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Euler Equations and Durable Goods

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Abstract

This paper deals with the estimation of the Euler Equation when durable consumption is taken into account. If durables are not separable in utility from non-durables, estimating the Euler Equation without conditioning on them leads to incorrect inference. I use microdata on non-durable and durable consumption from a US rotating panel, the Consumer Expenditure Survey (CEX). I concentrate on cars (new and used). Apart from housing, they represent the largest share of durable expenditure in the sample. I find an estimate of the intertemporal rate of substitution which is higher than in the case where durable goods are not conditioned on, while the evidence on the excess sensitivity is more mixed.

JEL classification: D91

Keywords: Euler equation, durable goods, intertemporal substitution.

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1 Introduction

A number of explanations have been suggested for the empirical failure of the life-cycle/permanent income hypothesis (LC/PI) through the testing of the Euler Equation for non-durable consumption (for a recent survey see Browning and Lusardi [10]).

In this paper I suggest that omitting durable goods from the set of 'regressors' in the Euler Equation leads to biased estimates of the parameters of interest. Thus, this work belongs to the set of contributions which consider the misspecification of preferences as a possible source of bias in the estimate of the Euler Equation.

Since the work of Mankiw [20], the literature has tried to assess the ability of the LC/PI model to generate the observed patterns of durable goods expenditure. Despite the wide interest that the durability issue has encountered among researchers, very little attention has been paid to investigate the role of durability for the dynamic properties of the non-durable consumption in *itself*. One noticeable exception is the article by Bernanke [7], who models the *joint* behvior of non-durable and durable expenditures using U.S. aggregate data and finds the non-separability between durable and non-durable goods to be unimportant.

There are several grounds on which the omission of the durable goods might endanger the empirical evaluation of the LC/PI model. First of all, if the durable goods are non-separable in utility from the non-durable goods, not conditioning on them would lead to biased inference. They bring an element of intertemporal non-separability into the individual problem. The presence of intertemporal non-separabilities makes the inference on the model much harder. This is so because individuals try to smooth a *weighted* average of past and present consumption. A increase of the consumption today depresses the marginal utility of consumption tomorrow, which makes the change in consumption to display a negative serial correlation. If the changes in income are negatively correlate (for instance, if they follow an MA(1) with negative coefficient) credit constraints are observationally equivalent to durability.

Moreover, while non-durable consumption is equivalent to the flow of services individuals enjoy, this is not the case for durable goods. This distinction is not vacuous since the theory delivers predictions in terms of what individuals enjoy. That means that individuals can still smooth over the flow of services from a durable good when they are liquidity constrained (see Browning and Crossley [9]). For instance, if they receive a negative shocks they may delay the date at which the old durable good is replaced.

Last, since stock of durable goods, such as cars, might exhibit an hump-shaped life-cycle profile, they can account for the concavity of the non-durable life-cycle profile observed in the micro data. They can play a role complementary or substitute for that of the demographics.

The main goal of this work is to see if the available results on the estimation of Euler Equation for *non-durable consumption* are robust to the omission of the durable goods. The key parameters I look at are those governing the intertemporal substitution of non-durable consumption, the non-separability of non-durable versus durable goods and the excess sensitivity parameter. I perform a conditional exercise that is robust to the determinants of the intratemporal choice over non-durable and durable goods. In other words, the validity of my results does not depend on the particular nature of the cost of adjusting the stock of durable goods. The omitted variable argument introduced above is effectively independent of whether or not the feasibility set the individuals face is convex.

Mainly due to a problem of data availability, the main difficulty being how to measure the stock of durable goods, there are not many studies using durable goods in an Euler Equation framework.[1] A subset of them tackles the issue of the estimation using microdata . The aggregation issues relevant to non-durable consumption, that the presence of non-convex adjustment cost can exacerbate even further, suggests me to use a sample of microdata. The data are from a representative American survey, the Consume Expenditure Survey.

Cars are the durable good I concentrate on. They represent the most important component of the durable expenditure in the US data, apart from housing.

The paper is organized as follows. In Section 2 an estimable model is derived and identification is discussed. Section 3 describes the data and the procedure used to compute the value of the stock of cars, while Section 4 discusses the estimation and the results. The last section concludes.

2 What Can Be and What Cannot Be Identified From the Euler Equation

The question I want to address here is whether omitting durable goods from an Euler Equation for non-durable consumption matters. To do this, I estimate an Euler Equation augmented for the presence of the stock of durable

[1] See, for example, Alessie et al. [1], Bernanke [6], [7] and Hayashi [17], Lam [19].

goods. In this section I derive the first-order condition to be exploited in the estimation and I explain what parameters I can recover from the estimation of such equation.

The model used here has a conditional nature in that no attention is paid to the mechanism governing the intratemporal allocation between durable and non-durable goods. The argument I make is similar to the one used by Browning and Meghir [11] to address the non-separability of consumption from labor choices.

In principle both the neoclassical and a non-convex adjustment cost model could be integrated in this approach using a flexible enough stochastic specification. In the model exposition, I assume that the households feasibility set is convex. Simple algebra shows that the Euler Equation holds in the same form in presence of non-convexities relevant.

In deriving the Euler Equation I follow the non-conventional approach taken by Attanasio and Browning [5]. Instead of specifying an utility function, they model the log of the indirect marginal utility of the consumer's expenditure. The main advantage of following this approach in the present context is to avoid the need of imposing any restriction on the parameters to guarantee that the marginal utility has the usual properties.

First, I specify the within period indirect utility which take the following form:

$$V(p,x,z) = v\left(\frac{x}{\alpha(p,z)}, z\right) + \psi(p,z) \tag{1}$$

where p is the price vector, x is the total outlay, $\alpha(p,z)$ is a price index which depends of a set of conditioning variable z. This paper comes to the role of durable goods including the stock of vehicles in the set of the conditioning variables. Finally, ψ is homogeneous of degree zero in p.

Next, I turn to the identification of the intertemporal rate of substitution. As shown by Browning [8] in a multi-goods model, the intertemporal elasticity of substitution is defined as

$$\eta(p,z,x) = \frac{V_x}{xV_{xx}} = \frac{v_c}{cv_{cc}} \tag{2}$$

where $c = \frac{x}{\alpha(p,z)}$. The Euler Equation for this problem is:

$$E_t[\rho\lambda_{t+1}(1+R_{t+1})] = \lambda_t \tag{3}$$

where λ_t is the marginal utility of wealth, ρ is the economy-wide discount rate and R_{t+1} is the nominal interest rate. It holds in the usual form, independently of the intratemporal allocation condition. This is so because the Euler Equation is a condition that relates to the ability of the consumer to smooth utility and, ultimately, wealth over time and states of nature. A more general problem is which aspects of preferences and, in the present notation, which aspects of the function $V(.)$ can be recovered and which cannot from the estimation of the Euler Equation. In particular, Euler Equations allow me to identify a subset of the preference parameters set. To identify the full set of parameters, I need also the within-period marginal rate of substitution. Thus, in this exercise the stock of durable goods is treated as a conditioning good. This makes the estimates presented here to share a partial information nature. For reasons that will be clear below, instruments provide identification.

To estimate equation (3) I need to observe λ_t. To make λ_t observable I differentiate the Lagrangean associated with the consumer's problem with respect to c, thus obtaining the envelope condition which allows us to rewrite (3) as:

$$v_{c_{t+1}}(1+R_{t+1})\frac{\alpha(p_t,z_t)}{\alpha(p_{t+1},z_{t+1})}\rho = v_{c_t}\varepsilon_{t+1} \tag{4}$$

where $E_t[\varepsilon_{t+1}] = 1$. Now, I assume that:

$$\ln v_{c_t}(c_t,z_t) = \frac{1}{\sigma}(-\ln c_t + \beta q_t + \gamma k_t) \tag{5}$$

where the vector of shifters z is partitioned in two parts: a vector of pure taste shifters and k, which is the stock of vehicles. The choice of this specification deserves some comments. First, this specification makes the model linear in the parameters of interest after log-linearizing. Second, this preference specification consistently aggregates over consumers. Attanasio and Weber [2] show that the bias arising from inconsistent aggregation can be dramatic. Third, the methodology used to construct the stock of vehicles requires it to enter linearly the estimating equation. This is so because the stock of vehicles is computed at cohort level as an average. Fourth, with this specification the marginal utility of not owning cars is finite.[2]

According to (5), the taste shifters act as state variable for the household problem. These variables shift the utility the households enjoy from a given consumption bundle. Consequently, they are treated as conditioning variable in the estimation. Notice that the possible endogeneity of fertility and labor supply decisions is not theoretically addressed. However, appropriate instrumenting 'solve' the question from an empirical point of view. Using

[2] The log of the marginal utility of non-durable consumption is a linear function of the stock of durable goods.

the above specification , the envelope condition and after log-linearizing , (3) can be written as:

$$E_t \left(\Delta \ln c_{t+1} - const - \beta' \Delta q_{t+1} - \sigma R_{t+1} - \gamma' \Delta k_{t+1} \right) = 0 \qquad (6)$$

where in general the constant term depends on the moments of order higher than one of the distribution of the growth rate of non-durable consumption conditional on the interest rate and absorbs the discount rate, while the expected value is taken with respect to the information available at time t. Thus, I omit from the estimating equation the variance of the growth rate of the consumption. While I am very well aware of the fact that the omission of this term can generate an omitted variable bias akin to that considered here and I believe that the precautionary motive for saving could be a potential important explanation of the observed pattern of non-durable consumption (see Carroll [13]), I would argue that whether or not this omission is 'relevant' is an empirical question which can be handled testing the specification of the model[3]. I would emphasize that the only condition I need to consistently estimate the Euler Equation is that the chosen instruments are orthogonal to the residuals of the model. Equation (6) provides the orthogonality condition used in the estimation.

From the model above, it is apparent that the household is assumed to enjoy the consumption of a homogeneous non-durable good. This is far from being correct if some goods entering the definition of the aggregate are luxuries and some other necessities because luxuries and necessities display different elasticities to permanent income. However, I have chosen not to address the issues directly related to the bias coming from aggregation over non-durable gods. This choice can be justified, at least in part, on the ground of the results in Attanasio and Weber [3]. They estimate two sets of equations: one which uses the parameter estimated in a previous stage from a full demand system, the other where a Stone Price index is used. They do not find evidence that the coefficient of the interest rate coefficient is biased if a Stone Price index is used instead of estimating a full demand system.

It is worth noticing that the model turns out to be a two goods model: non-durable vs durable goods (cars). The two step budgeting idea proposed by Browning [12] operates: in a first step consumers decide how much resources to devote to the consumption 'today' and 'tomorrow', in a second step they decide how they allocate their consumption within each period.

The exercise performed here can be regarded as concentrating on the

[3] A related issue is what test I can possibly device to detect the presence of the precautionary motive.

first step only. The question of what is lost when doing this is empirical.[4] Given that only the intertemporal allocation condition for non-durable consumption is used in estimation, the present approach can be viewed as a partial information approach. Efficiency could be enhanced using both the intratemporal and intertemporal conditions,[5] consistency is not in general an issue.[6]

3 The Data

The sample of the data is drawn from the Consumer Expenditure (CEX) Survey ran by the U.S. Bureau of labor Statistics (BLS). The CEX provides a unique opportunity for the exercise proposed here. It gives very detailed information about the model, the brand, the vintage and a rich set of characteristic to evaluate the stock of cars present in each household at each instant in time.

The CEX is not a full panel: households are interviewed for four consecutive quarters and then replaced. For a full description of the CEX, I refer to Attanasio and Weber [3].

The CEX data used in the present work come from the expenditure files (containing information on non-durable and durable expenditure), from the family files (containing demographics) and from owned vehicle Part B (detailed questions) and Part C (disposal) files. These last two files provide information on the stock and on the disposal of vehicles respectively and have been run since 1984.

Even if data on expenditure and demographics are available since 1980 (since that date the (BLS) has been running the Survey on a continuous basis), considerations about the quality of the data suggest discarding the first two years of the Survey. The latest interviews included were carried

[4] In general, from a demand system with non-durable goods the full system of preferences can be identified up to a monotonic transformation which is identified by the intertemporal condition.

[5] Conditioning on the relative prices to control for the intratemporal piece of information does not seem viable as long as households with no cars are observed.

Alternatively, I could stratify the sample by car ownership and then allow for a correction mechanism.

[6] The argument does not go through smoothly when households are liquidity constrained and durable goods can be used as a collateral. In this case the Euler Equation has a different form and the possibility of using the durable goods as a collateral make the intertemporal allocation condition not independent of the intratemporal allocation condition. However, this dependence goes through the stock of vehicles at time t that is given when conditioning on information available at that time.

out in the 1st quarter 1996.

The CEX is run by the BLS to construct the Consumer Price Index (CPI). This ensures the representativeness of the sample and the consistency of the expenditure categories with the corresponding price data.

I select out non-urban households, households residing in a student housing, households with incomplete income response, those aged more than 73 and less that 21. Overall, I am left with 217056 interviews .

Given that I cannot follow the same household for more than four quarters, I stratify the sample in 13 cohorts, by year of birth. Each cohort, but cohort 1, 12 and 13, covers an interval of 5 years of birth. The first cohort group those individuals born in 1909, the second those born between 1910 and 1914, the eleventh those born between 1955 and 1959. Table 1 reports report the cohort definition.

3.1 Expenditure, Demographics and Macro-Data

The main results refer to a basic measure of non-durable consumption. The inclusion of the so-called semi-durable and of small durable goods does not seem to affect consistently the pattern of the results. Non-durable consumption includes expenditure on food (defined as the sum of food at home, food away from home, alcohol and tobacco) and expenditure on other non-durable goods and services, such as heating fuel, public and private transport and personal care. Semi-durable consumption includes expenditure on clothing (defined as the sum of men, women, boy and girl clothing) and footwear, while small durable goods include computers, toys, pets, and household appliances. I leave out housing, health and personal education expenditure.

The expenditure data consists of monthly figures and refer to the three months before the interview. To construct quarterly data, at least two possibilities can be explored. Either I can average monthly data or I can pick one month of data. This second possibility is taken due to time aggregation considerations (if the expenditure variables are measured with a white error time averaging makes them to contain a MA(2) error). To simplify further the error structure only the first month preceding the interview is retained.

To keep the specification parsimonious few demographic and labor supply variables are considered to control for heterogeneity. I control for family size, the potential non-separability between consumption and leisure and for female labor market participation.

Three measures of income are considered: the wage and salary income received by family members in the 12 months preceding the interview, total family income before taxes, total family income after taxes.

The interest rate is the return on Municipal Bonds, that is tax-exempt, thus avoiding the need to compute the marginal tax rate. The *Economic Report of President 1996* reports an average of A graded bonds as computed by S&P. The CPI's published monthly by BLS are the price data used to compute the real counterpart of the expenditure variable considered here. Such indices are region-specific which adds cross-sectional variability. As stressed above these price indices match exactly the expenditure categories considered. For data consistency, the CPI's version before the recent revision is the one I used. With the CPI's on hand, household-specific price indices data are computed as weighted geometric average, using as a weight the budget share of each expenditure category (i.e. a Stone Price Index is computed). I do not estimate a demand system due to the conditional nature of the model.

In Figures 1 and 2 the log of non-durable consumption and the log of the family income after taxes are plotted against the age of the head of the household. Non-durable consumption is computed as the sum of all the expenditure categories. The profile of both consumption and income is hump-shaped. This called for a rejection of the LC-PI model in its simplest version (see Carroll and Summers [14]).

In Figure 3 the family size against age is plotted. The profile of the family size is hump-shaped, too. This could take account for the shape of the non-durable consumption, as pointed out by Attanasio and Weber [3]. My guess is that the concavity of the non-durable consumption profile could also be related to the fact that household seem to accumulate durable goods at the earlier stage of their life and later to decumulate (see Figure 4)

3.2 Vehicle Expenditure and the Stock of Vehicles

In what follows the term vehicles and cars will be used as synonymous, even if the CEX definition of vehicles is broader.[7] The CEX allows to distinguish between expenditure for new and used vehicles. This distinction is not minor given that new and used vehicles are expected to have different depreciation patterns. Accordingly, two trade-in allowance variables are defined: for new and used vehicles. Moreover, information on the amount received by the household for sold vehicles and the amount reimbursed to the household for vehicle damage or theft are recorded.

In sum, three definitions of vehicle net expenditure apply. The first is total vehicle expenditure, given by the expenditure for new vehicle plus

[7]In the definition used here, motorbikes, boats and airplanes are not included.

expenditure for used vehicles minus the trade-in allowance for new vehicles minus the trade-in allowance for used vehicles minus the amount of vehicles that have been sold or reimbursed. The other two definitions distinguish between new and used total vehicle expenditure.

Quarterly stock of vehicles is computed iterating the cohort average version of the following:

$$k_{t+1} = (1-\delta)k_t + i_{t+1} \tag{7}$$

As initial condition I use the cohort average of the stock of cars data at household level drawn from the Attanasio's study on *Ss* rules [4]. These values are reported in Table 2 below.

The methodology used is similar to that in Davies, Devereux and Weber [15] with UK data: the difference is that they compute the value of stock of vehicles from a data source (The National Travel Survey for the type and age of car owned and The Glass's Guide for the price of car) and, then, impute it to the households in Family Expenditure Survey using a reduced form equation that relates households characteristics to the car value.[8] Before going into the details of how I compute the value of the stock of vehicles, it is worth mentioning some of the aspects of the procedure adopted by Attanasio [4]. In that paper he uses data from the owned vehicles Part B and Part C files are used (then the first year of available data is 1984). These files record very detailed information on the vehicles owned by each household (type of vehicle, vehicle year, vehicle make model and other information aiming to correctly price the vehicle). When the price of the vehicle is not available, the data from the *Kelly Blue Books* are used. These books provide a wide range of prices on used vehicles and allow to evaluate the stock of vehicles at a given date in a reasonably precise way.

In the present framework, I could follow two routes to compute the quarterly stock of vehicles. Either the above formula is iterated at a monthly basis and then the quarterly stock is computed; or the quarterly expenditure is computed first and then the formula is iterated quarterly. To minimize the number of iterations,[9] the second route is chosen.[10] The stock of vehicles is computed in real terms along the lines described in the previous section. Given that the starting year is 1984, equation (7) is iterated back and forward.

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[8]Indeed, the main similarity is the use of the perpetual inventory method.

[9]Potentially, an error is associated with each iteration. In fact, if households systematically underreport their disposal of vehicles, the procedure tends to underestimate the stock when integrating back and overestimate when integrating forward.

[10]Estimation results with the stock of vehicles computed as in the first approach do not differ in a substantial way.

The missing piece of information I need to implement the above procedure is the depreciation rate. The depreciation has both a physical and an economic nature. In principle, it could be estimated from the price data[11]. Given that the main purpose of the exercise is not to model the depreciation patterns of the cars, I assume the stock of cars to depreciate geometrically. Some of the available evidence suggests that this is not a bad approximation (Hall [16]). Thus, I construct my measure of the stock of cars under various assumptions on the depreciation rate. Two set of experiments are performed. In the first set (rows numbered from 1 to 4 in Table 3) the depreciation rate is assumed to be the same for new and used cars. In the second (rows numbered from 5 to 10) I set three different depreciation rates: one for new cars, one for used cars and one for the starting value of the stock of cars. The full description of the experiments is provided in Table 3. The depreciation rate in the row numbered as 3 is roughly equal to that estimated for motor vehicles by the Bureau of Economic Analysis (BEA).

It is not easy to assess the quality of this procedure[12]. One way to do it is to compare the stock of cars so obtained with that obtained from Attanasio [4]. That amounts to compare the value of end-of-period stock of cars. From this, it seems that the values obtained here are reasonably close to the value obtained from the Attanasio's [4] data.

In Figure 5 the stock of cars is plotted against time for each cohort. The first four graphs from the left correspond to the experiments numbered from 1 to 4. The rest of the figure refers to experiment from 5 to 10. In these last, which allow for different depreciation pattern for new and used cars, the stock of cars i increases for young cohorts and then becomes flat when cohorts age.

4 Estimation

Synthetic panel techniques are used because the data come in form of time-series of cross-section. I just assume that the condition[13] under which the

[11]However, the estimation of the depreciation rate from the price data is not trivial. Endogeneity caveats apply since the choice of a given car and its depreciation rate are potentially simultaneous.

[12]I have compared the growth rate of the stock of cars obtained from my calculations with a measure of the aggregate obtained the data on autos published by the BEA. Averaging over all the experiments I performed I obtain a growth rate roughly comparable to that of the BEA, the roughly qualifier applying because the aggregate data are in per-capita form while my data are in per-household form.

[13]The debate on the virtue and limitations of using grouped data is huge: the issue 59 of the Journal of Econometrics surveys it.

synthetic panel approach is valid are satisfied. More precisely, the grouping criteria is assumed to be exogenous and the individual information set to smoothly aggregate up its cohort analogous (about this last problem, see Pischke [21]). Given that the main goal of the work is to obtain a model that is comparable to those already existing in the literature using the same data, this does not seem to be a dramatic simplification .

In the estimation, I exclude the first, the second, the third, the last two cohorts. This should prevents my estimates from being contaminated by extreme outliers. The sample restrictions ($t = 1982:1, ..., 1996:1$ and $c = 4, ..., 11$ where t and c are the quarter and cohort indices respectively) make the synthetic panel to be balanced. This simplifies the construction of the estimator. I end up with $T = 56$ (quarterly data are used) and $C = 8$. The cell-size is not constant over time and over cohorts. No cell-size correction is allowed for. This is not going to bias the estimates if the number of households for each cell is large. The stochastic structure comes mainly from the rational expectation hypothesis (REH). The theory delivers restrictions on the dynamic properties of the Euler Equation residuals which turn to be the expectation errors. These have to be orthogonal to the past information. Formally,

$$E(\eta_t|\Im_{t-1}) = 0 \tag{8}$$

where η_t is the residual of the Euler equation at time t and $\Im_{t-1}$ is the set of past information. In panel or pseudo-panel data, the sample analog of (8) could be either the cross-sectional or the time series mean. Notice, however, that there are no theoretical reasons to exclude that expectation errors are correlated across households. This is indeed the case when market are incomplete. So, consistency relies on the availability of a long panel.[14]

Regarding the grouped variables as variables measured with error adds an other component to the model. This last makes the Euler Equation residual follow an MA(1) process.[15]

All variables are treated as endogenous in the estimation.[16] The stochastic structure described above leads to choice of lagged 2 and more instruments, which are assumed to be orthogonal to the constant term in the Euler Equation. The literature I refer to does this assumption. Its violation

[14]It is worth stressing that under market incompleteness the Euler Equation cannot be estimated in the cross-section. This is the so-called Chamberlain critique. Even in the case I can estimate the Euler Equation with a cross-section, there is no guarantee that the interest rate is enough variable to identify the main parameter of interest.

[15]The variables in levels contains a white error.

[16]It has been pointed out that at quarterly level family size variable are not endogenous. Treating them as exogenous do not change the results.

invalidates the instruments in that the constant term absorbs the higher moments of the joint distribution of the growth rate of consumption and interest rate.

The matrix of instruments for each cohort is stacked. Alternatively, I could have chosen a set of instrument different for each cohort. Given that households can be interviewed more than once, if fixed effects matter, some care has to be paid to the construction of the instrument matrix to ensure consistency (see Attanasio and Weber [3]). Therefore, I form instruments lagged by two periods using only individuals at their fifth interview, those lagged by three using both individuals at their fifth and at their forth interview while those lagged by four exclude only individuals at their second interview.

The model is, then, estimated using a GMM technique. The construction of the weighting matrix reflects the presence of MA(1) residuals and the fact that I allow for these residuals to be contemporaneously correlated among cohorts. The Hayashi and Sims [18] estimator is used. It first (forward-)filters out from the model the serial dependence and, then, allows for heteroskedasticity of an unknown form. Under the REH, backward filtering would lead to inconsistent estimates.

In order to control for the effect of demographics which tend to concavify the life-cycle consumption profile, I include the growth rate of family size. Moreover, the non-separability with the female labor supply decision is addressed conditioning on a variable measuring the number of earners in each households. Experimenting with a dummy for the working wife does not deliver different results. Potentially the number of earners is a better measure to deal with non-separability between labor supply and consumption decision when the consumption unit does not simply include the head of the households and his spouse.

I report here the results using as income variable wage and earnings perceived by the family members in the 12 months before the interview. While the point estimates of the interest rate and the stock of cars coefficients do not sensibly change with the income measure used, in few cases the evidence on the overidentifying restrictions reject the null.

For the sake of comparability, a standard Euler Equation is estimated without including the stock of cars variables: this is called the baseline model (Table 4). The estimated coefficients are reasonably comparable with those found in the previous exercise using these data. The Sargan test does not reject the overidentifying restrictions.

In the second column of Table 4, the previous specification is augmented by the growth rate of income, as defined above. This is a standard excess sensitivity test: under the null individuals should not react to forecastable income innovations. In a regression context, this asks for the coefficient on the growth rate of income to be zero. Two things should be noticed: the coefficient on the growth rate of income is virtually zero and the Sargan test does not reject the null at the standard level. In the other two columns of Table 4 I report the same specifications than before estimated using OLS. Comparing these estimates with those obtained using GMM gives an informal check of the quality of the instruments. According to the picture displayed in this Table, there is *no* evidence of excess sensitivity.

Next, I turn to the estimation of the baseline specification augmented by the growth rate of the stock of cars. Moreover, I check if the inclusion of the stock of cars variable makes the excess sensitivity test to deliver a different answer. I report four set of results relating to four different experiment on the depreciation rate. The same pattern is found in the full set of results. Each table (Table 5-Table 8) report at the top the depreciation rate used to compute the stock of cars. The first two columns report coefficients estimated using GMM, while the last two columns those estimated using OLS.

The specification chosen seems to work well. The Sargan test does not reject the overidentifying restrictions and the OLS estimate are not close to their GMM homologue. The interest rate coefficient is sensibly higher than in the baseline case. This generates a much steeper non-durable consumption profile. This effect may be due to the non-separability with durable goods. Suppose that the interest rate increases. Individuals might want to postpone both non-durable and durable consumption. On the other hand, the increase of the interest rate causes the user cost to increase, thus reducing the stock of durable goods today and at all feature dates. If this last effect is prevailing, the increase in the interest rate reduce the stock of durable goods. This affects the marginal utility of non-durable consumption if preferences are not separable. If the non-durable and the durable goods are substitute, the marginal utility of non-durable consumption increases when the stock of durable goods decreases. In this case the effect of the interest rate the growth rate of non-durable is reinforced. The opposite is true when non-durable and durable goods are complement in utility.

The coefficient of the growth rate of the stock of cars is significant at a standard level and negative. This suggests that non-separabilities are important and that non-durable and durable goods are substitute. This results contrasts with the available evidence using macrodata(Bernanke [7]).

Finally, all the specifications pass the excess sensitivity test: when I condition on the growth rate of the stock of cars, the coefficient on the growth rate of income dramatically drops. This makes the non-separability between durable and non-durable goods to be potentially relevant for the estimation of the Euler Equation and the empirical testing of the model.

From this first round of estimates, I can conclude that the non-separabilities between non-durable ad durable goods may be an issue in that omitting durable goods from the estimation of the Euler Equation amounts to omit a relevant variable. In other words, this omission makes the parameters of interest to be biased. On the other hand, it is not clear if the inclusion of the stock of durable goods can 'solve' the excess sensitivity puzzle. This is so because also in the baseline specification the coefficient on the growth rate of income does not appear to be statistically different than zero. In particular, this lack of statistical significance could be due to the inability to instrument the growth rate of income : the rank test is 0.046, suggesting that the chosen set of instruments are weak in predicting the growth rate of income. To overcome this problem, I re-estimate the same specifications than above, replacing the growth rate of income with the income lagged by one period. Under the null, the coefficient on this last should be zero: past income belong to the individual information set.

In Table 9 I report the estimates of the baseline specification. The coefficient on the income variable is significant at a standard level and negative. Non-durable consumption displays excess sensitivity. In the Table from 10 to 13 I augment the baseline specification with the stock of cars computed under the same assumptions on the depreciation rate than in Tables 5-8. The novelty in these table is that the inclusion the stock of cars makes the coefficient on the income variable to be statistically insignificant. This can be interpreted as evidence of the fact that when the income variable is properly instrumented, the omission of the stock of durable goods can contribute to explain why the excess sensitivity test reject the null.

5 Conclusions

The large majority of the empirical studies which test the LC-PI model through the Euler Equation do not include any measure of durable consumption among the conditioning variable. This omission can be partly explained by a general problem of measurement of the stocks from where households are assumed to derive utility. This study tries to fill this gap using a very rich source of information, the American Consumer Expenditure Survey. If non-durable and durable consumption are separable in utility, omitting the durable consumption from the estimation of the Euler

Equation does not lead to any bias. As long as this separability cannot be assumed (or the non-separability cannot be rejected), the omission of this durable good could potentially lead to a false rejection of the model.

The exercise performed here suggests that the non-separability between durable and non-durable consumption can be an issue for the evaluation of the theory. The coefficient of the interest rate is sensibly larger than in the case where durable goods are not conditioned upon. The coefficient of the stock of cars is statistically different than zero, which means that the non-separabilities between durable and non-durable might be an issue. Moreover, when the specification I estimate include the stock of cars the evidence on excess sensitivity tends to disappear. Of course, the exclusion of durable goods is not the sole responsible for the rejection of the theory, if any, but the answer which this work offers points into the direction of departing from the standard framework where the choices over non-durable are modelled independently of choices over durable goods.

Table 1				
Cohort Definition				
Cohort	Year of Birth	Age in 1982	Average Cell Size	U.E.
1	1909	73	31	no
2	1910-1914	68-72	190	no
3	1915-1919	63-67	230	no
4	1920-1924	58-62	263	yes
5	1925-1929	53-57	260	yes
6	1930-1934	48-52	246	yes
7	1935-1939	43-47	265	yes
8	1940-1944	38-42	327	yes
9	1945-1949	33-37	418	yes
10	1950-1954	28-32	468	yes
11	1955-1959	23-27	487	yes
12	1960-1966	16-22	564	no
13	≥1967	≤15	247	no

Note: In the first column is the cohort number, in the second the cohort definition, in the third the average age in 1982, in the fourth the average cell-size, while in the last column 'no' stands for not used in the estimation and 'yes' stands or used.

Table 2

Cell Size and Average Stock of Cars, 1984

Cohort	Cell Size	Average Sock of Cars
1	21	2098.333
2	157	3212.279
3	192	4473.213
4	229	4880.836
5	249	5249.038
6	224	6091.652
7	257	5795.866
8	291	5392.927
9	373	5044.728
10	400	4380.69
11	378	3941.405
12	214	3100.18

Note: In the first column is the cohort number. The oldest cohort is 1. The cell-size of each cohort in 1984 is in the second column . In the third column the average stock of cars is reported.

Table 3

Quarterly Depreciation Rate

Depreciation Rate	*I*	*II*	*III*	*IV*
1	.03			
2	.0375			
3	.045			
4	.06			
5		.0375	.045	.03
6		.06	.045	.03
7		.0525	.06	.045
8		.0375	.06	.045
9		.045	.0375	.05
10		.03	.0375	.05

Note: In the first column the number of the experiment is reported. Each row corresponds to the set of depreciation parameters indexing each experiment. Column I refers to the common depreciation rate, column II to the depreciation rate for the stock of cars in 1984, column III to the depreciation rate for new cars and column IV to the depreciation rate for old cars. Experiments labelled from 1 to 4 refer to the case where the same depreciation rate is assumed for both new and used cars. Experiments from 5 to 10 refer to the case where three different depreciation rate are assumed: for the stock of cars in 1984, for new cars and for old cars.

Table 4

	GMM	GMM	OLS	OLS
Interest Rate	1.16	1.05	0.61	0.59
(0.43)	(0.40)	(0.45)	(0.23)	(0.23)
Growth Rate of Family Size	0.64	0.65	0.35	0.37
(0.07)	(0.30)	(0.32)	(0.08)	(0.08)
Change in Number of Earners	0.27	0.42	0.19	0.14
(0.09)	(0.21)	(0.21)	(0.04)	(0.05)
Growth Rate of Income		-0.06		0.02
(0.046)		(0.06)		(0.01)
Sargan	19.7	13.61		
p-value	0.23	0.55		

Note: The dependent variable is the growth rate of non-durable consumption. In the first column is the right-hand variable name and in parentheses is the R^2 of the first stage regressions.The columns headed by GMM report the GMM estimates, those by OLS the OLS estimates. Standard Errors are in parentheses. The instruments used are: the lag two and three of the growth rate of non-durable consumption and its square, the nominal interest rate, the inflation rate, the car expenditure; the lag two, three and four of the growth rate of the number of earners, the number of children and of the grwoth rate of the income . All the specifications include a constant and three seasonal dummies.

Table 5

$\delta = 0.0375$

	GMM	GMM	OLS	OLS
Interest Rate	1.86	1.84	0.61	0.59
(0.43)	(0.60)	(0.67)	(0.23)	(0.23)
Growth Rate of Family Size	0.54	0.53	0.35	0.36
(0.07)	(0.33)	(0.33)	(0.08)	(0.08)
Change in Number of Earners	0.40	0.44	0.19	0.14
(0.09)	(0.20)	(0.23)	(0.04)	(0.05)
Change in Stock of Vehicles	-0.80	-0.78	0.003	-0.04
(0.24)	(0.40)	(0.46)	(0.11)	(0.12)
Growth Rate of Income		-0.01		0.02
(0.046)		(0.07)		(0.01)
Sargan	12.74	11.31		
p-value	0.62	0.66		

Note: The dependent variable is the growth rate of non-durable consumption. In the first column is the right-hand variable name and in parentheses is the R^2 of the first stage regressions.The columns headed by GMM report the GMM estimates, those by OLS the OLS estimates. Standard Errors are in parentheses. The instruments used are: the lag two and three of the growth rate of non-durable consumption and its square, the nominal interest rate, the inflation rate, the car expenditure; the lag two, three and four of the growth rate of the number of earners, the number of children and of the grwoth rate of the income . All the specifications include a constant and three seasonal dummies. δ refers to the quarterly depreciation rate.

Table 6

$\delta = 0.045$

	GMM	GMM	OLS	OLS
Interest Rate	1.80	1.77	0.61	0.59
(0.43)	(0.59)	(0.65)	(0.23)	(0.23)
Growth Rate of Family Size	0.54	0.53	0.35	0.36
(0.07)	(0.33)	(0.33)	(0.08)	(0.08)
Change in Number of Earners	0.39	0.43	0.19	0.14
(0.09)	(0.20)	(0.23)	(0.04)	(0.05)
Change in Stock of Vehicles	-0.90	-0.85	0.002	-0.046
(0.22)	(0.44)	(0.50)	(0.12)	(0.12)
Growth Rate of Income		-0.02		0.02
(0.046)		(0.07)		(0.01)
Sargan	12.69	11.25		
p-value	0.62	0.66		

Note: The dependent variable is the growth rate of non-durable consumption. In the first column is the right-hand variable name and in parentheses is the R^2 of the first stage regressions.The columns headed by GMM report the GMM estimates, those by OLS the OLS estimates. Standard Errors are in parentheses. The instruments used are: the lag two and three of the growth rate of non-durable consumption and its square, the nominal interest rate, the inflation rate, the car expenditure; the lag two, three and four of the growth rate of the number of earners, the number of children and of the grwoth rate of the income . All the specifications include a constant and three seasonal dummies. δ refers to the quarterly depreciation rate.

Table 7

$\delta_0 = 0.0375, \delta_n = 0.045, \delta_u = 0.03$

	GMM	GMM	OLS	OLS
Interest Rate	1.94	1.92	0.60	0.60
(0.43)	(0.62)	(0.70)	(0.23)	(0.23)
Growth Rate of Family Size	0.53	0.53	0.35	0.36
(0.07)	(0.33)	(0.34)	(0.08)	(0.08)
Change in Number of Earners	0.39	0.44	0.19	0.14
(0.09)	(0.21)	(0.23)	(0.04)	(0.05)
Change in Stock of Vehicles	-0.82	-0.78	-0.002	-0.045
(0.25)	(0.40)	(0.46)	(0.11)	(0.12)
Growth Rate of Income		-0.02		0.02
(0.046)		(0.07)		(0.01)
Sargan	12.63	11.18		
p-value	0.63	0.67		

Note: δ_0 refers to the depreciation rate for the initial stock of cars, δ_n to the depreciation rate for new cars and δ_u to the depreciation rate for used cars.

Table 8

$\delta_0 = 0.0525, \delta_n = 0.06, \delta_u = 0.045$

	GMM	GMM	OLS	OLS
Interest Rate	1.72	1.70	0.61	0.60
(0.43)	(0.56)	(0.62)	(0.23)	(0.23)
Growth Rate of Family Size	0.55	0.53	0.35	0.36
(0.07)	(0.33)	(0.34)	(0.08)	(0.08)
Change in Number of Earners	0.39	0.43	0.19	0.14
(0.09)	(0.20)	(0.23)	(0.04)	(0.05)
Change in Stock of Vehicles	-0.10	-0.09	-0.006	-0.053
(0.20)	(0.04)	(0.05)	(0.12)	(0.12)
Growth Rate of Income		-0.02		0.02
(0.046)		(0.07)		(0.01)
Sargan	12.52	11.05		
p-value	0.63	0.68		

Note: δ_0 refers to the depreciation rate for the initial stock of cars, δ_n to the depreciation rate for new cars and δ_u to the depreciation rate for used cars.

Table 9

	GMM	GMM	OLS	OLS
Interest Rate	1.16	1.71	0.61	0.60
(0.43)	(0.40)	(0.53)	(0.23)	(0.23)
Growth Rate of Family Size	0.64	0.57	0.35	0.35
(0.07)	(0.30)	(0.33)	(0.08)	(0.08)
Change in Number of Earners	0.27	0.50	0.19	0.19
(0.09)	(0.21)	(0.22)	(0.04)	(0.04)
Income		-0.08		0.005
(0.16)		(0.03)		(0.09)
Sargan	19.7	10.43		
p-value	0.23	0.79		

Note: This is the baseline specification, i.e. without conditioning on the stock of cars augmented by the lagged by one income.

Table 10

$\delta = 0.0375$

	GMM	GMM	OLS	OLS
Interest Rate	1.86	1.88	0.61	0.60
(0.43)	(0.60)	(0.62)	(0.23)	(0.23)
Growth Rate of Family Size	0.54	0.53	0.35	0.35
(0.07)	(0.33)	(0.33)	(0.08)	(0.08)
Change in Number of Earners	0.40	0.48	0.19	0.19
(0.09)	(0.20)	(0.22)	(0.04)	(0.04)
Change in Stock of Vehicles	-0.80	-0.46	0.003	-0.02
(0.24)	(0.40)	(0.58)	(0.11)	(0.12)
Income		-0.05		0.005
(0.16)		(0.05)		(0.01)
Sargan	12.74	10.56		
p-value	0.62	0.72		

Note: Income is the lagged by one income.

Table 11

$\delta = 0.045$

	GMM	GMM	OLS	OLS
Interest Rate	1.80	1.86	0.61	0.60
(0.43)	(0.59)	(0.60)	(0.23)	(0.23)
Growth Rate of Family Size	0.54	0.53	0.35	0.35
(0.07)	(0.33)	(0.33)	(0.08)	(0.08)
Change in Number of Earners	0.39	0.47	0.19	0.19
(0.09)	(0.20)	(0.22)	(0.04)	(0.04)
Change in Stock of Vehicles	-0.90	-0.52	0.002	-0.02
(0.22)	(0.44)	(0.61)	(0.12)	(0.12)
Income		-0.05		0.005
(0.16)		(0.05)		(0.01)
Sargan	12.69	10.49		
p-value	0.62	0.72		

Note: Income is the lagged by one income.

Table 12

$\delta_0 = 0.0375, \delta_n = 0.045, \delta_u = 0.03$

	GMM	GMM	OLS	OLS
Interest Rate	1.94	1.93	0.60	0.60
(0.43)	(0.62)	(0.65)	(0.23)	(0.23)
Growth Rate of Family Size	0.53	0.53	0.35	0.35
(0.07)	(0.33)	(0.34)	(0.08)	(0.08)
Change in Number of Earners	0.39	0.48	0.19	0.19
(0.09)	(0.21)	(0.22)	(0.04)	(0.04)
Change in Stock of Vehicles	-0.82	-0.47	-0.002	-0.025
(0.25)	(0.40)	(0.57)	(0.11)	(0.12)
Income		-0.05		0.005
(0.16)		(0.05)		(0.01)
Sargan	12.63	10.47		
p-value	0.63	0.72		

Note: δ_0 refers to the depreciation rate for the initial stock of cars, δ_n to the depreciation rate for new cars and δ_u to the depreciation rate for used cars.

Table 13

$\delta_0 = 0.0525, \delta_n = 0.06, \delta_u = 0.045$

	GMM	GMM	OLS	OLS
Interest Rate	1.72	1.83	0.61	0.60
(0.43)	(0.56)	(0.58)	(0.23)	(0.23)
Growth Rate of Family Size	0.55	0.53	0.35	0.36
(0.07)	(0.33)	(0.34)	(0.08)	(0.08)
Change in Number of Earners	0.39	0.47	0.19	0.19
(0.09)	(0.20)	(0.22)	(0.04)	(0.04)
Change in Stock of Vehicles	-0.10	-0.06	-0.006	-0.028
(0.20)	(0.04)	(0.06)	(0.12)	(0.13)
Income		-0.006		0.005
(0.16)		(0.006)		(0.01)
Sargan	12.52	10.34		
p-value	0.63	0.73		

Note: δ_0 refers to the depreciation rate for the initial stock of cars, δ_n to the depreciation rate for new cars and δ_u to the depreciation rate for used cars.

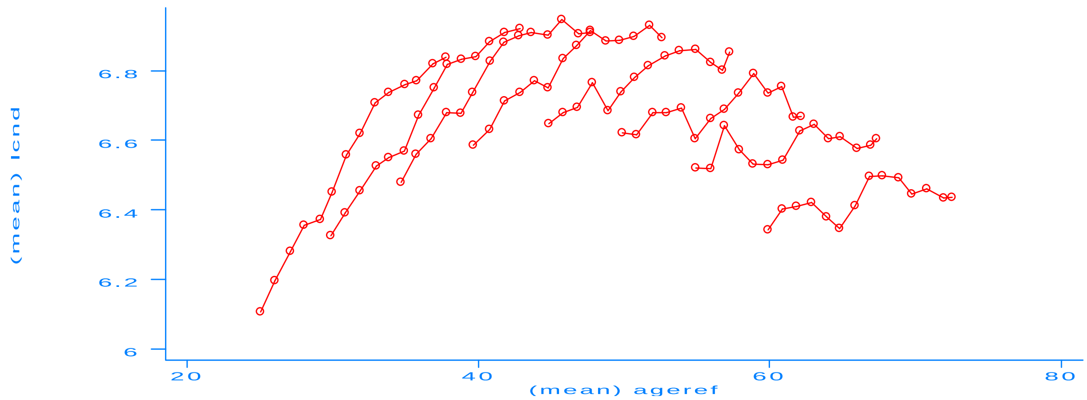

Figure 1: Household Non-Durable Consumption

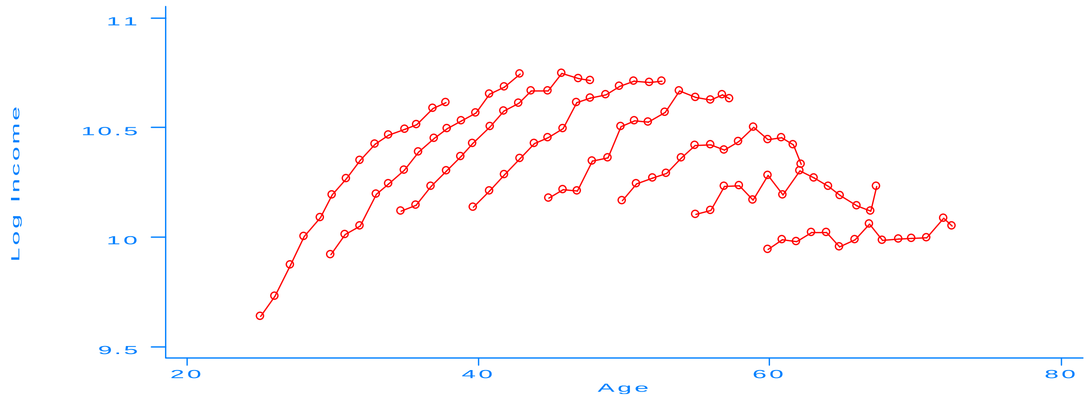

Figure 2: Household Income After Taxes

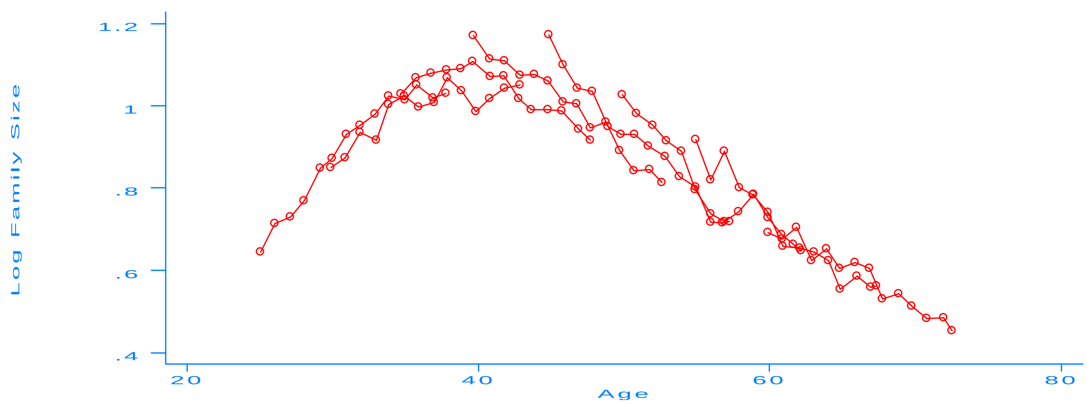

Figure 3: Household Family-Size

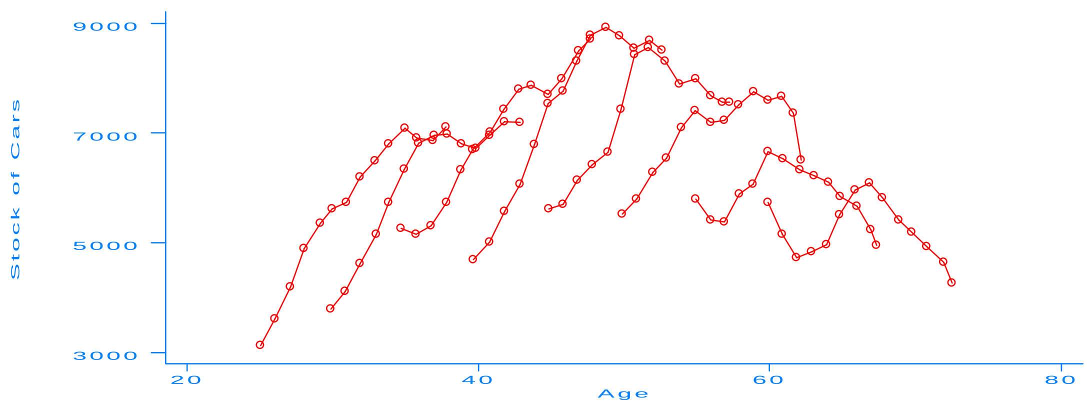

Figure 4: Household Stock of Cars

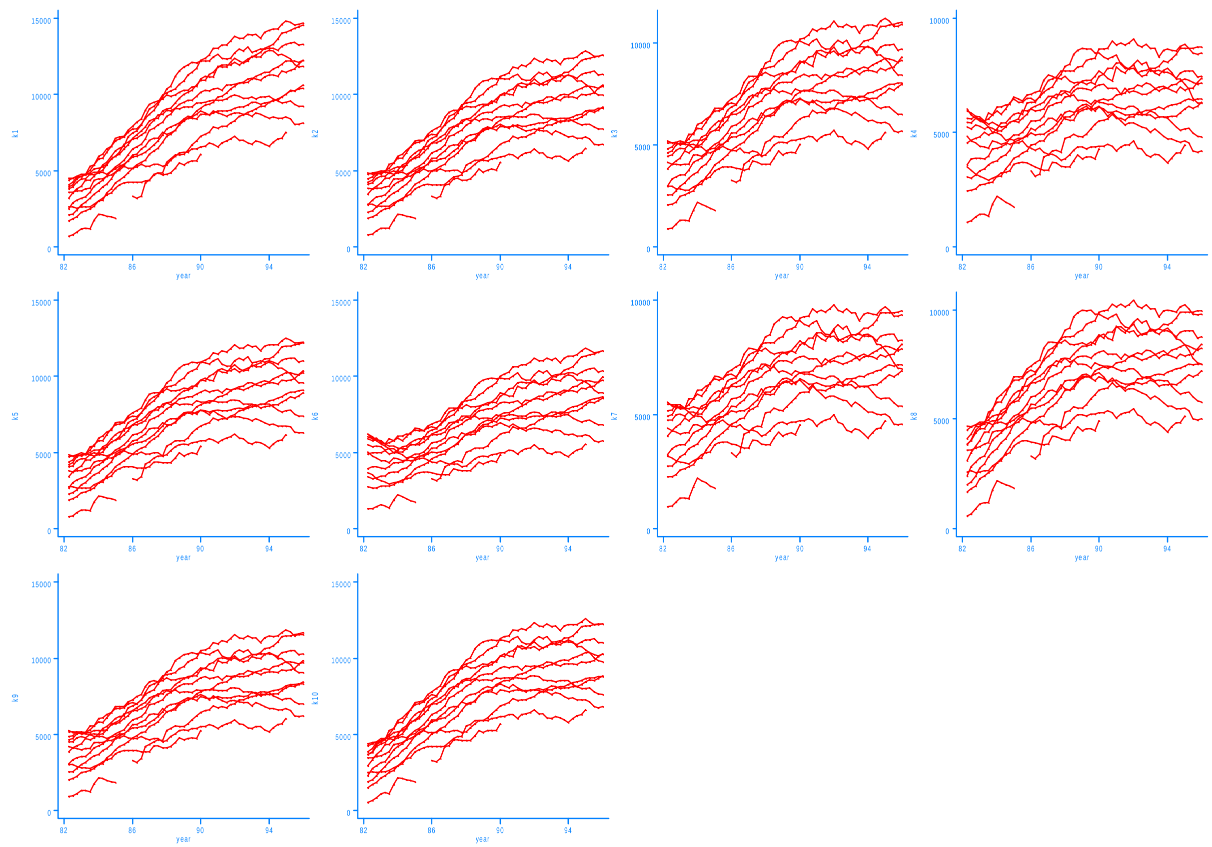

Figure 5: Stock of Cars

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