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Defining Consumption Behaviour in a Multi-Country Model

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ABSTRACT

This paper presents the consumption function of Marmotte, the multi-country model of CEPII-CEPREMAP, and its estimation for the 17 countries of the model. The consumption function is based on the permanent income model. We have extended this model to account for the presence of habit formation and liquidity constraints in the consumption behaviors. The results obtained give us reasonable values for the consumption function of Marmotte. Differences across the 17 countries concern only the habit behaviors. However, these differences are not large enough to imply significant differences in terms of consumption responses to shocks in the simulations of the model.

Keywords : Consumption, habit formation, liquidity constraints, generalized method of moments.

JEL classification: C33, C51, E21, E44.

RESUME

Ce document de travail présente la fonction de consommation de Marmotte, le modèle multinational du CEPII-CEPREMAP, et son estimation sur les 17 pays du modèle. Les études macro-économétriques sur la consommation reposent souvent sur des extensions du modèle de revenu permanent. Avec ce modèle les séries temporelles agrégées sont interprétées comme la solution d'un programme de maximisation de la somme actualisée des utilités instantanées d'un agent représentatif à durée de vie infinie. Prenant en compte ses préférences, l'agent choisit entre consommer aujourd'hui et épargner pour consommer plus tard en comparant les effets de chacun de ces choix sur son bien-être.

Si le modèle de revenu permanent est économétriquement facile à mettre en œuvre, les travaux empiriques ont tous montré que ce modèle pose deux problèmes. Premièrement, le modèle sous-estime l'inertie de la consommation par rapport au revenu permanent (le fameux "excès de lissage" de la consommation). Deuxièmement, le modèle sous-estime également la sensibilité de la consommation au revenu courant car il néglige l'existence de contraintes de liquidité (certains ménages ne peuvent emprunter contre leur revenu futur et consomment entièrement leur revenu courant).

Pour tenir compte de l'excès de lissage de la consommation, nous sommes revenus sur l'hypothèse d'une fonction d'utilité séparable dans le temps en introduisant dans le modèle des effets de formation d'habitude de la part du consommateur. Aussi, le modèle de consommation avec habitudes implique un degré important de lissage de la consommation, i.e. une certaine inertie dans le processus de consommation. Pour tenir compte des contraintes de liquidité, nous avons supposé deux types d'agents dans l'économie dont la proportion est constante dans le temps. Les ménages du premier type sont contraints financièrement tandis que ceux du second type ont un libre accès aux marchés financiers et agissent selon un comportement d'arbitrage. Pour estimer économétriquement la part des agents contraints, nous l'avons inclus directement dans l'équation d'Euler en supposant que les ménages non-contraints connaissaient cette part et la prenaient en compte dans l'optimisation.

L'estimation sur un panel de 17 pays nous a permis d'étudier les sources de différences structurelles entre pays dans les comportements de consommation. Les résultats obtenus nous donnent des valeurs raisonnables pour la fonction de consommation de Marmotte. La part des ménages contraints financièrement est cohérente avec les résultats d'études récentes. La présence d'habitude dans les décisions de consommation est vérifiée empiriquement, supportant ainsi le choix de spécification. Seul le paramètre d'habitude diffère entre pays. Ceci implique quelques légères différences en terme de degré de lissage de la consommation. Cependant, le principal résultat est que ces différences entre les 17 pays de Marmotte ne sont pas assez importantes pour impliquer des différences significatives en terme de réponses de la consommation à des chocs lors de simulations du modèle.

SUMMARY

This paper presents the consumption function of Marmotte, the multi-country model of CEPII-CEPREMAP, and its estimation for the 17 countries of the model. Macro-econometric studies on consumption often lie on extensions of the permanent income model. It implies that aggregated time series is interpreted as the solution to the infinite-lived representative consumer program. The representative consumer maximizes the discounted sum of his instantaneous utilities. Taking his preferences into account, it chooses between consuming today and saving to consume later by comparing the effects of each of these two choices on his welfare.

If the permanent income model is econometrically easy to implement, the empirical works related to this model have all shown at least two limits. First, the model underestimates the inertia of consumption relative to the permanent income (the so-called 'excess smoothness' of consumption). Second, the model underestimates also the sensitivity of consumption to the current income due to liquidity constraints (households are unable to borrow against their future income and consume all their current income).

To account for the excess smoothness of consumption, we have reconsidered the assumption of a time separable utility function and introduced in the model habit formation from the consumer. As a consequence, the consumption model with habits implies a large degree of smoothness of consumption, i.e. the inertia of the consumption process. To account for liquidity constraints, we have assumed two different types of households whose proportion in the economy is constant over time. The households of the first group are liquidity-constrained whereas the households of the second group have a free access to financial markets and behave according to an arbitrage equation. To estimate econometrically the share of the liquidity-constrained agents, we have included it directly in the Euler equation by assuming that the unconstrained households know this share and account for it in the optimization.

The estimation on a panel of 17 countries has allowed us to study the sources of structural differences across countries in the consumption behaviors. The results obtained give us reasonable values for the consumption function of Marmotte. The share of liquidity constrained households is in line with recent studies on this topic. The presence of habits in the consumption decisions is empirically verified, supporting then the specification choice. Only the habit parameter seems to differ across countries. This implies some slight differences in terms of degree of smoothness of consumption. However, the main result is that differences across the 17 countries present in Marmotte are not large enough to imply significant differences in terms of consumption responses to shocks in the simulations of the model.

DEFINING CONSUMPTION BEHAVIOR IN A MULTI-COUNTRY MODEL

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I. INTRODUCTION

This paper presents the consumption function of Marmotte, the multi-country model of CEPII-CEPREMAP, and its estimation for the 17 countries of the model. Macro-econometric studies on consumption often lie on extensions of the permanent income model. Even if we owe the concept of Permanent Income to Friedman (1957), the model used in the recent literature is due to Hall (1978). It implies that aggregated time series is interpreted as the solution to the infinite-lived representative consumer program. It considers a representative consumer who maximizes the discounted sum of his instantaneous utilities. Taking his preferences into account, each individual chooses between consuming today and saving to consume later by comparing the effects of each of these two choices on his welfare.

The strong conclusion of the infinite-horizon model is that changes in consumption follow a martingale difference. However, this conclusion was challenged by empirical studies. Hall's model seems to underestimate both the inertia of consumption relative to the permanent income (the 'excess smoothness' of consumption has been shown first by Deaton, 1988) and the sensitivity of consumption to the current income (Flavin, 1981, Campbell and Mankiw, 1989). This second limit is related to the existence of liquidity constraints that undermine the model's assumption of competitive financial markets. In spite of the financial deregulation implemented at some time in the past two decades in almost all the industrialized countries, part of households may still be unable to borrow against their future income. Finally, from a theoretical point of view, the infinite life framework has also been criticized for the lack of realism of its assumption concerning the agent's horizon, which avoids taking into account life cycle features and the distribution of income across generations.

One of the first extension to a finite life horizon is due to Blanchard (1985). It makes possible the analysis of intergenerational distribution issues, such as the burden of public debt. The main feature of this approach is to account for the uncertainty that an individual agent faces relative to its life horizon. Although life expectancy is perfectly known, this uncertainty leads to unexpected bequests. With a perfectly competitive life insurance system, this introduces a distinction between the individual and the national rate of return. Then the real interest rate of the economy will differ from each agent's time preference

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rate, within a range limited by the probability of dying. An important consequence of this framework is to rule out pure Ricardian equivalence: households anticipate that part of the burden of an increase in public debt will fall on younger households and future generations (lack of altruism). However, the flexibility given by the Blanchard's specification should not be overstated. Uncertainty about life horizon increases the private discount factor by the probability of dying. This gives some flexibility in setting the interest rate, which has not to be strictly equal to the time preference rate. But the rate of death is very low in industrialized countries (less than 0.5% per annum), so this flexibility and the departure from pure Ricardian equivalence are quantitatively limited.

The implementation of Blanchard's style consumption function in a macro-econometric model is complex. First, the estimation of the model's parameters requires building data for unobserved variables, such as human wealth (i.e. the permanent income) and the expectations of the future path of real interest rates. There is no trivial way to deal with this problem. As we know the motion law of the two unobserved data, it is tempting to compute the series by assuming starting values far enough in the past. This solution has been implemented in Multimod Mark 3. However, one can be skeptical about the use of "home-made" data in the estimation of the "deep" parameters of the economy. Besides, the integration of income profiles in Multimod is also questionable. They are assumed to be the same across countries and are calibrated using US data. They are consistent with US population trends, but not at all with those of the other OECD countries. In spite of this extension, Multimod cannot really address the consequences of changing demographic trends such as the aging of population (which would require endogenous changes in the income profiles).

Considering that the empirical costs exceed the economic benefits of the finite life model, we have decided to choose for Marmotte a more traditional framework based on an extension of the Hall's model. Extending the infinite-horizon model is related with the use of the capital asset pricing model, which considers that the individual has access to complete financial markets without transaction cost. Hence, any type of financial asset can be used as a means of saving. The arbitrage condition builds up a relationship between the asset's expected return and the marginal rate of intertemporal substitution, i.e. the relative importance given by the individual between consuming today and consuming in the next period. Assuming an infinite-horizon framework allows us to preserve its convenience and its tractability in terms of econometric estimation. Furthermore, we attempt to deal with two empirical limits of the Hall's model: (a) excess smoothness of consumption relative to permanent income and (b) liquidity constraint.

To account for the excess smoothness of consumption, we reconsider the assumption of a time separable utility function to take into account habit formation. Following Weil (1989) and Constantinides (1990), we expect to enhance the ability of the model to explain consumption inertia. We derive an arbitrage condition from an iso-elastic instantaneous utility function with current and past consumption as arguments.

The liquidity constraint effect is difficult to integrate in a theoretical model in a tractable way. More precisely, the heterogeneity across agents regarding their financial wealth makes it impossible to derive any micro-based macro-economic relation. A practical solution consists in assuming two different types of households whose proportion in the economy is constant over time. The households of the first group are liquidity-constrained. Although they want to borrow, they find no counterpart on the financial market. This means that they consume all their current income. The households of the second group have free access to financial markets and behave according to the arbitrage equation. Introducing liquidity constraints enables us to account for one of the main sources of non Ricardian equivalence: the imperfection of financial markets. This kind of assumption was also introduced in other multi-country models like Multimod Mark 3 or Quest II. However, for these models the proportion of liquidity-constrained agents was not estimated. Here, we have desired to include the liquidity constraints directly in the arbitrage equations in order to derive it directly from the econometric estimation.

The theoretical framework of the behavioral equations retained for Marmotte is presented in section II. Then, section III displays the estimation of the parameters and discusses the relevance of country-specific values for the 17 countries modeled in Marmotte. Section IV concludes.

II. THE THEORITICAL FRAMEWORK

1. Habit Formation in the Consumers' Behavior

We consider here the approach of a representative agent with an infinite life horizon. The theoretical base of what follows is related to the consumption based capital asset pricing model (C-CAPM) theory as developed for instance by Weil (1989) and Constantinides (1990). These models have been motivated by the inability of the traditional model with a time separable utility function to explain observed risk premia (problem known as the " equity premium puzzle ", see Mehra and Prescott, 1985). The C-CAPM requires an unwisely high risk aversion coefficient to make up for the low volatility of consumption growth relative to the equity premium. This 'equity premium puzzle' has led some economists to question the specification of the model, in particular the time-separability of the representative agent's utility. Relaxing the hypothesis of time separable utility induces to extend the temporal effects of the consumption realized in a given period to the intertemporal utility of the consumer. We consider here the simple case where the present consumption has also an impact on the utility of the next period. The assumption of a time dependent utility function gives some flexibility to the model. More precisely, the impact of current consumption on future instantaneous utility reflects the formation of habits. Besides, this specification should enhance the ability of the model to explain consumption inertia (Fuhrer, 2000).

We assume an economy with a representative agent who chooses his consumption path so as to maximize the expected discounted sum of instantaneous utilities under his budget constraint. He has access to complete financial markets and holds *n* different assets. We define the instantaneous utility as a function of current and lagged (one period) consumption. This is a convenient way to break time separability. If lagged consumption depresses the current utility, consumption is characterized by habit formation: the representative agent gauges his utility partly by considering his previous level of consumption as a benchmark. On the contrary, if lagged consumption has a positive effect on the current utility, consumption is characterized by durability[2].

Two other parameters enter the consumption function: the time discount rate and the concavity of the instantaneous utility function. The interest of such a model is that the inter-temporal elasticity of substitution is no more equal to the inverse of risk aversion, but depends also on the habit (or durability) parameter.

The maximization program is as follows:

$$\text{Max}\, E_t H_t = E_t\left[\sum_{\tau=t}^{+\infty} \beta^{\tau-t} U\left(C_\tau - \alpha C_{\tau-1}\right)\right] \quad (1)$$

$$pc_t C_t + \sum_{i=1}^{n} p_{i,t} S_{i,t+1} - \sum_{i=1}^{n}\left(p_{i,t} + d_{i,t}\right) S_{i,t} - YD_t = 0 \quad (2)$$

where C_t is the level of the per capita consumption in real terms and pc_t the price of a unit of consumption at time t. E_t is the expectation of the representative agent conditional to the information set available at time t, β is the current discount factor, α is the habit parameter (if $0<\alpha<1$) or the durability parameter (if $-1<\alpha<0$). YD_t is the consumer's nominal disposable income. We can notice that habits depend on the past consumption realized *by the agent*, and not on the average level of past consumption in the economy as a whole[3]. When determining the level of its current consumption, the consumer takes into account not only the immediate satisfaction he gets from it, but also the impact these expenses have on its satisfaction in the next period.

The consumer holds a portfolio constituted by *n* assets. We note $S_{i,t}$ the number of assets i (i = 1, ..., n) bought in t-1 by the agent and held until time t, $p_{i,t}$ the price of the asset i in t and $d_{i,t}$ the amount of interest, coupon or dividends paid for each unit of the asset *i* hold between t-1 and t. Each asset has a return $R_{i,t}$. Among these *n* assets, the first one (i=1) is a risk-free asset whose return $R_{1,t}$ is certain. The *n-1* other assets are risky.

The first-order condition is:

$$E_t\left[\frac{\partial H_t}{\partial C_{t+1}} / \frac{\partial H_t}{\partial C_t}\left[1 + R_{i,t+1}\right]\right] = 1 \quad \forall i = 1,\dots, n \quad (3)$$

where $1 + R_{i,t+1} = \left(\frac{pc_t}{pc_{t+1}}\right)\left(\frac{p_{i,t+1} + d_{i,t+1}}{p_{i,t}}\right)$

2 The habit formation model is presented in more details in Allais, Cadiou et Dées (2000).

3 This class of model is referred to as " catching-up-with the Joneses " (Abel, 1990).

with an iso-elastic utility function of the following form:

$$U(C_t - aC_{t-1}) = \frac{(C_t - aC_{t-1})^{1-g}}{1-g}$$

the first order condition (3) becomes:

$$E_t\left[(C_t - aC_{t-1})^{-g} - b(a + (1+R_{i,t+1}))(C_{t+1} - aC_t)^{-g} + ab^2(1+R_{i,t+1})(C_{t+2} - aC_{t+1})^{-g}\right] = 0 \qquad (4)$$
$$\forall i = 1,\ldots,n$$

Equation (4) gives the form of the Euler equation, which reflects the consumption behavior of not unconstrained households.

2. How to Deal with the Liquidity Constraint Issue ?

Introducing liquidity constraints in the habit model can be realized quite easily. As Adda and Boucekkine (1996), we can re-write the maximization program by modifying the constraint (2). Liquidity constraints can then be included just by adding a simple form imposing that the consumer cannot borrow if its financial wealth is above a threshold level $\overline{W}$:

$$\begin{cases} \sum_{i=1}^{n} p_{i,t} S_{i,t+1} = \sum_{i=1}^{n} \left(p_{i,t} + d_{i,t}\right) S_{i,t} + YD_t - pc_t C_t \\ \sum_{i=1}^{n} p_{i,t} S_{i,t+1} > \overline{W} \qquad \forall i = 1,\ldots,n \end{cases} \qquad (2')$$

The last inequality is a simple form for the liquidity constraint. However, due to the non-linearity and non-differentiability of the Euler equations, it is not possible to derive closed-form decision rules for optimal consumption. The model can only be solved using numerical simulations. It seems then difficult to identify the different characteristics of this general model, in particular between time non-separability and liquidity constraints (Adda and Boucekkine, 1996).

Yet, we need a specification for the consumption function that can be econometrically estimated. Consequently, we turn to an *ad hoc* specification, which aims at adding the liquidity constraint effect to the arbitrage equation with habit formation (equation 4). We suppose that a constant share of households faces a liquidity constraint. This simple assumption corresponds to a very specific form of the liquidity problem. With two types of consumers, we implicitly rule out the possible movements from one group to the other. This means that each individual consumer is either always or never liquidity constrained over his lifetime. This assumption could be criticized since agents may only face a liquidity constraint at the beginning of their life. Assuming constant flows from one group to the other has more appeal. However, under this alternative assumption the proportion of households facing a constraint would depend on the age structure of the population. There are also reasons to expect the liquidity constraint to be correlated to the business cycle, due for example to credit channel mechanisms.

Taking into account a time varying share of constrained agents would be both difficult and fragile. Here, as Campbell and Mankiw (1989, 1991), we consider a constant share of constrained households. However, these authors estimate a liquidity-constraint effect assuming a quadratic, time separable utility function, and thus taking advantage of the linearity of the marginal utility of consumption. Indeed, in this case the change in the consumption of unconstrained households equals the expectation error on their permanent income, which is orthogonal to the information set of the agent. Thus, the share of consumption change explained by the change in current income can be assimilated to the share of constrained agents.

The transposition of this strategy to an iso-elastic utility function, also proposed by Campbell and Mankiw, has been considered but it has appeared too demanding. More precisely, the linearization of Euler equations such as (3) rests upon the log-normality assumption of the conditional distribution of consumption and of financial asset returns.

Using the following transformations: $r_{i,t+1} = \ln(1+R_{i,t+1})$ and $m_{t+1} = \ln\left(\frac{\partial H_t}{\partial C_{t+1}} / \frac{\partial H_t}{\partial C_t}\right)$, equation (3) becomes:

$$E_t\{r_{i,t+1}\} + E_t\{m_{t+1}\} + \frac{1}{2}\left[s_t^2\{r_{i,t+1}\} + s_t^2\{m_{t+1}\} + 2Cov_t\{r_{i,t+1}, m_{t+1}\}\right] = 0 \qquad (3')$$

where s_t^2 and Cov_t are respectively the variance and the covariance conditional to the information set.

Assuming that $E_t\{m_{t+1}\}$ can be expressed as a linear combination of Δc_{t-1}, Δc_t, Δc_{t+1} and Δc_{t+2}, where $c_t = \ln(C_t)$, we would still have to ignore the variance and co-variance terms of equation (3') in order to estimate the parameters of the model. From our attempts to do so, it appears that this last assumption is much too strong. For example, without habit formation, i.e. with $a = 0$ and $E_t\{m_{t+1}\} = gE_t\{\Delta c_{t+1}\}$, the estimation of (3') gives very high values for g, whereas the estimation of the genuine non-linear specification (3) gives more reasonable values for this parameter. We have the same result with habit formation, although in that case we also need to deal with the non-linearity of $E_t\{m_{t+1}\}$[4].

We propose here another way to estimate the share of liquidity constrained households in the economy. We assume that unconstrained households observe the behavior of constrained households. The rationality of unconstrained households rests upon the fact that they know the working of the whole economy. In particular, they are aware that liquidity-constrained households consume their current income and that these households represent a share l of the economy (in particular, they receive a share of the aggregated disposable income equal to l).

Thus, the maximization program of unconstrained households becomes:

[4] This has been done considering the Taylor development of $E_t\{m_{t+1}\}$ around a steady state.

$$\text{Max}\, E_t H_t = E_t\left[\sum_{t=t}^{+\infty} b^{-tt} U\left(C_t^u - aC_{t-1}^u\right)\right] \tag{8}$$

$$\begin{cases} pc_t C_t + \sum_{i=1}^{n} p_{i,t} S_{i,t+1} - \sum_{i=1}^{n}\left(p_{i,t} + d_{i,t}\right) S_{i,t} - YD_t = 0 \\ C_t = C_t^u + lYD_t \end{cases} \tag{9}$$

where C_t^u is the consumption of unconstrained households and lYD_t that of constrained households.

This gives the new Euler equations (10):

$$\begin{aligned} &E_t\Big\{\left((C_t - lYD_t) - a(C_{t-1} - lYD_{t-1})\right)^{-g} - b(a + (1 + R_{i,t+1}))\left((C_{t+1} - lYD_{t+1}) - a(C_t - lYD_t)\right)^{-g} \\ &+ ab^2(1 + R_{i,t+1})\left((C_{t+2} - lYD_{t+2}) - a(C_{t+1} - lYD_{t+1})\right)^{-g}\Big\} = 0 \\ &\forall i = 1,\ldots,n \end{aligned} \tag{10}$$

3. Implementation in Marmotte

In Marmotte, the representative agent allocates its financial wealth between four assets: a one period, risk free bill, long term government bonds, a domestic risky asset (the national stock index) and a foreign asset. The Euler equation (10) should be written for each asset, each equation linking the expected marginal substitution rate of consumption to the expected return of this asset. Thus, the estimation of the preference parameters should be based on a stochastic system of four arbitrage equations.

To simplify, we have preferred to write only the Euler equation related to the risk-free asset's return. This simplification is theoretically justified only when there is no uncertainty. In this case, the four Euler conditions are equivalent to one arbitrage equation for a specific asset and three relations setting the expected return of this asset equal to the expected return of the other types of assets.

Even if in Marmotte, we have included this simplification, for the estimation, we have used two arbitrage equations. The first one is related with the risk-free asset and the second one is related with government bonds. Data availability problems for stock returns for the 17 countries of Marmotte, and the low share of foreign assets in the households' financial wealth have led to the removal of the other two equations[5].

5 An analysis of the habit consumption model with stock returns for the G7 countries is provided by Allais, Cadiou and Dées (2000).

III. ESTIMATING THE PARAMETERS OF THE CONSUMPTION FUNCTION

As we have previously seen, the specification of consumption behaviors in Marmotte allows the existence of two different types of consumers. The first one behaves according to an Euler equation. The second one faces a liquidity constraint and spends all its current income. In this section, we provide estimates for the parameters of equation (10) with the methodology developed in Allais, Cadiou and Dées (2000). These estimates will be used to parametrize the consumption function of the 17 countries modeled in Marmotte. Besides, they will be used to study the structural differences in consumption behaviors across those countries. With the model developed here, these differences are likely to come both from consumers' preferences (risk aversion, time preference, habit) and from market imperfection (liquidity constrained households).

1. The system of Euler equation

The consumption parameters are estimated from the two-equation system made of equations (10) written for the short-term asset (with return R_1) and bonds (with return R_2)[6]:

$$E_t\left\{\left((C_t - lYD_t) - a(C_{t-1} - lYD_{t-1})\right)^{-g} - b(a + (1+R_{i,t+1}))\left((C_{t+1} - lYD_{t+1}) - a(C_t - lYD_t)\right)^{-g}\right.$$
$$\left. + ab^2(1+R_{i,t+1})\left((C_{t+2} - lYD_{t+2}) - a(C_{t+1} - lYD_{t+1})\right)^{-g}\right\} = 0$$

for i=1,2.

We have to estimate 4 parameters: the habit parameter (α), the discount factor (β), the curvature of the utility function (γ), and the share of liquidity constrained agents (λ). The estimations are realized assuming that unconstrained consumers have access to both bonds and money market asset.

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[6] The long-term bond is considered as a proxy of a perpetual bond whose return is defined as follows: $i_t^l + \frac{i_{t-1}^l}{i_t^l}$, where i_t^l is the long-term interest rate.

2. The Database

The estimations are realized with yearly series over the period starting in 1971 and ending in 1998. The database includes the 17 countries of Marmotte (Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands, Portugal, Spain, Sweden, the United Kingdom and the United States). The variables required for the estimations are *per capita* consumption (in nominal and real terms), disposable income, short-run interest rates and long-run interest rates. Households' consumption corresponds to the definition of the OECD Economic Outlook. The consumption deflator is obtained by dividing consumption in nominal terms by consumption in real terms. Data for disposable income are derived from households' saving ratio reported in the OECD Economic Outlook. Short-run interest rates are generally money market rates or 3-months Treasury bill rates as reported in the OECD Economic Outlook. As this series is partially missing for Spain in the early 70s, we have used the Bank of Spain intervention rate, which is very close to the OECD data during the period where the two series are available. For the long run interest rate, the OECD Economic Outlook series have been used for all the countries. These series usually refer to the 10-year government bonds.

3. Econometric Methodology

The econometric methodology used in this paper is based on the Generalized Method of Moments (GMM). This method is adapted to the optimization problem with first order conditions such as $E_t\{e_{t+1}(q)\}=0$. E_t refers to the expectations conditional to the information set available in time t. This method rests on the fact that the forecast errors are independent from the household's information set. The use of the GMM is also adapted to the estimation of non-linear models according to the procedure defined by Hansen and Singleton (1982).

We define a set of k instruments belonging to the information set. These instruments must be orthogonal to the error term ε_{t+1}. We have then to estimate $p \times k$ equations such as $E_t\left[e_{p,t+1}(q)Z'_t\right]=0$ where p is the number of countries and Z is matrix of instruments (by convention the first instrument is the identity vector). The GMM consists in finding a value for θ, such that the empirical moments of the Euler equations are equal to zero.

The important number of equations is likely to yield a bad estimation of the errors' covariance matrix. The latter has $(p\times k)(2p\times k+1)$ parameters, i.e. 5253 parameters for 17 countries, 2 assets and 3 instruments. To reduce the number of parameters of the covariance matrix, we assume the shocks hitting the different countries at a same time come from a limited number of common factors. We adopt here the methodology, based on factorial analysis, defined by Doz (1998) and developed by Guichard and Laffargue (2000). The structure imposed on the covariance matrix assumes that national economies face shocks that can reasonably be summarized by a combination of world-wide shocks. If f is the number of factors, there are only $(f+1)(2n\times p\times k)$ parameters, i.e. 408 here for 3 factors.

To study the differences across countries, we implement a test strategy based on the general to specific philosophy. We start by testing the less constrained model (all the parameters are assumed to differ across countries) against the models where only one parameter is constrained (e.g.) the model where g is constrained but where the others are allowed to differ across countries). The test strategy is the following. One starts by estimating the more constrained model and one saves its covariance matrix. Then, one estimates the less constrained model with the former covariance matrix. One realizes a likelihood ratio test with the constraint on a parameter across the 17 countries as the null hypothesis. This method is explicitly defined by Ogaki (1993). For each test, we accept the null hypothesis at the 5 percent significance level.

4. Identification and Stationarity

The use of the GMM requires first, the parameters to be identifiable and, second, the variables to be stationary (Hansen 1982).

The problem of identification was discussed in Allais, Cadiou and Dées (2000). We only summarize here the transformation we must make to overcome the identification issue. The main problem of the estimation of equation (10) is that $g = 0$ is a trivial solution, since the objective function to be minimized is equal to zero in that case. Indeed, when $g = 0$, the Euler equation simplifies to: $(1-ab)E_t\left[1-b(1+R_{t+1})\right]=0$. Hence, any couple of values of α and β verifying $a = 1/b$ is a solution. As a result, one of these parameters cannot be determined. This indeterminacy problem is not critical since the case $g = 0$ has no economic sense in a model with habit formation. More precisely, we are interested in a solution within the class of strictly concave utility functions.

How to constraint g to be strictly positive? Traditionally (see Allais, 1999 or Ogaki, 1993) the Euler equation is divided by $(1-ab)\left[1-b(1+R_{t+1})\right]$. Then the objective function takes large values when the parameters approach to $ab = 1$ and $b(1+E_t\{R_{t+1}\})=1$, rejecting these combinations as solutions. In our opinion, this method has serious drawbacks since this *ad hoc* modification has in practice a strong influence on the parameters that minimize the objective function.

The method chosen in this paper (explained in more details in Allais, Cadiou and Dées, 2000) avoids modifying too much the objective function. As b must not exceed 1 and $|a| \leq 1$, there is only one evident solution which is $a = 1$ and $g = 0$. As we are interested in a model with habit formation, the case where $g = 0$ has no relevance for us even if it corresponds to the global minimum of the objective function. In other words, we concentrate on the class of utility functions that are strictly concave, by searching the best local minimum that satisfies $g > 0$. Practically, rather than estimating directly γ, we estimate a parameter θ such as $g = \exp(q)$. Hence, we start to investigate solutions whose initial values are sufficiently far away from the evident solution. Finally, to ensure that λ remains positive, we also use the following variable change: $l = \exp(t)$, and we estimate the parameter τ.

The last problem concerns the stationarity condition. Per capita consumption in the 17 countries are likely to be non-stationary, even though unit root tests are not powerful over such a small sample (28 years). To deal with this problem, we divide equation (10) by $\left((C_t - \lambda YD_t) - \alpha(C_{t-1} - \lambda YD_{t-1})\right)^{-\gamma}$, which involves estimating the following equation:

$$E_t\left\{1-\beta\left(\alpha+(1+R_{i,t+1})\right)\left(\frac{(C_{t+1}-\lambda YD_{t+1})-\alpha(C_t-\lambda YD_t)}{(C_t-\lambda YD_t)-\alpha(C_{t-1}-\lambda YD_{t-1})}\right)^{-\gamma}\right. \\ \left.+\alpha\beta^2\left((1+R_{i,t+1})\right)\left(\frac{(C_{t+2}-\lambda YD_{t+2})-\alpha(C_{t+1}-\lambda YD_{t+1})}{(C_t-\lambda YD_t)-\alpha(C_{t-1}-\lambda YD_{t-1})}\right)^{-\gamma}\right\}=0 \qquad (10')$$

5. Estimation Results

5.1. Estimation results of the different models and tests

Two different Euler equations are estimated simultaneously, each being related to a different asset return (short term and long term interest rates). The theoretical model that we want to estimate has four parameters: γ the curvature of the instantaneous utility function, α the habit parameter, β the discount factor and λ the share of constrained households. This model is estimated for the 17 countries. We want to test the existence of significant differences in the value of the parameters across countries. The combinations of constraints on the parameters imply to estimate 16 different models. We present in Appendix the results of these estimations. To guide our choice among the 16 models, we have implemented the nested test strategy.

If the equlity constraint across the 17 countries is accepted for one parameter, then the model where this parameter is identical across countries becomes the reference model relative to which the equality of each of the two other parameters is tested. This procedure is continued until the equality constraint across countries is rejected for all the remaining unconstrained parameters. We have then the final model to retain.

If the estimation of all the models has been realized, most of the results exhibit unreasonable values in an economic viewpoint. For several models, the GMM algorithm tends to solutions where the curvature of the utility function is infinite. Besides, the parameter λ (the share of constrained agents), is sometimes larger than one. After having run the series of nested tests, we reached the conclusion that the best model retains identical parameters across the 17 countries. However, the tests between the most constrained model and the models for which only one parameter is country specific are unfair. Actually, the most constrained model is close to a trivial solution where $\gamma = 0$ and $\alpha = 1$, the other parameters being undetermined. It however stops before reaching this solution (at $\gamma = 0.03$ and $\alpha = 0.92$), owing to the non-negativity constraint of $(C_t - \lambda YD_t) - \alpha(C_{t-1} - \lambda YD_{t-1})$. In other words, when all the parameters are the same across countries, there is no solution in the class of strictly concave utility function. However, in that case, the corresponding likelihood function used for the test is almost equal to zero making this uninteresting model the best one. Then, we must look at the models where one parameter is country-specific. In that case, the best model is the model where habit is country-specific. The estimates of this model are displayed in Table 1. This model performs quite well since it would not be rejected at the 11% level against the "unfair" constrained model. Besides, the estimated values are reasonable in an economic viewpoint. This model is the one retained for Marmotte.

The model exhibits habit formation, i.e. positive values for α. This coefficient is significant for all the countries but Canada, Sweden and the UK. The discount factor is highly significant and the share of the constrained consumers is significant at the 10% level. It is equal to 13 %. This share has been estimated in several papers. One of the first estimations was realized by Campbell and Mankiw (1991). They found a share for the G7 countries ranging between 22% for the UK and 65% for Germany. These estimation were realized for periods starting in the 50s or 60s according to the countries and ending in 1986. These estimates are largely higher than ours. However, more recent studies all reckon a significant decrease in the share of constrained consumers due to the financial liberalization of the 80s. Patterson and Pesaran (1992) find 0.21 as an estimate of liquidity constrained consumption for the UK and 0.44 for the US over the period 1955-89. They also find that this share has fallen significantly in the 80s, to 0.13 for the UK and to 0.1 for the US. The latter estimates are in line with other empirical evidence of the decline in liquidity constrained consumption following the 80s financial liberalization (e.g. Sefton and In't-Veld, 1999).

Table 1: Estimation results

	Value	*t-Stat*
Common parameters		
γ *(curvature of the utility function)*	0,84	1,1
λ *(share of constrained agents)*	0,13	1,6
β *(discount factor)*	0,96	75,0
α **(Habit parameter)**		
Austria	-0,74	-8,7
Belgium	-0,64	-3,1
Canada	-0,20	-0,4
Denmark	-0,83	-2,7
Finland	-0,63	-1,7
France	-0,70	-4,8
Germany	-0,63	-3,4
Greece	-0,94	-21,9
Italy	-0,64	-4,2
Ireland	-0,82	-6,0
Japan	-0,97	-13,5
Netherlands	-0,63	-2,8
Portugal	-0,69	-6,1
Spain	-0,73	-6,6
Sweden	-0,39	-1,4
UK	-0,82	-1,5
US	-0,81	-5,1

5.2. Interpretation of the results for the unconstrained consumers

The elasticity of intertemporal substitution summarizes the consumer behavior in the face of uncertainty on the level of consumption. It is defined by:

$$1/EIS_t = -\frac{C_t \dfrac{\partial^2 V_t}{\partial^2 C_t}}{\dfrac{\partial V_t}{\partial C_t}}$$

, where V_t is the intertemporal utility function.

In our case, this is equivalent to:

$$1/EIS_t = \gamma \frac{C_t\left[\left(C_t - \alpha C_{t-1}\right)^{-\gamma-1} + \beta\alpha^2\left(C_{t+1} - \alpha C_t\right)^{-\gamma-1}\right]}{\left(C_t - \alpha C_{t-1}\right)^{-\gamma} - \beta\alpha\left(C_{t+1} - \alpha C_t\right)^{-\gamma}}$$

Following Lettau and Uhlig (1997), we derive the expression of the elasticity of inter-temporal substitution by considering that the logarithm of consumption follows a random walk with drift: $c_{t+1} = g + c_t + \varepsilon_{t+1}$. This assumption simplifies the computation of the conditional expectations and gives an indication of the sensitivity of the elasticity of intertemporal substitution to the model's parameters:

$$1/EIS = \left(\frac{g}{1-ae^{-g}}\right)\left(\frac{1+ba^{2}e^{-g(g+1)}}{1-bae^{-gg}}\right)$$

We find then that without habit formation (α=0), the inverse of the elasticity of intertemporal substitution is equal to the curvature of the instantaneous utility function. The elasticity of intertemporal substitution is a decreasing function of both habit and the curvature of the utility function. It also decreases with the discount factor β as soon as we have habit (α>0).

Relative risk aversion summarizes the consumer's behavior in the face of uncertainty on wealth:

$$RRA_t = -\frac{W_t \dfrac{\partial^2 V_t}{\partial^2 W_t}}{\dfrac{\partial V_t}{\partial W_t}}$$, where W_t is the wealth of the representative agent.

Constantinides (1990) gives the expression of relative risk aversion in the case of a production economy in which the agent's wealth is endogenous. We take here the formula in Lettau and Uhlig (1997), again in the case where the logarithm of consumption follows a random walk with drift:

$$RRA = \frac{g}{1-ae^{-g}\dfrac{e^{-gg}-bg}{e^{-gg}-ba}}$$

The relative risk aversion decreases strongly with the degree of habit. On the other hand, the higher the habit coefficient is, the less relative risk aversion is sensitive to the curvature of the utility function (γ)

The advantage of the habit model is that it does not impose an equality constraint between relative risk aversion and the inverse of the elasticity of intertemporal substitution. In particular, Constantinides (1990) shows that, with habit formation, the product RRA x EIS is below one:

$$RRA_t \times EIS_t = \frac{\partial C_t}{\partial W_t}\frac{W_t}{C_t} < 1$$

This indicates that for the same elasticity of intertemporal substitution, relative risk aversion is weaker in a model with habit. The economic interpretation of this inequality is that the consumer smoothes its consumption more than is required by life cycle consideration.

With these formulas and the values of α, β and γ derived from our estimations, we can compute the values of RRA and EIS for our preferred model. We also assume that consumption (in logarithm) follows a random walk with a drift that is country-specific[7]. Even if this hypothesis on the consumption growth process is quite strong, it allows us to derive easily values required to compare the consumption behavior across countries.

Table 2 presents the values of the elasticity of intertemporal substitution (EIS) and of the relative risk aversion (RRA) according to the formulas presented above.

The model gives interesting consumers' preferences. The low values of the elasticity of intertemporal substitution are consistent with the assumption that agents favor a very important smoothing of their consumption over time, although it takes extreme values for Greece and Japan. Without habit, these low elasticities of intertemporal substitution would lead to very high relative risk aversion. Here, coefficients for the relative risk aversion are reasonable. They range between 0.88 for Canada and 3.01 pour the UK[8].

The consumption models with habit formation are characterized by an excess smoothing of consumption relative to that implied by the life cycle hypothesis (Constantinides, 1990). The product $RRA \times EIS$, equal to one for the time separable models and less than one here, gives a measure of this excess smoothing. Our estimations indicate that the presence of habit implies a very low change of consumption relative to a change in wealth, in a ratio of 1 to 10 for most of the countries (Austria, Belgium, France, Italy, Portugal, Spain, the UK and the US). This relative change of consumption to wealth is a bit higher for Denmark, Finland, Germany, Ireland, and the Netherlands (1 to 6). The especially low excess smoothing for Sweden and Canada is a particular case and should be taken very cautiously, since the estimates for the habit coefficient are badly estimated in these cases.

[7] The drift is computed as being the average of $\log(C/C_{-1})$ over the estimation period.

[8] Note that the approximations underlying the formula for RRA do not apply for values of habit close to one, as shown in the case of Japan and Greece.

Table 2: Elasticity of Intertemporal Substitution and Relative Risk Aversion

	γ	α	β	Drift	**RRA**	**1/EIS**	**EIS xRRA**
Austria	0.84	0.74	0.96	0.024	**1.57**	**14.97**	**0.10**
Belgium	0.84	0.64	0.96	0.021	**1.20**	**7.83**	**0.15**
Canada	0.84	0.20	0.96	0.019	**0.88**	**1.34**	**0.66**
Denmark	0.84	0.83	0.96	0.017	**1.93**	**11.26**	**0.17**
Finland	0.84	0.63	0.96	0.020	**1.18**	**7.41**	**0.16**
France	0.84	0.70	0.96	0.021	**1.38**	**11.47**	**0.12**
Germany	0.84	0.63	0.96	0.018	**1.19**	**7.48**	**0.16**
Greece	0.84	0.94	0.96	0.023	**-0.81**	**162.94**	**0.00**
Ireland	0.84	0.64	0.96	0.028	**1.19**	**7.64**	**0.16**
Italy	0.84	0.82	0.96	0.025	**3.00**	**29.59**	**0.10**
Japan	0.84	0.97	0.96	0.027	**-0.34**	**311.91**	**0.00**
Netherlands	0.84	0.63	0.96	0.018	**1.18**	**7.46**	**0.16**
Portugal	0.84	0.69	0.96	0.022	**1.33**	**10.63**	**0.13**
Spain	0.84	0.73	0.96	0.021	**1.52**	**14.11**	**0.11**
Sweden	0.84	0.39	0.96	0.009	**0.95**	**2.49**	**0.38**
UK	0.84	0.82	0.96	0.024	**3.01**	**29.81**	**0.10**
US	0.84	0.81	0.96	0.019	**2.65**	**27.84**	**0.10**

IV. CONCLUSION

This paper has aimed at defining the consumption function of the multi-country model Marmotte and at estimating econometrically its parameters. We have assumed an infinite-horizon framework by extending the permanent income model. It has allowed us to preserve the tractability in terms of econometric estimation, which is absent in the works based on the life cycle hypothesis. In addition, we have attempted to account for two empirical weaknesses of the permanent income model: (a) excess smoothness of consumption relative to permanent income and (b) liquidity constraint.

To account for the excess smoothness of consumption, we have reconsidered the assumption of a time separable utility function and introduced in the model habit formation. By including habits in the consumption function, we have got reasonable parameters, as shown especially by our approximation of the degree of risk aversion of the consumers. As a consequence, the consumption model with habits implies a large degree of smoothness of consumption, i.e. inertia of the consumption process. In a macro-econometric model, accounting for this inertia is likely to replicate the usually observed slow response of consumption to shocks and to avoid the large, unrealistic volatility of consumption that traditional Euler equation produces.

To account for liquidity constraints, we have assumed two different types of households whose proportion in the economy is constant over time. The households of the first group are liquidity-constrained whereas the households of the second group have free access to financial markets and behave according to an arbitrage equation. To estimate econometrically the share of the liquidity-constrained agents, we have included it directly in the Euler equation by assuming that the unconstrained households know this share and account for it in the optimization.

The results obtained give us reasonable values for the consumption function of Marmotte. The share of liquidity constrained households is in line with recent studies on this topic. The presence of habits in the consumption decisions is empirically verified, hence supporting the specification choice. Finally, the combination of the parameters is consistent with reasonable consumers' preferences and the properties of the consumption function are likely to produce realistic responses to shocks.

The estimations on a panel of countries has allowed us to get both more data to make our empirical evidence more robust and to study what are the sources of structural differences across countries. By estimating the "deep" parameters of the consumption function (degree of risk aversion, degree of inertia in the consumption process, presence of habits in the consumers' preference, …), we have provided an evidence of the roots of differences. Only habit parameters seem to differ across countries. This implies some slight differences in terms of degree of smoothness of consumption. However, the main result is that differences across the 17 countries present in Marmotte are not large enough to imply significant differences in terms of consumption responses to shocks in the simulations of the model.

APPENDIX

Estimation results

Model 1					
curvature (γ)	*Value*	*t-Stat*	**habit (α)**	*Value*	*t-Stat*
Austria	>100	0.0	Austria	-0.77	-0.6
Belgium	>100	0.0	Belgium	-0.73	-1.0
Canada	>100	0.0	Canada	-0.70	0.0
Denmark	>100	0.0	Denmark	-0.74	-0.9
Finland	>100	0.0	Finland	-0.75	-0.2
France	>100	0.0	France	-0.76	-0.3
Germany	>100	0.0	Germany	-0.77	-2.0
Greece	>100	0.0	Greece	-0.70	-0.2
Italy	>100	0.0	Italy	-0.71	-0.3
Ireland	>100	0.0	Ireland	-0.65	-0.2
Japan	>100	0.0	Japan	-0.86	-0.1
Netherlands	>100	0.0	Netherlands	-0.72	0.0
Portugal	>100	0.0	Portugal	-0.79	-0.3
Spain	>100	0.0	Spain	-0.75	-0.1
Sweden	>100	0.0	Sweden	-0.67	-0.4
UK	>100	0.0	UK	-0.76	-0.1
US	>100	0.0	US	-0.73	-1.3
liquidity c. (λ)	*Value*	*t-Stat*	**discount f. (β)**	*Value*	*t-Stat*
Austria	>100	0.0	Austria	0.90	0.7
Belgium	>100	0.0	Belgium	0.94	7.0
Canada	>100	0.0	Canada	0.88	0.3
Denmark	>100	0.0	Denmark	0.89	0.8
Finland	>100	0.0	Finland	0.97	0.5
France	>100	0.0	France	0.91	0.3
Germany	>100	0.0	Germany	1.14	0.4
Greece	>100	0.0	Greece	0.99	0.7
Italy	>100	0.0	Italy	0.91	0.7
Ireland	>100	0.0	Ireland	0.98	2.8
Japan	>100	0.0	Japan	0.86	0.1
Netherlands	>100	0.0	Netherlands	0.92	0.1
Portugal	>100	0.0	Portugal	0.75	0.2
Spain	>100	0.0	Spain	0.89	0.2
Sweden	>100	0.0	Sweden	0.91	1.8
UK	>100	0.0	UK	0.93	0.4
US	>100	0.0	US	0.93	0.5

Model 2					
curvature (γ)	*Value*	*t-Stat*	**habit (α)**	*Value*	*t-Stat*
17 countries	>100	0.0	Austria	-0.82	-0.8
			Belgium	-0.76	-2.6
			Canada	-0.74	-0.2
			Denmark	-0.79	-1.5
			Finland	-0.78	-0.4
			France	-0.81	-0.7
			Germany	-0.79	-2.4
			Greece	-0.70	-1.3
			Italy	-0.74	-0.5
			Ireland	-0.64	-0.5
			Japan	-0.92	-0.1
			Netherlands	-0.76	-0.1
			Portugal	-0.86	-1.1
			Spain	-0.80	-0.7
			Sweden	-0.70	-0.7
			UK	-0.81	-0.2
			US	-0.76	-3.2
liquidity c. (λ)	*Value*	*t-Stat*	**discount f. (β)**	*Value*	*t-Stat*
Austria	79.67	0.0	Austria	0.90	1.0
Belgium	2.85	0.1	Belgium	0.95	10.0
Canada	>100	0.0	Canada	0.90	0.5
Denmark	>100	0.0	Denmark	0.91	2.3
Finland	>100	0.0	Finland	0.96	1.4
France	>100	0.0	France	0.91	1.4
Germany	2.06	0.1	Germany	1.17	1.6
Greece	>100	0.0	Greece	0.99	9.0
Italy	>100	0.0	Italy	0.92	1.2
Ireland	>100	0.0	Ireland	0.98	16.7
Japan	>100	0.0	Japan	0.83	0.2
Netherlands	>100	0.0	Netherlands	0.93	0.3
Portugal	>100	0.0	Portugal	0.72	0.3
Spain	>100	0.0	Spain	0.91	1.6
Sweden	>100	0.0	Sweden	0.94	3.3
UK	>100	0.0	UK	0.95	0.9
US	27.44	0.0	US	0.94	5.9

Model 3					
curvature (g)	*Value*	*t-Stat*	**habit (a)**	*Value*	*t-Stat*
Austria	>100	0.0	17 countries	-0.79	-1.6
Belgium	>100	0.0			
Canada	>100	0.0			
Denmark	>100	0.0			
Finland	>100	0.0			
France	>100	0.0			
Germany	>100	0.0			
Greece	>100	0.0			
Italy	>100	0.0			
Ireland	>100	0.0			
Japan	>100	0.0			
Netherlands	>100	0.0			
Portugal	>100	0.0			
Spain	>100	0.0			
Sweden	>100	0.0			
UK	>100	0.0			
US	>100	0.0			
liqu. c. (l)	*Value*	*t-Stat*	**disc. f. (b)**	*Value*	*t-Stat*
Austria	>100	0.0	Austria	0.89	1.2
Belgium	5.29	0.0	Belgium	0.91	6.0
Canada	>100	0.0	Canada	0.80	0.3
Denmark	>100	0.0	Denmark	0.85	0.5
Finland	>100	0.0	Finland	0.96	1.1
France	>100	0.0	France	0.90	1.1
Germany	>100	0.0	Germany	1.16	0.6
Greece	>100	0.0	Greece	0.95	3.5
Italy	>100	0.0	Italy	0.86	1.3
Ireland	>100	0.0	Ireland	0.94	3.0
Japan	>100	0.0	Japan	0.94	0.1
Netherlands	>100	0.0	Netherlands	0.87	0.5
Portugal	>100	0.0	Portugal	0.75	0.3
Spain	>100	0.0	Spain	0.86	0.7
Sweden	>100	0.0	Sweden	0.82	0.9
UK	>100	0.0	UK	0.91	0.6
US	>100	0.0	US	0.89	0.3

Model 4					
curvature (g)	**Value**	*t-Stat*	**habit (a)**	*Value*	*t-Stat*
Austria	8.77	0.2	Austria	-0.83	-2.4
Belgium	>100	0.1	Belgium	-0.77	-2.8
Canada	>100	0.0	Canada	-0.74	-0.2
Denmark	>100	0.0	Denmark	-0.78	-1.0
Finland	>100	0.0	Finland	-0.77	-0.5
France	>100	0.0	France	-0.82	-0.6
Germany	>100	0.0	Germany	-0.78	-0.4
Greece	>100	0.0	Greece	-0.70	-0.6
Italy	>100	0.0	Italy	-0.74	-0.3
Ireland	>100	0.0	Ireland	-0.64	-0.3
Japan	>100	0.0	Japan	-0.91	-0.1
Netherlands	>100	0.0	Netherlands	-0.76	-0.2
Portugal	>100	0.0	Portugal	-0.85	-0.4
Spain	>100	0.0	Spain	-0.80	-0.7
Sweden	>100	0.0	Sweden	-0.70	-0.7
UK	>100	0.0	UK	-0.81	-0.4
US	50.80	0.0	US	-0.77	-1.8
liqu. c. (l)	*Value*	*t-Stat*	**disc. f. (b)**	*Value*	*t-Stat*
17 countries	0.21	0.8	Austria	0.91	3.2
			Belgium	0.96	8.6
			Canada	0.91	0.3
			Denmark	0.91	2.3
			Finland	0.99	1.6
			France	0.92	1.4
			Germany	1.18	0.2
			Greece	1.01	4.7
			Italy	0.92	0.6
			Ireland	0.99	7.8
			Japan	0.85	0.1
			Netherlands	0.93	0.6
			Portugal	0.69	0.6
			Spain	0.91	0.7
			Sweden	0.94	3.3
			UK	0.96	0.7
			US	0.95	5.1

Model 5					
curvature (γ)	*Value*	*t-Stat*	**habit (α)**	*Value*	*t-Stat*
Austria	>100	0.0	Austria	-0.71	-1.8
Belgium	>100	0.0	Belgium	-0.71	-1.9
Canada	>100	0.0	Canada	-0.52	-0.5
Denmark	>100	0.0	Denmark	-0.65	-1.4
Finland	>100	0.0	Finland	-0.86	-0.7
France	>100	0.0	France	-0.68	-1.0
Germany	>100	0.0	Germany	-0.91	-1.7
Greece	>100	0.0	Greece	-0.82	-0.6
Italy	>100	0.0	Italy	-0.65	-0.5
Ireland	>100	0.0	Ireland	-0.77	-1.3
Japan	>100	0.0	Japan	-0.78	-0.2
Netherlands	>100	0.0	Netherlands	-0.65	-0.3
Portugal	>100	0.0	Portugal	-0.56	-1.0
Spain	>100	0.0	Spain	-0.67	-0.7
Sweden	>100	0.0	Sweden	-0.59	-0.5
UK	>100	0.0	UK	-0.76	-0.1
US	>100	0.0	US	-0.71	-2.3
liqu. c. (λ)	*Value*	*t-Stat*	**disc. f. (β)**	*Value*	*t-Stat*
Austria	>100	0.0	17 countries	0.94	9.5
Belgium	18.70	0.0			
Canada	>100	0.0			
Denmark	>100	0.0			
Finland	1.08	0.2			
France	>100	0.0			
Germany	0.47	0.5			
Greece	>100	0.0			
Italy	>100	0.0			
Ireland	>100	0.0			
Japan	>100	0.0			
Netherlands	>100	0.0			
Portugal	>100	0.0			
Spain	>100	0.0			
Sweden	>100	0.0			
UK	>100	0.0			
US	41.37	0.0			

Model 6		
curv. (g)	*Value*	*t-Stat*
17 countries	5.47	0.2
habit (a)	*Value*	*t-Stat*
17 countries	-0.80	-4.6
liqu. c. (l)	*Value*	*t-Stat*
Austria	27.64	0.0
Belgium	0.29	1.0
Canada	>100	0.0
Denmark	>100	0.0
Finland	>100	0.0
France	12.33	0.0
Germany	0.67	0.3
Greece	1.67	0.1
Italy	>100	0.0
Ireland	>100	0.0
Japan	>100	0.0
Netherlands	>100	0.0
Portugal	>100	0.0
Spain	6.43	0.0
Sweden	>100	0.0
UK	>100	0.0
US	1.30	0.2
disc. f. (b)	*Value*	*t-Stat*
Austria	0.91	2.2
Belgium	0.94	7.7
Canada	0.85	0.4
Denmark	0.89	1.9
Finland	0.95	2.4
France	0.91	4.0
Germany	1.17	3.4
Greece	0.97	5.9
Italy	0.88	2.4
Ireland	0.96	6.1
Japan	0.97	2.3
Netherlands	0.90	1.8
Portugal	0.81	0.8
Spain	0.90	2.2
Sweden	0.87	1.4
UK	0.95	1.7
US	0.92	4.1

Model 7		
curv. (g)	*Value*	*t-Stat*
17 countries	2.72	0.4
habit (a)	*Value*	*t-Stat*
Austria	-0.84	-3.9
Belgium	-0.78	-3.8
Canada	-0.75	-0.5
Denmark	-0.81	-1.8
Finland	-0.78	-1.0
France	-0.83	-0.9
Germany	-0.81	-2.1
Greece	-0.70	-2.0
Italy	-0.75	-0.5
Ireland	-0.65	-0.9
Japan	-0.94	-2.9
Netherlands	-0.77	-0.6
Portugal	-0.88	-2.1
Spain	-0.81	-1.2
Sweden	-0.71	-1.1
UK	-0.82	-0.8
US	-0.78	-2.5
liqu. c. (l)	*Value*	*t-Stat*
17 countries	0.18	1.2
disc. f. (b)	*Value*	*t-Stat*
Austria	0.92	6.0
Belgium	0.96	14.6
Canada	0.92	1.6
Denmark	0.92	3.1
Finland	0.97	11.5
France	0.92	2.4
Germany	1.16	1.1
Greece	1.00	18.2
Italy	0.93	1.6
Ireland	0.98	16.7
Japan	0.85	0.9
Netherlands	0.94	2.8
Portugal	0.71	0.6
Spain	0.93	2.5
Sweden	0.95	7.2
UK	0.97	4.0
US	0.96	9.0

Model 8		
curv. (g)	*Value*	*t-Stat*
17 countries	0.59	0.5
habit (a)	*Value*	*t-Stat*
Austria	-0.70	-4.1
Belgium	-0.75	-2.1
Canada	-0.23	-0.4
Denmark	-0.92	-2.3
Finland	-0.90	-2.3
France	-0.53	-2.4
Germany	-0.59	-2.6
Greece	-0.83	-2.4
Italy	-0.61	-4.0
Ireland	-0.72	-1.4
Japan	-0.95	-1.5
Netherlands	-0.52	-1.8
Portugal	-0.70	-3.7
Spain	-0.84	-2.6
Sweden	-0.56	-1.7
UK	-0.78	-1.0
US	-0.82	-5.7
liqu. c. (l)	*Value*	*t-Stat*
Austria	1.96	0.1
Belgium	>100	0.0
Canada	>100	0.0
Denmark	>100	0.0
Finland	10.79	0.0
France	>100	0.0
Germany	2.19	0.1
Greece	55.46	0.0
Italy	1.83	0.1
Ireland	>100	0.0
Japan	3.66	0.0
Netherlands	>100	0.0
Portugal	>100	0.0
Spain	74.21	0.0
Sweden	>100	0.0
UK	>100	0.0
US	0.41	0.5
disc. f. (b)	*Value*	*t-Stat*
17 countries	0.96	70.2

Model 9			**Model 10**			**Model 11**		
curvature (γ)	*Value*	*t-Stat*	**curvature (γ)**	*Value*	*t-Stat*	**curvature (γ)**	*Value*	*t-Stat*
Austria	>100	0.0	Austria	>100	0.0	Austria	12.82	0.1
Belgium	17.62	0.1	Belgium	>100	0.0	Belgium	26.51	0.1
Canada	>100	0.0	Canada	>100	0.0	Canada	7.72	0.2
Denmark	>100	0.0	Denmark	60.79	0.0	Denmark	12.85	0.1
Finland	>100	0.0	Finland	>100	0.0	Finland	9.06	0.2
France	>100	0.0	France	>100	0.0	France	8.85	0.2
Germany	7.51	0.2	Germany	>100	0.0	Germany	1.75	0.7
Greece	12.57	0.1	Greece	>100	0.0	Greece	>100	0.0
Italy	>100	0.0	Italy	>100	0.0	Italy	>100	0.0
Ireland	35.76	0.0	Ireland	>100	0.0	Ireland	6.42	0.2
Japan	>100	0.0	Japan	>100	0.0	Japan	>100	0.0
Netherlands	>100	0.0	Netherlands	>100	0.0	Netherlands	13.30	0.1
Portugal	>100	0.0	Portugal	>100	0.0	Portugal	>100	0.0
Spain	>100	0.0	Spain	>100	0.0	Spain	>100	0.0
Sweden	>100	0.0	Sweden	>100	0.0	Sweden	>100	0.0
UK	>100	0.0	UK	>100	0.0	UK	>100	0.0
US	24.45	0.1	US	>100	0.0	US	2.37	0.8
habit (α)	**Value**	*t-Stat*	**habit (α)**	**Value**	*t-Stat*	**habit (α)**	**Value**	*t-Stat*
17 countries	-0.78	-4.0	17 countries	-0.69	-4.8	Austria	-0.72	-6.2
liquity c. (λ)	*Value*	*t-Stat*	**liquity c. (λ)**	*Value*	*t-Stat*	Belgium	-0.81	-2.6
17 countries	0.41	0.6	Austria	0.65	0.3	Canada	-0.34	-0.7
disc. f. (β)	*Value*	*t-Stat*	Belgium	0.78	0.3	Denmark	-0.73	-1.7
Austria	0.89	1.9	Canada	>100	0.0	Finland	-0.72	-0.8
Belgium	0.91	7.1	Denmark	>100	0.0	France	-0.62	-2.2
Canada	0.81	0.3	Finland	0.88	0.3	Germany	-0.64	-2.9
Denmark	0.84	1.3	France	0.62	0.2	Greece	-0.88	-0.2
Finland	0.96	4.0	Germany	>100	0.0	Italy	-0.61	-1.5
France	0.90	4.1	Greece	4.07	0.1	Ireland	-0.72	-5.5
Germany	1.10	3.4	Italy	>100	0.0	Japan	-0.92	-1.7
Greece	0.97	5.3	Ireland	>100	0.0	Netherlands	-0.57	-1.5
Italy	0.86	1.6	Japan	0.62	0.4	Portugal	-0.50	-1.1
Ireland	0.94	3.9	Netherlands	34.08	0.0	Spain	-0.69	-4.2
Japan	0.94	2.8	Portugal	>100	0.0	Sweden	-0.48	-1.0
Netherlands	0.87	1.5	Spain	>100	0.0	UK	-0.87	-0.4
Portugal	0.77	0.4	Sweden	>100	0.0	US	-0.82	-6.8
Spain	0.87	0.9	UK	>100	0.0	**liquity c. (λ)**	*Value*	*t-Stat*
Sweden	0.83	1.0	US	1.26	0.1	17 countries	0.09	1.7
UK	0.92	0.7	**disc. f. (β)**	*Value*	*t-Stat*	**disc. f. (β)**	*Value*	*t-Stat*
US	0.89	3.2	17 countries	0.96	20.1	17 countries	0.97	27.9

Model 12

curv. (g)	*Value*	*t-Stat*
17 countries	1.62	0.7
habit (a)	**Value**	*t-Stat*
17 countries	-0.81	-5.8
liquity c. (l)	*Value*	*t-Stat*
17 countries	0.18	1.4
disc. f. (b)	*Value*	*t-Stat*
Austria	0.94	12.1
Belgium	0.96	10.8
Canada	0.90	12.3
Denmark	0.92	7.2
Finland	0.97	12.2
France	0.93	19.8
Germany	1.17	4.0
Greece	0.99	8.8
Italy	0.90	8.2
Ireland	0.97	8.8
Japan	0.99	10.7
Netherlands	0.93	12.8
Portugal	0.84	7.5
Spain	0.93	10.2
Sweden	0.91	11.9
UK	0.98	10.1
US	0.95	9.9

Model 13

curv. (g)	*Value*	*t-Stat*
17 countries	>100	0
habit (a)	**Value**	*t-Stat*
17 countries	-0.92	-29.7
liquity c. (l)	*Value*	*t-Stat*
Austria	13.04	0.0
Belgium	1.07	0.2
Canada	>100	0.0
Denmark	2.31	0.1
Finland	7.33	0.0
France	1.20	0.1
Germany	0.94	0.1
Greece	>100	0.0
Italy	>100	0.0
Ireland	1.61	0.1
Japan	>100	0.0
Netherlands	>100	0.0
Portugal	>100	0.0
Spain	0.65	0.4
Sweden	>100	0.0
UK	1.44	0.2
US	0.82	0.3
disc. f. (b)	*Value*	*t-Stat*
17 countries	0.96	183.7

Model 14

curv. (g)	*Value*	*t-Stat*
17 countries	0.84	1.1
habit (a)	**Value**	*t-Stat*
Austria	-0.74	-8.7
Belgium	-0.64	-3.1
Canada	-0.20	-0.4
Denmark	-0.83	-2.7
Finland	-0.63	-1.7
France	-0.70	-4.8
Germany	-0.63	-3.4
Greece	-0.94	-21.9
Italy	-0.64	-4.2
Ireland	-0.82	-6.0
Japan	-0.97	-13.5
Netherlands	-0.63	-2.8
Portugal	-0.69	-6.1
Spain	-0.73	-6.6
Sweden	-0.39	-1.4
UK	-0.82	-1.5
US	-0.81	-5.1
liquity c. (l)	*Value*	*t-Stat*
17 countries	0.13	1.6
disc. f. (b)	*Value*	*t-Stat*
17 countries	0.96	75.0

Model 15

curv. (g)	*Value*	*t-Stat*
Austria	2.16	0.9
Belgium	5.74	0.3
Canada	>100	0.0
Denmark	5.90	0.2
Finland	2.38	0.7
France	3.03	0.6
Germany	>100	0.0
Greece	0.93	0.6
Italy	1.63	1.1
Ireland	8.57	0.1
Japan	0.94	1.1
Netherlands	3.37	0.4
Portugal	>100	0.0
Spain	2.17	1.0
Sweden	33.62	0.0
UK	1.98	0.6
US	1.77	1.1
habit (a)	**Value**	*t-Stat*
17 countries	-0.75	-14.4
liquity c. (l)	*Value*	*t-Stat*
17 countries	>100	0
disc. f. (b)	*Value*	*t-Stat*
17 countries	0.96	44.3

Model 16		
curvature (g)	*Value*	*t-Stat*
17 countries	0.03	1.6
habit (a)	**Value**	*t-Stat*
17 countries	-0.92	-158.8
liquidity c. (l)	*Value*	*t-Stat*
17 countries	9.72	0.0
discount f. (b)	*Value*	*t-Stat*
17 countries	0.96	329.3

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