of variance of the observed income attributable to a random component of measurement error. In the literature of measurement error this second issue is assessed by the so called reliability coefficient, which is defined as the ratio between the variance of the "true" (unobservable) income and the variance of the observable income. It is this second source of error, i.e. a reliability coefficient different than one, the one that can seriously bias the usual OLS estimates of parameters of interest such as the effect of income on expenditures. The latent-variable model approach used in this paper prevents this type of bias.

With regard to the life-cycle household typology, we consider the following groups:

1. YOUNG: Young singles or young couples without children. Those are families of one or two (married) members in which the head of the family is less than 65 years old.
2. CHILDREN: Families with young children (at least one child is less than 15 year old). These are families in which the presence of a child is the only common characteristic. Families in which the head of the family is the grandfather are mixed with families constituted by just one couple and some children, or families of single or divorced parents.
3. TEENS: Families with older children (the youngest child is more than 14 years old and less than 25). Again families are mixed, as in the preceding group.
4. ADULTS: Families constituted exclusively by adults, other than couples or singles. This group includes young couples living with their parents, old couples living with non- emancipated siblings, or just non-related people living together.
5. OLD: Old singles or couples living by themselves. Those are families of one or two (married) members in which the head of the family is more than 64 years old.

2.2 Model

The latent-variable model approach has been used successfully in several areas of empirical investigation. One of the oldest models of this type is the Factor Analysis model, which postulates that the covariance among a set of observable variables is produced by the variation of underlying latent variables (factors). Nowadays, a very popular latent-variable model is LISREL (Jöreskog and Sörbom, 1994). To give a few economic related examples of latent-variable models, we can cite the work of Punj and Staelin (1983) in consumer behavior, the work of Anderson (1985) and Bagozzi (1980) in marketing, Fritz (1986) in management science, or McFatter (1987) in discrimination in salaries. For an introduction to structural equations with latent-variable models see Bollen (1989).

In this paper we specify a simple latent-variable model that can explain the behavior of most products' expenditures. The model establishes relationships among variables some of which can be unobservable or latent. Each expenditure is assumed to depend on two factors (latent-variables) which are linearly related to measures of monetary and non-monetary income of the households in different periods of time. The number of members of the household is used as a covariant of the model.

The main hypothesis associated to the life-cycle analysis is that the spending behavior of families varies not only due to changes in income, but also depending on the stage of life the family is going through at the moment. That is, a young single household is thought to show very different consumption patterns from a household with young children, or an old age couple household. It is not just a matter of income, but a matter of preferences, taste, family composition, family needs, and so on. A common model is analyzed for different groups of households, the groups corresponding to different life-cycle stages. The analysis assesses the variation of the parameters of the model across groups, not only of the intercept parameters but also of the regression coefficients. The intercept parameters determine the mean levels of the variables while the regression coefficients affect the relationships between expenditures, income and number of members of the family.

The estimated model, which is the same for all groups, is the following:

$$\text{PRODUCT} = \alpha_0 + \beta_1 \text{ MEMBER} + \beta_2 \text{ F1} + \beta_3 \text{ F2} + e_0$$

(1)

$$\text{INCOME1} = \alpha_1 + \text{F1} + \varepsilon_1$$

(2)

$$\text{INCOME2} = \alpha_2 + \text{F2} + \varepsilon_2$$

(3)

$$\text{INCOME1}_{-1} = \alpha_3 + \lambda_1 \text{ F1} + \varepsilon_3$$

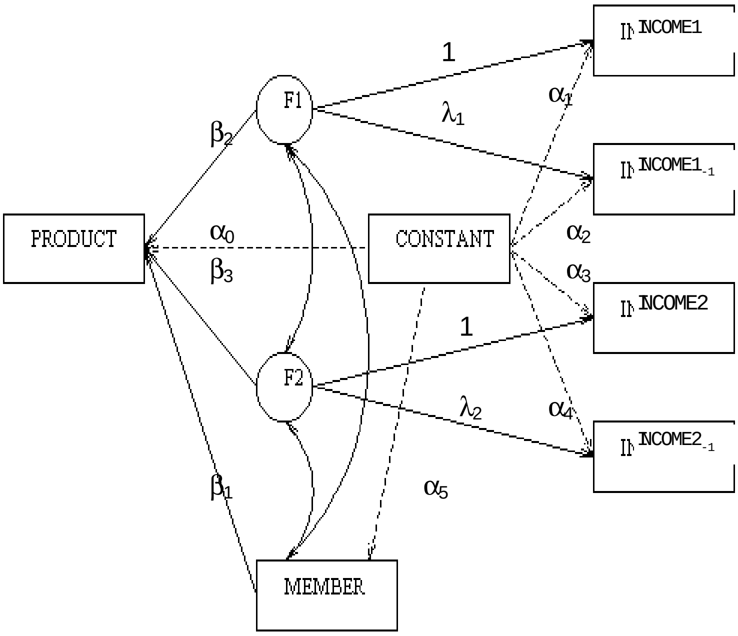
(4)

$$\text{INCOME2}_{-1} = \alpha_4 + \lambda_2 \text{ F2} + \varepsilon_4$$

(5)

where: PRODUCT is the product expenditure we want to consider; MEMBER is the number of members in the household; and F1 (F2) is a latent-variable underlying two indicators (current and one quarter behind) of reported monetary (non-monetary) income, namely INCOME1 and INCOME1_{-1} (INCOME2 and INCOME2_{-1}). The α parameters are the intercepts of the regression equations; the β's are the regression coefficients measuring the effects of two sources of income on consumption; finally, the λ 's are the regression coefficients (here “loadings”) of the observed variables on the different factors. The ε's are disturbance terms of the regression and measurement equations. Figure 1 shows the path-diagram representation of the model.

Figure 1: Path Diagram of the Expenditures Model



The above model is a specific case of the Bentler-Week's model implemented in the EQS package (Bentler, 1995). We use the multiple-group approach with various levels of constraints across groups. The across-group constraints correspond to substantive hypothesis on life-cycle effects. The model is estimated by Generalized Least-Squares with an optimal weight matrix under normality. We use asymptotic robust standard errors and test statistics to take care for possible non-normality of the data (see, for example, Satorra (1993), and Satorra and Bentler (1994) for the theory of asymptotic robustness of LISREL type models). In this paper we have used the statistical package LISREL ((Jöreskog and Sörbom, 1994) , which in its latest version also provides robust standard errors and t-statistics. To deal with censored and ordinal dependent variables we used the statistical software PRELIS ((Jöreskog and Sörbom, 1994). An alternative commercial software to carry out this type of analysis is EQS. See Appendix 1 for more details on the statistical analysis used in this paper.

3. RESULTS

The following subsections describe the results of the analysis for each type of expenditure.

3.1 Transportation and Communications Expenditures

Tables 1 to 4 report the parameter estimates and the test statistics of the model presented in section 2, for Transportation, Food, Durable and Medical expenditures respectively. (We do not show standard errors and t-values for those parameters which are known to be significant from a priori grounds, such as the λ's and the α's.). Asymptotic robust t-values are shown within brackets below the parameter estimates. The right columns of the table show the test statistics and the restricted (across-groups) parameter estimates associated to different null hypothesis concerning life-cycle behavior. In all the tables, when a parameter estimate is significantly different than zero or a test statistic rejects the null hypothesis, the corresponding value is emphasized in bold.

Table 1 reports an acceptable fit of the unrestricted model: the chi-square goodness-of-fit of the unrestricted model is 23.87 (30 d.f.), which corresponds to a P-value of 0.78. We also observe that the intercept of the

Transportation equation is basically the same for the first four groups, however it drops dramatically with the last group (old singles living alone or old couples).

Table 1 shows also that the number of members in the household does not affect significantly the transportation and communications expenditures. The coefficient of the first latent-variable -whose indicators are monetary income in the current and previous periods- is highly significant, while the coefficient of the second latent-variable (indicated by the non-monetary income variables) is significant only for the third (families in which the youngest member is a teenager) and last group (old singles living alone or old couples).

The last two columns serve to analyze life-cycle behavior. In these columns we show statistics associated to multiple-group analysis for testing various equalities of parameters across groups. We report the value of the difference chi-square test statistics and the estimated restricted parameters. The number in brackets below the test statistics is the corresponding P-value. First of all we note that the number of members of the household (MEMBER) does not affect transportation expenditures, therefore it makes no sense to evaluate a life-cycle effect on β_1. The same non-significant effect results are observed for the β_3 coefficient, i.e. the impact of non-monetary income on expenditures, with the exception of groups 3 (TEENS) and 5 (OLD) in which we appreciate a significant value. In contrast, we realize that the β_2 coefficients, i.e. the effect of monetary income on transportation, are highly significant for each group; on the other hand, we can not reject the hypothesis of equality of the β_2 parameters across groups (i.e., we do not observe a life-cycle effect on the impact of monetary income on Transportation). Life-cycle effects are further investigated through the statistics of the last columns of the table.

The variation across groups of the intercept of the regression equation for expenditures (the α_0's parameters) is described in Figure 2. Note the highly significant life-cycle effects reflected by the variation of these parameters, which correspond to the variation of expenditures after controlling for family size and unobserved income. In contrast with previous analysis, our model allows for an effect of income and family size that varies across the life-cycle groups. Figure 3 is a graphic representation of the variation across life-cycle stages of the intercepts of the measurement equations (parameters a_1 to a_4), i.e. the means of the different income measures. Differences in income related to the life-cycle are clearly appreciated.

TABLE 1: Parameter estimates and test statistics for Transportation expenditures

						Testing for Life-cycle effects on a:			
	Groups					single parameter		set of parameters	
	1	2	3	4	5	Difference test	Restricted Parameters	Differences test	Restricted parameters
N	278	896	586	380	426				
β_1 MEMBER	-0.01 *(-0.61)*	-0.01 *(-0.98)*	0.02 *(0.95)*	0.00 *(-0.02)*	0.04 *(1.46)*	3.42 *(0.49)*	0.00 *(0.20)*	---	---
β_2 F1	**0.11** *(5.43)*	**0.07** *(7.30)*	**0.07** *(6.27)*	**0.09** *(3.75)*	**0.08** *(4.97)*	7.17 *(0.13)*	**0.08** *(12.54)*	15.69 *(0.05)*	**0.08** *(12.38)*
β_3 F2	-0.02 *(-0.63)*	0.05 *(1.82)*	**0.11** *(3.16)*	-0.01 *(-0.18)*	**0.09** *(2.54)*	9.32 *(0.05)*	**0.06** ***(3.32)***		**0.06** *(3.22)*
λ_1 F1	**1.15**	**1.03**	**1.23**	**1.53**	**1.22**	9.42 *(0.05)*	**1.15**	14.05 *(0.08)*	**1.15**
λ_2 F2	**1.03**	**1.01**	**1.08**	**0.89**	**1.00**	4.49 *(0.34)*	**1.01**		**1.01**
α_0	**0.49**	**0.68**	**0.65**	**0.51**	**0.10**	**51.41**	**0.37**	**1103.10** *(0.00)*	**0.58**
α_1	**3.86**	**4.93**	**5.37**	**5.02**	**2.31**	**403.03**	**4.37**		**4.86**
α_2	**4.33**	**5.37**	**6.03**	**6.05**	**2.77**	**364.3**	**4.65**		**5.40**
α_3	**0.98**	**1.05**	**1.14**	**1.06**	**0.77**	**64.24**	**1.00**		**1.08**
α_4	**0.97**	**1.06**	**1.15**	**1.04**	**0.78**	**63.45**	**1.00**		**1.08**
α_5	**1.70**	**4.32**	**3.94**	**2.89**	**1.57**	**406.03**	**1.73**		**3.40**
χ^2	23.87 (P = 0.78, d.f. = 30)								

Numbers in brackets below parameter estimates are asymptotic robust t-values. Numbers in brackets below test statistics are p-values. Bold indicates significant at the 5% level.

Figure 2: Intercepts of the expenditures equations

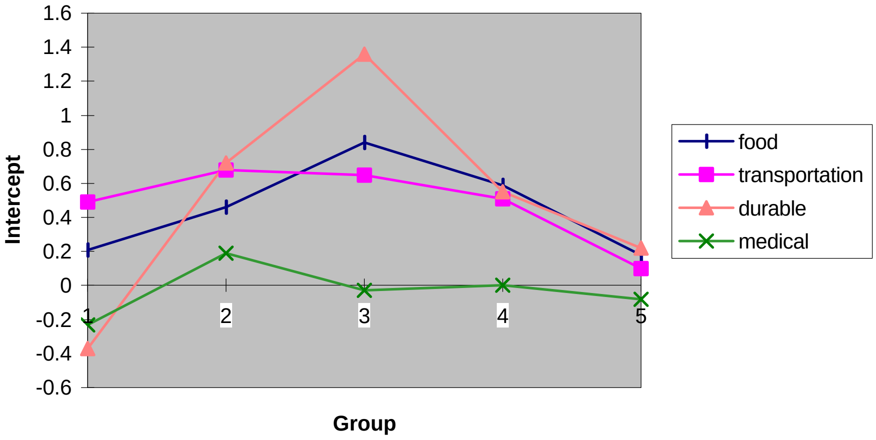
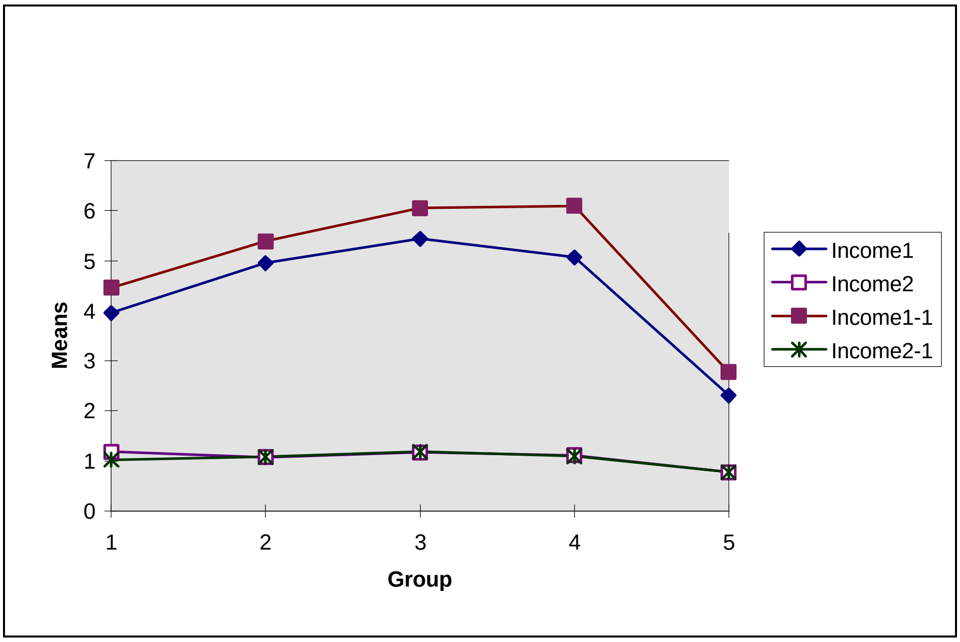


Figure 3: Means of the income measures



3.2 Food Expenditures

Table 2 shows also an excellent fit of the model when the product expenditure analyzed is food. The chi-square goodness-of-fit of the unrestricted model is 20.37 (30 d.f.), which corresponds to a P-value of 0.91. In contrast with the transportation expenditures case, now the β_1's (the regression coefficients for MEMBER) are highly significant in each group. We also note a highly significant life-cycle effect on β_1, since the hypothesis of equality across groups (a chi-square value of 13.42 for 4 d.f., P-value of 0.01) is rejected. Regarding the impact of income on food expenditures, we observe significant values for the regression coefficients of the factor associated to monetary income in groups 2 (with children) and 3 (with teenagers), and to less extend in groups 4 (adults) and 5 (old singles and old couples), but not significant for the first group (young singles or young couples). The regression coefficient of the factor associated to non-monetary income is clearly non-significant. In conclusion, food expenditures are basically explained by family composition and exhibit a clear life-cycle effect through the intercepts and the β_1 coefficient.

TABLE 2: Parameter estimates and test statistics for Food expenditures

						Testing for Life-cycle effects on a:			
	Groups					single parameter		set of parameters	
	1	2	3	4	5	Difference test	Restricted Parameters	Differences test	Restricted parameters
N	284	885	588	377	426				
β_1 MEMBER	**0.45** *(6.52)*	**0.28** *(10.63)*	**0.23** *(6.18)*	**0.29** *(5.48)*	**0.46** *(8.91)*	**13.42** ***(0.01)***	**0.29** *(15.83)*	**---**	**---**
β_2 F1	0.03 *(1.48)*	**0.05** *(4.53)*	**0.09** *(4.98)*	**0.05** *(2.39)*	**0.08** *(2.36)*	6.33 *(0.18)*	**0.06** *(7.06)*	6.98 *(0.54)*	**0.06** *(7.18)*
β_3 F2	0.05 *(1.18)*	0.05 *(1.38)*	0.05 *(1.16)*	0.04 *(0.80)*	0.01 *(0.24)*	0.43 *(0.98)*	**0.04** *(2.11)*		**0.04** *(2.00)*
λ_1 F1	**1.20**	**1.01**	**1.21**	**1.46**	**1.30**	**11.75** ***(0.02)***	**1.16**	14.41 *(0.07)*	**1.16**
λ_2 F2	**1.03**	**1.01**	**0.99**	**0.90**	**0.94**	3.17 *(0.53)*	**0.99**		**0.98**
α_0	0.21	**0.46**	**0.84**	**0.59**	**0.18**	**15.5**	**0.40**	**1138.57** *(0.00)*	**0.53**
α_1	**3.92**	**4.90**	**5.36**	**4.99**	**2.31**	**415.04**	**4.38**		**4.85**
α_2	**4.43**	**5.34**	**6.02**	**6.03**	**2.77**	**380.31**	**4.66**		**5.39**
α_3	**1.00**	**1.04**	**1.15**	**1.06**	**0.77**	**68.82**	**1.00**		**1.08**
α_4	**0.99**	**1.05**	**1.16**	**1.04**	**0.78**	**68.09**	**1.00**		**1.08**
α_5	**1.70**	**4.31**	**3.95**	**2.89**	**1.57**	**415.04**	**1.73**		**3.40**
χ^2	20.37 (P = 0.91 , d.f. = 30)								

Numbers in brackets below parameter estimates are asymptotic robust t-values. Numbers in brackets below test statistics are p-values. Bold indicates significant at the 5% level.

3.3 Durable Expenditures

The results for the durable expenditures are shown in Table 3. The chi-square goodness-of-fit of the unrestricted model is 18.77 (30 d.f.), which corresponds to a P-value of 0.94. In this case monetary income is the variable that influences spending in all the cases considered. The value of the β_1 coefficient show that the number of members in the family has a positive effect in the first group, indicating that young couples spend more in durable goods than young singles. Non-monetary income has a weak effect in groups one (YOUNG) and two (CHILDREN). Figure 2 shows the pattern of the intercept of the durable expenditures equation across life-cycle stages. The life-cycle effects are quite evident when we look at the picture. Expenditures rise sharply from group 1 (YOUNG) to group 3 (TEENS) as families are constituted and children are born and grow, and then decrease also quite sharply thereafter. The last columns of the table confirm that the strong life-cycle effects are reflected on the intercepts of the equations for which we reject the hypothesis of equality across groups. We can not reject the same hypothesis for the coefficients of the income and number of members variables.

TABLE 3: Parameter estimates and test statistics for Durable Expenditures

						Testing for Life-cycle effects on a:			
	Groups					single parameter		set of parameters	
	1	2	3	4	5	Difference test	Restricted Parameters	Differences test	Restricted parameters
N	284	904	602	384	426				
β_1 MEMBER	**0.39** ***(3.07)***	-0.03 (-0.56)	**-0.19** ***(-2.65)***	-0.05 (-0.21)	-0.02 (-0.31)	9.25 *(0.06)*	-0.04 *(-1.17)*	**--**	**--**
β_2 F1	**0.04** *(2.06)*	**0.14** *(4.61)*	**0.16** *(4.12)*	**0.20** *(2.21)*	**0.18** *(3.08)*	8.68 *(0.07)*	**0.14** *(7.03)*	13.37 *(0.10)*	**0.14** ***(7.32)***
β_3 F2	**0.17** *(2.34)*	**0.17** *(2.03)*	0.08 *(0.91)*	-0.13 *(-0.58)*	-0.01 *(-0.26)*	6.04 *(0.20)*	0.04 *(1.10)*		0.04 *(1.16)*
λ_1 F1	**1.18**	**1.01**	**1.14**	**1.34**	**1.32**	**14.29** *(0.01)*	**1.15**	**18.40** *(0.02)*	**1.14**
λ_2 F2	**1.05**	**1.00**	**1.04**	**0.90**	**0.93**	**4.99** *(0.29)*	**0.99**		**0.99**
α_0	**-0.37**	**0.72**	**1.36**	0.55	0.22	**17.35**	**0.33**	**1261.78** *(0.00)*	**0.45**
α_1	**3.90**	**4.95**	**5.42**	**5.06**	**2.31**	**520.84**	**4.41**		**4.95**
α_2	**4.41**	**5.39**	**6.06**	**6.08**	**2.77**	**465.37**	**4.72**		**5.50**
α_3	**0.99**	**1.06**	**1.15**	**1.06**	**0.77**	**85.25**	**1.00**		**1.09**
α_4	**0.98**	**1.07**	**1.16**	**1.04**	**0.78**	**84.88**	**1.01**		**1.09**
α_5	**1.70**	**4.31**	**3.94**	**2.90**	**1.57**	**520.84**	**1.73**		**3.48**
χ^2	18.77 (0.94)	d.f. = 30							

Numbers in brackets below parameter estimates are Normal theory and asymptotic robust t-values. Numbers in brackets below test statistics are p-values. Bold indicates significant at the 5% level.

3.4 Medical Expenditures

The chi-square goodness-of-fit of the unrestricted model is 30.22 (30 d.f.), which corresponds to a P-value of 0.45. We observe that the t-values associated with the effect of income on this type of expenditure are much lower than in the previous cases. The β_2 coefficient is not significantly different from zero for the group 3 (TEENS). There is a slight significance of the coefficient of the non-monetary income in group 5 (OLD). Controlling for the number of members of the family becomes unnecessary, since its coefficient is never significantly different from zero at the 5%. As in the preceding case in which we analyzed durable expenditures, life-cycle effects are present only through the intercepts of the different equations.

TABLE 4: Parameter estimates and test statistics for Medical Expenditures

						Testing for Life-cycle effects on a:			
	Groups					single parameter		set of parameters	
	1	2	3	4	5	Difference test	Restricted Parameters	Differences test	Restricted parameters
N	284	904	602	384	426				
β_1	0.09	-0.02	0.01	0.00	-0.01	2.73	-0.01	--	--
MEMBER	*(1.05)*	*(-2.00)*	*(0.26)*	*(-0.11)*	*(-0.36)*	*(0.60)*	*(-1.62)*		
β_2	**0.03**	**0.03**	0.03	**0.04**	**0.07**	2.12	**0.03**	4.14 *(0.84)*	**0.03**
F1	*(2.00)*	*(3.04)*	*(0.82)*	*(3.43)*	*(3.33)*	*(0.71)*	*(4.39)*		***(4.33)***
β_3	0.02	0.04	0.02	0.07	**0.08**	0.00	**0.05**		**0.05**
F2	*(0.27)*	*(1.24)*	*(0.27)*	*(1.03)*	***(2.07)***	*(1.00)*	***(2.45)***		***(2.45)***
λ_1	**1.20**	**0.94**	**1.11**	**1.36**	**1.30**	**14.84**	**1.10**	**18.08** ***(0.02)***	**1.10**
F1						***(0.01)***			
λ_2	**1.04**	**1.00**	**1.03**	**0.92**	**0.94**	3.58	**0.99**		**0.98**
F2						*(0.47)*			
α_0	-0.23	**0.19**	-0.03	0.00	-0.08	**14.59**	0.05	**1153.17** ***(0.00)***	-0.01
α_1	**3.90**	**4.95**	**5.42**	**5.06**	**2.31**	**427.51**	**4.41**		**4.95**
α_2	**4.41**	**5.39**	**6.06**	**6.08**	**2.77**	**393.02**	**4.72**		**5.50**
α_3	**0.99**	**1.06**	**1.15**	**1.06**	**0.77**	**72.08**	**1.01**		**1.09**
α_4	**0.98**	**1.07**	**1.16**	**1.04**	**0.78**	**71.83**	**1.01**		**1.08**
α_5	**1.70**	**4.31**	**3.94**	**2.90**	**1.57**	**427.51**	**1.73**		**3.48**
χ^2	30.22 (0.45) d.f. = 30								

Numbers in brackets below parameter estimates are asymptotic robust t-values. Numbers in brackets below test statistics are p-values. Bold indicates significant at the 5% level.

4. CONCLUSION

In the context of Spanish household consumption data, we have analyzed the relationship between product expenditures and income, controlling for family size. A latent-variable model approach was used to assess the impact of income on expenditures, allowing us to circumvent the problem of measurement error present in the income variables. We have also allowed for the case in which expenditures exhibit a pattern of infrequent purchases. The explanatory variables in the regression equations were the number of members in the household and two factors underlying repeated measures of monetary and non-monetary income.

We have found that multiple-group analysis is an useful framework through which to specify and test life-cycle hypothesis using classical chi-square tests. Life-cycle effects in spending behavior were reflected on the variation of intercept and regression parameters across different family typologies.

We conclude that there are life-cycle effects on expenditures, and that these effects vary with the type of expenditure considered. An important finding of our paper is that these life-cycle effects have been detected not only on the mean level of consumption but also on the coefficients that assess the impact of income and family size on expenditures.

REFERENCES

AASNESS J., E. BIØRN & T. SKJERPEN (1995), "Distribution of Preferences and Measurement Errors in a Desegregated Expenditure System", "Discussion Papers No. 149. Statistics Norway.

AASNESS J., E. BIØRN & T. SKJERPEN (1993), "Engel Functions, Panel Data, and Latent-variables”, *Econometrica*, 61(6): 1395-1422.

ANDERSON, J.C. (1985), “A measurement model to assess measure-specific factors in multiple informant research”, *Journal of Marketing Research*, 22:86-92.

BAGOZZI R.P. (1980), *Causal models in marketing*. Wiley, New York.

BIØRN E. (1992), “The Bias of Some Estimators for Panel Data Models with Measurement Errors”, *Empirical Economics*, 17:51-66.

BOLLEN K. A. (1989), *Structural Equations with Latent-variables*. John Wiley & sons.

BENTLER P. (1995), *EQS. Structural Equations Program Manual.* University of California, Los Angeles. Encino, CA: Multivariate Software,Inc.

ECPF (1996) , Encuesta Continua de Presupuestos Familiares, Instituto Nacional de Estadística. Spain

FRITZ W. (1986), “The Lisrel-approach of causal analysis as an instrument of critical theory comparison within management science”, in: W. Gaul & M. Schader (Eds.), *Classification as a tool of research*, (pp. 142-152). Amsterdam: Elsevier Science.

HADI A.S. (1992) , “Identifying multiple outliers in multivariate data”, *Journal of the Royal Statistical Society*, Series B, (54):761-771.

JÖRESKOG, K. G. & D. SÖRBOM (1994), *LISREL 7 and PRELIS, A guide to the program and applications.* Chicago: SPSS

LABEAGA J.M. & A. LÓPEZ (1994), “Estimation of the Welfare Effects of Indirect Tax Changes on Spanish Households: An Analysis of the 1992 Vat Reform” , *Investigaciones Económicas*, XVIII(2):289-311.

LIVIATAN, N. (1961), "Errors in Variables and Engel Curve Analysis", *Econometrica*, 29:336-362.

MAGNUS, J. R. & H. NEUDECKER (1991), *Matrix Differential Calculus,* 2nd de. Chichester: Wiley.

MCFATTER, R.F. (1987), “Use of latent-variable models for detecting discrimination in salaries”, *Psychological Bulletin* , (101):120-125.

PUNG G. N. & R. STAELIN (1983), “A model of consumer information search behavior for new automobiles”, *Journal of Consumer Research*, (9):366-380.

SATORRA A. (1992), “Asymptotic Robust Inferences in the Analysis of Mean and covariance Structures”. In: P.V. Marsden (ed.). *Sociological Methodology 1992* (pp. 249-278). Cambridge, MA: Basic Blackwell.

SATORRA A. (1993), “Asymptotic Robust Inferences in multi-sample analysis of augmented-moment structures”. In: C.M. Cuadras and C.R. Rao (Eds.). *Multivariate analysis: Future directions 2* (pp. 211-229). North Holland: Elsevier Science.

SATORRA, A. & P.M. BENTLER (1994). “Corrections to Test Statistics and standard errors in covariance structure analysis”. In: Alexander von Eye and C.C. Clogg (Eds.). *Latent-variables analysis: applications to developmental research* (pp. 399-419). Thousand Oaks, CA: SAGE .

SATORRA A. & H. NEUDECKER (1994), "On the Asymptotic Optimality of Alternative Minimum-Distance Estimators in Linear Latent-Variable Models", *Econometric Theory*, 10:867-883.

SCHANINGER C. M. & W. D. DANKO (1993), “A Conseptual and Empirical Comparison of Alternative Household Life-cycle Models”, *Journal of Consumer Research*, 19:580-594.

STATACORP. (1997), Stata Statistical Software : Release 5.0 College Station, TX: Stata Corporation.

SUMMERS R. (1959), "A Note on Least Squares Bias in Household Expenditure Analysis", *Econometrica* , 27: 121-126.

WILKES, R. E. (1995), “Household Life-Cycle Stages, Transitions, and Product Expenditures”, *Journal of Consumer Research*, 22: 27-42.

APPENDIX 1: ESTIMATION METHOD

The model considered in the paper is a specific case of the following general linear latent-variable model

$$\eta_i^{(g)} = B^{(g)}\eta_i^{(g)} + \Gamma^{(g)}\xi_i^{(g)} \qquad (1)$$

$$z_i^{(g)} = G^{(g)}\nu_i^{(g)}, \quad g = 1,\ldots,G;\; i = 1,\ldots,n^{(g)} \qquad (2)$$

where for each group g, $z_i^{(g)}$ and $n^{(g)}$ are respectively the vector of observable variables and sample size in the g th sample, $\nu_i^{(g)} = (\eta_i^{(g)}{}', \xi_i^{(g)}{}')'$ is a vector of observable and latent variables, $G^{(g)}$ is a fully specified selection matrix, $B^{(g)}$, $\Gamma^{(g)}$ and the moment matrix $\Phi^{(g)} = E(\xi_i^{(g)}\xi_i^{(g)}{}')$ are parameter matrices of the model. This is the Bentler-Weeks's (e.g., Bentler, 1985) specification of a linear latent-variable model, which is equivalent to the specification in LISREL (Jöreskog and Sörbom, 1995).

A specific model expresses the matrices $B^{(g)}$, $\Gamma^{(g)}$ and $\Phi^{(g)}$, $g = 1,\ldots,G$, as matrix-valued functions of a common vector of parameters θ, where θ collects the unknown independent elements of the matrices $B^{(g)}$'s, $\Gamma^{(g)}$'s and $\Phi^{(g)}$'s.

Equations (1) and (2) imply

$$z_i^{(g)} = G^{(g)}\begin{pmatrix}(I - B^{(g)})^{-1}\Gamma^{(g)} \\ I\end{pmatrix}\xi_i^{(g)} = \Lambda^{(g)}\xi_i^{(g)} \qquad (3)$$

say, where

$$\Lambda^{(g)} = G^{(g)}\begin{pmatrix}(I - B^{(g)})^{-1}\Gamma^{(g)} \\ I\end{pmatrix};$$

hence, the moment matrices $\Sigma^{(g)} = Ez_i^{(g)}z_i^{(g)}{}'$, g = 1,…,G, can be expressed as

$$\Sigma^{(g)} = \Lambda^{(g)}\Phi^{(g)}\Lambda^{(g)}{}' = \Sigma^{(g)}(\theta),$$

since, for a given model, the $G^{(g)}$'s are known matrices and the $\Phi^{(g)}$'s, $B^{(g)}$'s and $\Gamma^{(g)}$'s are matrix-valued functions of θ.

The analysis proceeds by fitting by GLS the $\Sigma^{(g)}(\text{q})$'s to the sample moment matrices $S^{(g)} = \frac{1}{n}\sum_{i=1}^{n_g} z_i^{(g)} z_i^{(g)}{}'$, g = 1,…,G. We use the following GLS fitting function:

$$F_{GLS}(\text{q}) = \frac{1}{2}\sum \frac{n_g}{n}\, tr\left\{(S^{(g)} - \Sigma^{(g)})S^{(g)-1}\right\}^2 ,$$

where $\Sigma^{(g)} = \Sigma^{(g)}(\text{q})$ and $n = n_1 + \ldots + n_G$. The minimizer $\hat{\text{q}}$ of $F_{GLS}(\text{q})$ is a minimum-distance estimator that is asymptotically optimal when the $z_i^{(g)}$'s are iid normally distributed (see, e.g., Satorra, 1989).

For general type of distributions, asymptotic robust standard errors and test statistics can be developed. Define[3]

$$\text{s} = (\text{s}^{(1)},\ldots,\text{s}^{(G)})',$$

with $\text{s}^{(g)} = \text{vech}\Sigma^{(g)}$;

$$s = (s^{(1)},\ldots,s^{(G)})',$$

with $s^{(g)} = \text{vech}S^{(g)}$; the Jacobian matrix $R = \frac{\text{¶s}}{\text{¶q}'}\Big|_{\text{q=q}}$; and, finally,

$$V = \text{diag}\left\{\frac{n_1}{n}V^{(1)},\ldots\frac{n^{(G)}}{n}V^{(G)}\right\}$$

with

$$V^{(g)} = \frac{1}{2}D'(\Sigma^{(g)-1} \otimes \Sigma^{(g)-1})D. \qquad (4)$$

Under this set-up, the general expression for the variance matrix of estimates is

$$\text{avar}(\hat{\text{J}}) = \frac{1}{n}J^{-1}R'V\Gamma VRJ^{-1}, \qquad (5)$$

---

[3] For a symmetric matrix A, $\text{vec}A = D\text{vech}A$ where D is the so-called duplication matrix and “vec” denotes the usual vectorization of a matrix (see Magnus and Neudecker, 1991).

where $J = R'VR$ and Γ is the asymptotic variance matrix of s. The above variance matrix can be estimated substituting V, R and Γ for corresponding consistent estimates. A consistent estimate $\hat{V}$ of V is obtained by substituting in (4) $S^{(g)}$ for $\Sigma^{(g)}$; a consistent estimate $\hat{R}$ of R is obtained by evaluating R at the estimated value $\hat{\theta}$. Finally, an estimate of Γ that is consistent under general distribution conditions is

$$\hat{\Gamma} = \operatorname{diag}\left\{ \frac{n}{n^{(1)}} \hat{\Gamma}^{(1)}, \ldots, \frac{n}{n^{(G)}} \hat{\Gamma}^{(G)} \right\}$$

where

$$\hat{\Gamma}^{(g)} = \frac{1}{n^{(g)}} \sum_{i=1}^{n^{(g)}} h_i^{(g)} h_i^{(g)\prime},$$

with $h_i^{(g)} = \operatorname{vech}(z_i^{(g)} - s^{(g)})(z_i^{(g)} - s^{(g)})'$ and $s^{(g)} = \operatorname{vech} S^{(g)}$. Under normality of the $z_i^{(g)}$'s, the expression of Γ is such that the estimates' asymptotic variance matrix simplifies to

$$\operatorname{avar}(\hat{\vartheta}) = \frac{1}{n} J^{-1}, \tag{6}$$

an expression which we call the normal theory (NT) form of the variance matrix of estimates. See Satorra (1993) for full details on the derivations of the above results.

The test statistic for the goodness-of-fit of the model is obtained as n times the minimum of the fitting function, i.e. $T = nF_{GLS}(s, \hat{\sigma})$. When the model is true and the distribution assumptions are met, then it can be shown that T is a chi-square statistic of r degrees of freedom, where r is the number of independent restrictions implied by the model on the set of moment matrices. Under general distributional assumptions, a scaled version of this statistic that is approximately chi-square distributed despite non-normality has been developed (Satorra and Bentler, 1994). The scaled statistic is defined as $\bar{T} = c^{-1} T$ where

$$c = r^{-1}\mathrm{tr}\left\{(\hat{V} - \hat{V}\hat{R}\hat{J}^{-1}\hat{R}'\hat{V})\hat{\Gamma}\right\}$$

where r is the degrees of freedom of the goodness-of-fit test.

When there are variables that show an infrequent purchase pattern (in our paper, durable and medical expenditures), we assume that the observed values of the variable are the result of censoring an underlying normal variable. In this case we modify the matrices $S^{(g)}$ used. In a first stage of the analysis, the matrices $S^{(g)}$ are computed as consistent estimates of the moment matrix involving the underlying uncensored variables. The modified matrices $S^{(g)}$, with a modification of the estimate $\hat{\Gamma}$ of Γ, are obtained using the PRELIS computer software of (Jöreskog and Sörbom, 1997). Once we have the new matrices $S^{(g)}$'s and the new estimate $\hat{\Gamma}$, the analysis proceeds using the minimum-distance approach described above.

APPENDIX 2: PROGRAM CODE

In this appendix we reproduce PRELIS and LISREL code used in this paper.

PRELIS Code:

```
DA NI=7 NO=2600 MI= -999999 TR=LI
LA
GROUP NMEMB DURABLE TMY_1 TNMY_1 TMY_2 TNMY_2
RA=C:\WINDOWS\TEMP\~LS3963.TMP FO; (8F15.6)
OR GROUP
CO NMEMB
CB DURABLE
CO TMY_1
CO TNMY_1
CO TMY_2
CO TNMY_2
CL GROUP 1 = YOUN 2 = CHIL 3 = TEEN 4 = ADUL 5 = OLD
SC 1 =1
OU MA=AM
```

LISREL Code:

```
MULTIGROUP ANALYSIS. EQUALITY CONSTRAINTS ON THE REGRESSION
COEFICIENTS OF
THE TWO FACTORS UNDERLIYING INCOME IN THE PRODUCT EQUATION.

TI LIFE-CYCLE  EFFECTS ON TRANSPORTATION-   GROUP 1
DA NI=7 NO=278 NG=5 MA=CM
LA
NMEMB TRANSPOR TMY_1 TNMY_1 TMY_2 TNMY_2 CONSTANT
CM FI=C:\DATA\LISREL~1\COVARI~1\GROUP1.AM SY
AC FI=C:\DATA\LISREL~1\COVARI~1\GROUP1.ACM
SE
1 2 3 4 5 6 7/
MO NY=7 NE=5 BE=FU,FI PS=SY,FR TE=DI
LE
NMEMB TRANSPOR F1 F2 CONSTANT
FI TE(1,1), TE(2,2),TE(7,7)
FI PS(2,1), PS(3,2), PS(4,2), PS(5,1), PS(5,2), PS(5,3),PS(5,4), PS(5,5)
FR BE(2,1), BE(1,5), BE(2,3), BE(2,4), BE(2,5)
FR LY(3,5), LY(4,5), LY(5,3), LY(5,5), LY(6,4), LY(6,5)
VA 1 LY(1,1) LY(2,2) LY(3,3) LY(4,4) LY(7,5) PS(5,5)
ST 1.0 ALL
PD
OU ME=ML   IT=550 AD=OFF SE TV

TI LIFE-CYCLE  EFFECTS ON TRANSPORTATION-   GROUP 2
DA NI=7 NO=896 MA=CM
LA
NMEMB TRANSPOR TMY_1 TNMY_1 TMY_2 TNMY_2 CONSTANT
CM FI=C:\DATA\LISREL~1\COVARI~1\GROUP2.AM SY
AC FI=C:\DATA\LISREL~1\COVARI~1\GROUP2.ACM
SE
```

```
1 2 3 4 5 6 7/
MO
FI TE(1,1), TE(2,2), TE(7,7)
FI PS(2,1), PS(3,2), PS(4,2), PS(5,1), PS(5,2), PS(5,3),PS(5,4), PS(5,5)
FR BE(2,1), BE(1,5), BE(2,3), BE(2,4), BE(2,5)
FR LY(3,5), LY(4,5), LY(5,3), LY(5,5), LY(6,4), LY(6,5)
VA 1 LY(1,1) LY(2,2) LY(3,3) LY(4,4) LY(7,5) PS(5,5)
ST 2.0 ALL
EQ BE 1 2 3 BE 2 3
EQ BE 1 2 4 BE 2 4
PD
OU IT=550 SE TV AD=OFF

TI LIFE-CYCLE EFFECTS ON TRANSPORTATION-   GROUP 3
DA NI=7 NO=586 MA=CM
LA
NMEMB TRANSPOR TMY_1 TNMY_1 TMY_2 TNMY_2 CONSTANT
CM FI=C:\DATA\LISREL~1\COVARI~1\GROUP3.AM SY
AC FI=C:\DATA\LISREL~1\COVARI~1\GROUP3.ACM
SE
1 2 3 4 5 6 7/
MO
FI TE(1,1), TE(2,2),TE(7,7)
FI PS(2,1), PS(3,2), PS(4,2), PS(5,1), PS(5,2), PS(5,3),PS(5,4), PS(5,5)
FR BE(2,1), BE(1,5), BE(2,3), BE(2,4), BE(2,5)
FR LY(3,5), LY(4,5), LY(5,3), LY(5,5), LY(6,4), LY(6,5)
VA 1 LY(1,1) LY(2,2) LY(3,3) LY(4,4) LY(7,5) PS(5,5)
ST 3.0 ALL
EQ BE 1 2 3 BE 2 3
EQ BE 1 2 4 BE 2 4
PD
OU IT=550 SE TV AD=OFF

TI LIFE-CYCLE EFFECTS ON TRANSPORTATION-   GROUP 4
DA NI=7 NO=380 MA=CM
LA
NMEMB TRANSPOR TMY_1 TNMY_1 TMY_2 TNMY_2 CONSTANT
CM FI=C:\DATA\LISREL~1\COVARI~1\GROUP4.AM SY
AC FI=C:\DATA\LISREL~1\COVARI~1\GROUP4.ACM
SE
1 2 3 4 5 6 7/
MO
FI TE(1,1), TE(2,2),TE(7,7)
FI PS(2,1), PS(3,2), PS(4,2), PS(5,1), PS(5,2), PS(5,3),PS(5,4), PS(5,5)
FR BE(2,1), BE(1,5), BE(2,3), BE(2,4), BE(2,5)
FR LY(3,5), LY(4,5), LY(5,3), LY(5,5), LY(6,4), LY(6,5)
VA 1 LY(1,1) LY(2,2) LY(3,3) LY(4,4) LY(7,5) PS(5,5)
ST 1.0 ALL
EQ BE 1 2 3 BE 2 3
EQ BE 1 2 4 BE 2 4
PD
OU IT=550 SE TV AD=OFF

TI LIFE-CYCLE EFFECTS ON TRANSPORTATION-   GROUP 5
DA NI=7 NO=426 MA=CM
LA
NMEMB TRANSPOR TMY_1 TNMY_1 TMY_2 TNMY_2 CONSTANT
CM FI=C:\DATA\LISREL~1\COVARI~1\GROUP5.AM SY
AC FI=C:\DATA\LISREL~1\COVARI~1\GROUP5.ACM
```

```
SE
1 2 3 4 5 6 7/
MO
FI TE(1,1), TE(2,2),TE(7,7)
FI PS(2,1), PS(3,2), PS(4,2), PS(5,1), PS(5,2), PS(5,3),PS(5,4), PS(5,5)
FR BE(2,1), BE(1,5), BE(2,3), BE(2,4), BE(2,5)
FR LY(3,5), LY(4,5), LY(5,3), LY(5,5), LY(6,4), LY(6,5)
VA 1 LY(1,1) LY(2,2) LY(3,3) LY(4,4) LY(7,5) PS(5,5)
ST 1.5 ALL
EQ BE 1 2 3 BE 2 3
EQ BE 1 2 4 BE 2 4
PD
OU IT=650 SE TV AD=OFF
```