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Consumption Habit and Equity Premium in the G7 Countries

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ABSTRACT

The consumption capital asset pricing model (C-CAPM) fails to explain the observed equity premia apart from considering implausible values of the risk aversion coefficient. This equity premium puzzle has been attributed in particular to the time-separability of the consumers' preferences. This paper investigates empirically the ability of the C-CAPM to solve this puzzle once assumed that consumption behaviour presents habit formation. From the estimation of the model's parameters for the G7 countries, we show that the consumption model with habit formation is able to account for financial asset returns with more reasonable preference.

Keywords : Consumption, habit formation, equity premium, Generalized method of moments.

JEL classification : C13, E21, E44, G12.

RÉSUMÉ

Les travaux macro-économétriques de la consommation s'appuient le plus souvent sur des extensions de la théorie du revenu permanent. Ces modèles considèrent un agent représentatif qui maximise la somme actualisée des utilités que lui procure à chaque période sa consommation. Compte tenu de ses préférences, chaque individu choisit entre consommer aujourd'hui et épargner pour consommer plus tard en comparant les conséquences de chacun de ces deux choix sur son bien être. Le modèle d'évaluation des actifs financiers formalise cette idée en considérant que l'individu a accès à des marchés financiers complets et sans coûts de transaction. Chaque type d'actif financier peut donc, sans restriction, servir de support à l'épargne. La condition d'arbitrage établit alors une relation entre le rendement espéré de l'actif et le taux marginal de substitution intertemporelle de la consommation, c'est-à-dire l'importance relative apportée par l'individu entre consommer aujourd'hui et consommer la période suivante.

La pertinence empirique de ce type de modèle a été rejetée dans le cas de fonction d'utilité iso-élastique séparable dans le temps. En effet, le taux marginal de substitution intertemporelle est dans ce cas fonction du taux de croissance anticipé de la consommation. Or, pour des valeurs raisonnables de l'aversion relative pour le risque, la volatilité du taux de croissance de la consommation est trop faible pour rendre compte de l'écart de rendement anticipé entre les actifs risqués et un actif non risqué (la prime de risque).

Cette « énigme de la prime de risque » caractérise un modèle de consommation bien spécifique, où la fonction d'utilité est séparable et les marchés financiers sont supposés complets. La question est alors de savoir si relâcher une des hypothèses de ce modèle permet d'expliquer le niveau de la prime de risque. Nous revenons dans cette étude sur la séparabilité temporelle de l'utilité de l'agent représentatif en considérant que la consommation réalisée à une période donnée continue à avoir un effet sur l'utilité intertemporelle du consommateur. Une manière simple de mettre en œuvre cette idée est de considérer que la consommation courante a aussi un impact sur l'utilité de la période suivante (comportements d'habitude).

Nous étudions la pertinence empirique d'un modèle simple avec habitude en nous concentrant sur les différences de préférences des consommateurs entre les pays du G7. Les paramètres du modèle sont tirés de l'estimation sur données annuelles (1972-1996) d'équations d'arbitrage obtenues pour deux types d'actifs financiers : un actif sans risque et un actif risqué. Le modèle comprend trois paramètres : le taux d'escompte des ménages, la courbure de la fonction d'utilité et le paramètre d'intensité des habitudes. Ces relations étant non linéaires et comprenant des espérances conditionnelles, leur estimation est réalisée par la méthode des moments généralisés. Plutôt que d'estimer les relations d'arbitrage pays par pays avec le risque de sur-évaluer les différences entre pays, nous préférons réaliser des estimations sur données de panel et tester dans ce cadre les différences de paramètres entre pays.

Les estimations conduisent à un degré d'aversion relatif pour le risque raisonnable. Ces résultats confirment ainsi la capacité du modèle de consommation avec habitudes à résoudre l'énigme de la prime de risque. Si la prise en compte des habitudes permet d'obtenir une aversion pour le risque satisfaisante, elle conduit cependant à une élasticité de substitution intertemporelle très faible. Cela signifie que le consommateur lisserait beaucoup plus sa consommation que ce qui est justifié par l'hypothèse du cycle de vie où l'élasticité de la consommation par rapport à la richesse est unitaire.

SUMMARY

Macro-econometric studies on consumption often lie on extensions of the permanent income theory. These models consider 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 capital asset pricing model gives a formalization of this idea by considering 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 at the next period.

The empirical evidence of this kind of model has been rejected in the case of iso-elastic, time-separable utility functions. In this case, the marginal rate of intertemporal substitution is a function of the expected growth rate of consumption. However, for reasonable values of the relative risk aversion, the volatility of the consumption growth rate is too low to account for the expected excess return of risky assets relative to a risk-free one (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 (habit behavior).

We study the empirical relevance of a simple model with habit, by concentrating on the differences in terms of consumers' preferences across the G7 countries. The model's parameters are estimated on annual data (1972-1996) form arbitrage equations based on two types of assets: a risk-free asset and a risky one. The model has three parameters: the consumers' discount factor, the curvature of the utility function, and the habit parameter. These relationships being non-linear and including conditional expectations, their estimation has been realized by the Generalized Method of Moments. Instead of estimating the arbitrage equations country by country at the risk of overvaluing the differences across countries, we prefer to realize our estimations on panel data and to test in this framework the parameter differences across countries.

The estimations lead to a reasonable degree of relative risk aversion. Results confirm then the ability of the consumption model with habit to solve the equity premium puzzle. If taking into account habits enables us to get a satisfying relative risk aversion, it leads however to a very low elasticity of intertemporal substitution. That means that the consumer would smooth much more his consumption than justified by the life cycle hypothesis where the elasticity of the consumption relative to wealth is unitary.

Consumption Habit and Equity Premium in the G7 Countries

Olivier Allais#, Loï c Cadiou§ et Stéphane Dées§

I - INTRODUCTION

The consumption capital asset pricing model relates the asset returns and the marginal rate of intertemporal substitution of consumption. The empirical relevance of this kind of model has been rejected in the case of time-separable utility function (Mehra and Prescott, 1985). The marginal rate of intertemporal substitution is in this case a function of the expected growth rate of consumption. However, for reasonable values of the relative risk aversion, the volatility of the consumption growth rate is too low to account for the expected excess return of risky assets relative to a risk-free one (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 (Weil, 1989 and Constantinides, 1990). Relaxing the hypothesis of time separable utility induces to extend the temporal effects of the consumption realised 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 sign and the size of such an impact account for habit or durability in the consumer behaviour.

This paper analyses the empirical relevance of such a model for the G7 countries and studies the differences in the consumer's preferences across countries. We consider two types of assets : a risk-free asset (whose return is the short-term interest rate) and a risky asset (the stock market index). The parameters of the model are estimated from non-linear arbitrage equations with conditional expectations. Their estimations are realised using the Generalised Method of Moment (GMM) on a panel constituted by the G7 countries and on annual data from 1972 to 1996. The high number of orthogonality conditions imposes to make assumptions on the correlation of errors across countries. Hence, we assume that the shocks affecting each economy can be summarised by a limited number of common factors. This is realised by a factor analysis of the errors' covariance matrix of the whole set of equations. As a consequence, the number of this matrix's parameters to be estimated is considerably reduced.

The estimation on a panel of countries enables us to test for the parameter differences across countries. According to these tests at least one of the parameter of the consumption model is different across countries. By relaxing the time-separable assumption of the utility function, the model parameters can no longer be directly interpreted in terms of time preference rate and relative risk aversion. The relative risk aversion and the elasticity of intertemporal substitution become non-linear combinations of the parameters. The

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interpretation we put on our econometric results in terms of consumers' preferences is based on the explicit computation of the relative risk aversion and the elasticity of intertemporal substitution in a model of habit. Part II presents what is called the 'equity premium puzzle' and shows how the model with habit formation can *a priori* solve the puzzle. Part III presents the estimation strategy and the procedure for testing the preference similarities across countries. Econometric results and their economic interpretation are the subject of the last part.

II - PRESENTATION OF THE MODEL AND THE DATA

1. The Consumption Capital Asset Pricing Model (C-CAPM)

1.1. General framework

We consider a representative agent whose utility function depends on its past, present and future consumption. He has access to complete financial markets and holds *n* different assets. He maximises its expected intertemporal utility subject to its budget constraint.

$$\underset{C_t, S_{i,t}}{\text{MAX}} \quad E_t\left\{V_t\left(..,C_{t-n},...,C_t,...C_{t+n},...\right)\right\} \qquad (1)$$

$$pc_{t+t}C_{t+t} + \sum_{i=1}^{n} p_{i,t+t}S_{i,t+t+1} \leq \sum_{i=1}^{n}\left(p_{i,t+t} + d_{i,t+t}\right)S_{i,t+t} \; \forall t \geq 0 \qquad (2)$$

where C_t is the level of the per capita consumption 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 I_t available at time t. We assume that V_t is a concave, increasing utility function. 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 consumption behaviour and the portfolio choice of the agent is described by the first-order conditions:

$$E_t\left\{\frac{\left(\dfrac{\partial V_t}{\partial C_{t+1}}\right)}{\left(\dfrac{\partial V_t}{\partial C_t}\right)}\left(1+R_{i,t+1}\right)\right\} = 1 \qquad \text{for i = 1…n} \qquad (3)$$

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

Let $M_{t+1}=\dfrac{\left(\dfrac{\partial V_t}{\partial C_{t+1}}\right)}{\left(\dfrac{\partial V_t}{\partial C_t}\right)}$ and $r_{i,t+1}=\ln(1+R_{i,t+1})$, $c_{i,t+1}=\ln(C_{i,t+1})$, $m_{i,t+1}=\ln(M_{i,t+1})$.

With the log-normality assumption of the conditional distribution of consumption and of financial asset returns, equation (3) becomes[2]:

$$E_t\{r_{i,t+1}\}+E_t\{m_{t+1}\}+\frac{1}{2}\left[s_t^2\{r_{i,t+1}\}+s_t^2\{m_{t+1}\}+2Cov_t\{r_{i,t+1},m_{t+1}\}\right]=0 \qquad (4)$$

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

By definition, the risk-free return is equal to its conditional expectation. Therefore:

$$r_{1,t+1}=-E_t(m_{t+1})-\frac{1}{2}s_t^2(m_{t+1}) \qquad (4.a)$$

And the equity premium is:

$$E_t\{r_{i,t+1}\}-r_{1,t+1}=-\frac{1}{2}s_t^2\{r_{i,t+1}\}-Cov_t\{r_{i,t+1},m_{t+1}\}\text{ for } i\neq 1 \qquad (4.b)$$

The relation (4.b) is the pricing equation of the financial asset, based on consumption. It defines a relationship between the conditional expectation of the equity premium, the conditional variance of the risky asset and the conditional covariance between the risky asset and the marginal rate of intertemporal substitution.

The preferences of the representative agent must imply a marginal rate of intertemporal substitution (M_{t+1}) compatible with equation (4.b). But the latter is a function of the process followed by consumption and the elasticity of intertemporal substitution. Hence, we can write $c_{t+1}=E_t(c_{t+1})+\varepsilon_{t+1}$ where e_{t+1} is the innovation on the log of consumption. The process followed by the log of the marginal rate of intertemporal substitution is then defined by : $m_{t+1}=E_t m_{t+1}+\dfrac{1}{h_{t+1}}e_{t+1}$ where h is the elasticity of intertemporal substitution. Equation (4.b) can be re-written as:

[2] When x follows a normal distribution, $E\{\exp(x)\}=\exp\left(E\{x\}+\frac{1}{2}s^2\{x\}\right)$

$$E_t\{r_{i,t+1}\} - r_{1,t+1} = -\frac{1}{2} s_t^2 \{r_{i,t+1}\} - Cov_t\left\{r_{i,t+1}, \frac{e_{t+1}}{h_{t+1}}\right\} \text{for } i \neq 1 \qquad (5.b)$$

The risk premium is then a function of the elasticity of intertemporal substitution, which depends on the consumer preferences and, possibly, on the process followed by consumption. Equation (5b) highlights the role played by the elasticity of intertemporal substitution in this model.

1.2. The equity premium puzzle

To assess the compatibility of the data with the relationship (5b), we can temporarily merge conditional and non-conditional expectation and assume that the elasticity of intertemporal substitution is constant over time. We also assume that the log of consumption follows a random-walk with drift : $c_{t+1} = g + c_t + e_{t+1}$.

When the consumer preferences are represented by a time-separable utility function and by a constant relative risk aversion, the absolute value of the elasticity of intertemporal substitution is equal to the inverse of relative risk aversion. In this case, the intertemporal utility is $V_t = \sum_{t \geq 0} b^t U_{t+t}$ where $U_{t+t} = \frac{C_{t+t}^{1-g} - 1}{1-g}$.

The expression of the marginal rate of intertemporal substitution is simply: $M_{t+1} = b\left(\frac{C_{t+1}}{C_t}\right)^{-g}$

Then[3], $h_t = -1/g$

As Campbell (1999), the data analysis for the G7 countries, presented in Appendix 1, shows that equation (5.b) applied to the stock market leads to very low values of the elasticity of intertemporal substitution.

When the relative risk aversion takes the values of Appendix 1-Table 1, the agent is too risk adverse for present consumption to be influenced by its expectation on future economic conditions. This result corresponds to the ‘equity premium puzzle’ (Mehra and Prescott, 1985).

2. Habit formation in consumption

2.1. The consumption model with habit formation

A solution to the equity premium puzzle is to relax the assumption of a time-separable utility function (Constantinides, 1990). More precisely, we consider here a fairly simple

[3] $\log(M_{t+1}) = E_t \log(M_{t+1}) - g e_{t+1}$

form with an instantaneous utility written as: $U_{t+1} = U\left(C_{t+1} - aC_t\right)$. Such a specification increases the flexibility of the model. In particular, it reduces the elasticity of intertemporal substitution without implying an unreasonable relative risk aversion. Such an approach is then able to reconcile the financial asset pricing and the consumption growth process.

Before showing to which extent taking into account habit is able to solve the equity premium puzzle, let us give a simple economic interpretation to the new utility function specification. Consider first the case where a is positive. The instantaneous utility at time t depends positively on consumption at t and negatively of consumption at t-1. This last effect accounts for the fact that the consumer has acquired a taste for the level of consumption that was reached during the previous periods. Not having the same level of consumption in t would procure some utility loss. In effect, the instantaneous utility can be written as: $U_t = U\left[(1-a)C_t + a(C_t - C_{t-1})\right]$. The higher the coefficient a is, the more the consumer measures its welfare at time t by comparing its consumption to the level reached at time t-1. Hence, when deciding the current level of consumption, the representative agent also takes into account the negative impact on its future utilities of a high consumption at time t. He will set consumption in t at a level that he will be able to maintain in the future[4]. Here, we talk about habit or inertia effects.

Consider now the case where α is negative. The instantaneous utility at time t depends positively on the consumption at t but also on the consumption at t-1. An increase in consumption raises not only the consumer's welfare at the present time but also in the future. Here, we talk about durability or saturation effect.

For convenience, and anticipating the empirical part, we will call this theoretical model "the consumption model with habit formation". By integrating the new form of the instantaneous utility, the representative agent program is then as follows:

$$\underset{C_t, S_{i,t}}{MAX} \quad E_t\left\{V_t = \sum_{t \geq 0} b^t U_{t+t}\right\} \tag{6}$$

$$C_{t+t} + \sum_{i=1}^{n} p_{i,t+t} S_{i,t+t+1} \leq \sum_{i=1}^{n}\left(p_{i,t+t} + d_{i,t+t}\right) S_{i,t+t} \; \forall t \geq 0$$

$$U_t = \frac{\left(C_t - aC_{t-1}\right)^{1-g} - 1}{1-g} \tag{7}$$

We find again the first-order conditions:

$$E_t\left\{M_{t+1}\left(1 + R_{i,t+1}\right)\right\} = 1 \qquad \text{for i = 1 … n}$$

[4] Here, the representative agent is aware of the effect of its present consumption on its future utility. This is not the case in all the models with habit effects. When each individual consumer measures its instantaneous utility relative to the level of *per capita* consumption reached previously in the economy ('catching up with the Joneses'), the present consumption choice is realised in a framework of time separable utilities (Abel, 1990). $U_t = U\left(C_t - a\overline{C}_{t-1}\right)$ where $\overline{C}_{t-1}$ is the *per capita* consumption of the economy at t-1.

with :

$$M_{t+1} = b\left(\frac{C_{t+1}}{C_t}\right)^{-g} \frac{\left(1-aC_t/C_{t+1}\right)^{-g} - ba\left(C_{t+2}/C_{t+1}-a\right)^{-g}}{\left(1-aC_{t-1}/C_t\right)^{-g} - ba\left(C_{t+1}/C_t-a\right)^{-g}} \qquad (8)$$

2.2. Habits and the equity premium puzzle

Constantinides (1990) shows that taking into account habit reduces the elasticity of intertemporal substitution. In effect, the latter corresponds to the inclination (or the reluctance) of the representative agent to report its consumption from a period to another. Intuitively, a habit behaviour corresponds to a greater reticence, since the consumer is concerned with maintaining its current level of consumption. Hence, contrary to the case of a time-separable utility, the curvature of the instantaneous utility function (γ) must not necessarily take very high values. With these values, the levels of relative risk aversion become more sensible (Constantinides,1990 and Lettau and Uhlig,1997).

This appears clearly when we compute explicitly the expressions of the elasticity of intertemporal substitution (EIS) and the coefficient of relative risk aversion (RRA). The elasticity of intertemporal substitution summarises the consumer behaviour in the face of uncertainty on the level of consumption. It is defined by:

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

here 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 intertemporal substitution by considering that the logarithm of consumption follows a random walk with drift : $c_{t+1} = g + c_t + e_{t+1}$. 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 :

$$1/EIS = \left(\frac{\gamma}{1-\alpha e^{-g}}\right)\left(\frac{1+\beta\alpha^2 e^{-g(\gamma+1)}}{1-\beta\alpha\, e^{-g\gamma}}\right) \qquad (9)$$

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 summarises the consumer's behaviour in the face of uncertainty on his wealth[5].

$$RRA_t = -\frac{W_t \frac{\partial^2 V_t}{\partial^2 W_t}}{\frac{\partial V_t}{\partial W_t}}$$, 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:

$$RRA = \frac{g}{1 - ae^{-g} \frac{e^{-gg} - bg}{e^{-gg} - ba}} \qquad (10)$$

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).

Because the consumption growth rate is not volatile enough, we have seen previously that the elasticity of intertemporal substitution should be very low to explain the level of the equity premium. Without habit, the relative risk aversion of the representative agent takes then values that are unreasonable. 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. 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. In fact:

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

We find then an elasticity of consumption relative to wealth that is less than one.

Table 1 presents the values of the two indicators according to the value of the curvature of the instantaneous utility function and for three levels of habit[6].

[5] For more details about definitions and formulas, see Eeckhoudt and Gollier (1992).
[6] The computations presented in the table assume an annual *per capita* consumption growth rate of 2%.

Table 1 : EIS and RRA in a model with habit formation (b = 1)

g	a=0.25			a=0.50			a=0.75		
	1/EIS	*RRA*	*RRAxEIS*	*1/EIS*	*RRA*	*RRAxEIS*	*1/EIS*	*RRA*	*RRAxEIS*
1.0	1.9	1.0	*0.53*	4.8	1.0	*0.21*	22.0	0.9	*0.04*
2.0	3.7	1.5	*0.40*	9.3	0.9	*0.01*	41.7	0.4	*0.01*
5.0	9.0	2.0	*0.22*	21.9	0.8	*0.04*	89.5	0.2	*0.00*
10.0	17.5	2.0	*0.11*	40.1	0.7	*0.02*	145.6	0.1	*0.00*

The data analysis presented in Appendix 1 indicates that the inverse of the elasticity of intertemporal substitution must in general take values larger than 10 without habit effect. Table 1 shows that the presence of habit formation allows to reach such values for levels of RRA less than 2. Concerning relative risk aversion, the computations presented here indicate that the model of habit is likely to account better for financial assets price changes. However, the elasticity of intertemporal substitution tends toward 0 when the curvature and habit coefficients rise. Hence, the equity premium puzzle seems to be solved only partly.

The assessment of the empirical relevance of a habit behaviour will be provided by the econometric estimation of this model. Then it will remain to be seen whether the estimated values correspond to preferences of the representative agent preferences that are acceptable from an economic point of view.

III - ESTIMATION STRATEGY

1. The estimated model

We consider two kinds of assets: a risk-free asset (whose return is the short term interest rate) and a risky asset corresponding to an equity portfolio (the stock market index[7]). The two Euler equations are the following:

$$E_t \left\{ M_{t+1} \left(1 + R_{i,t+1}\right) \right\} = 1 \qquad \text{for} \quad i = 1,2$$

$$\text{with}: M_{t+1} = b \left(\frac{C_{t+1}}{C_t} \right)^{-g} \frac{\left(1 - aC_t / C_{t+1}\right)^{-g} - ba\left(C_{t+2} / C_{t+1} - a\right)^{-g}}{\left(1 - aC_{t-1} / C_t\right)^{-g} - ba\left(C_{t+1} / C_t - a\right)^{-g}}$$

[7] We use the indices computed by MSCI (Morgan Stanley Capital International).

The model can be written as:

$$
\begin{aligned}
&E_t\{e_{i,t+1}\} = 0 \\
&e_{i,t+1} = (C_t - aC_{t-1})^{-g} - b(1 + R_{i,t+1} + a)(C_{t+1} - aC_t)^{-g} + ab^2(1 + R_{i,t+1})(C_{t+2} - aC_{t+1})^{-g}
\end{aligned}
\quad (11)
$$

Without habit, the error term ($e_{i,t+1}$) is time-independent. But with habit formation, it presents some auto-correlation. More precisely, in the model considered here, $e_{i,t+1}$ depends on C_{t+1} and C_{t+2}. Then, the error term of the model is auto-correlated of order one, since $E_t\{e_{i,t+1} | e_{i,t}\} \neq 0$ and $E_t\{e_{i,t+k} | e_{i,t}\} = 0$ for $k \geq 2$.

2. GMM on a panel of G7 countries

The estimation of the parameters is realised on the panel constituted by the G7 countries (Canada, France, Germany, Italy, Japan, UK and US). Data are available from 1971 to 1998. Given the number of leads and lags, the estimation period covers 25 years (1972-1996).

Such a panel approach is convenient to test whether the model parameters are different across countries, i.e. whether the absence of structural differences across countries can be rejected. Furthermore, it allows to obtain more robust estimators since the information set is larger than for estimations country by country. These estimations also constitute an empirical analysis of the ability of the habit model to solve the equity premium puzzle, at least in some countries.

The parameters are estimated using the General Method of Moment (GMM). This method is adapted to problems of intertemporal optimisation which give first-order conditions such as $E_t\{e_{t+1}(q)\} = 0$, where E_t represents the expectation conditional to the information set at time t. In effect, this method allows the explicit writing of the orthogonality between the forecast error and the variables representing the agent's information set (instruments). 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).

The problem consists then in estimating a set of n x p x k equations such as $E_t\left[e_{n,p,t+1}(q)Z'_t\right] = 0$ where n is the number of assets, p the number of countries and Z the instrument set whose size is k (the first instrument will be the unity vector). The GMM consists in finding the value for q such that the empirical moments of the Euler equation set is equal to zero. The solution is the result of the minimisation of the quadratic form $h(q) = g(q)'\Omega^{-1}g(q)$ where $\left(g(q)\right)_{(k,n,p)} = \left(\frac{1}{T}\sum_{t=1}^{T} e_{n,p,t+1}(q)Z_{k,n,p,t}\right)$ and Ω is the estimated covariance matrix of the n x p x k orthogonality conditions. The GMM is iterative. From a starting value of Ω (identity matrix), we estimate q and we compute the covariance matrix of the errors. The latter is corrected from the first order autocorrelation by the Newey-West method, and is re-used as a starting matrix for a new estimation of θ. This sequence is run until the parameters have converged.

3. Identification and stationarity

Hansen (1982) has established necessary conditions to the application of the GMM. On one side, the variables must be stationary. On the other side, the parameters to be estimated must be identifiable, which is not always the case for non-linear equations.

3.1. Stationarity

The *per capita* consumption in the G7 countries is not a stationary variable, even if the power of unit roots tests is weak for such a small sample (28 years). For α different from one, $(c_t - \alpha c_{t-1})$ is not stationary. The equation being quasi-linear in $(c_t - \alpha c_{t-1})^{-\gamma}$, we chose to divide the relationship (11) by $(c_t - \alpha c_{t-1})^{-\gamma}$, which gives the equation:

$$E_t\left\{1-\beta\left(1+R_{i,t+1}+\alpha\right)\left(\frac{c_{t+1}-\alpha c_t}{c_t-\alpha c_{t-1}}\right)^{-\gamma}+\alpha\beta^2\left(1+R_{i,t+1}\right)\left(\frac{c_{t+2}-\alpha c_{t+1}}{c_t-\alpha c_{t-1}}\right)^{-\gamma}\right\}=E_t\{\varepsilon_{t+1}\}=0 \quad (12)$$

3.2. Identification

The estimation of equation (12) poses a problem of identification. For some of the parameters values, the relationship (12) is verified whatever the consumption growth process. More precisely, when the curvature of the utility function is equal to zero ($\gamma = 0$), the Euler equation becomes: $(1-\alpha\beta)E_t\left[1-\beta(1+R_{i,t+1})\right]=0$. Any couple of α and β such as α=1/β is solution. If we impose that $\alpha \neq 1/\beta$, which is reasonable since we expect β<1 and -1<α<1, then $\beta = E_t\left[1/(1+R_{i,t+1})\right]$. The problem is that α is then undetermined.

Thus, the estimation of the parameters of equation (12), on a minimisation criteria of a quadratic function of this equation's left hand side, has a solution $(\gamma = 0, \alpha = \delta, \beta = 1/\delta)$ for any $\delta \neq 0$, or ($\gamma = 0$, $\beta = E_t\left[1/(1+r_{t+1})\right]$, $\alpha = \delta$) for any real δ. Any minimisation algorithm may give one of these solutions. In all cases, we have γ=0.

The problem is that these evident solutions are not very interesting from an economic point of view. Indeed, a curvature equal to zero (γ =0) corresponds to the case where the instantaneous utility is proportional to the present and lagged levels of consumption. The representative agent maximises then:

$V_t = E_t\left[\sum_{n=t}^{+\infty}\beta^{(n-t)}\left(c_n - \alpha c_{n-1}\right)\right] = (1-\alpha\beta)E_t\left[\sum_{n=t}^{+\infty}\beta^{(n-t)}c_n\right] - \alpha c_{t-1}$. Here, the habit coefficient plays the inverse role of the discount factor in the intertemporal allocation of consumption. One more unit of consumption at time *t* yields a utility loss at time *t+1* whose discounted value is $a\beta$. If $a\beta=1$, the value of the intertemporal utility function at time t takes a degenerated form $V_t = -a c_{t-1}$, which has no sense. Imposing $a \neq 1/b$ gives a second type of solution, where the habit parameter is not identified: $V_t = (1-ab)E_t\left[\sum_{n=t}^{+\infty} b^{(n-t)} c_n\right] - a c_{t-1}$.

These evident solutions are a limit case of our specification, for which the economic mechanism that we are interested in are absent. Our goal is not only to ensure the identification of the parameters, but also to get values that have a sense relative to the present economic issue. More precisely, the imperative condition is that the instantaneous utility is strictly concave ($\gamma>0$). This is an economically sensible hypothesis when one is concerned with the assessment of habit behaviour. However, the solution $\gamma=0$, $\beta<1$ and α undetermined is not aberrant *a priori*. But, it excludes simply any habit formation. Besides, the GMM is not robust when the estimators are on the frontier of the possible value set of the parameters.

We choose to turn down any problem of identification without modifying too much the objective function. To avoid $\gamma=0$ in a roundabout way seems to us unsatisfactory. We search values for the parameters for which the objective function reaches a local minimum different from $\gamma=0$[8]. In other words, we investigate only the instantaneous utility functions which are strictly concave. Practically, to be sure that $\gamma>0$ we use the following change in the parameter: $\gamma=\exp(\mu)$. We then estimate μ. If whatever the starting values of the parameters, the algorithm tends to very negative values for μ, then no minimum exists in the class of strictly concave functions. If, on the other hand, the minimisation converges towards a value for γ far enough from zero, then it is a minimum in the class of the strictly concave functions. After having verified that this minimum is global, we consider it as the solution of the estimation.

Finally, there is a last constraint on the parameters since $C_t - aC_{t-1}$ must always be positive and almost all the G7 countries have registered a decrease in their *per capita* consumption between 1971 and 1998 Thus, a must be strictly below $\overline{a} = \min(C_t / C_{t-1}) < 1$. In practice, the minimisation procedure may converge and give values for the parameters habit $\alpha = \overline{\alpha}$. However, this solution is fallacious since the optimisation algorithm stops before reaching one of the evident solutions. Hence, the results where g is very low and a is very close to one must be considered cautiously (see in particular Braun, Ferson and Constantinides, 1992).

[8] A more radical solution consists in dividing the Euler equation (12) by $(1-ab)\ [1-b(1+R_{t+1})]$. The objective function takes in that case very high values at the neighbourhood of $ab=1$ and $b(1+E_t\{R_{t+1}\})=1$, moving away the values of the parameters from the solutions of one of these equations. The problem of this method is that it modifies strongly the objective function, and, as a consequence, the economic problem investigated. Practically, this modification has a large influence on the parameters that minimise the new objective function. To be convinced, we have realised some estimations by dividing the equations by $(1-ab)^x$ for different values of x (1/2, 1 and 2). Yet, this method is chosen by Ogaki (1993).

4. Restrictions on the covariance matrix

The large number of equations of the model is likely to give a bad estimation of the errors' covariance matrix. This one contains $\frac{(n\times p\times k)(n\times p\times k+1)}{2}$ parameters, i.e. 903 for 7 countries, 3 instruments and 2 financial assets. To get a covariance matrix of the shocks that hit the different countries at a same date, we assume a factorial analysis structure reduced to a limited numbers of factors. We take here the method defined by Doz (1998) and applied by Guichard and Laffargue (1999). The factorial analysis of the covariance matrix of the errors induces to structure the links between the shocks hitting the countries and to reduce considerably the number of the parameters of the matrix. If f is the number of factors, there is only $(f+1)(n\times p\times k)$ parameters, i.e. 168 for 7 countries, 3 instruments, 2 assets and 3 factors. Practically, we limit the number of factors to three. The factorial analysis is realised for each iteration of the GMM procedure.

5. Test strategy of the differences across countries

The theoretical model that we want to estimate has three parameters : g the curvature of the instantaneous utility function, α the habit parameter and β the discount factor. This model is estimated for the G7 countries. We realise two types of tests. On one side, we test the existence of significant differences in the value of the parameters across countries. On the other side, we test the empirical relevance of the habit formation.

We test as the null hypothesis the equality of these parameters across countries by proceeding from the general to the particular. The procedure is the following. For each parameter, we estimate the model where this parameter is identical across countries. Then, we estimate the model where all the parameters are country-specific by using the covariance matrix of the previous model. We realise a likelihood ratio test (as defined by Ogaki, 1993) with, as the null hypothesis, the constrained model and, as the alternative hypothesis, the unconstrained model. For each test, we accept the null hypothesis at the 5 percent significance level.

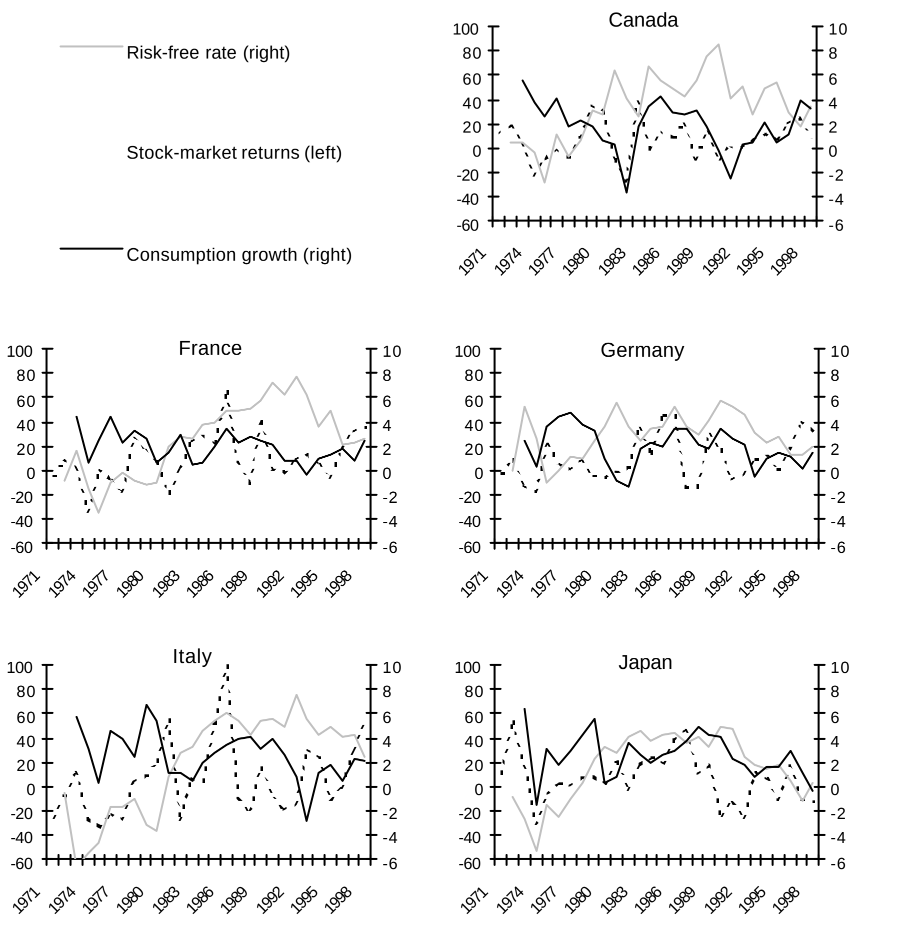
If the constraint across the G7 countries is accepted for one parameter, then the model where this parameter is identical across countries becomes the reference model relative to which the equality of each of the two other parameters is tested. This procedure is continued until the equality constraint across countries is rejected for all the remaining unconstrained parameters. We have then the final model to retain.

From this model, we test the null hypothesis of the absence of habit formation, again with a likelihood ratio test.

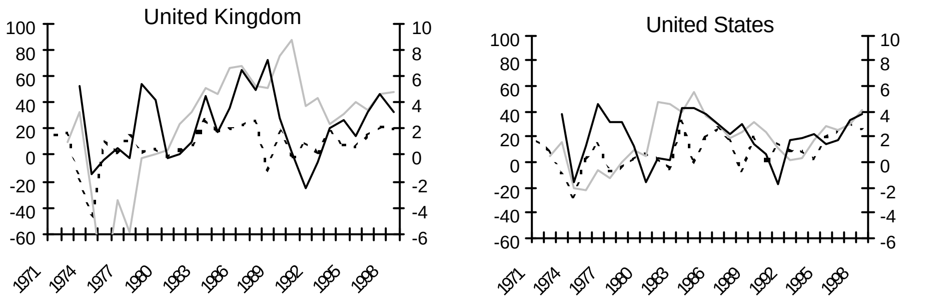
IV- PRESENTATION AND INTERPRETATION OF THE RESULTS

Consumption growth and asset returns are presented in Appendix 1. The average annual growth rate of per capita consumption ranges between 1.6 percent in Canada and 2.5 percent in Japan. Short-term interest rates displayed comparable average values (from 1.75 percent in the US to 3.6 percent in Canada). The average and the variance of the stock-market return are much more important. Hence, the equity premium (gap between the stock-market return and the short term interest rate) averages 6 percent in the US, the UK, Germany and France. It is around 3 percent in the three other G7 countries (Japan, Italy and Canada).

Box 1 : Consumption growth and asset returns



Box 1 : Consumption growth and asset returns (continued)



The estimations of the consumption model with habit formation have been realised under the assumption of a discount factor (β) equal to one. This induces, on one side, to stress the importance of the habit effects in the temporal link of the consumer decisions. On the other side, the estimation of this parameter has not always been possible, preventing from the systematic comparison of the estimations and the realisation of the tests of a constraint on the parameters. This seems to indicate that there is an identification problem of this parameter. When it can be estimated, it generally takes values very close to one. We chose, in a first stage, to fix it to one before analysing the sensitivity of our results to this parameter.

Although our main concern is the equity premium puzzle, it is interesting to estimate also the model of habit when the agent has only a risk-free asset in his portfolio. This gives an indication of the representative agent preferences without risk on his wealth. Only the arbitrage condition (4.a) is estimated. The estimation results of this model (called later the « one asset model ») indicate whether the addition of the risk premium modifies the values of the parameters. This comparison has a particular interest since, except for the US and the UK, the importance of the stock market for the consumers (compared to the short-term asset market or the market of bonds) is limited over the estimation period (1972-1996).

1. Estimation results

Table 2 presents all our results. The first part of the table concerns the case where the estimations are only realised with the risk-free asset (short-term interest rate). The second part concerns the case where the estimations are realised with two assets (risk free asset and stock index). We consider an information set constituted by the lagged consumption growth rate and the financial asset return of the previous period.

The first observation is that the consumption model with habit formation is accepted by the data. The estimators of g and a have the expected sign and are statistically significant. The parameter a being positive, there is effectively habit formation in the representative agent behaviour.

Table 2 : Estimation of the models with b =1

Models with the risk-free asset	***g* constrained α constrainted**		*g* unconstrained α constrained		*g* constrained α unconstrained		*g* unconstrained α unconstrained	
	Coeff.	***T Student***	Coeff.	*T Student*	Coeff.	*T Student*	Coeff.	*T Student*
*g*_Canada	**1.98**	***12.5***	3.00	*3.5*	2.68	*4.3*	7.22	*0.8*
*g*_France	**1.98**	***12.5***	2.73	*2.3*	2.68	*4.3*	1.86	*3.2*
*g*_Germany	**1.98**	***12.5***	2.12	*3.1*	2.68	*4.3*	1.70	*5.2*
*g*_Italy	**1.98**	***12.5***	1.27	*2.9*	2.68	*4.3*	1.31	*1.7*
*g*_Japan	**1.98**	***12.5***	1.22	*4.7*	2.68	*4.3*	1.07	*2.7*
*g*_UK	**1.98**	***12.5***	1.90	*5.1*	2.68	*4.3*	1.32	*2.8*
*g*_US	**1.98**	***12.5***	2.14	*6.7*	2.68	*4.3*	1.13	*6.0*
α_Canada	**0.58**	***28.9***	0.56	*10.0*	0.49	*6.5*	0.63	*4.8*
α_France	**0.58**	***28.9***	0.56	*10.0*	0.57	*6.3*	0.38	*3.0*
α_Germany	**0.58**	***28.9***	0.56	*10.0*	0.65	*5.7*	0.34	*1.7*
α_Italy	**0.58**	***28.9***	0.56	*10.0*	0.71	*6.8*	0.51	*4.5*
α_Japan	**0.58**	***28.9***	0.56	*10.0*	0.63	*5.1*	0.50	*2.4*
α_UK	**0.58**	***28.9***	0.56	*10.0*	0.60	*4.4*	0.33	*1.9*
α_US	**0.58**	***28.9***	0.56	*10.0*	0.58	*3.9*	0.27	*1.3*
P-Hansen	**0.87**		0.55		0.51		0.09	
Models with two assets	*g* constrained α constrained		***g* unconstrained α constrained**		*g* constrained α unconstrained		*g* unconstrained α unconstrained	
	Coeff.	*T Student*	**Coeff.**	***T Student***	Coeff.	*T Student*	Coeff.	*T Student*
*g*_Canada	3.67	*4.3*	**4.33**	***1.4***	5.87	*3.2*	>100	*0.0*
*g*_France	3.67	*4.3*	**4.99**	***2.5***	5.87	*3.2*	>100	*0.0*
*g*_Germany	3.67	*4.3*	**4.40**	***2.4***	5.87	*3.2*	21.89	*0.3*
*g*_Italy	3.67	*4.3*	**2.06**	***2.1***	5.87	*3.2*	14.32	*0.4*
*g*_Japan	3.67	*4.3*	**2.23**	***2.5***	5.87	*3.2*	18.10	*0.3*
*g*_UK	3.67	*4.3*	**16.33**	***1.8***	5.87	*3.2*	>100	*0.0*
*g*_US	3.67	*4.3*	**20.72**	***0.8***	5.87	*3.2*	>100	*0.0*
α_Canada	0.56	*7.4*	**0.49**	***5.6***	0.61	*3.4*	0.71	*2.3*
α_France	0.56	*7.4*	**0.49**	***5.6***	0.57	*5.3*	0.70	*3.6*
α_Germany	0.56	*7.4*	**0.49**	***5.6***	0.65	*3.1*	0.76	*5.4*
α_Italy	0.56	*7.4*	**0.49**	***5.6***	0.65	*6.2*	0.40	*0.3*
α_Japan	0.56	*7.4*	**0.49**	***5.6***	0.58	*5.2*	0.48	*1.0*
α_UK	0.56	*7.4*	**0.49**	***5.6***	0.56	*4.2*	0.62	*2.7*
α_US	0.56	*7.4*	**0.49**	***5.6***	0.52	*4.1*	0.68	*4.0*
P-Hansen	0.86		**0.94**		0.93		0.00	

The instrument set used in these estimations is constituted by the constant, $(1+\Delta c_{-1})$ and $(1+R_{-1})$.

The second observation concerns the impact of the taking into account of the risky asset in the estimation of the Euler equation. Let's take as a reference the more constrained models (γ and α identical across countries). In the one asset model, the curvature parameter (γ) is equal to 1.98 and the habit parameter (α) is equal to 0.58. Whereas the habit parameter is hardly modified (0.56) by the introduction of the risky asset in the model, the curvature of the instantaneous utility function becomes much higher (3.67).

The test strategy established previously allows a more selective reading of our results. The following figures present the results of the test of constraints on the parameters across countries. The reading of these figures is from top to bottom; the displayed values are the p-values of the tests.

Figure 1 : Tests of the parameter equality among countries (one asset model)

(p-values of the tests displayed)

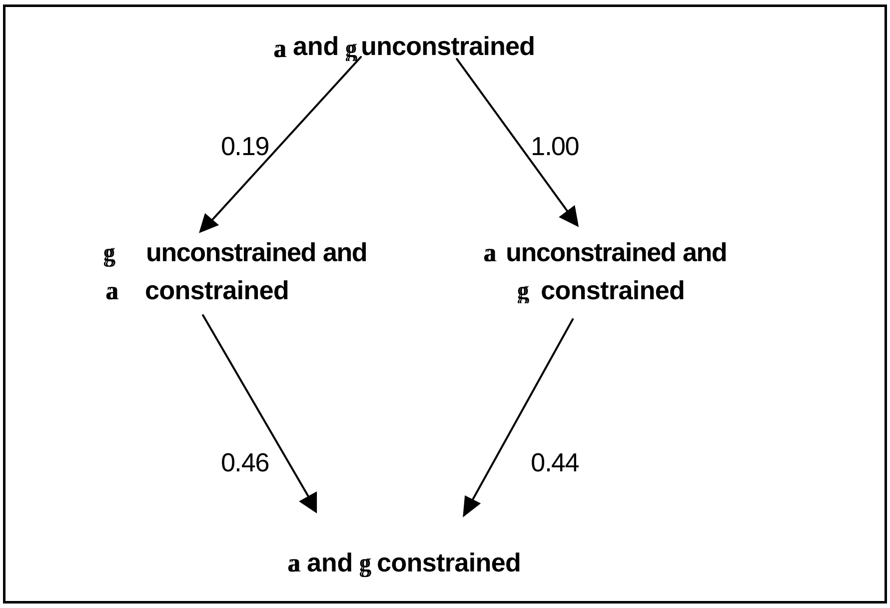
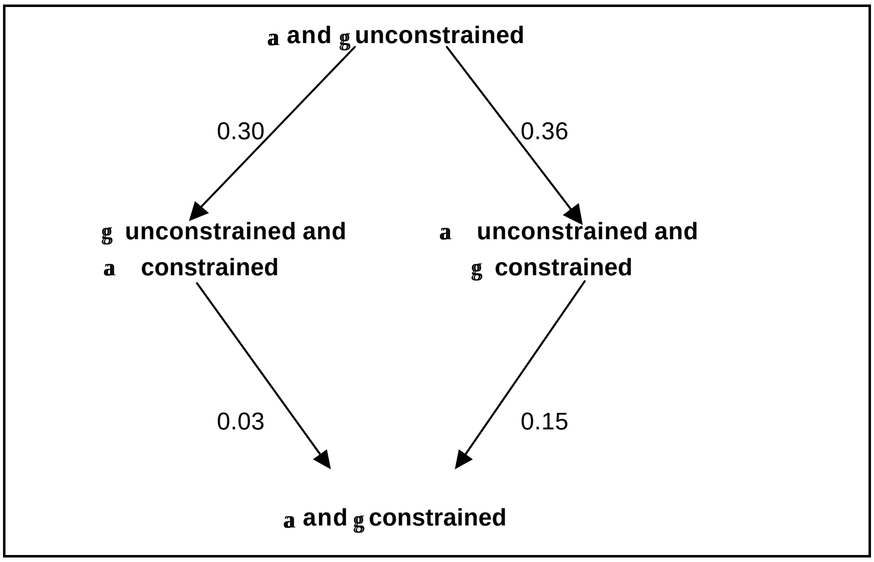


Figure 2 : Tests of the parameter equality across countries (two assets model)

(p-values of the tests displayed)



With the risk-free asset, the tests valid the totally constrained model. In this case, we cannot identify significant differences across countries. With two assets, the critical values of the tests are generally lower than in the one asset case. The tests lead us to prefer the model for which only the curvature parameter is country-specific. The habit coefficient (α), identical across countries, is lower in the two asset model (0.49) than in the one asset model (0.58). On the contrary, the curvature of the instantaneous utility function (γ) is higher and the differences across countries are very stressed (between 2.06 and 20.72). However, the highest coefficients are badly estimated.

These estimations have been realised assuming that the discount factor was equal to one. The estimation of the discount factor has only been possible for the one asset model. The results of estimations and tests are presented in Appendix 2. In the preferred model, the curvature and the habit parameter are not country-specific but the consumers have discount factors that differ across countries. The discount factor varies between 0.98 and 1 and the habit coefficient (0.5) is nearly close to the values previously found. Only the curvature parameter seems lower (1.03 vs. 1.98 when the discount factor is equal to one). Relaxing the constraint on the discount factor seems then to have a significant influence on the curvature of the instantaneous utility function.

Considering our failure to estimate the discount factor (β) in the two-assets model, we made further estimations for different values of β (assumed to be equal across countries). Table 3 presents, for some values of β, the results of the estimations of the model chosen when β = 1. This discount factor can take values slightly higher than one if the curvature parameter of the utility function is itself strictly higher than one and if consumption follows an increasing trend in the long-run (the case present here, see Kocherlakota, 1990)[8].

The estimations obtained when β = 0.99 and β = 1.01 are rather close to those obtained when the discount factor is equal to one. We can see however that the habit parameter diminishes when the discount factor increases. This shows the similarity of the role played by these two parameters in the determination of the elasticity of intertemporal substitution. Both a high habit and a low time preference affect the importance of future consumption in the choice of present consumption. When the discount factor is too low the model estimation deteriorates especially for France and the US. In the US, several empirical studies have already shown the necessity of a discount factor higher than one to explain the equity premium puzzle.

Table 3 : Estimation of two-assets models with different values of b

Models with two assets	β=*1.01*		β=*1*		β=*0.99*		β=*0.98*	
	Coeff.	*T Student*	**Coeff.**	***T Student***	Coeff.	*T Student*	Coeff.	*T Student*
*g*_Canada	5.21	*1.6*	**4.33**	***1.4***	3.69	*1.2*	2.10	*2.7*
*g*_France	5.53	*2.9*	**4.99**	***2.5***	4.79	*1.7*	27.88	*2.0*
*g*_Germany	5.00	*2.6*	**4.40**	***2.4***	3.94	*1.9*	2.51	*3.5*
*g*_Italy	2.58	*2.3*	**2.06**	***2.1***	1.63	*1.7*	0.90	*2.1*
*g*_Japan	2.70	*2.8*	**2.23**	***2.5***	1.83	*1.9*	1.04	*6.1*
*g*_UK	16.89	*1.8*	**16.33**	***1.8***	15.16	*1.7*	9.97	*2.2*
*g*_US	19.71	*1.1*	**20.72**	***0.8***	18.01	*0.8*	>100	*0.0*
α_Canada	0.47	*5.64*	**0.49**	***5.6***	0.52	*5.56*	0.46	*6.81*
α_France	0.47	*5.64*	**0.49**	***5.6***	0.52	*5.56*	0.46	*6.81*
α_Germany	0.47	*5.64*	**0.49**	***5.6***	0.52	*5.56*	0.46	*6.81*
α_Italy	0.47	*5.64*	**0.49**	***5.6***	0.52	*5.56*	0.46	*6.81*
α_Japan	0.47	*5.64*	**0.49**	***5.6***	0.52	*5.56*	0.46	*6.81*
α_UK	0.47	*5.64*	**0.49**	***5.6***	0.52	*5.56*	0.46	*6.81*
α_US	0.47	*5.64*	**0.49**	***5.6***	0.52	*5.56*	0.46	*6.81*
P-Hansen	0.97		**0.94**		0.84		0.96	

[8] More precisely, Kocherlakota (1990) shows the existence of a solution of the consumption program as soon as $b < (1+\dot{c})^{g-1}$ where $\dot{c}$ is the *per capita* trend growth rate.

2. Structural differences and equity premium puzzle

To interpret our results, we compute the relative aversion of the consumer facing a change in his consumption (1/EIS) and facing a change in his wealth (RRA), by assuming that consumption (in logarithm) follows a random walk with drift[9]. This hypothesis on the consumption growth process is quite strong. Relaxing it necessitates to compute the conditional expectation from, for example, an approximation of the Gauss-Hermite's quadrature (see Judd, 1998). This method has been implemented by Cecchetti, Lam and Mark (1994) and applied to France by Allais (1999). However, assuming a random walk process with drift allows us to derive more directly values to compare the consumption behaviour across countries.

Table 4 presents the values of the elasticity of intertemporal substitution (EIS) and of the relative risk aversion (RRA) according to the formula presented previously (equation (9) and (10)) for the two assets model.

Table 4 : Elasticity of Intertemporal Substitution and Relative Risk Aversion

	γ	α	β	Drift	**1/EIS**	**RRA**	**EISxRRA**
Canada	4.33	0.49	1	0.019	**18.496**	**0.902**	**0.049**
France	4.99	0.49	1	0.021	**20.803**	**0.863**	**0.041**
Germany	4.40	0.49	1	0.018	**18.874**	**0.906**	**0.048**
Italy	2.06	0.49	1	0.025	**9.022**	**0.956**	**0.106**
Japan	2.23	0.49	1	0.027	**9.657**	**0.945**	**0.099**
UK	16.33	0.49	1	0.024	**54.218**	**0.395**	**0.007**
US	20.72	0.49	1	0.019	**69.082**	**0.389**	**0.006**

Note: Two assets model (discount factor equal to one).

For low values of the elasticity of intertemporal substitution, the model gives coefficients for the relative risk aversion that are reasonable. This is the most important aspect of the habit model. Consumers are intrinsically reluctant to change their consumption level. Hence, it is not necessary any more to make the assumption that they are adverse to the risk of change in their wealth.

The elasticity of intertemporal substitution derived from our estimations is however low, especially in the US and in the UK. Taking into account habits in the C-CAPM accounts for observed risk premia only if we assume that agents favour a very important smoothing of their consumption over time.

The consumption models with habit formation are characterised 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 in Italy and in Japan, of 1 to 20 in France, Canada and Germany, and of 1 to 60 in

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

the US and the UK. In that sense, introducing habit solves the equity premium puzzle only partly. Indeed, the values of the inverse of the elasticity of intertemporal substitution in Table 3 are less than those of the time separable model presented in Appendix 1 (from 33 to 18 in Canada, from 509 to 21 in France, from 29 to 10 in Japan, from 71 to 54 in the UK and from 101 to 69 in the US). These values are nevertheless too high to be able to solve totally the equity premium puzzle.

Can the difficulties in estimating the discount factor explain these results? From the estimates of Table 3, we have calculated the preference indicators of consumers (EIS and RRA) for values of β ranging between 0.98 and 1.01. Table 5 gives an idea of the sensitivity of preferences to the discount factor. The main lesson of this table is that allowing β to be less than one gives preference values even more reasonable. For $\beta = 0.98$, the equity premium puzzle seems to be solved for Canada, Germany, Italy and Japan. The relative risk aversion is, in that case, close to one and the elasticity of intertemporal substitution ranges between 1/3 and 1/10. The excess smoothing of consumption relative to wealth is highly reduced (EIS ranges from 0.3 for Italy to 0.1 for Germany) relative to the case of a unit discount factor. The results for the other countries (France, UK and US) seem to be surprising for such values of β. This remark suggests that best results could be found if it was possible to estimate all the parameters when allowing β to differ across countries.

These results are encouraging. Although the estimation of the discount factor is technically problematic, the previous computations indicate that the consumption model with habit formation is able to account for the financial asset returns with reasonable consumer preferences. For the US and the UK, it is even likely that the discount factor should be higher than one. In that sense, this model is able to solve the equity premium puzzle. The major obstacle from an empirical point of view is the non-linear form of the arbitrage equations, which makes difficult the estimation of the discount factor.

Table 5 : Sensibility of preferences to the discount factor

Value of β	β=1.01			**b=1**			β=0.99			β=0.98		
	1/EIS	RRA	EISxRRA	**1/EIS**	**RRA**	**EISxRRA**	1/EIS	RRA	EISxRRA	1/EIS	RRA	EISxRRA
Canada	22.1	0.77	0.035	**18.5**	**0.90**	**0.049**	18.0	0.85	0.047	8.1	1.07	0.132
France	23.0	0.75	0.032	**20.8**	**0.86**	**0.041**	22.6	0.80	0.035	75.4	0.24	0.003
Germany	21.4	0.79	0.037	**18.9**	**0.91**	**0.048**	19.3	0.85	0.044	9.6	1.07	0.111
Italy	11.3	0.84	0.074	**9.0**	**0.96**	**0.106**	8.2	0.93	0.114	3.5	0.98	0.280
Japan	11.7	0.83	0.071	**9.7**	**0.94**	**0.099**	9.1	0.92	0.101	4.0	1.00	0.249
UK	55.2	0.30	0.005	**54.2**	**0.40**	**0.007**	56.7	0.37	0.006	32.5	0.77	0.024
US	66.1	0.34	0.005	**69.1**	**0.39**	**0.006**	68.8	0.39	0.006	>100	0.69	< 0

V - CONCLUSION

An explanation of the failure of the consumption capital asset pricing model relates to time-separable of utility. In this model, the gap between the risky asset return and the risk-free one (the equity premium) is a function of the marginal rate of intertemporal substitution, which depends on the expected growth of consumption when utility is time-separable. However, consumption is not volatile enough to be compatible with the level of the equity premium apart from assuming unrealistic relative risk aversion levels.

Relaxing the assumption of time-separability, by considering that the present consumption has an influence at the next period, leads to more general arbitrage conditions, likely to account better for the equity premium. The marginal rate of the intertemporal substitution is then a function of the lagged, present and future consumption growth rate. Non-time separable preferences can make marginal utility more volatile. We find this result when utility depends not only on the current level of consumption but also on its change relative to the past levels. The estimation of this kind of model, realised here for the G7 countries, confirms the non-time separability of the utility function. More precisely, the representative agent is characterised in these countries by a habit behaviour, in the sense that he modifies his present consumption level only if he is able to maintain this level durably. This habit effect implies an increase in his unwillingness to report consumption from a period to another. In other words, habit reduces the elasticity of intertemporal substitution of the consumer. However, unlike the case of the time separable utility, this is no more accompanied by an unreasonable relative risk aversion. The econometric results obtained in this paper indicate that the latter is close to one.

If taking into account habit formation in consumption gives a satisfying relative aversion level for the consumer facing a risk on his wealth, it leads to a low elasticity of intertemporal substitution (i.e. a high level of aversion in the face of a risk on consumption). Hence, the consumer would smooth more his consumption than justified by the life cycle hypothesis. This excess smoothing would be more important in the US and the UK (the elasticity of consumption relative to wealth is less than 0.01), than in Canada, France and Germany (the elasticity is equal to 0.05) and than in Italy and Japan (the elasticity is equal to 0.1). In other words, the model with habit formation that has been estimated here does not solve totally the ‘equity premium puzzle’, in the sense that it does not lead to fully satisfying consumer’s preferences. However, it is likely that this is due to the difficulty to estimate the discount factor, parameter fixed to one in the study. Indeed, the elasticity of intertemporal substitution can increase significantly for values of the discount factor slightly lower than one, without modifying significantly the relative risk aversion. It is then likely that the consumption model with habit formation comes up simply against a practical constraint, that is the estimation of the parameters from a very non-linear relationship.

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APPENDIX 1

Sources and analysis of the data

The estimation of the model realised in this paper requires series for the *per capita* consumption and for the returns of a risk-free asset (short-run interest rate) and a risky asset (stock index). This appendix presents first the sources of the data used and the way the problems of discrete time modelling have been solved. Then, we present the graphs of the series used and some information on the importance of the stock market for the households in the G7 countries. Finally, with our data, we propose a descriptive analysis of the relationship between financial assets and consumption in the model with time-separable utility in order to stress the equity premium puzzle in such a model.

1- Statistical sources

This paper works with annual data on macroeconomic agregates and equity markets variables.

Macroeconomic data

The main source for data on consumption and population is the OECD Economic Outlook database covering the period 1970-1998. Consumption is denominated in constant dollar in order to make the levels of *per capita* consumption comparable. The consumption deflator is computed from data for value and volume of consumption.

Financial data

Short term interest rates come from the OECD Economic Outlook database. The diversity in the organisations and the developments of the interbank markets over the period imply not to use the same asset for all the countries. Treasury bonds are used for 4 countries (the US, France, the UK and Canada) and monetary market rates for the three others (Germany, Japan and Italy). The return of this risk-free asset is the interest rate in annual average (average of the 12 monthly interest rates, in annual return).

The stock indices used in this study are from the MSCI (Morgan Stanley Capital International) database. Annual stock market data are based on the monthly national price and gross return indices in local currency. Index prices and dividend rates allow to compute the global return of the stock index. The computation of the annual average return is realised as follows. The monthly return rate and the monthly price of the index gives the dividends paid each month. The sum on the year of the monthly dividends determines the annual dividend. The annual price of the index is the average of the monthly prices. The average annual return is then obtained by using the lagged and the present average prices and the annual dividend : $R_{i,t} = \frac{p_{i,t} + d_{i,t}}{p_{i,t-1}} - 1$

2- Descriptive analysis of the relationship between financial assets and returns consumption in the time-separable utility model

This presentation uses the process defined by Campbell (1998) to illustrate the importance of the equity premium puzzle for the G7 countries.

The equity premium is defined by :

$$E_t\{re_{t+1}\} - rf_{t+1} = -\frac{1}{2}\sigma_t^2\{re_{t+1}\} + \gamma Cov_t\{re_{t+1}, \Delta\ln(C_{t+1})\}$$

where *re* is the stock index return and *rf* the risk-free rate

E, σ, σ², cov and ρ are respectively the expectation, the standard-error, the variance, the covariance and correlation coefficients.

The equity premium puzzle

1971-1998	E(*re-rf*) +σ²(*re*)/2	σ(*re-rf*)	σ(*M*)	σ(ΔlnC)	ρ(*re-rf*, ΔlnC)	cov(*re-rf*, ΔlnC)	RRA1	RRA2
Canada	3.47	15.53	22.56	2.04	0.33	10.58	33	11
France	6.52	18.44	34.28	1.21	0.05	1.11	590	29
Germany	7.75	22.57	35.13	2.22	-0.15	-7.71	<0	15
Italy	3.61	26.64	13.13	1.90	-0.01	-0.38	<0	7
Japan	5.28	18.78	27.39	1.96	0.50	18.50	29	14
UK	5.84	16.47	34.39	2.48	0.20	8.22	71	14
US	6.64	12.84	49.09	1.78	0.29	6.59	101	29

This table illustrates the equity premium puzzle in the model with time-separable utility. The first column represents the average excess log return on stock over the risk-free asset plus one half the variance of this excess return (in percentage). The standard-errors of the excess log return and the consumption growth are presented respectively in the second and the fourth column. σ (M) is the ratio of the first and the second column (multiplied by 100). These values (third column) can be interpreted as a lower bound on the standard deviation of the log stochastic discount factor (in percentage). The fifth column gives the correlation coefficient between the excess return and the consumption growth. The last column (cov(re, ΔlnC)) is the product ρ(*re-rf*,Δ*C*).σ(*re-rf*).s(Δ*C*).

RRA1 is a measure of the relative risk aversion (γ) computed from the values of the empirical standards errors as :

$$RRA1 = 100 \frac{E_t\{re_{t+1} - rf_{t+1}\} + \frac{1}{2}s_t^2\{re_{t+1}\}}{Cov_t\{re_{t+1}, \Delta\ln(C_{t+1})\}}$$

RRA2 is a measure of the relative risk aversion by assuming a perfect correlation between the risk premium and the growth of consumption.

APPENDIX 2

Econometric results when the discount factor (b) is estimated

Estimation of the model with the risk-free asset

Models with β constrained	*g* constrained α constrained		*g* unconstrained α constrained		*g* constrained α unconstrained		*g* unconstrained α unconstrained	
	Coeff.	*T Student*	Coeff.	*T Student*	Coeff.	*T Student*	Coeff.	*T Student*
*g*_Canada	0.43	*1.8*	3.02	*1.3*	1.09	*1.1*	5.56	*0.6*
*g*_France	0.43	*1.8*	4.35	*1.6*	1.09	*1.1*	1.92	*0.8*
*g*_Germany	0.43	*1.8*	1.77	*1.9*	1.09	*1.1*	1.55	*0.8*
*g*_Italy	0.43	*1.8*	0.91	*1.3*	1.09	*1.1*	6.11	*0.1*
*g*_Japan	0.43	*1.8*	0.86	*2.3*	1.09	*1.1*	1.42	*0.7*
*g*_UK	0.43	*1.8*	2.04	*1.8*	1.09	*1.1*	1.81	*0.5*
*g*_US	0.43	*1.8*	1.32	*2.8*	1.09	*1.1*	2.07	*0.3*
α_Canada	0.82	*13.3*	0.64	*7.8*	0.61	*7.7*	0.68	*5.2*
α_France	0.82	*13.3*	0.64	*7.8*	0.69	*4.8*	0.59	*2.8*
α_Germany	0.82	*13.3*	0.64	*7.8*	0.74	*4.8*	0.56	*2.1*
α_Italy	0.82	*13.3*	0.64	*7.8*	0.81	*5.8*	0.75	*2.9*
α_Japan	0.82	*13.3*	0.64	*7.8*	0.75	*4.2*	0.69	*2.5*
α_UK	0.82	*13.3*	0.64	*7.8*	0.73	*4.3*	0.62	*1.9*
α_US	0.82	*13.3*	0.64	*7.8*	0.74	*4.3*	0.65	*1.8*
β	0.969	*128.6*	0.989	*88.0*	0.9755	*94.2*	0.985	*53.2*
P-Hansen	0.84		0.50		0.44		0.07	

Estimation of the model with the risk-free asset (continued)

Models with β unconstrained	*g* constrained α constrained		*g* unconstrained α constrained		*g* constrained α unconstrained		*g* unconstrained α unconstrained	
	Coeff.	*T Student*	Coeff.	*T Student*	Coeff.	*T Student*	Coeff.	*T Student*
*g*_Canada	**1.03**	***4.5***	4.74	*0.6*	0.90	*1.9*	3.23	*1.1*
*g*_France	**1.03**	***4.5***	>100	*0.0*	0.81	*5.3*	2.73	*0.0*
*g*_Germany	**1.03**	***4.5***	16.40	*0.1*	0.87	*2.2*	2.62	*0.4*
*g*_Italy	**1.03**	***4.5***	0.78	*2.2*	1.00	*1.3*	2.45	*0.3*
*g*_Japan	**1.03**	***4.5***	>100	*0.0*	1.19	*0.9*	2.62	*0.0*
*g*_UK	**1.03**	***4.5***	>100	*0.0*	0.86	*2.5*	2.67	*0.0*
*g*_US	**1.03**	***4.5***	>100	*0.0*	1.14	*1.0*	2.70	*0.1*
α_Canada	**0.50**	***10.1***	0.64	*4.5*	0.61	*5.1*	0.43	*1.6*
α_France	**0.50**	***10.1***	0.64	*4.5*	0.69	*3.2*	0.49	*0.9*
α_Germany	**0.50**	***10.1***	0.64	*4.5*	0.74	*2.8*	0.56	*0.9*
α_Italy	**0.50**	***10.1***	0.64	*4.5*	0.81	*4.3*	0.68	*1.1*
α_Japan	**0.50**	***10.1***	0.64	*4.5*	0.75	*2.5*	0.60	*0.0*
α_UK	**0.50**	***10.1***	0.64	*4.5*	0.73	*3.0*	0.56	*0.0*
α_US	**0.50**	***10.1***	0.64	*4.5*	0.74	*2.6*	0.52	*0.1*
β_Canada	**0.979**	***150.2***	0.990	*15.0*	0.975	*54.3*	1.009	*16.0*
β_France	**0.986**	***160.0***	0.990	*21.3*	0.975	*58.6*	1.009	*0.8*
β_Germany	**0.987**	***97.6***	0.990	*24.5*	0.975	*27.2*	1.009	*8.2*
β_Italy	**0.997**	***91.7***	0.989	*48.6*	0.976	*14.5*	1.008	*4.8*
β_Japan	**0.999**	***122.0***	0.989	*53.3*	0.975	*27.7*	1.009	*0.2*
β_UK	**0.992**	***111.1***	0.990	*23.6*	0.975	*30.2*	1.009	*0.1*
β_US	**0.994**	***153.2***	0.987	*40.9*	0.975	*27.1*	1.009	*1.0*
P-Hansen	**0.42**		0.08		0.06		*	

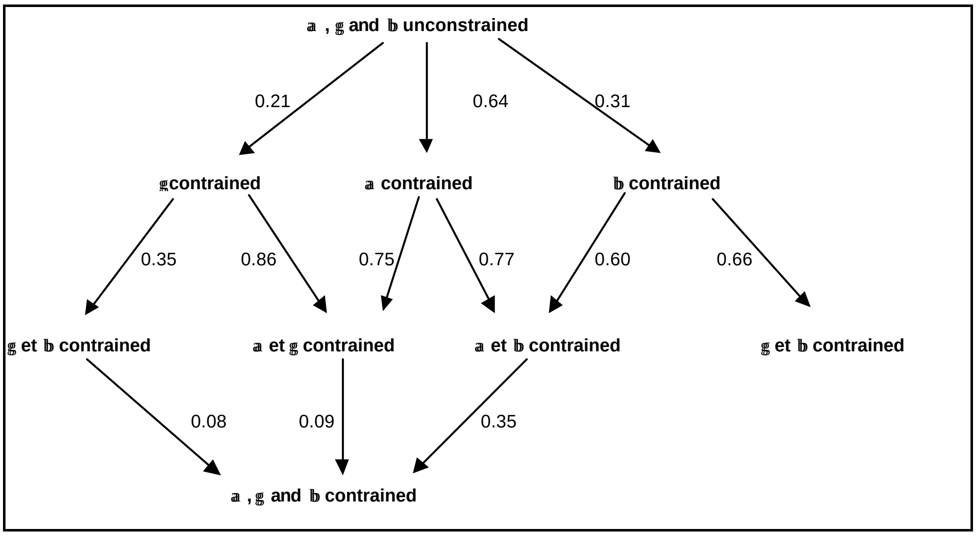
Instruments uses in these estimations are the constant, $(1+\Delta c_{-1})$ and $(1+R_{-1})$.

** In this model, the system is totally identified, the number of equations being equal to the number of parameters to be estimated.*

Consider first the model with the risk-free asset (see table). The tests of the constraints on parameters imply to retain two kinds of differences among countries, at the 10 percent significance level (see figure supra). In the first case, the curvature and the habit parameters are not statistically different from a country to another, but the consumers have different discount factors. The curvature of the utility function is equal to 1.03 and the habit parameter is equal to 0.5. In the second model, the consumers are different because of their habit parameter. The curvature is equal to 1.09 and the discount factor is equal to 0.975.

The habit parameter varies between 0.61 in Canada and 0.81 in Italy. However, the non-significativity of the curvature leads us to reject this model on behalf of the first one.

Models with the risk-free asset



(p-values displayed)

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