EULER EQUATION WITH HABITS AND MEASUREMENT ERRORS: ESTIMATES ON RUSSIAN MICRO DATA

Abstract

This paper presents estimates for the consumption Euler equation for Russia. The estimation is based on micro-level panel data and accounts for the preference heterogeneity, measurement errors, and the impact of macroeconomic shocks. The presence of multiplicative habits is checked with the LM-test in a GMM framework. We obtain estimates of the elasticity of intertemporal substitution and of the subjective discount factor, which are consistent with the theoretical model and can be used for calibration, as well as for a Bayesian estimation of DSGE models for the Russian economy. We also show that the effects of habit formation are not significant. The hypotheses on habits (external, internal, and both external and internal) are not supported by the data.

1 Introduction

Since the advent of the hypotheses of permanent income (Friedman, 1957) and life cycle consumption (Modigliani and Brumberg, 1954), the concept of consumption smoothing is widely used to describe household consumption behavior. This framework is based on the assumption that economic agents smooth their spending over time to maximize utility throughout his or her life. Hall's seminal paper (1978) proposes the idea that aggregate consumption dynamics should be modeled as a first-order condition for the optimal choice of a single, fully rational, and forward-looking representative consumer. The first-order condition for this optimization problem is known as the Euler equation. Hall showed that income has no predictive power for consumption dynamics, while interest rates do have such power. The results were widely discussed in the literature and became the baseline for contemporary consumption behavior analysis.

The Euler equation approach has been applied to different micro- and macro-economic models and used to estimate preference parameters in a variety of specifications. A large number of empirical studies use the utility function with constant relative risk aversion (CRRA) preferences. In this case, the Euler equation allows for the identifying of the subjective discount factor, as well as the elasticity of intertemporal substitution (EIS), which shows the strength of the link between interest rates and consumption growth.

Despite the fact that it is common to assume that household preferences are homogenous and separable across time, there are alternative approaches that relax these assumptions. The assumption of homogenous preferences can be relaxed by introducing so-called taste shifters (an agent's specific and time-varying characteristics), while the assumption of time-separability is often relaxed by introducing consumption habits. This approach implies that current consumption is not significant by itself, but is compared with some benchmark level of consumption(Deaton, 1992),

Analyzing consumption behavior is considered to be an important issue, not only for economists, but also for public policy makers. The Euler equation represents one of the key blocks of dynamic stochastic general equilibrium (DSGE) models – currently one of the most popular tools of macroeconomic analysis (Obstfeld and Rogoff, 1995, 1998; Corsetti and Pesenti, 2001; Smets and Wouters, 2004, 2007). DSGE models allow one to identify the impact of preference parameters on the effectiveness of macroeconomic policy (Galí and Monacelli, 2008). It follows that proper estimates of the parameters are of high priority. The contemporary literature implies that the analysis of modified utility functions with external (Smets and

Wouters, 2003, 2007) and/or internal (Christiano, Eichenbaum, and Evans, 2005) habit formation. Researchers either base their analysis on estimates of Euler equations from micro data (Hall and Mishkin, 1982; Runkle, 1991; Attanasio and Weber, 1995), or perform this estimation using aggregate data.

Many empirical papers support the hypothesis of permanent income and find a significant relation between consumption growth and interest rate movements. Estimates of the elasticity of intertemporal substitution for the US economy are usually positive and not high, in many cases between zero and 0.5. For example, investigating aggregated data, Summers (1982) presents EIS estimates between 0.06 and 0.26 for different interest rates, while Hall (1988) states that almost all the tests give an EIS of not more than 0.2, Campbel and Mankiw (1989) conclude that the EIS is about 0.2, and Hahm (1998) finds statistically significant positive elasticity estimates around 0.3.

In DSGE framework, the model implies estimation on macro data using a Bayesian technique. Smets and Wouters (2004) use the classical form of the Euler equation with external habits. Their estimate of the EIS for the US is 0.62 (the mean of posterior distribution), which is close to the value of 0.5 that is frequently used in the Real Business Cycle (RBC) literature. The external habit stock is estimated to be 55% of past consumption. Christiano, Eichenbaum, and Evans (2005) present the estimate of habit persistence equal to 0.65 for the US economy based on aggregated monthly data. This value is close to the point estimate of 0.7, reported in Boldrin, Christiano, and Fisher (2001). Another paper of Ratto, Roeger, and Veld (2008) for the Euro area includes habit persistence in consumption and leisure. The authors find a habit persistence in consumption of 0.56 and an EIS of 0.25.

A debatable question that is widely discussed in the literature regards the circumstance, under which estimating the Euler equation yields unbiased and consistent estimates of the structural parameters. Most authors agree that, due to agent heterogeneity, estimating on aggregated data can lead to biased estimates of the parameters (Attanasio and Weber, 1993). As a rule, to resolve this problem, authors use household-level panel data, taking into account some specific characteristics of households. Although data on household consumption suffer from appreciable measurement errors, various solutions to this problem are applicable.

When estimating the Euler equation on US micro data, researchers usually use data from the Panel Study on Income Dynamics (PSID) on food consumption (Hall and Mishkin, 1982; Runkle, 1991, Alan and Browning, 2010) or from a panel survey of households, such as the Consumer Expenditure (CEX) Survey by the Bureau of Labor Statistics (Attanasio and Weber, 1995; Vissing-Jorgensen, 2002; Attanasio and Low, 2004; Alan, Attanasio and Browning, 2009; Alan, 2012). The studies show significant positive values of the EIS between zero and 1. Runkle

(1991) estimates an EIS of approximately 0.45; Attanasio and Weber (1995) show that the EIS is about 0.67; Vissing-Jorgensen (2002) produce estimates that are between 0.3 and 1, depending on the interest rate; and Alan and Browning (2010) presented estimates for the relative risk aversion (RRA) coefficient of between 1.803 and 2.1, depending on education level, which correspond to the EIS, lying between 0.48 and 0.55.

A number of papers on DSGE modeling avoid problems with estimating Euler equation parameters and state, for example, the EIS as unity (Schorfheide, 2000; Semko, 2011). Other researchers assume the EIS to be 0.5, following standard RBC literature (see, among others, Dib, Mendicino, and Zhang, 2008). Studies on the Russian economy usually calibrate the model by setting the EIS equal to 1 (Sosunov and Zamulin, 2007; Polbin, 2013) or to 0.5 (Semko, 2013) and assume no habits in the model or take the habit persistence parameter from the studies for other countries (as, for example, in Polbin, 2013).

The main reason why authors use these values to calibrate DSGE models for Russia is the absence of parameter estimates. Our paper aims to fill this gap and find estimates that can be used in DSGE modeling of the Russian economy. As shown in the complete review of Havranek et al (2013), the EIS estimates obtained for different countries vary significantly: from negative values for Argentina and France, to 4 and higher for Austria and New Zealand. Thus, using an EIS equal to 0.5 or 1 for calibrating models may not be valid for Russia. In this paper, we show that the EIS for Russia is much higher than those obtained for the US, and a hypothesis of the EIS being equal to 1 (or 0.5) is not supported by the data. The hypothesis of habit formation is also not supported by the Russian data.

We base estimation on household micro data from the Russian Longitudinal Monitoring Survey of the Higher School of Economics (RLMS-HSE[1]) for the period from 2000 to 2013. The advantage of the RLMS data is that it includes questions concerning the complete measure of consumption expenditures for each household over a long period of time, which allows meaningful longitudinal analysis to be conducted. We introduce agent heterogeneity by allowing utility to depend on household income and working hours. As asset returns, we use credit and deposit rates. We show that, even in the presence of measurement errors, consistent estimates of the subjective discount factor and the EIS can be obtained using the standard GMM technique. We use two-step optimal GMM to get estimates of the parameters of the Euler equation without habits and run an LM-test to check for internal and external multiplicative habits. The analysis provides estimates that are consistent with the theoretical framework.

The rest of the paper is organized as follows: in section 2 we present the theoretical model, in section 3 we describe our empirical methodology, while in section 4 we describe our dataset and estimation results, and in section 5 we provide a conclusion.

2 The model

2.1 Preferences

Following Khorunzhina and Roy (2011), we assume that the preferences of household i in period t may be described by the following utility function

$$U_{it} = \sum_{\tau=t}^{\infty} \beta^{\tau-t} \frac{\tilde{c}_{i\tau}^{1-\gamma}}{(1-\gamma)} \phi_{i\tau}, \tag{1}$$

where $\tilde{c}_{i\tau}$ denotes consumption services, $\phi_{i\tau}$ denotes household-specific taste shifters, $0 < \beta < 1$ is the subjective discount factor, and $\gamma > 0$ is the utility curvature parameter.

We mainly focus our attention on estimating β and γ, as they are the key parameters that determine consumer behavior in the framework of DSGE models. In the absence of internal habit formation, parameter γ equals both the RRA and the reciprocal of the EIS. In its turn, the EIS reflects the strength of the link between interest rates and consumption growth, such that γ defines the co-movement of these two variables (see Appendix A). For the model with internal habit formation, the interpretation of γ is more complicated, as both the RRA and EIS depend now on household-specific characteristics and other parameters of the model (see, for example, Khorunzhina and Roy, 2011).

Taste shifters $\phi_{i\tau}$ introduce agent heterogeneity into the model and allow preferences to depend on household-specific characteristics, such as income and working time. We define them as

$$\phi_{i\tau} = \exp(\mu_i + x_{i\tau}'\delta), \tag{2}$$

where $x_{i\tau}$ denotes a vector of household-specific characteristics, δ is a vector of coefficients, and μ_i is a constant term that relates to household-specific time-invariant individual effects.

In the absence of habits, consumption services $\tilde{c}_{i\tau}$ equals current consumption $c_{i\tau}$. In that case, preferences are time-separable, so that current period utility depends only on current consumption. Introducing habit formation implies that current consumption is not significant by itself, but is compared with the benchmark consumption level.

2.2 Habit formation

There are several classifications of habit formation. Generally, habits may be divided into two

types: *external* and *internal*. External habits, also as known as "catching up with the Joneses" (Abel, 1990; Campbell and Cochrane, 1999) or "keeping up with the Joneses" (Gali, 1994), imply that household preferences are based on the history of aggregate consumption. In other words, external habits represent interdependent preferences and show the linkage between the consumption behavior of one household and the known decisions about consumption of some outside reference group (the average consumption of the neighbor community or the overall economy). On the contrary, internal habits are based on a household's own past consumption and reflect the inert process of habit formation (Ryder and Heal, 1973; Sundaresan, 1989; Constantinides, 1990). As a result, these two types of habits have different psychological grounds – external habits refer more to envy motives, while internal habits refer to the psychological aspects of habit formation of a particular household — and thus might lead to different economic implications.

Households can either form habits for consumption of a single aggregate good – "*standard*" habits – or they can form habits at the level of each type of good in their consumption basket – "*deep*" habits (Ravn, Schmitt-Grohe, and Uribe, 2006).

As for modeling issues, habits may be introduced in an *additive* or a *multiplicative* way. In the case of additive habits, the difference between consumption and the habit stock matters (Christiano, Eichenbaum, and Evans, 2005; Smets and Wouters, 2004) such that consumption services for both internal and external habits is defined by

$$\widetilde{c}_{i\tau} = c_{i\tau} - \alpha c_{i\tau-1} - \omega \overline{c}_{\tau-1}. \tag{3}$$

On the contrary, multiplicative habits mean that utility depends on the ratio of consumption to the habit stock (McCallum and Nelson, 1999; Fuhrer, 2000; Amato and Laubach, 2004), so that consumption services is

$$\widetilde{c}_{i\tau} = \frac{c_{i\tau}}{c_{i\tau-1}^{\alpha} \overline{c}_{\tau-1}^{\omega}}. \tag{4}$$

For both equations (3) and (4), $\overline{c}_{\tau-1}$ denotes the past average consumption of a reference group, which we define as the average consumption of all other households in the economy, $0 \leq \alpha < 1$ measures the strength of internal habits and $0 \leq \omega < 1$ measures the strength of external habits (here also $\alpha + \omega < 1$).

In this paper, we test for both internal and external habits and introduce them in a multiplicative manner (4). We do not test for additive habits, because we use micro data that are characterized by a high variance of consumption. The high variance of consumption makes estimation problematic, since for high values of α and/or ω, consumption services may be negative, meaning that utility cannot be computed. We do not test for deep habits and leave this issue for further research.

2.3 The Euler Equation

To derive the Euler equation, we assume that households choose consumption in order to maximize expected utility

$$\mathsf{E}(U_{it}|\mathsf{F}_{it}) \to \max_{c_{it}} \tag{5}$$

subject to a budget constraint

$$B_{it+1} = B_{it}R_{it+1} + y_{it} - c_{it}, \tag{6}$$

where $\mathsf{E}(\cdot\,|\,\mathsf{F}_{it})$ denotes expectations conditional on a set of information F_{it}, available to the i-th household in period t, B_{it} is a stock of an asset of the household in period t, R_{it+1} denotes gross real return of an asset held from period t to $t+1$, and y_{it} represents the income of the household.

By the calculus of variations approach, the first-order condition (FOC) for this optimization problem is

$$\mathsf{E}\left(\frac{\partial U_{it}}{\partial c_{it+1}}\mathrm{d}c_{it+1} - \frac{\partial U_{it}}{\partial c_{it}}\mathrm{d}c_{it}\Bigg|\mathsf{F}_{it}\right) = 0. \tag{7}$$

From the budget constraint we know that the household may transfer assets from period t to $t+1$ with the real gross return R_{it+1}. In this case, the relation between consumption in these two periods is given by

$$\mathrm{d}c_{it+1} = R_{it+1}\mathrm{d}c_{it}. \tag{8}$$

Substituting (8) into (7), we may rewrite FOC as

$$\mathsf{E}\left(\frac{\partial U_{it}}{\partial c_{it+1}}R_{it+1} - \frac{\partial U_{it}}{\partial c_{it}}\Bigg|\mathsf{F}_{it}\right) = 0. \tag{9}$$

This FOC represents the Euler equation in a general form. Intuitively, it says that if a household decides to redistribute consumption between periods t and $t+1$, this brings no expected utility gain.

In the absence of habit formation ($\alpha = 0$ and $\omega = 0$) and with the preferences described above, equation (9) simplifies to

$$\mathsf{E}\left(\beta\exp(\Delta x_{it+1}{}'\delta)\left(\frac{c_{it+1}}{c_{it}}\right)^{-\gamma}R_{it+1} - 1\Bigg|\mathsf{F}_{it}\right) = 0, \tag{10}$$

where $\Delta x_{it+1} = x_{it+1} - x_{it}$ is the future change of household-specific characteristics. The Euler equation for the model with habit formation is derived in Appendix B.

2.4 Measurement errors

As mentioned above, to take agent heterogeneity into account, the Euler equation is usually estimated on micro data. The main problem of micro data on household consumption is measurement errors that may lead to inconsistent estimates of the parameters (Amemiya, 1985). For instance, Runkle (1991) finds that 76% of consumption growth variation in the PSID is due to measurement errors.

A number of techniques have been proposed to deal with this problem. Instead of analyzing particular households, some authors consider cohorts (Attanasio and Weber, 1995; Jacobs and Wang, 2004) or clusters of households (Grishchenko and Rossi, 2012), which they construct by individual characteristics, such as income, education, age, savings rate, and so on. This technique assumes that measurement errors are averaged out from the per capita consumption of a cohort or cluster. But even using aggregated data (by cohort or cluster), it still accounts for agent heterogeneity by allowing preferences of households from different cohorts or clusters to be different.

Other authors prefer to estimate a linearized version of the Euler equation, which is less sensitive to the influence of measurement errors (Attanasio and Low, 2004). It is assumed that measurement errors move to error the term of regression such that the instrumental variable estimator can be used to obtain consistent estimates. One can apply log-linearizing as well as Taylor approximation around a steady state, which allows for a higher-order approximation of the equation (Hansen, Singleton, 1983). However, this technique has several disadvantages. For instance, it does not allow us to identify subjective discount factor and fails to deal with the problem of measurement errors in the case of internal habit formation (Alan, Attanasio, and Browning, 2009).

In this paper, we use the idea that, under certain assumptions, measurement errors may lead to an inconsistent estimate only of the subjective discount factor, while estimates of the EIS remain consistent (Ventura, 1994; Hong and Tamer, 2003; Khorunzhina and Roy, 2011). Moreover, we show that, if the time between two observations may vary across households, then it is also possible to obtain consistent estimates of the subjective discount factor (see Subsection 3.1).

We assume that observed consumption is given by

$$c_{it}^o = c_{it} \nu_i \eta_{it}, \tag{11}$$

where ν_i and η_{it} are random variables within the domain $(0,+\infty)$ that represent household-specific time-invariant and time-varying components of measurement error, respectively.

Since the time-invariant component drops out from the Euler equation (10), we only need to make assumptions about η_{it}. As shown by Khorunzhina and Roy (2011), if this term is

stationary and independent from all variables that enter the Euler equation and from information set F_{it}, the equation for observed consumption is

$$
\mathsf{E}\left(\kappa \beta \exp(\Delta x_{it+1}'\delta)\left(\frac{c_{it+1}^{o}}{c_{it}^{o}}\right)^{-\gamma} R_{t+1} - 1 \middle| \mathsf{F}_{it} \right) = 0, \tag{12}
$$

where κ is a constant that depends on the parameters of distribution of η_{it} and the parameters of the model (see Appendix C). It is necessary to note that this form still allows for correlation between household characteristics and measurement errors (at least, its time-invariant part).

3 Empirical Methodology

3.1 Accounting for varying length of periods

In this paper, we use data with annual frequency — households are interviewed once a year about their last month's consumption, income, working hours, and so on (see Section 4). But the month of the interview may change from one wave of the survey to another. Therefore, the number of months between two interviews may vary from wave to wave and between households.

To account for different numbers of months between interviews, we need to specify our notations. Let subscript t denote the wave of the interview, c_{it}^{o} denote the last observed month of consumption for the i-th household in the t-th wave (the same is for taste shifters x_{it}), and R_{it+1} is the gross real return of an asset held between interviews of i-th household in waves t and $t+1$, and denote $h(i,t)$ to be the number of months between interviews of the i-th household in waves t and $t+1$. Then the Euler equation for this notation is almost the same:

$$
\mathsf{E}\left(\kappa \beta^{h(i,t)/12} \exp(\Delta x_{it+1}'\delta)\left(\frac{c_{it+1}^{o}}{c_{it}^{o}}\right)^{-\gamma} R_{it+1} - 1 \middle| \mathsf{F}_{it} \right) = 0, \tag{13}
$$

except for the fact that β — the discount factor for annual data — is powered by the appropriate length of the period between two interviews.

An interesting result is that if the length of periods did not change in time, then we could not separate the estimate of β from that of κ. But due to the varying length of periods between interviews, we can identify subjective discount factor β as well as κ.

3.2 GMM Estimation

To estimate the parameters of the model, we use information on two return rates — the interest rate on credits R_{it+1}^{C}, and the interest rate on deposits R_{it+1}^{D}. Since the Euler equation must hold

for both these rates, we may combine them to get moment conditions for GMM estimation.

Let us denote θ to be a vector of unknown parameters of the model, z_{it} to be a vector of instrumental variables that form information set F_{it} of the i-th household in period t, and the expression under the expectation operator in (13) to be

$$f_{it}^C(\theta) = \kappa\beta^{h(i,t)/12}\exp(\Delta x_{it+1}'\delta)\left(\frac{c_{it+1}^o}{c_{it}^o}\right)^{-\gamma}R_{it+1}^C - 1 \tag{14}$$

and

$$f_{it}^D(\theta) = \kappa\beta^{h(i,t)/12}\exp(\Delta x_{it+1}'\delta)\left(\frac{c_{it+1}^o}{c_{it}^o}\right)^{-\gamma}R_{it+1}^D - 1 \tag{15}$$

for credit and deposit rates, respectively. Then the moment conditions for GMM are

$$\mathsf{E}\left(\begin{matrix}f_{it}^C(\theta_0)z_{it}\\f_{it}^D(\theta_0)z_{it}\end{matrix}\right) = 0, \tag{16}$$

where θ_0 is the vector of true values of the parameters. Intuitively, this set of moment conditions says that gain, which a household may get from transferring consumption between periods, should not correlate with a vector of instrumental variables z_{it}. In other words, a household makes a forecast of its lifetime utility using information on some variables z_{it}, and chooses its current consumption c_{it} in order to maximize this forecast.

A sample counterpart to the left hand side of the moment conditions is given by

$$\hat{f}(\theta) = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{f}_{it}(\theta), \tag{17}$$

where

$$\hat{f}_{it}(\theta) = \left(\begin{matrix}f_{it}^C(\theta)z_{it}\\f_{it}^D(\theta)z_{it}\end{matrix}\right), \tag{18}$$

N denotes the number of households and T denotes the number of periods. Then the GMM estimator of parameters is

$$\hat{\theta} = \underset{\theta}{\operatorname{argmin}}\ \hat{f}(\theta)'A\hat{f}(\theta), \tag{19}$$

where A is a positive definite weighting matrix.

To obtain estimates, we use two-step optimal GMM. On the second step of estimation and to compute standard errors, we use estimates of the moment covariance matrix that accounts for the correlation between observations of the same period (see Appendix D for more details). In particular, this correlation may arise due to macroeconomic shocks.

3.3 LM-Test For Habit Formation

To test the hypotheses about habit formation, we use an LM-test. The reason for using an LM-test is the problems with identification that arise when we try to estimate the Euler equation with habits and measurement errors (equation C3 of Appendix C).

One may note that the GMM estimator for this model has a trivial solution $\kappa_1 = \kappa_2 = \delta_y = \delta_l = 0$ and $\kappa_3 = \alpha = \beta = \gamma = 0$, when sample counterparts to moment conditions (and, thus, the objective function for the maximization problem of GMM) are equal to zero and do not depend on data. That is why the identification of parameters becomes problematic. Khorunzhina and Roy (2011) solve this problem by implying a restriction of $\delta_y = 1$. But in our opinion, this assumption is too restrictive, does not necessarily hold, and thus may lead to inconsistent results.

Instead, we use an LM-test, which does not require estimating the unrestricted model (the model with habit formation). This test is valid, since the parameters of the unrestricted model are locally identified, regardless of the trivial solution[2].

We test the null hypothesis of no habit formation ($\alpha = \omega = 0$) against three alternative hypotheses: external habits ($\omega \neq 0$), internal habits ($\alpha \neq 0$) and both external and internal habits ($\omega \neq 0$ and $\alpha \neq 0$).

4 Data and estimation results

4.1 Sample structure

The samples used in the paper are drawn from the 9th-21st waves of the RLMS-HSE representative sample, which correspond to the period from September 2000 to February 2013. The RLMS-HSE is an unbalanced panel based on a survey conducted by the National Research University Higher School of Economics and ZAO "Demoscope", together with the Carolina Population Center at the University of North Carolina at Chapel Hill and the Institute of Sociology RAS.

In comparison with other commonly used databases (the PSID and CEX Survey for the US), the RLMS-HSE includes information not only about food consumption, but also questions concerning the complete measure of consumption expenditures for each household for a long period of time, so that it is possible to conduct meaningful longitudinal analysis.

We use household files to construct such variables as consumption of nondurable goods and services, household income, place of residence (urban/rural), number of household members,

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[2] We verify this by checking that the Jacobian of moment conditions has full rank.

their sex and age, and the weights for the basket of nondurable goods and services to calculate inflation. To obtain working hours of household members, we use the (individual) files of the survey for household members.

Each household is interviewed once in each wave in the period from September to March. But the month of the interview for the same household may vary from wave to wave. We account for this by rewriting the Euler equation in the form (13).

In this paper we use two samples. The estimation on the *short sample* is based on 9 waves of the survey (unlike 10 waves in the *long sample*). We do this in order to test for internal habit formation: for the LM-test we need to compute moment functions for an unrestricted model (the model with internal habits), which includes one additional lead of the variables (consumption, income, etc.). Thus as we need one additional lead, we can obtain LM-statistics only for the sample that consist of 9 (not 10) waves.

From the original sample of 12,375 households (about 4,231 households per wave), we drop those households who live in rural areas or if there is no non-retired adult member in the household. To exclude obvious reporting and coding errors, we use filters on consumption growth and income growth. In addition, we drop those households who were interviewed for too short a period (less than four waves) so that the final number of households is 1,363 for the short sample and 1,800 for the long sample (about 568 and 704 households per wave, respectively). A more detailed description of samples and variables is available in Appendix E.

4.2   Nondurable goods and services

When investigating the Euler equation on panel data, authors traditionally define consumption as expenditures on nondurable goods and services per household member. There are several definitions of nondurable goods in the literature (Jacobs and Wang, 2004; Grishchenko and Rossi, 2012).

In this paper, to define consumption we follow a standard approach. The theoretical framework of permanent income hypothesis implies analyzing durable and nondurable consumption without investments in durables and with adding services (Hall, 1978). However, there is no available data on the stock of durables to separate investments from consumption. Moreover in the basic model, consumption is time-separable, so that a household receives utility from current consumption only in the current period and no utility from that consumption thereafter. Since the theoretical foundations of the utility function apply to individual categories of consumption, authors follow Hall (1978) and drop durables altogether and consider consumption of nondurable goods and services. Earlier papers based on PSID used micro data on food consumption (Hall and Mishkin, 1982; Runkle, 1991). However, as disaggregated CEX

data became available for the US economy, researchers began to use wider definitions of nondurable goods to estimate consumption preferences (Attanasio and Weber, 1995).

In this paper, we compute consumption as the sum of expenditures on items such as food, alcoholic beverages, tobacco products, utilities, clothing, public transport, fuel, personal care items, and communication services (see Appendix E for more details).

4.3 Descriptive statistics

We compute observed consumption c_{it}^o as the real consumption of nondurable goods and services, defined above.

As taste shifters, we use the logarithm of real household income y_{it} and working time share l_{it} so that

$$\phi_{it} = \exp(\mu_i + \delta_y y_{it} + \delta_l l_{it}). \tag{20}$$

We assume that observed income may suffer from measurement errors like the observed consumption. In this case, equation (13) does not change except for the fact that κ depends now on the distribution of measurement errors of both consumption and income (see Appendix C). We define working time-share as the average number of working hours for adult members in the last month divided by 720 (the approximate number of hours in a month).

As asset returns we use real bank interest rates: up to 1-year average weighted interest rates on individual credits R_{it+1}^C and deposits R_{it+1}^D. We do not use stock market returns, because households prefer using bank credits and deposits to transfer money between periods, so that the share of stockholders in the sample we use is less than 1%.

Tab. 1. Descriptive statistics of the variables

Description	Notation	Short sample	Long Sample
Growth rate of real per capita consumption	c_{it+1}^o / c_{it}^o	1.162 (0.565)	1.167 (0.581)
Change of logarithm of real per capita income	$\Delta \ln(y_{it+1}^o)$	0.099 (0.408)	0.095 (0.406)
Change of working time	Δl_{it+1}	0.004 (0.155)	0.002 (0.158)
Gross real credit rate	R_{t+1}^C	1.148 (0.058)	1.153 (0.057)
Gross real deposit rate	R_{t+1}^D	0.964 (0.027)	0.968 (0.028)
Number of waves	T	9	10
Average number of households per wave	N	568	704
Number of observations	$N \times T$	5109	7042
Sample period		2000:2013	2000:2013
Sample period without lags and leads		2002:2011	2002:2012

Notes: Table presents mean values of variables. Standard deviations are in parenthesis.

Source: Author calculations.

4.4. Instruments

Instrumental variables, which form the information set F_{it} of the i-th household, should satisfy two conditions. First, they must be available to the household at the moment of making a decision about current consumption c_{it}. And, second, they must contain useful information for making the decision, meaning information about current and future dynamics of such variables as consumption, income, working hours, and returns.

In addition, one of the assumptions we use to obtain the Euler equation (13) is that measurement errors should not correlate with instrumental variables. It is easy to show that, for example, measurement error η_{it} of consumption is correlated with observed consumption growth c_{it}^o/c_{it-1}^o. It is implied by the fact that observed current consumption c_{it}^o depends on this measurement error. Therefore, we cannot include current growth rates of consumption and income into the list of instruments. Having regard for these assumptions, we use the following set of instruments:

- reciprocal of the past consumption growth rate: $\left(c_{it-1}^o/c_{it-2}^o\right)^{-1}$;

- exponent of the change in past income: $\exp(\Delta\ln(y_{it-1}^o))$;

- reciprocal of exponent of current and past change of working
  time: $\exp(-\Delta l_{it})$, $\exp(-\Delta l_{it-1})$;

- lagged credit rates: R_{it}^C, R_{it-1}^C;

- lagged deposit rates: R_{it}^D, R_{it-1}^D;

- growth rates of average consumption: $\bar{c}_t/\bar{c}_{t-1}$, $\bar{c}_{t-1}/\bar{c}_{t-2}$;

- dummy variables for the crisis period: $d_{2007}, d_{2008}, d_{2009}$.

- a constant.

From a theoretical point of view, there is no difference in using the past consumption growth rate or its reciprocal as an instrument. But in practice, the reciprocal $\left(c_{it-1}^o/c_{it-2}^o\right)^{-1}$ gives better identification of the parameters, since consumption growth c_{it+1}^o/c_{it}^o enters the Euler equation (13) as a negative power. For the same reason, we use the reciprocal of the exponent of change in working time.

We add growth rates for average consumption, since these instruments may help households to make the decision about consumption in the case of external habit formation. And, therefore, these instruments may be crucial when testing for external habits. Here we assume that measurement errors in average consumption are averaged out and, thus, we may use current growth rate $\bar{c}_t/\bar{c}_{t-1}$ as an instrument.

We use dummy variables $d_{2007}, d_{2008}, d_{2009}$ as instruments to account for the effects of the financial crisis of 2008. These dummy variables take a value 1 if the year of the interview is equal to 2007, 2008, or 2009, respectively, and they take a value 0 if otherwise.

4.5 Estimation Results

Since long sample estimates are more precise as they use more observations, we interpret only these estimates below. We use the short sample just to test for the habit formation.

The key result is that our estimate of the utility curvature parameter γ is significantly greater than zero. This result supports the consumption-smoothing hypothesis and suggests a positive relationship between expected consumption growth and the interest rate in Russia. This value of γ corresponds to an EIS[3] of 4.167 with a 95% asymptotic confidence interval (2.499, 5.834). This estimate of the EIS is much higher than most estimates obtained for the US economy. Moreover, the EIS confidence interval rejects the hypothesis of the logarithmic utility function (EIS equal to 1), which is usually used to calibrate DSGE models of the Russian economy.

Tab. 2. GMM-Estimates of The Model

Parameter	Short Sample	Long Sample
β	0.808***	0.905***
	(0.056)	(0.055)
γ	0.149***	0.240***
	(0.042)	(0.049)
δ_y	0.511***	0.589***
	(0.039)	(0.043)
δ_l	0.203***	0.222***
	(0.026)	(0.029)
κ	1.093***	0.962***
	(0.075)	(0.058)
Hansen J-test for overidentification	14.201	15.809
	[0.921]	[0.863]
LM-test (H$_1$: external habits)	0.111	0.205
	[0.739]	[0.651]
LM-test (H$_1$: internal habits)	4.074	—
	[0.254]	
LM-test (H$_1$: internal and external habits)	4.176	—
	[0.383]	
Number of waves	9	10
Average number of households per wave	568	704

Notes: *, **, *** denotes significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parenthesis. P-values for tests are in square brackets.

Source: Author calculations.

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[3] The EIS estimate is computed as the inverse of the estimate of γ. Standard errors obtained with the Delta-method.

From our point of view, such a high estimate of the EIS is mainly due to our choice of return rates. Attanasio and Vissing-Jorgensen (2003) show that the EIS for bond holders is significantly higher than that for shareholders. A simple explanation of this phenomenon is that a one-percent change in bond returns brings more information and is more important than a one-percent change in share returns, since bond returns are less volatile. Thus, we may expect the response of consumption growth to a one-percent change in bond returns to be more significant and, hence, we may expect the EIS to be higher. In our paper, we use credit and deposit rates, which are less volatile than both share returns and bond returns, so that the high estimate of the EIS we obtain seems reasonable.

However, this result is not so uncommon as it may seem. For example, positive estimates of the EIS, which are significantly higher than 1, have been obtained for the US (see, among others, Attanasio and Vissing-Jorgensen, 2003; Hasseltoft, 2012), Japan (for example, Osano and Inoue, 1991; Okubo, 2011), Canada (Bosca et al, 2006), the Philippines (Bautista, 1999), the UK (for example, Bagliano, 1994), Korea (Ueda, 2000), and Greece (Nieh and Ho, 2006).

The estimate of β, which refers to the subjective discount factor for annual data, is also consistent with the theoretical model — it is positive and close to 1. Assuming exponential discounting, the estimate of the subjective discount factor for quarterly data is a 4th root of the estimate for annual data and equals 0.975. The 95% asymptotic confidence interval for the parameter is (0.852, 1.098), meaning that the hypothesis of the subjective discount factor being close to 1 is not rejected by the data.

The hypothesis of no habit formation in household consumption is not rejected by the data. Thus it is not necessary to account for external and/or internal habits when modeling consumption dynamics for Russian households.

However, this result does not imply that there are no habits in the consumption of Russian households. In this paper, we use data on monthly consumption with annual frequency and, thus, we define habit stock as the amount of consumption in a month of the year of the interview. Hence, the result we obtain says only that households do not form habits on last year's consumption. But they still may form habits, for example, on the last month or the last quarter.

Both taste shifters — income and working hours — significantly influence household utility. According to the estimation results, an increase in household income (or a decrease in working hours) — current or expected in the future — raises household utility.

Based on estimation results for the long sample, we present in Tab. 3 parameter values that may be used as priors for Bayesian estimation or for calibration of DSGE models for Russia.

Tab. 3. Parameter values for DSGE models

Parameter	Estimate	Standard Error
Relative risk aversion coefficient	0.240	0.049
Elasticity of intertemporal substitution (EIS)	4.167	0.851
Subjective discount factor, annual data	0.905	0.055
Subjective discount factor, quarterly data	0.975	0.063

Notes: Standard errors for the estimates of the elasticity of intertemporal substitution and the subjective discount factor for quarterly data are computed using the Delta-method.

Source: Author calculations.

5   Conclusion

In this paper, we present estimates of the Euler equation for Russia. The estimation is based on household data from the RLMS-HSE panel survey and accounts for measurement errors in consumption and income, as well as for the impact of macroeconomic shocks. We use credit and deposit rates as asset returns. Preference heterogeneity is introduced with taste shifters — household income and working hours. To estimate the parameters of the model, we use GMM. We run an LM-test to check for multiplicative habit formation.

The estimates of the elasticity of intertemporal substitution and the subjective discount factor are both consistent with the theoretical framework. The significant positive estimate of the EIS supports the hypothesis of consumption smoothing. The hypothesis of preference heterogeneity is also supported by the data — both income and working hours influence household utility and, as a consequence, the marginal utility of consumption. The hypotheses of multiplicative habit formation (external, internal, and both external and internal) are not supported by the data.

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Appendix

A. Relative risk aversion and elasticity of intertemporal substitution

For the model without habits ($\alpha = \omega = 0$), using definition for the RRA, we obtain

$$RRA_{it} \equiv -c_{it} \frac{\partial^2 U_{it}/\partial c_{it}^2}{\partial U_{it}/\partial c_{it}} = \gamma. \tag{A1}$$

And the EIS is

$$EIS_{it} \equiv \frac{\mathrm{d}(c_{it+1}/c_{it})}{\mathrm{d}(MU_{it}/MU_{it+1})} \frac{MU_{it}/MU_{it+1}}{c_{it+1}/c_{it}} = \frac{1}{\gamma}, \tag{A2}$$

where $MU_{it} = \partial U_{it}/\partial c_{it}$ and $MU_{it+1} = \partial U_{it}/\partial c_{it+1}$ are the marginal utility of current and future consumption, respectively.

Both of these parameters show the curvature of the utility function, but have different intuitive interpretations. The RRA reflects household attitudes towards risk — the higher the RRA is, the more households do not like uncertainty.

In the models of consumption, the EIS shows the relation between consumption growth and interest rates. For a model without uncertainty, the FOC is

$$\frac{MU_{it}}{MU_{it+1}} = R_{it+1}. \tag{A3}$$

Thus, the EIS is given by

$$EIS_{it} = \frac{\mathrm{d}(c_{it+1}/c_{it})}{\mathrm{d}R_{it+1}} \frac{R_{it+1}}{c_{it+1}/c_{it}}, \tag{A4}$$

and, therefore, reflects the relationship between consumption growth and interest rates. If we introduce uncertainty, the FOC becomes

$$\mathsf{E}\left(\frac{MU_{it+1}}{MU_{it}} R_{it+1} \middle| \mathsf{F}_{it}\right) = 1, \tag{A5}$$

and we cannot simplify the expression for the EIS. But it still has a similar intuitive interpretation – though not so straightforward – and most authors treat the EIS as the power of the relationship between consumption growth and interest rates.

B. The Euler Equation for a Model with Habits

The derivation of the Euler equation here is analogous to that in Khorunzhina and Roy (2011), except for some notations.

For the model with both internal and external habits, the derivative of the utility function with respect to current consumption is given by

$$\frac{\partial U_{it}}{\partial c_{it}} = \frac{\phi_{it}}{c_{it}}\left(\frac{c_{it}}{c_{it-1}^{\alpha}\bar{c}_{t-1}^{\omega}}\right)^{1-\gamma} - \alpha\beta\frac{\phi_{it+1}}{c_{it}}\left(\frac{c_{it+1}}{c_{it}^{\alpha}\bar{c}_{t}^{\omega}}\right)^{1-\gamma}. \tag{B1}$$

And the derivative with respect to future consumption is

$$\frac{\partial U_{it}}{\partial c_{it+1}} = \beta\frac{\phi_{it+1}}{c_{it+1}}\left(\frac{c_{it+1}}{c_{it}^{\alpha}\bar{c}_{t}^{\omega}}\right)^{1-\gamma} - \alpha\beta^2\frac{\phi_{it+2}}{c_{it+1}}\left(\frac{c_{it+2}}{c_{it+1}^{\alpha}\bar{c}_{t+1}^{\omega}}\right)^{1-\gamma}. \tag{B2}$$

Substituting (B1) and (B2) into FOC (9) and dividing by $\phi_{it}\left(\dfrac{c_{it}}{c_{it-1}^{\alpha}\bar{c}_{t-1}^{\omega}}\right)^{1-\gamma}$, we get the Euler

equation for the model with habits:

$$\mathsf{E}\left[\beta\frac{g_{it+1}^{\phi}}{g_{it+1}^{c}}\left(\frac{(g_{it+1}^{c})}{(g_{it}^{c})^{\alpha}(\bar{g}_{t}^{c})^{\omega}}\right)^{1-\gamma}\left(1-\alpha\beta(g_{it+2}^{\phi})\left(\frac{(g_{it+2}^{c})}{(g_{it+1}^{c})^{\alpha}(\bar{g}_{t+1}^{c})^{\omega}}\right)^{1-\gamma}\right)R_{it+1} + \right.$$
$$\left. +\alpha\beta g_{it+1}^{\phi}\left(\frac{(g_{it+1}^{c})}{(g_{it}^{c})^{\alpha}(\bar{g}_{t}^{c})^{\omega}}\right)^{1-\gamma} -1\middle|\mathsf{F}_{it}\right] = 0, \tag{B3}$$

where $g_{it+1}^{\phi} = \phi_{it+1}/\phi_{it}$ represents the growth of taste shifters function, $g_{it+1}^{c} = c_{it+1}/c_{it}$ denotes the

growth rate of consumption, and $\bar{g}_{t+1}^{c} = \bar{c}_{t+1}/\bar{c}_{t}$ denotes the growth rate of average consumption.

Without habits $(\alpha = \omega = 0)$ and with specification for the taste shifters function

$g_{it+1}^{\phi} = \exp(\Delta x_{it+1}'\delta)$, this Euler equation simplifies to equation (10).

C. Euler Equation with Measurement Errors

Consider Euler equation (10) and assume that observed consumption c_{it}^{o} differs from actual

consumption c_{it} by measurement error $v_i\eta_{it}$, like in (11). Expressing actual consumption from

(11) and substituting it into (10), we get

$$\mathsf{E}\left(\beta\exp(\Delta x_{it+1}'\delta)\left(\frac{c_{it+1}^{o}}{c_{it}^{o}}\frac{\eta_{it}}{\eta_{it+1}}\right)^{-\gamma}R_{it+1} -1\middle|\mathsf{F}_{it}\right) = 0. \tag{C1}$$

The time-invariant part of measurement error drops out from the Euler equation. Assuming that

the time-specific part of measurement error is independent from actual consumption, taste

shifters, and information set F_{it}, we may rewrite (C1) as

$$\mathsf{E}\left(\left(\frac{\eta_{it}}{\eta_{it+1}}\right)^{-\gamma}\right)\mathsf{E}\left(\beta\exp(\Delta x_{it+1}'\delta)\left(\frac{c_{it+1}^{o}}{c_{it}^{o}}\right)^{-\gamma}R_{t+1} -1\middle|\mathsf{F}_{it}\right) = 0. \tag{C2}$$

Denoting the first expectation in (C2) by κ and moving it under expectation operator, we obtain

Euler equation (13).

If we assume that household income also suffers from a measurement error of the same

type, we can again obtain equation (13), but κ is now defined by

$$\kappa = \mathsf{E}\!\left(\left(\frac{\xi_{it+1}}{\xi_{it}}\right)^{\delta_y}\left(\frac{\eta_{it}}{\eta_{it+1}}\right)^{-\gamma}\right), \tag{C3}$$

where ξ_{it} is the time-specific part of the income measurement error.

Following the same steps, we can obtain the Euler equation for the model with habits and measurement errors:

$$\mathsf{E}\!\left[\beta\frac{g_{it+1}^{\phi}}{g_{it+1}^{c}}\left(\frac{(g_{it+1}^{c})}{(g_{it}^{c})^{\alpha}(\overline{g}_{t}^{c})^{\omega}}\right)^{1-\gamma}\left(\kappa_1 - \kappa_2\alpha\beta(g_{it+2}^{\phi})\left(\frac{(g_{it+2}^{c})}{(g_{it+1}^{c})^{\alpha}(\overline{g}_{t+1}^{c})^{\omega}}\right)^{1-\gamma}\right)R_{t,t+1}\right.$$

$$\left.+\kappa_3\alpha\beta g_{it+1}^{\phi}\left(\frac{(g_{it+1}^{c})}{(g_{it}^{c})^{\alpha}(\overline{g}_{t}^{c})^{\omega}}\right)^{1-\gamma}-1\middle|\mathsf{F}_{it}\right]=0, \tag{C4}$$

where κ_1, κ_2, and κ_3 are some constants, which depends only on the distribution of household-specific parts of measurement errors.

D. Moments Covariance Matrix

In the first step of the two-step optimal GMM, we use a weighting matrix

$$A = \left(\begin{array}{cc} \dfrac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}(z_{it}z_{it}') & 0 \\ 0 & \dfrac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}(z_{it}z_{it}') \end{array}\right)^{-1}, \tag{D1}$$

which is independent from unknown parameters and is the consistent estimator of Ω in the case of independent observations. In the second step, we estimate the covariance matrix of moment conditions Ω and set $A = \hat{\Omega}^{-1}$ to obtain final estimates of the parameters.

A standard GMM technique for independent data assumes that terms $f_{it}(\theta)$ of moment conditions are independent for different observations. But since data on different households are collected for the same time periods, we relax this assumption and estimate the moment covariance matrix, accounting for the possible correlation between $f_{it}(\theta)$ for different households. In particular, this correlation may arise due to macroeconomic shocks.

Consider two households i and j. Household i was interviewed in October 2011 and in October 2012 and household j was interviewed in November 2011 and in November 2012. Then $f_{it}(\theta)$ for household i depends on the growth rates of consumption, income, and working hours for the period from October 2011 to October 2012, which were affected by the macroeconomic shocks of these 12 months. The same is for household j, but for the period from

November 2011 to November 2012. Therefore, $f_{it}(\theta)$ and $f_{j\tau}(\theta)$ were affected by the same macroeconomic shocks of 11 months (from November 2011 to October 2012). Let us refer to these 11 months as an intersection period and denote the number of common months for terms $f_{it}(\theta)$ and $f_{j\tau}(\theta)$ as $\Delta_{it,j\tau}$.

In the case of correlated observations, the asymptotic covariance matrix of moment conditions is given by

$$\Omega = \lim_{NT \to \infty} \mathrm{var}\left(\frac{1}{\sqrt{NT}} \sum_{i=1}^{N} \sum_{t=1}^{T} f_{it}(\theta_0) \right), \tag{D2}$$

where $\mathrm{var}(\cdot)$ stands for the variance operator, y_{it} is the vector of variables of the model, and θ_0 is the true value of the parameter vector θ. So we may estimate Ω by

$$\hat{\Omega} = \frac{1}{NT} \sum_{i=1}^{N} \sum_{t=1}^{T} \sum_{j=1}^{N} \sum_{\tau=1}^{T} w(\Delta_{it,j\tau}) Est.Cov.\big(f_{it}(\theta_0), f_{j\tau}(\theta_0)\big), \tag{D3}$$

where $w(\Delta_{it,j\tau})$ are the positive weights increasing in $\Delta_{it,j\tau}$, which we use to ensure that $\hat{\Omega}$ is positive definite. We define them in the spirit of the Newey-West variance estimator by setting

$$w(\Delta_{it,j\tau}) = 1 \quad for\ i = j \tag{D4}$$

and

$$w(\Delta_{it,j\tau}) = 1 - \frac{\Delta_{max} - \Delta_{it,j\tau} + 1}{\Delta_{max} + 1} \quad for\ i \neq j, \tag{D5}$$

where Δ_{max} is the maximum value of the intersection period. One may note that the weight for two observations with a zero intersection period equals zero.

And finally, assuming that macroeconomic shocks are uncorrelated in time, we define the estimator of covariance of moment conditions for two observations by

$$Est.Cov.\big(f_{it}(\theta_0), f_{j\tau}(\theta_0)\big) = \frac{1}{n(\Delta_{it,j\tau})} \sum_{\Delta_{it,j\tau}} f_{it}(\hat{\theta}) f_{j\tau}(\hat{\theta})', \tag{D6}$$

where $n(\Delta_{it,j\tau})$ is the number of pairs of observations for which the intersection period equals $\Delta_{it,j\tau}$, and $\sum_{\Delta_{it,j\tau}}$ denotes the summation over all such pairs of observations.

E. Data

E.1. Consumption, income, and working time-share

The samples used in the paper are drawn from the 9th-21st waves of the RLMS-HSE representative sample, which corresponds to the period from September 2000 to February 2013. We use household files to construct such variables as consumption of nondurable goods and

services, household income, place of residence (urban/rural), number of household members, their sex and age, and weights for the basket of nondurable goods and services to calculate inflation. To obtain working hours of household members, we use individual files from the survey.

In the paper we define consumption of nondurable goods and services as the sum of expenditures on items presented in Tab. E1. Since the questionnaire contains questions about expenditures of the last week (*panels A and B of Tab. E1*) along with questions about expenditures from the last month (*panels C-E of Tab. E1*) and last quarter (*panel F of Tab. E1*), we transform all the responses to monthly expenditures and compute the nominal consumption of nondurable goods and services as follows:

$$c_{it}^{nom} = \left(4c_{it}^{week} + c_{it}^{month} + c_{it}^{quarter}/3\right)/n_i, \tag{E1}$$

where c_{it}^{week} is the last week's expenditures on *food, alcohol, and tobacco*, c_{it}^{month} is the last month's expenditures on *fuel, communication services, and other nondurable goods and services*, $c_{it}^{quarter}$ is the last quarter's expenditures on *clothing and shoes*, and n_i is the number of members in the i-th household.

As the expenditures on each item of *food* consumption, we use the expenditures reported by the interviewee. If the interviewee did not report the expenditures, but reported the amount of the item bought, we computed the expenditures by multiplying this amount by the average price of this item. We compute the average price as the average ratio of expenditures to the amount of the item reported by households interviewed in the same wave and who live in the same region. If the interviewee reported neither the expenditures nor the amount, but answered that she had expenditures on this item, we compute them as the average expenditures of households of the same wave and same region. When doing these calculations, we use expenditures per household member to account for the different sizes of households. We use an analogous procedure to compute expenditures on other items of nondurable goods and services.

As nominal income we use the reported household income per household member. To construct the real consumption of nondurable goods and services and real income, we use the inflation of nondurable goods and services described below.

For each household member, we construct working hours as the sum of the last month's hours of work reported for all jobs, regardless as to whether they are principal or occasional. We compute household working time-share as the average working hours of non-retired adult members divided by 720 (the approximate number of hours in a month).

Tab. E1. List of nondurable goods and services

№	Expenditures	RLMS code	Period
A	*Food*		
1	White (wheat) bread	*e1.1c	Last 7 days
2	Black (rye) bread	*e1.2c	Last 7 days
3	Rice, other cereals	*e1.3c	Last 7 days
4	Flour	*e1.4c	Last 7 days
5	Macaroni products	*e1.5c	Last 7 days
6	Potatoes	*e1.6c	Last 7 days
7	Canned veg., excluding pickled	*e1.7c	Last 7 days
8	Cabbage, including sauerkraut	*e1.8c	Last 7 days
9	Cucumbers, including pickles	*e1.9c	Last 7 days
10	Tomatoes, including pickled	*e1.10c	Last 7 days
11	Beets, carrots, other roots	*e1.11c	Last 7 days
12	Onions, garlic	*e1.12c	Last 7 days
13	Squash, pumpkins, etc.	*e1.13c	Last 7 days
14	Other vegetables	*e1.14c	Last 7 days
15	Watermelons, melons, including pickled and dried	*e1.15c	Last 7 days
16	Fruit/berry preserves	*e1.16c	Last 7 days
17	Fresh berries	*e1.17c	Last 7 days
18	Fresh fruit	*e1.18c	Last 7 days
19	Dried fruits, berries	*e1.19c	Last 7 days
20	Nuts, sunflower seeds	*e1.20c	Last 7 days
21	Canned meat	*e1.21c	Last 7 days
22	Beef, veal	*e1.22c	Last 7 days
23	Lamb, goat meat	*e1.23c	Last 7 days
24	Pork	*e1.24c	Last 7 days
25	Giblets: liver, kidneys, etc	*e1.25c	Last 7 days
26	Fowl	*e1.26c	Last 7 days
27	Lard, other animal fats	*e1.27c	Last 7 days
28	Sausage, smoked meat	*e1.28c	Last 7 days
29	Semi-prepared meat products	*e1.29c	Last 7 days
30	Canned/powdered milk	*e1.30c	Last 7 days
31	Fresh milk	*e1.31c	Last 7 days
32	Sour milk products: kefir, yogurt, etc	*e1.32c	Last 7 days
33	Sour cream, cream	*e1.33c	Last 7 days
34	Butter	*e1.34c	Last 7 days
35	Curd, cream cheese	*e1.35c	Last 7 days
36	Cheese, feta cheese	*e1.36c	Last 7 days
37	Ice cream	*e1.37c	Last 7 days
38	Vegetable oil	*e1.38c	Last 7 days
39	Margarine	*e1.39c	Last 7 days
40	Sugar	*e1.40c	Last 7 days
41	Candy, chocolate	*e1.41c	Last 7 days
42	Preserves, jam	*e1.42c	Last 7 days
43	Honey	*e1.43c	Last 7 days
44	Cookies, pastries, cakes, waffles, gingerbread, buns	*e1.44c	Last 7 days
45	Eggs	*e1.45c	Last 7 days
46	Fish: fresh, frozen, dried, prepared by a fishmonger	*e1.46c	Last 7 days
47	Canned fish	*e1.47c	Last 7 days

№	Expenditures	RLMS code	Period
48	Tea	*e1.48c	Last 7 days
49	Coffee, caffeinated drinks, cocoa	*e1.49c	Last 7 days
50	Nonalcoholic drinks, juice	*e1.50c	Last 7 days
51	Salt, other spices, various sauces	*e1.51c	Last 7 days
52	Mushrooms	*e1.52c	Last 7 days
53	Spending on eating out of door	*e3	Last 7 days
B	**Alcohol and tobacco**		
54	Vodka	*e1.53c	Last 7 days
55	Wine, other alcohol	*e1.54c	Last 7 days
56	Beer	*e1.55c	Last 7 days
57	Tobacco products	*e1.56c	Last 7 days
C	**Fuel**		
60	Fuel for running vehicles, motors, generators	*e8.1b	Last 30 days
61	Firewood, coal, peat, kerosene	*e8.2b	Last 30 days
62	Bottled gas	*e8.3b	Last 30 days
D	**Communication services**		
63	Postal/telegraph service, including long-distance telephone calls	*e9.6b	Last 30 days
64	Wireless phone services	*e9.8b	Last 30 days
65	Internet services	*e9.9b	Last 30 days
E	**Other nondurable goods and services**		
66	Washing materials (e.g., soap, laundry detergent)	*e13.32b	Last 30 days
67	Personal hygiene (e.g., shampoo, toothpaste, toilet paper, sanitary napkins, diapers, etc.)	*e13.33b	Last 30 days
68	Cosmetics and perfume	*e13.34b	Last 30 days
69	Tailoring, clothing repair, shoe repair	*e9.2b	Last 30 days
70	Laundry, dry cleaner, public bath, hairdresser	*e9.5b	Last 30 days
71	Transportation services: local, intercity	* e9.1b	Last 30 days
F	**Clothing and shoes**		
58	Spending on buying clothing and shoes for adults	*e6.1	Last 3 month
59	Spending on clothing and shoes for children	*e6.2	Last 3 month

Notes: * stands for variable indicator of each particular round (from *a* for the 5th wave to *q* for the 21st wave)

E.2. Asset returns and inflation

As asset returns we use up to one-year average interest rates on individual credits and deposits, as reported by The Bank of Russia. Initially these interest rates are reported for the period of 12 months. But the period between two interviews of a household is not necessarily 12 months. The month of the interview may change from wave to wave, meaning that one household may be interviewed even twice a year – for example, in January 2012 (20th wave) and in December 2012 (21st wave). To account for the varying number of months between interviews, we transform interest rates as follows:

(a) if the number of months between interviews of the i-th household in waves t and $t+1$ denoted by $h(i,t)$ is less than or equal to 12, we use reported interest rate powered by the appropriate length of the period

$$R_{it+1} = \left(R^*_{m(i,t)}\right)^{h(i,t)/12},$$
(E2)

where $R^*_{m(i,t)}$ is the annual interest rate reported in month $m(i,t)$ (for the next 12 months), $m(i,t)$ is the month of the interview of the i-th household in wave t;

(b) if the number of months between interviews is more than 12, we use the geometrical average of current and future annual interest rates powered by the appropriate length of the period

$$R_{it+1} = \left({}^{(h(i,t)-11)}\sqrt{\prod_{\tau=0}^{h(i,t)-12} R^*_{m(i,t)+\tau}} \right)^{h(i,t)/12}.$$ (E3)

We do these transformations for both credit and deposit rates.

To construct real consumption, real income, and real interest rates, we use inflation for nondurable goods and services, which we compute using RLMS-HSE data and price indices for each particular item of nondurable goods. We define the inflation rate between two dates t and τ as

$$\pi_{t,\tau} = \frac{\sum_{j=1}^{J} \omega_{jt} P_{j\tau}}{\sum_{j=1}^{J} \omega_{jt} P_{jt}} - 1,$$ (E4)

where ω_{jt} is the average share of spending on the j-th item of nondurables in the total spending on nondurables, computed using RLMS-HSE data, J is the number of items of nondurables, and P_{jt} is the price index of j-th item, which we get from official statistics[4].

E.3. Sample structure

The initial representative sample of the 9th to 21st waves of the survey contains data on about 12,375 households[5], but most of the households were interviewed only for several waves, meaning that the average number of households per wave is 4,231. From the original sample we drop those households who live in rural areas, and we drop household-wave observations if there is no non-retired adult member in the household. Following Attanasio and Weber (1995), in order to exclude obvious reporting and coding errors, we drop household-wave observation if consumption growth is such that one of the following criteria holds: (a) $c^o_{it+1}/c^o_{it} < 0.2$ or $c^o_{it+1}/c^o_{it} > 5$, (b) $c^o_{it}/c^o_{it-1} < 0.5$ and $c^o_{it+1}/c^o_{it} > 2$, (c) $c^o_{it}/c^o_{it-1} > 2$ and $c^o_{it+1}/c^o_{it} < 0.5$. We use a similar filter for income growth.

To obtain estimates, we need each household to be interviewed for at least four consecutive waves — two waves to construct growth rates, plus two waves to construct a set of instruments. Moreover, to test for internal habit formation, we need one additional wave to

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[4] Consumer price indices (tariff) for products and services. *Source: Federal State Statistics Service*, http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/en/figures/prices/
[5] Our own calculations based on merging data from different waves by household identification variable.

construct one additional lead of the variables. Thus, households who have no observations for *four* consecutive waves are excluded from *the long sample*, and households who have no observations for *five* consecutive waves are excluded from *the short sample*. The losses associated with each criterion applied consecutively to the original sample are presented in Tab. E2.

Tab. E2. Number of households after applying selection criteria

Selection Criteria	Short Sample	Long Sample
Number of households in original sample	12,375	12,375
Lives in urban area	9,578	9,578
Has at least one non-retired adult member in any wave	7,755	7,755
Pass consumption growth filter for any wave	7,407	7,407
Pass income growth filter for any wave	7,309	7,309
There are observations for four consecutive waves	1,800	1,800
There are observations for five consecutive waves	1,363	—
Number of households in final sample	1,363	1,800