Intertemporal choice and debt-financed durable goods[1]

Sergey Filyasov
e-mail: mcgintyserg@yandex.ru,
Nizhniy Novgorod, HSE,
academic advisors: Alexander Larin, Anna Novak.

Aggregate consumption is a major component of GDP. That is why to analyze business cycles, possible effects of monetary policy, etc., one need to consider factors, which affect aggregate consumption dynamics.

The main challenge is to understand what affect agent's decision consumption level in a given period. The consumption-smoothing hypothesis suggests that consumers maximize their lifetime utility by smoothing consumption throughout their lives. The result of this maximization subject to the dynamic budget constraint is the first order condition, which is called the Euler equation. This FOC implies that consumers choice depends on the interest rate expectations.

The parameters of the Euler equations (primarily the elasticity of intertemporal substitution) are very important for the calibration of DSGE models. For instance, the paper of Emmanuel-De-Veirman and Ashley Dunstan proves that intertemporal substitution is an important factor in determining cyclical fluctuations of consumption (De Veirman et al., 2011). In addition, the parameters play a central role in studies of the asset pricing, the impact of taxation on savings, and the effects of monetary policy.

However, the main issue here is that there is no consensus among empirical studies (Havranek et al., 2015). Therefore, while modeling the agents' behavior it is crucial to take into account all the significant factors that may have an influence on this behavior.

One of the most important aspects of modeling is durable goods – due to its volatility and therefore due to its importance for business cycle analysis (see, for example, Ogaki and Reinhart (1998)). Using the model with durables, Ogaki and Reinhart found positive and significant estimates (0.32-0.45) of elasticity of intertemporal substitution (EIS henceforth) in contrast to the Hall's estimates (Hall, 1988). Further studies confirmed the importance of durables as well: DelaCruz et al. (2007) (who estimate an EIS between 1.5 and 3.2), Gomes et al. (2009) (EIS equals 0.66), Okubo (2011) (EIS is between 0.96 and 3.9), Kim and Ryou (2012) (EIS equals 2). All these papers report estimates that are significantly different from zero.

Now I describe the problem more formally.

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Consider the utility function $u(C_t, D_t)$, that depends on real consumption of nondurable goods (C_t) as well as on real service flow from durable goods (D_t). The latter is defined as: $D_{t+1} = E_t + (1-\delta)D_t$, where E_t is the expenditures on durables at time t, $\delta \in [0,1]$ is the rate of depreciation. The household maximizes its life-time utility function, defined as the discounted sum of one-period functions, subject to the following budget constraint: $A_{t+1} = R_{t+1}(A_t + Y_t - C_t - p_t E_t)$, where Y_t is the non-financial income, A_t is the financial assets, p_t is the relative price of durables to nondurables at time t and R_{t+1} is the gross interest rate at time $t+1$. Solving this problem one can derive the following system of Euler equations (for more details see, for example, Siegel (2008)):

$$\frac{\partial u(C_t.D_t)}{\partial C_t} = \beta R_{t+1} E_t \left[\frac{\partial u(C_{t+1}.D_{t+1})}{\partial C_{t+1}}\right], \tag{1}$$

$$p_t \frac{\partial u(C_t.D_t)}{\partial C_t} = \beta E_t \left[\frac{\partial u(C_{t+1}.D_{t+1})}{\partial D_{t+1}} + (1-\delta) p_{t+1} \frac{\partial u(C_{t+1}.D_{t+1})}{\partial C_{t+1}}\right]. \tag{2}$$

The equation (1) is the same as there were no durable goods in the utility function. However, now the marginal utility is affected by durables. As for equation (2) one of the ways of interpretation can be presented as follows. The left-hand side represents the cost of purchasing a unit of durable goods in terms of nondurables while the right-had side is the discounted sum of the direct utility from unit of durables and the price of a unit of durables in term of nondurables at time $t+1$.

In the empirical papers, it is common to use the utility function of the CES type:

$$u(C_t.D_t) = \frac{\left[(1-\alpha)C_t^{\rho} + \alpha D_t^{\rho}\right]^{\frac{1-\gamma}{\rho}}}{1-\gamma}, \tag{3}$$

where $\alpha \in (0,1)$, $1/(1-\rho)$ is the elasticity of substitution between nondurable and durable goods consumption, $\gamma > 0$ is the coefficient of relative risk aversion with respect to intraperiod utility flow. The EIS is then defined as $1/\gamma$. In this case, the system of Euler equations takes the following form:

$$E_t \left[\beta \left(\frac{C_{t+1}}{C_t}\right)^{-\gamma} \left(\frac{1 + \alpha\left(\left(\frac{D_{t+1}}{C_{t+1}}\right)^{\rho} - 1\right)}{1 + \alpha\left(\left(\frac{D_t}{C_t}\right)^{\rho} - 1\right)}\right)^{\frac{1-\gamma-\rho}{\rho}} R_{t+1} - 1\right] = 0, \tag{4}$$

$$E_t\left[\beta\frac{1}{1-\delta}\frac{\alpha}{1-\alpha}\frac{1}{p_{t+1}}\left(\frac{D_{t+1}}{C_{t+1}}\right)^{-\gamma}\left(\frac{\alpha+(1-\alpha)\left(\frac{D_{t+1}}{C_{t+1}}\right)^{-\rho}}{1+\alpha\left(\left(\frac{D_{t+1}}{C_{t+1}}\right)^{\rho}-1\right)}\right)^{\frac{1-\gamma-\rho}{\rho}}\right.$$

$$\left.--\frac{1}{1-\delta}\frac{p_t}{p_{t+1}}\left(\frac{C_{t+1}}{C_t}\right)^{\gamma}\left(\frac{1+\alpha\left(\left(\frac{D_t}{C_t}\right)^{\rho}-1\right)}{1+\alpha\left(\left(\frac{D_{t+1}}{C_{t+1}}\right)^{\rho}-1\right)}\right)^{\frac{1-\gamma-\rho}{\rho}}+\beta\right]=0. \tag{5}$$

It is worth noticing that now intertemporal condition for nondurables (eq. 4) is affected by the ratio of durable to nondurable goods consumption. These equations can be used for further estimation of the parameters.

In order to estimate the parameters, the interview dataset of the U.S. Consumer Expenditure Survey (CEX henceforth) is used. This dataset covers 19-year period from 1996 to 2014 years. The data on households is collected in the following way. A household is surveyed 5 times every 3 months. The first survey is trial, so the results are not available for the public. Thus, each household has at most 4 observations. In this case, it is reasonable to construct a time series by aggregating the household data.

Following the common approach, the household consumption of nondurable goods and services includes the following: food, alcohol beverages, tobacco and smoking, apparel and services, household-related expenses on nondurable goods and services, vehicle-related expenses, public transportation, reading, personal care.

The vehicles (here “cars” and “vehicles” are used interchangeably) are used as a proxy for durable goods. There are a few reasons for this. First, apart from housing, they represent the largest share of durable expenditure as Padula indicates (1999). Secondly, houses may be purchased for several reasons: as a dwelling for own living and as an income-generating asset while cars are purchased mainly for the own needs of the consumer.

In order to construct a stock of cars I use households with complete record of the prices for all currently owned cars. The depreciation rate, δ, equals 0.045[2].

One of the most important issues is the choice of relevant interest rate. The prevailing number of studies use the yields of different financial assets such as shares, bonds etc. However, in this case, the relevant interest rate is the lending rate for car purchases. The intuition behind this is rather simple. If a household is going to buy a car and take a loan (it becomes a borrower), it will adjust its consumption according to the auto-loan rate. For this reason, I keep only those households that are borrowers in the reference period. Moreover, I exclude households without

[2] The average depreciation rate used by Padula (1999). The estimates do not change substantially if other rates are used.

transactions in the reference period. Since there are transaction costs of buying a car, the adjustment of this stock is sticky and not instant as was pointed out by Attanasio (2000). Therefore, I conclude that Euler equations hold only when the stock of durables is far from optimum and transaction costs are no longer the most important factor that defines the behavior of household. I also drop rural households and ones with financial assets in order to eliminate their influence on the behavior of the former (I keep only net borrowers).

The growth rates are constructed as follows, where t is the reference quarter of expenditures (stock):

$$gc_{it} = \frac{C_{it+1}}{C_{it}}, gd_{it} = \frac{D_{it+1}}{D_{it}}.$$

They are cleared of the seasonal factor if it is necessary. The observations with missing values of growth rates are dropped. In addition, I exclude households that meet the following conditions: $gc_{it} > 3, gc_{it} < 1/3, gd_{it} > 10$. These rates are further aggregated.

I use the deflated Finance Rate on Consumer Installment Loans at Commercial Banks for New Autos 48 Month Loan as an interest rate (it is available at Federal Reserve Bank of St. Louis). The data is available only for first months of the calendar quarters therefore I use the following interpolation procedure. The gaps are filled with weighted average of two nearest rates (preceding and subsequent) that are originally available. The weights equal 2/3 for the closest observation and 1/3 for another.

Furthermore, according to Vissing-Jorgensen (2002) it is acceptable to use the following gross interest rate on the ground of simplicity, where t indicates the quarter and m indicates the month:

$$R_{t+1} = (1 + r_{m-1})(1 + r_m)(1 + r_{m+1})(1 + r_{m+2}).$$

All variables are treated as endogenous in the estimation and therefore the HAC consistent GMM estimator is used. I specify the Newey-West weight matrix with six lags. Moreover, due to overlapping nature of observations and measurement errors, the following instruments are used:

- 6-month lagged growth rate of real nondurable goods consumption;
- 6-month lagged growth rate of real stock of durables;
- 5-month lagged real gross interest rate.

Table 1. Estimation results

	Estimates	**95% confidential interval**
$\boldsymbol{\beta}$	1.02* (0.01)	(0.99; 1.04)
$\boldsymbol{\gamma}$	0.77* (0.29)	(0.20; 1.34)

α	0.04* (0.02)	(0.01; 0.07)
ρ	0.97* (0.33)	(0.33; 1.60)
p-value (J-stat)	0.64	
T	164	

** - 1% significance level*

As we can see from a table above, all estimates are significant at 1% level. The EIS, $1/\gamma$, approximately equals *1.3* that is greater than the estimates in the most of previous papers. The estimate of the parameter α depends on the scaling of durable stock and its interpretation confines to its statistical significance. The estimate of the parameter ρ, however, is rather surprisingly near 1 implying on the high value of elasticity of intratemporal substitution (near 33). It makes the durables and nondurables almost the perfect substitutes. Moreover, it is worth stressing that the confidence interval of this estimate conflicts with the theory ($\rho \leq 1$), therefore, further research is needed.

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