Taste shocks in preferences and the Risk Premium in the Exchange rate market

Juan-Angel Jimenez-Martín\textsuperscript{(*)}

\textsuperscript{(*)} Dpto. de Fundamentos de Análisis Económico II, Complutense University, Somosaguas, Madrid, 28223, Spain.

Abstract:
This paper examines the contribution of taste changes on the risk premium in the exchange rate markets. It presents a Two-country, pure exchange, cash-in-advance economy in which agents have preferences subject to taste shocks. Under these preferences one can distinguish between two types of uncertainty that will play a prominent role in the risk premium: the “fundamental uncertainty” and the “preference uncertainty”. The former refers to the anticipated uncertainty over the fundamental variables. The latter is associated with taste shocks. Taste shocks in preferences can be justified by numerous reasons such as reflecting measurement errors in the variables, stochastic rates of time preferences, miss-specifications of the parameterization of preferences, or merely, expected shifts in the market structure. The spirit is similar to Hu’s (1997) model, but taste shocks in preferences lead to a stochastic discount factor that should be sufficiently volatile to deliver a higher risk premium.

JEL Classification: F31, F41, G12, G15
Keywords: Risk premium, taste shocks, fundamental uncertainty.

* Corresponding author. Tel.: +34 91 394 23 55. Fax: +34 91 394 2613;
E_mail: juanangel@ccce.ucm.es

#I am grateful to R. Flores, G. Kaminsky, A. Novales, and P. Vega for helpful comments. The paper has benefited from comments from seminar participants at the George Washington University. I would like to acknowledge the financial support of the Ministerio de Educación, Spain, through Project BEC2003-03965 and the Fundacion Caja Madrid. Parts of this work were completed while visiting George Washington University, Washington, DC. The author is grateful to this institution for its hospitality.
1.- INTRODUCTION

An intense research effort has been paid in recent years to characterize the determinants of excess returns in the forward market for exchange rates [see Hodrick, 1987, Bekaert and Hodrick, 1992, and Verdelhan 2006, among many others]. As a consequence, significant progress has been made in identifying the factors that lead to the presence of a risk premium in exchange rates, although characterizing how its size changes over time remains an open question.

An extensive literature has analyzed the excess returns in forward contracts for exchange rates using *intertemporal asset valuation* models á la Lucas (1982), which establishes a link between financial markets and markets of goods. Along this line, Hansen and Hodrick (1983), Kaminsky and Peruga (1990), and Hu (1997) show that the exchange rate is a function of fundamental variables such as money supply, output, and real income. In equilibrium, the excess return in the currency market is determined by the preferences of private agents and the volatility of the fundamental variables in the economy. However, these models have failed to consistently explain the observed data. The moderate amount of risk in fundamental variables does not guarantee the high average excess returns one observes, unless an unreasonably large relative risk aversion is assumed. We know since Mehra and Prescott (1985) that stochastic discount factors must have a large variance in order to price stock excess returns.

Various authors have attempted to solve the empirical problem associated with the standard representative agent model by introducing more general preferences that make marginal utility of consumption extremely sensitive to small variations in consumption. Campbell and Cochrane (1999) use habit to explain stock market prices. Backus, Gregory and Telmer (1993) and Verdelhan (2006) employ habit formation to explain the exchange rate risk premium and Bekaert (1996) examines the ability of a model along these lines to generate large and variables foreign exchange risk premium. Others papers explore whether the risk premium can be explained by using preferences subject to taste shocks, Normandin and St-Amour (1998) investigate the relative contribution of risk aversion, inter-temporal substitution, and taste shocks on the equity premia.

The work presented here is related with this last line of research. It examines the contribution of taste shocks\(^1\) on the risk premium in the exchange rate markets. It presents a Two-country, pure exchange, cash-in-advance economy in which agents have preferences subject to taste shocks. Under these preferences one can distinguish between two types of uncertainty that

---

\(^1\) Taste shocks have proved to be useful in various settings, such as consumption (Miron, 1986 and Caballero, 1990), exchange rates (Jimenez and Flores, 2007), money demand (Townsend, 1989), and business cycle behavior (Bencivenga, 1992).
will play a prominent role in the risk premium: the “fundamental uncertainty” and the “preference uncertainty”. The former refers to the anticipated uncertainty over the fundamental variables. The latter would be associated with taste shocks. Taste shocks in preferences can be justified by numerous reasons such as reflecting measurement errors in the variables, stochastic rates of time preferences, miss-specifications of the parameterization of preferences, or merely, expected shifts in the market structure. The spirit is similar to Hu’s (1997) model, but taste shocks in preferences lead to a stochastic discount factor that should be sufficiently volatile to deliver a higher risk premium.

The taste shocks are represented by a scaling preference parameter that affects the domestic and foreign stochastic discount factors differently. In order to keep the problem tractable I assume taste shocks whose evolution are not affected by agents’ decision. In this model the taste shocks uncertainty translates directly to the stochastic discount factors. Like in Backus, Foresi, and Telmer (2001) assuming log-normal discount factors, the model relates the risk premium to the variances of the domestic and foreign discount factors.

The main contribution of this paper is to present a model explaining the determinants of risk premium in currency markets as an explicit function of the amount of uncertainty observed by private agents. The model allows us to split the risk premium into terms due to the fundamental macroeconomic uncertainty, taste risk, and the relationship between the two. Like in previous studies, the model establishes the relationship between the excess return and the observed volatility of money supply and output. Additionally, taste risks include anything else (non-consumption shocks) that matters to agents’ welfare and may lead to shifts in preferences. In these economies, even if money supply and output processes are smooth, risk premium can be quite volatile because taste shocks have a high volatility.

I test this model for the transition period to the European currency considering bilateral exchange rates between the French franc, British pound, and Spanish peseta all of them with the German mark. The uncertainty on the success of convergence process may explain the excess return observed in some European currencies in this period, even though the variability of observable macroeconomic variables such as money, output, and consumption did not change very much. The euro would eliminate exchange rate uncertainty and the currency conversion cost

---

2 The agent’s taste changes in different ways as he/she ages or due to situations she/he has never encountered, for instance, the change from flexible to fixed rates is an essential shift in market structure. A credibly fixed exchange rate has neither volatility nor an expected rate of change. So the risk premium disappears. The situation is dramatically different when the exchange rate either floats explicitly, or is fixed unreliably so that speculative attacks are possible. In this case forces other than those from money and goods markets drive the foreign exchange market. Taste shocks may explain how the agent inter-temporal consumption attitudes might be affected for this situation.
among the member states, which would spur international trade and investment. Furthermore, the monetary union would create the potential for some countries to “import monetary credibility” (Herrendorf, 1997) from other member countries with reputation for prudent monetary policy (e.g., Germany). The participation of such countries in the union would lower expected inflation throughout the union that would contribute to financial deepening and greater investment. Therefore, euro would have implications for agents’ investment and saving decisions. Taste shocks in preferences are intended to capture the effect of the expected new currency on the agent inter-temporal consumption attitudes.

Three western European countries in the EMS, United Kingdom, Denmark and Sweden, have not yet adopted the euro. Besides, the European Union has incorporated twelve Eastern European countries as new members. Hence, although I use the initial convergence process to the euro as an illustration, our methodology can be used to analyze possible exchange rate risk premium in these countries. A similar analysis could also be applied if common currency areas in Latin America or South East Asia are eventually approved.

I proceed as follows. In section two, I present the theoretical model and describe the relations among risk premium, fundamental uncertainty, and taste shocks that are obtained from the Euler condition. The third section describes a particular model specifying agents’ preferences and the stochastic behavior of the main variables. I exploit these assumptions to derive an analytical expression for the risk premium allowing for statistical tests to be performed. In the fourth section, as an illustration, I apply this model to account for the risk premium during the transition period to the European currency. Section five presents the main conclusions.

2.- THEORETICAL MODEL

The consumption-based asset pricing model is derived in a standard representative agent setting following Lucas (1982) and Hu (1997). The model considers two countries (domestic and foreign) and two perishable commodities, \( x^D \) and \( x^F \). In each country, a different currency is used to pay for transactions in their respective commodities. At each period \( t \), the domestic (foreign) country receives a stochastic endowment \( Y_t^D (Y_t^F) \) of good \( x^D (x^F) \), and zero units of the other commodity. Domestic (foreign) country also receives a stochastic endowment \( M_t^D (M_t^F) \) of its currency. Thus, \( R_t = (Y_t^D, Y_t^F) \) and \( N_t = (M_t^D, M_t^F) \) define the state vectors of real and nominal endowments respectively. Real endowments and money stocks follow a multivariate stochastic process to be specified below.
Consumers are identical in both countries. The model is written from the perspective of the domestic country. The representative consumer has preferences characterized by:

$$U_i = E_t \sum_{s=t}^{\infty} \beta^{t-s} U(c_i^D, c_i^F, Z_i) \quad 0 < \beta < 1$$

(1)

where $E_t$ denotes the mathematical conditional expectation on information known at the beginning of period $t$. $c_i^D, c_i^F$ represent the consumption levels of the domestic and foreign goods by the representative agent of country $i$ at period $s$, and $Z_i$ is a stochastic taste shock. I assume the utility function $U(., .)$ to be bounded, continuously differentiable, increasing and strictly concave in all the arguments. $U_{CZ_i}$, where the subscript on $U$ denotes the partial derivative of $U$ with respect to the corresponding argument, can take any sign. $\beta$ is the constant time discount factor.

I assume that each economy is subject to a cash-in-advance constraint. At the beginning of each period, consumers receive the endowments of goods and money. Since money does not produce any utility by itself, consumers will use it to buy consumption commodities. In order to be able to purchase foreign goods, they first need to exchange currency through either spot or forward contracts at their corresponding equilibrium prices. From money market equilibrium, nominal prices must satisfy:

$$P_i^j (R_i, N_i) = M_i^j / Y_i^j, \text{ for } j = D, F.$$  

(2)

where $P_i^j$ is the domestic and foreign currency price for good $j$ at time $t$.

In order to describe an equilibrium solution of the model, we require a distribution of wealth. We have assumed that wealth of every kind is evenly divided between the residents of the two countries. Specifically, the resident of each country owns half of the domestic and foreign endowments, and the stocks of domestic and foreign money. Given this distribution of wealth, consumption is given by:

$$c_i^j = Y_i^j / 2, \quad j, i = D, F.$$  

(3)

As shown by Hu (1997) the equilibrium exchange rate (units of domestic currency per unit of foreign currency) is given by:

---

5 In Bakshi and Chen (1996) $Z_t$ stands for the spirit of capitalism, and in Campbell and Cochrane (1999) $Z_t$ is introduced through time-varying habits in which the bliss point is a function of past consumption. In this paper $Z_t$ means a shock to marginal utility. $Z_t$ implies a kind of state-dependent preferences.
As an alternative, currency exchange can take place through *forward* contracts, which allows consumers to insure themselves against the uncertainty on the future purchasing power of their own currencies. I assume that these contracts last a single period, being purchased at the end of each period. Hence, *forward* contracts determine the distribution of currency for the following period.

To obtain the *forward* exchange rate, in units of domestic currency per unit of foreign currency, let us first consider bonds denominated in either domestic or foreign currency. From the first order condition describing the optimal consumption and portfolio decisions, the domestic (foreign) value $b^D_t$ ($b^F_t$) of a bond that pays one unit of domestic (foreign) currency at time $t+1$ satisfies:

$$b^j_t = E_t \left( q^j_{t+1} \right), \quad \text{for} \quad j = D, F,$$

where $q^D_{t+1} (q^F_{t+1})$ denotes the domestic (foreign) intertemporal marginal rate of substitution (IMRS). As shown by Hu (1997) the IMRS of this model is given by:

$$\frac{\beta U_{e^D_t} \left( R^D_{t+1}, Z^D_{t+1} \right) \pi^j_{t+1}}{U_{e^D_t} \left( R^D, Z^D \right) \pi^j_t} = q^j_{t+1}, \quad \text{for} \quad j = D, F,$$

where $\pi^j_{t+1} \equiv \left( P^j \left( R^j_{t+1}, N^j_{t+1} \right) \right)^{1} = Y^j_{t+1} / M^j_{t+1}, \quad \text{for} \quad j = D, F.$ \(^5\)

Following Backus et al. (2001), let’s consider a forward contract specifying at date $t$ the exchange at $t+1$ of one unit of foreign currency and $F^t_{t+1}$ units of domestic currency. This contract specifies a net flow of foreign currency at date $t+1$ of $F^t_{t+1} S^t_{t+1}$. Since it involves no payments at date $t$, pricing relation (5) implies:

\(^4\)This solution is the perfectly pooled equilibrium of Lucas (1982).

\(^5\)To gain same intuition, expression (6) can be written as: $b^j_t U_{e^D_t} \left( R^j, Z^j \right) \pi^j_t = \beta E_t \left( U_{e^D_t} \left( R^j_{t+1}, Z^D_{t+1} \right) \pi^j_{t+1} \right)$, for $j = D, F$. The left hand side is the marginal utility cost of consuming $b^D_t (b^F_t)$ units of domestic (foreign) currency less at time $t$; the right-hand side is the expected marginal utility benefit form investing the units of domestic (foreign) currency in an asset denominated in domestic (foreign) currency at time $t$, obtaining one unit of domestic (foreign) currency at time $t+1$, and consuming the proceeds. The consumer equates the marginal cost and marginal benefit.
\[ E_t \left( q_{t+1}^D \left( F_{t+1}^{s} - S_{t+1} \right) \right) = 0. \] (7)

From (4) and (6), one can define the change in the exchange rate as the ratio of the two IMRSs at home and abroad:

\[ \frac{S_{t+1}}{S_t} = \frac{q_{t+1}^F}{q_{t+1}^D}. \] (8)

Dividing (7) by \( S_t \) and applying (8), one can obtain the forward premium as:

\[ \frac{F_{t+1}^{s}}{S_t} = \frac{E_t \left( q_{t+1}^F \right)}{E_t \left( q_{t+1}^D \right)}. \] (9)

Thus, taking conditional expectations on the future spot rate \( S_{t+1} \) from (4) and subtracting the value of the forward rate \( F_{t+1}^{s} \) from (9), one can obtain the expected return in a forward contract,

\[ E_t^{s} = E_t \left[ \frac{M_{t+1}^d Y_{t+1}^F U_{y_{t+1}^F} \left( Y_{t+1}^D / 2, Y_{t+1}^F / 2, Z_{t+1} \right)}{M_{t+1}^D Y_{t+1}^D U_{y_{t+1}^D} \left( Y_{t+1}^D / 2, Y_{t+1}^F / 2, Z_{t+1} \right)} \cdot \frac{q_{t+1}^F}{q_{t+1}^D} \cdot U_{y_{t+1}^F} \left( Y_{t+1}^D / 2, Y_{t+1}^F / 2, Z_{t+1} \right) \right]. \] (10)

This is a generalization of the result derived by Hu (1997). Equation (10) shows that the expected excess return from a forward contract is determined by real and monetary variables, as well as by the preferences of the representative agent like in Hu (1997). Additionally, in this paper the excess return in forward contracts is also determined by taste shocks. Therefore, in this economy, even if real and monetary variables were smooth, the risk premium could be very volatile if shocks in preferences, which are one of the driving forces behind the market uncertainty, were sufficiently volatile.

3.- EMPIRICAL METHOD

The characterization of risk premium in (10) is very general and additional structure must be introduced prior to testing the theory. So now I incorporate into the model three assumptions that lead to a testable analytical formulation of the risk premium. First, I alter slightly the concept of risk premium to avoid some practical difficulties. Secondly, I specify the preferences of the representative consumer since they play a central role in the

\[ \frac{F_{t+1}^{s}}{S_t} E_t \left( q_{t+1}^D \right) = E_t \left( q_{t+1}^D \frac{S_{t+1}}{S_t} \right) = E_t \left( q_{t+1}^D \right) \]
determination of the risk premium. Finally, some assumptions on the stochastic behavior of the variables in the model are made.

3.1.- Redefining the risk premium

The definition of risk premium in (10) is not invariant to changes in the units of measurement. Specifically, it is subject to the Siegel paradox, as a consequence of Jensen’s inequality. The value of the risk premium emerging from this expression is different depending on whether one measures the exchange rate in units of domestic currency per unit of foreign currency ($S_t$), or the reverse ($1/S_t$). To avoid this problem it is standard in the literature to use a definition of risk premium that incorporates a logarithmic transformation. Doing this the change of units only affects the sign of the risk premium: $E_t [\ln(1/S_{t+1})] = -E_t [\ln(S_{t+1})]$. Then I can define the new measure of risk premium as $RP_{t+1} = E_t [s_{t+1} - f_{t+1}]$, where $s_{t+1}$ is the log of $S_{t+1}/S_t$ (i.e. the depreciation rate of the domestic currency), and $f_{t+1}$ is the log of $F_{t+1}/S_t$ (i.e. the forward premium). This measure is related to the risk premium in (10) through: $E_t [s_{t+1} - f_{t+1}] \approx E_t [(S_{t+1} - F_{t+1})/S_t]$ when using the approximation $\ln (1+x) \approx x$ (for a small value of $x$).

Thus, given (8) and (9) the risk premium can be written as,

$$RP_{t+1} = E_t(s_{t+1}) - E_t \log(q_{t+1}^F) + E_t \log(q_{t+1}^D) = E_t(s_{t+1}) + r^F_i - r^D_i,$$

(11)

where $r^i = -\log E_t \left[ q_{t+1}^i \right]$, for $i=D, F$, is the interest rate of the one-period bond defined in the previous section. Therefore, the exchange rate risk premium is the excess return of a domestic investor who borrows one unit of domestic currency at home, buys $1/S_t$ worth of foreign currency, lends it on the foreign market for a defined period and finally reconverts his earnings to the domestic currency.

To see more clearly how the monetary and real variables as well as the taste shocks affect the risk premium, additional assumptions on consumer preferences and stochastic properties of these variables have to be done.

3.2.- Consumer preferences

As a standard illustration, I assume a separable utility function,

$$U(c^D_t, c^F_t) = \frac{(c^D_t)^{1-\alpha}}{1-\alpha}Z_t^{\gamma_D} + \frac{(c^F_t)^{1-\gamma}}{1-\gamma}Z_t^{\gamma_F} \quad \alpha, \gamma \geq 0 \quad \text{and} \quad \alpha \neq 1, \gamma \neq 1$$

(12)
where $\beta$ and $\gamma$ are the risk aversion parameters, $Z_t$ is a stochastic taste shock$^7$ and $\lambda_j$, for $j=D, F$, measures the extent to which taste shocks affect to domestic and foreign goods.$^8$

Additionally, it is necessary to make some assumptions on the joint stochastic behavior of real and nominal endowments, as well as on the probability distribution of taste shocks before obtaining a tractable expression for the risk premium.

### 3.3. The stochastic process for the main variables

The risk premium depends on conditional expectations of cross products of random variables. Under general conditions, these products do not have a well defined probability distribution which might allow for computing their expectations. Therefore, I need to incorporate some restrictions on the stochastic behavior of the main variables in the model. That will also allow us to find a formulation for the risk premium as a function of the main sources of uncertainty in the economy.

Given (6) and separable preferences in (12) both domestic and foreign IMRS are:

$$
q_{t+1}^F = \left(\frac{y_{t+1}^F}{m_{t+1}^F}\right)^{\gamma-1} z_{t+1}^F
$$

$$
q_{t+1}^D = \left(\frac{y_{t+1}^D}{m_{t+1}^D}\right)^{\gamma-1} z_{t+1}^D
$$

where $y_{t+1} = \frac{Y_{t+1}}{Y_{t}}, m_{t+1} = \frac{M_{t+1}}{M_{t}},$ for $i=D, F$ and $z_{t+1} = Z_{t+1}/Z_t$.

More precisely, I consider the case where the output and money supply growth as well as taste shock growth are conditionally jointly log-normal. Following Hu (1997), I assume that discount factors are log-normal.$^9$ Assuming log-normal IMRS, Backus et al. (2001) show that the

$^7$ Bakshi and Chen (1996) analyze the implications for consumption, portfolio holdings and stock-market prices of the hypothesis that investors accumulate wealth not only for the sake of consumption but also for wealth-induced social status. According Max M. Weber (1958), this hypothesis essentially captures the spirit of capitalism. Bakshi and Chen (1996) postulate that $Z_t$ is the investor’s relative social standing. They postulate that $Z_t$ is strictly increasing in wealth (so as to reflect the spirit of capitalism), but decreasing in social-wealth standards (so that status is only relative). On the contrary that Bakshi and Chen, I assume that $Z_t$ evolution is not affected by agent’s decisions.

$^8$ Using this utility function the spot exchange rate is given by,

$$
S_t = 2^{\alpha-\beta} \rho \left(\frac{Y_t^F}{M_t^D}\right)^{\gamma-1} \left(\frac{Y_t^D}{M_t^F}\right)^{\alpha-\beta} Z_t^{x^F-x^D}
$$

When $x^F > x^D$, a positive shock in preferences will increase the marginal utility on foreign goods more than on domestic goods, which in turn leads to a higher demand for foreign goods, and thereby increasing the relative price of $x^F$. Hence, the spot exchange rate increases, producing a depreciation in the domestic currency.

$^9$ It is further from evident that log-normality of $m_t, y_t,$ and $z_t$ guarantees that their product is also lognormal if these variables are conditionally correlated.
risk premium is equal to half of the difference between conditional variances of the two intertemporal marginal rates of substitution:

$$RP_{it} = \frac{1}{2} \sigma_{q_t} - \frac{1}{2} \sigma_{q_{t+1}},$$

(14)

where $\sigma_{q_t}$ is the conditional variance of the logarithm of the IMRS for $i=D, F$. This expression tells us that if the domestic IMRS were conditionally more volatile than the foreign IMRS, one would expect a positive risk premium. To see this more clearly, the short interest rate can be written as $-r_t = \log E_t [q_{t+1}^F] = E_t \log (q_{t+1}) + \frac{1}{2} \sigma_{q_{t+1}}$. From (9) the expected change in the exchange rate is:

$$E_t \left[ \Delta e_{t+1} \right] = \log E_t [q_{t+1}^F] - \log E_t [q_{t+1}^D] = -r_t^F + r_t^D - \frac{1}{2} \sigma_{q_t^F} + \frac{1}{2} \sigma_{q_t^D}.$$

Therefore, if $\sigma_{q_t^D} > \sigma_{q_t^F}$, one would expect an exchange rate depreciation, which in turn would imply that investing in the foreign currency should provide a positive excess return. The domestic investor would expect positive foreign currency excess return at period $t$ to compensate him/her for the expected loss when his/her assets are abroad.

Finally, from (13) and (14), I can express the risk premium in terms of the properties of output growth, monetary aggregates, and preference tastes:

$$RP_{it} = \frac{1}{2} \sigma^c + \frac{1}{2} \sigma_{m_t}^D - \frac{1}{2} \left( \lambda^c \right)^2 + \frac{1}{2} \left( \lambda^D \right)^2 + \frac{1}{2} \left( \lambda^F \right)^2 - \frac{1}{2} \left( \lambda^E \right)^2 + \frac{1}{2} \left( \lambda^Z \right)^2 - \frac{1}{2} \left( \lambda^F \right)^2 + \frac{1}{2} \left( \lambda^D \right)^2 + \frac{1}{2} \left( \lambda^E \right)^2 + \frac{1}{2} \left( \lambda^Z \right)^2,$$

(15)

where $\sigma_{q_t} \equiv \var \left( \log \left( x_{t+1} \right) \right)$ and $\sigma_{q_t^D} \equiv \cov \left( \log \left( x^F_{t+1} \right), \log \left( p^F_{t+1} \right) \right)$. Equation (15) states that expected risk premium is determined by (i) the conditional variance of the domestic and foreign output, (ii) the conditional variance of the domestic and foreign money supply, (iii) the conditional covariance between output and money supply, and (iv) the conditional variance of the

---

10) i), ii), and iii) can be explained through their contribution to the volatility of the purchasing power parity of both currencies given the cash in advance constraints. An increase in the volatility of nominal or real endowments in the domestic country, or a decrease in their covariance, increases the volatility of the purchasing power of the domestic currency, which in turn leads to an increase on the volatility of the domestic IRMS. An increase in the volatility of nominal or real endowments for the foreign country or a decrease in their joint covariance would lead to the opposite effect on the risk premium.
taste shocks, and (v) the conditional covariance between money supply, output and the taste shocks. i), ii), and iii) are related to the macroeconomic uncertainty, and iv) is associated to the preference uncertainty.

This model generalizes that derived by Hu (1997). Here the exchange rate risk premium contains a second source of risk associated to taste shocks. The presence of taste shocks could provide the additional degree of freedom necessary to reproduce the high currency risk premium without requiring unreasonable coefficients of relative risk aversion via the incremental taste covariance it implies. A large premia would be required to offset the impact of shifting marginal utilities of consumption due to the presence of taste shocks.

In the next section I test whether this model can account for the observed risk premium during the transition period to the European currency using bilateral exchange rates between the French franc, British pound, and the Spanish peseta, all with the German mark. Fundamental macroeconomic uncertainty did not generate sufficient risk to reconcile the traditional model with the data. Forces other than those from money and goods markets seem to be the most important sources of uncertainty in these transition countries. Taste shocks in preferences –capturing changes in the taste for domestic and foreign assets because of shifts in the market structure- may offer a potential explanation for these other disturbances driving the foreign exchange market.

4. TESTING THE MODEL

To test (15), I use a two-step estimation strategy: first, I identify and estimate the source of the taste shocks and obtain the conditional variances and covariances for the exogenous variables. Second, I use that information to estimate (15) by OLS, applying standard specification

\[ \lambda \text{ measures how the taste shock uncertainty affects to the risk of domestic and foreign bonds. To gain some intuition, one could assume that taste shocks are independent of the state of the money supply and production. From (13): } \sigma^\alpha_{zt} = \sigma^\alpha_{zt} + (1-\alpha)\sigma^\alpha_{zt} - 2(1-\alpha)\sigma^\alpha_{zt} + \sigma^\alpha_{zt} \left( \lambda^D \right) \sigma^\alpha_{zt} \text{ and } \sigma^\alpha_{zt} = (1-\gamma)\sigma^\alpha_{zt} + \sigma^\alpha_{zt} - 2(1-\gamma)\sigma^\alpha_{zt} + \sigma^\alpha_{zt} \left( \lambda^F \right) \sigma^\alpha_{zt}. \text{ Therefore, the effect on the IMRS volatility of a rise in the preference uncertainty, } \sigma^2_{zt}, \text{ depends on } \lambda^D \text{ for } j = D, F. \text{ If } \lambda^D > \lambda^F, \text{ an increase in } \sigma^2_{zt} \text{ has a greater effect on the domestic IMRS than it does on the foreign IMRS. As consequence, given (14) excess return would be higher.}

\[ 12 \text{ I consider the bilateral relationships between Spanish peseta (SPA), Deutsche mark (DEM), Sterling pound (GBP) and French franc (FRF). The sample starts on January 1, 1986 after Spain became a member of the European Economic Community and ends in April 1998 (In May 1998 the European Council announced the countries that would form the euro area on January 1, 1999). I use monthly data for Spain (SP), Germany (GER), France (FR) and United Kingdom (UK). The industrial production (IP) is used as an indicator of economic activity and M2 as the monetary aggregate. To compute probabilities of convergence I use interest rates for swaps at 3-year maturities for all countries, from 1992:1 to 1998:04. Finally, spot and forward exchange rates represent the value for the last day of the month. Preliminary data analysis (unit root tests and intervention analysis [Box and Tiao (1975)]) shows that all variables, but risk premium, are I(1). Therefore, all variables are differenced in the model for the conditional variance. These results are not reported here but are available upon request.} \]
tests. The constant term in the regression acts as a proxy for the set of second order conditional moments that are not time varying. Since fundamental variables are measured differently in each country, their volatilities are not directly comparable, so it is not possible to estimate the model under the constraints imposed by international symmetry. Hence, I only estimate the unrestricted version of the model, which incorporates all conditional moments separately. Therefore, testing the theory implies test the significance and the sign of the estimated parameters.

4.1. Measuring variables

In order to keep the problem tractable, I will assume that taste shocks are independent of the state of the money supply and the production. I assume that the dynamic of real and monetary variables, represented by the money supply and the industrial production, can be summarized by a VARMA model in logged differences with GARCH innovations, which allows us to capture any possible nonlinear dependence among their innovations.

The mayor difficulty in estimating the exchange risk premium expression is that taste shocks are not observed. Several approaches are available for addressing this problem such as relating the unobservable components to an arbitrary set of observable variables, or as modeling the taste shock growth from a given law of motion (i.e. Markov Chain). In this paper I follow a similar strategy to that of the so-called Peso problem (Krasker, 1980, Lewis, 1988 and Kaminsky and Peruga, 1991). Agents know that something can and will affect them and their tastes in the future but they cannot specify exactly when it will occur.

I assume \( z_t \), the growth of the taste shock, may follow one of two possible regimes: \( \delta_0, \delta_1 \), with \( \delta_1 > \delta_0 \). \( \delta_0 \) represents the actual state and \( \delta_1 \) represents a positive shocks on preferences (in this case, it would mean that the domestic country fulfills the convergence criteria established in the Maastricht agreement). There is a probability of a positive shock in preferences and the market estimates this likelihood as \( p_t = \text{Prob} (\delta_{t+1} = \delta_1 / \delta_t = \delta_0) \). This probability should be expected to change over time as a function of the evolution of some economic indicators that agents consider.

---

13 The concept 'peso problem' has its origin in studies made on the Mexican peso at the beginning of the 70s. Traders in currency markets anticipated a Mexican peso devaluation, and for some time the peso was being sold at a discount in forward markets, even though the government maintained its value until 1976. This effect made the forward exchange rate to deviate from being an unbiased predictor of future spot exchange rate over that period of time.

14 To gain some intuition, let us focus on the transition period to the European currency. Agents in the economy realize that their future welfare depends on whether the country fulfills the convergence criteria established in the Maastricht agreement, what means that the currency would take part on the common European currency since the beginning. The euro creates the potential for some countries to “import monetary credibility” and a lower expected inflation that would contribute to financial deepening and greater investment. These expected facts could have a large impact on the optimal consumption-portfolio plans of the agents, which in turn leads to changes on the equilibrium asset prices.
relevant when predicting future policy decisions. The probability that the current state lasts for at least one more period is \( P_{t+1} = \text{Prob}(\delta_{t+1} = \delta_t) = P_{t+1} \).

The conditional expectation of the shift on preferences indicator, \( z_{t+1} \), is:
\[
E_t[z_{t+1}] = p_t\delta_1 + (1-p_t)\delta_0
\]
and its variance:
\[
\text{Var}_t(z_{t+1}) = p_t(1-p_t)(\delta_1 - \delta_0)^2
\]

Thus equations (15) can be expressed as:
\[
R_{t+1}^e = \lambda p_t(1-p_t)(\delta_1 - \delta_0)^2
\]

Because of the shocks in preferences that take into account the effect of the new expected currency on the agents’ investment and saving decisions, the exchange rate risk premium in (16) depends on the volatility of \( z_{t+1} \), which stands for the “preference uncertainty”. In this case, the “preference uncertainty” is a non linear function of the perceived probability of the success of the convergence process. The variance of \( z_{t+1} \) is zero when \( p_t \) is either 0 or 1, reflecting absolute certainty about the shocks in preferences. The effect of \( p_t \) on the “preference uncertainty” reaches its maximum value for intermediate values of \( p_t \). When \( p_t < 1/2 \), a larger probability will increase taste shocks uncertainty. Whereas, for \( p_t > 1/2 \), a larger probability would reduce the variance of \( z_{t+1} \).

In expression (16), if \( \lambda > 0 \) –i.e. \( \lambda^D > \lambda^F \) - a rise in the variance of \( z_{t+1} \) leads to a higher risk premium. In the empirical model, one would expect a positive sign for \( p_t \) and a negative sign for \( p_t^2 \). As shown in the previous section, if \( \lambda^D > \lambda^F \) a rise in the variance of \( z_{t+1} \) depreciates the expected exchange rate and the domestic investor would expect positive foreign currency excess return at period \( t \) to compensate him/her for the expected loss when his/her assets are abroad.\(^{15}\)

Convergence Probability (and how to measure it)

The exchange rate risk premium in (16) depends on the perceived probability of convergence. To substitute for this unobserved probability assigned by the financial markets to the event that the country belongs to the EMU by January 1999, I use a procedure similar to JP Morgan EMU calculator. The basic feature of the EMU calculator is that the observed interest rate spread at time \( t \), \( IR_{SPR} \), is supposed to be a weighted average of the IN spread, \( IR_{SPR^{IN}} \), which

\(^{15}\) Assuming \( \lambda^D > \lambda^F \) is as if (to use a concrete example) during the convergence period to the euro, the increase in the probability of the Spanish peseta participating in the euro since the beginning had a larger effect on the Spanish economy than on the German economy.
would apply if the country adopts the single currency and the \( \text{OUT} \) spread, \( \text{IR\_SPR}^{\text{OUT}} \), corresponding to the case when the country is out of the EMU. The weights are the corresponding probabilities of each event,

\[
\text{IR\_SPR}_t = p_t \text{IR\_SPR}_t^{\text{IN}} + (1 - p_t) \text{IR\_SPR}_t^{\text{OUT}}
\]

(17)

In a monetary union, financial instruments from different countries with the same maturity, liquidity and credit risk must have the same yield. So, if in January 1999 a country fulfills the convergence criteria\(^{16}\) and enters into the EMU, its riskless interest rate should be equal to those in the other countries of the monetary union. On the other hand, if the country does not enter into the union, its interest rate will be determined by a variety of factors including its own monetary policy and it will generally maintain a positive spread relative to countries in the union. Hence, if \( \text{IR\_SPR}_t^{\text{IN}} = 0 \) and \( \text{IR\_SPR}_t^{\text{OUT}} = \theta > 0 \) in (20), one can estimate the probability assigned by the financial markets at time \( t \) to the event that the country belongs to the EMU by January 1999:

\[
p_t = 1 - \text{IR\_SPR}_t / \theta.
\]

(18)

When estimating I use a more flexible functional form by taking (17) to suggest a negative relationship between the convergence probability and the interest rate swap:

\[
p_t = \alpha_0 - \alpha_t \text{IR\_SPR}_t,
\]

(19)

then

\[
p_t (1 - p_t) = (\alpha_0 - \alpha_t \text{IR\_SPR}_t) - (\alpha_0 - \alpha_t \text{IR\_SPR}_t)^2.
\]

Thus (16) becomes a regression equation of the form,

\[
\text{RP}_{t+1} = s_{t+1} - f_{t+1} = \beta_0 + \beta_t \text{IR\_SPR}_t + \beta_t \text{IR\_SPR}_t^2,
\]

(20)

with \( h = \lambda (\delta - \delta_t) \gamma^2; \ \beta_0 = h \alpha_0 (1 - \alpha_0); \ \beta_1 = -h \alpha_1 (1 - 2 \alpha_0); \ \beta_2 = -h \alpha_1^2; \)

Expression (22) includes the excess return in forward contracts (\( \text{RP}_{t+1} \)) as dependent variable, projected on a constant and the interest rate spread (\( \text{IR\_SPR} \)) approximating the

---

\(^{16}\) To enter EMU, the Maastricht Treaty indicates that candidates must lower inflation to within 1.5% of the lowest three in the European Community, push budget deficits below 3% of GDP, lower debt-to-GDP ratios to 60% and maintain a stable currency.
convergence probability. The square value of the proxy for the convergence probability is also included in the model. The risk premium expression also includes conditional variances \( \left( \sigma^2 \right) \), \( \sigma^2 m_{t+1} \), \( \sigma^2 v^t \), \( \text{and} \sigma^2 \), and covariances \( \left( \sigma_{y^t,m^t} \text{ and} \sigma_{y^t,m^t} \right) \).

The unquestionable participation of Germany in the euro area makes it reasonable to focus the analysis on differentials with German interest rates. Therefore, the probability of the country adopting the single currency from the outset of the EMU is inversely related to the spread of interest rates with Germany. I consider interest rates from swap markets to be more reliable than those from the market for government bonds, which is rather narrow and illiquid in some countries. Furthermore, the tax treatment of returns on public debt is different across countries. On the contrary, the swap market is very liquid and contracts are standardized across currencies, including the tax treatment of returns, and they are not affected by default risk.\(^{17}\) Using the spread of 3-year swap rate as a proxy for the probability of convergence is based on our belief that a 3-year maturity is more likely to capture expectations of convergence to the euro area for a country. Its behavior is similar to those of the 5- and 10-year rates, while the 1-year rate is very influenced by monetary policy decisions.

Interest rate spread with Germany and risk premium values for France, Spain, and United Kingdom are shown in Figure 1 for the 1994:01-1998:04 period. In all cases, the risk premium series is clearly more volatile than the spread. Over 1994 and the first part of 1995, the spread increased for Spain, sharply decreasing during 1996, which could reflect a growing probability that this country could adopt the single currency from the beginning. There was a transitory increase at the beginning of 1997 and the spread returned very quickly to a decreasing path. The spread with France widened in the spring of 1995, from zero to about 1 percentage point, remaining at that level until the end of 1996, when it fell back to zero. This is consistent with a high probability of this country in adopting the single currency from the beginning. On the other hand, the spread showed a positive trend since the beginning of 1994 for the United Kingdom, stabilizing after 1996 but without the sharp decrease observed for Spain and France. These graphs suggest that for Spain and France, an increase in IR_SPR (i.e. a loss in market confidence) induces an increase in the volatility of the risk premium. However, for the United Kingdom, the figure could indicate that this country was not considered to be a likely participant in the EMU. Therefore, in this case the correlation between spread and risk premium is more difficult to explain.

\(^{17}\) Extracting market expectations on a given event from asset prices is a question that has attracted a great deal of interest [see Dillen and Edlund (1997), Favero et al. (2000). For reviews see Söderlind and Svensson (1997), and Bates (1998)].
4.2.- Accounting for the risk premium

I first present in Table 1 least-squares estimates of (20) for the full sample, 1986:02-1998:04, and for the three bilateral relationships without taking into account the effect of taste shocks, so that conditional second order moments are the only explanatory variables. This sample exploits all available data on conditional second order moments. Using risk premium data corrected from extreme values, sharply decreases the evidence of residual autocorrelation. R² values are rather low, although estimated parameters show their right sign when significant. However, the overall suggestion is that macroeconomic uncertainty may not be the most important factor determining risk premium in exchange rates.

Alternatively, I studied whether the uncertainty implied by the taste shocks (as measured by the two spread variables) can account for the risk premium. Using the longer available sample for interest rate swaps, 1992:02-1998:04, I obtained a poor fit, probably because of including the period prior to formal approval of the Union Treaty. Convergence criteria were adopted in the European Union Treaty, which was approved at the European Council celebrated at Maastricht in February 1992, although their final approval at the level of the Congress of each country took place in November 1993. Hence, from 1992, governments considered the possibility of implementing policy with a goal of achieving convergence, although it is just from 1994 that convergence criteria had a formal validity.

When the shorter period is considered in Table 2, 1994:01 - 1998:04, results become much more satisfactory in terms of explanatory power as well as significance and sign of individual coefficients. Simple and adjusted R² coefficients are between 10% and 15%, well above their values for the largest sample. The interest rate spread is statistically significant except for the GBP/GEM relationship. In this case, lack of significance seems to be a consequence of colinearity between the two interest rate spread variables. A Wald test for joint significance of both variables confirms this result. The sign of the coefficients is as expected, except for the GBP/GEM exchange rate, suggesting that the linear probability term would not capture adequately all the information regarding the risk premium in that currency. It seems that it was only after 1994 when the preference uncertainty became a relevant factor in the time evolution of the risk premium for these currencies.

Table 3 presents the estimation results for the entire model, for the 1994:01-1998:04 period, including macroeconomic uncertainty and the nonzero probability for the event that the

---

18 Appendix 1 shows the specification and estimation procedure of conditional second order moments. Parameter estimates are available upon request.
agent preferences might change. Conditional second order moments of fundamental macroeconomic variables are generally not significant. On the contrary, convergence probability is almost always significant.

One can assess the contribution to the fitted risk premium of both the macroeconomic uncertainty and the preference uncertainty using Figure 2. The left column shows, for the 1994:01-1998:04 period, the actual exchange risk premium and the fitted values from the model in Table 3; the middle column shows the part of the fitted risk premium accounted for the macroeconomic uncertainty, $\hat{\beta}_I \sigma^2_{\mu_{i,t}} + \hat{\beta}_2 \sigma^2_{\Phi_{i,t}} + \hat{\beta}_3 \sigma_{\gamma_{i,t}} + \hat{\beta}_4 \sigma_{\gamma_{i,t} \Phi_{i,t}} + \hat{\beta}_5 \sigma_{\gamma_{i,t} \mu_{i,t}} + \hat{\beta}_6 \sigma_{\gamma_{i,t} \mu_{i,t}}$; and the right column displays the part of the fitted risk premium accounted for the preference uncertainty, $\hat{\beta}_2 IR_{SPR} + \hat{\beta}_4 IR_{SPR2}$. Figure 4 presents several scatter diagrams for the fitted risk premium versus: (i) the observed exchange risk premium (left column), (ii) the macroeconomic uncertainty contribution (middle column), and (iii) the “preference uncertainty” contribution (right column). An inspection of these diagrams reveals that the risk premium is extremely volatile and it is more closely related to taste shock uncertainty than to macroeconomic uncertainty. That is also reflected in the correlations coefficients between each variable with the fitted risk premium, which are significantly higher for preference (between 0.70 and 0.93) than for the macroeconomic uncertainty (between 0.19 and 0.58).

The general conclusion is that the uncertainty on whether the country fulfills the convergence criteria established in the Maastricht agreement is more important explaining the risk premium than the fundamentals of the economy. Furthermore, this evidence arises only after 1994, suggesting that it was the formal approval of the Maastricht criteria, more than the Maastricht agreement itself, the starting point for the exchange rate markets to incorporate the probability of convergence into the determination of the risk premium.

We now have all the information needed to compute the probability that the market attaches to the event that one of the countries analyzed in this section joins the European Monetary Union at a given date. The probabilities computed in this paper are similar to those estimated using the J.P. Morgan EMU Calculator. Next section explains how to calculate these probabilities from expression (20)
4.3. Numerical estimates of convergence probabilities

From the estimation of (20) in Table 3 one can recover estimates\textsuperscript{19} for the probabilities that France, Spain, and UK joined the euro area in April 1999. These estimated probabilities of joining the EMU, normalized so that \( p_t \in [0, 1] \), are shown in Figure 3. The results look fairly reasonable. For Spain and France the value of the indicator rose since the beginning of 1996. The upward trend confirms the current perception of an increased probability that Spain and France would adopt the single currency from the outset of the EMU. The United Kingdom had a high probability of entering the EMU during late 1993 but it collapsed during the general wave of pessimism on the future of the currency union during 1994. Since then, the probability continuously decreased until the end of 1997, suggesting, as it was finally the case, that the likelihood of this country in joining the euro area was not considered to be particularly great.

5.- CONCLUSIONS

I have proposed a general equilibrium model to characterize the risk premium in the exchange rate market. The model has a main feature: agents experience consumption risk as well as taste shocks. In this model the excess return is a function of two factors: i) the volatility of fundamental variables (money and output), and ii) the preference uncertainty (taste shocks).

Stochastic discount factors are connected to the properties of money, output and taste shocks in preferences. Taste shocks make stochastic discount factor more sensitive to small variation in consumption. Therefore, the emphasis placed upon consumption risks in capturing actual risk premium movements is reduced.

The model is consistent with the observed risk premium during the convergence period to the euro. Expected shifts in the market structure because of the euro had implications for agents’ investment and saving decisions. It seems that forces other than those from money and goods markets were important sources of uncertainty during this period, a fact that was reflected in the risk premium. This makes the model presented in this paper suitable to be used in a scenario like this. Taste shocks are quantitatively important in reproducing the observed risk premium over the convergence process. Interest rate spreads and square spread values, used as proxies for the amount of observed taste risk, have an acceptable significant explanatory power in the 1994-1998 period.

\textsuperscript{19}From the estimation of (20) in Table 3 one can recover estimates for \( \alpha_0, \alpha_1 \), and \( h \). The system of equations listed in (20) does not have an analytical solution and one needs to use a numerical method to solve it in MATLAB. Then, from (19) it is straightforward to compute the convergence probabilities.
once national Parliaments approved the Maastricht criteria. Regarding fundamental uncertainty, the relevance of conditional variances of money supply and industrial production as well as the conditional covariance between these two variables is rather limited in consistency with the results reached by other authors.

A natural theoretical extension is to investigate more flexible versions of the utility function used in this paper. Additionally, further work will improve the way to measure the taste shocks in preferences.
References:


Appendix 1-
Specification and estimation of conditional second order moments

With regard to fundamental uncertainty, I will assume, as in Hu (1992), that, conditional on available information, growth rates in the fundamental variables \((m_{i+1}^t, y_{i+1}^t; i = D, F)\) follow a joint lognormal distribution. I assume that the dynamic of real and monetary variables, represented by the money supply and industrial production, can be summarized by a VARMA model in logged differences with GARCH innovations, which allows us to capture any possible nonlinear dependence among their innovations.\(^{20}\)

Standard specification tools\(^{21}\) suggested a VARMA(1, 1) model for \((\ln(m_t), \ln(y_t))\) for Spain, VAR(3) for Germany, VAR (2) with a seasonal VAR(1) component for the UK, and a VAR (3) with a seasonal VAR (2) for France. Evidence of seasonal components shows up in spite of using seasonally adjusted time series data. All these models are special cases of:

\[
\begin{align*}
(1 + \phi_1^1 B + \phi_2^1 B^2 + \phi_3^1 B^3) & \begin{pmatrix} m_t^1 \\ m_t^2 \\ m_t^3 \\ m_t^4 \\ m_t^5 \\ m_t^6 \end{pmatrix} + \begin{pmatrix} \epsilon_{m1} \\ \epsilon_{m2} \\ \epsilon_{m3} \\ \epsilon_{m4} \\ \epsilon_{m5} \\ \epsilon_{m6} \end{pmatrix} = \lambda_1 + \begin{pmatrix} \epsilon_{y1} \\ \epsilon_{y2} \\ \epsilon_{y3} \end{pmatrix} \\
(1 + \Phi_1^1 B + \Phi_2^1 B^2 + \Phi_3^1 B^3) & \begin{pmatrix} y_t^1 \\ y_t^2 \\ y_t^3 \end{pmatrix} = \Lambda_1 + \begin{pmatrix} \epsilon_{y1} \\ \epsilon_{y2} \\ \epsilon_{y3} \end{pmatrix}
\end{align*}
\]

(21)

\[
\begin{pmatrix} \epsilon_{m1} \\ \epsilon_{m2} \end{pmatrix} / I_{t-1} \sim N \left( \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{m1}^2 & \sigma_{m1y} \\ \sigma_{m1y} & \sigma_{y1}^2 \end{pmatrix} \right)
\]

(22)

With \(B\) being the backshift operator, and \(\epsilon_t\) the innovation vector.

As initial conditions, I used estimates under the assumption of no heteroskedasticity. Lagrange multiplier and Ljung-Box statistics on the residuals point out to possible conditional heteroskedasticity in the money supply for France and the UK, as well as for an autoregressive structure for the covariance between the money supply and the industrial production in France. These tests led us to a GARCH(1, 1) model for conditional variances and covariance in (22). We estimate the specification:

\[
\begin{pmatrix} \sigma_{m1}^2 \\ \sigma_{m1y} \\ \sigma_{y1}^2 \end{pmatrix} = \begin{pmatrix} c_{01} \\ c_{02} \\ c_{03} \end{pmatrix} + \begin{pmatrix} a_{11} & 0 & 0 \\ 0 & a_{22} & 0 \\ 0 & 0 & a_{33} \end{pmatrix} \begin{pmatrix} \epsilon_{m1,\tau-1}^2 \\ \epsilon_{m1y,\tau-1}^2 \\ \epsilon_{y1,\tau-1}^2 \end{pmatrix} + \begin{pmatrix} g_{11} & 0 & 0 \\ 0 & g_{22} & 0 \\ 0 & 0 & g_{33} \end{pmatrix} \begin{pmatrix} \sigma_{m1,\tau-1}^2 \\ \sigma_{m1y,\tau-1}^2 \\ \sigma_{y1,\tau-1}^2 \end{pmatrix}
\]

(23)

\(^{20}\) As proposed by Bollerslev (1986) and Baba, Engle, Kraft and Kroner (1991), among many others.

\(^{21}\) Partial and simple autocorrelation functions as well as Akaike, Hannan and Quinn, and Schwarz criteria.
I imposed diagonality constraints \( \left( \sigma_{m,y}^2, \sigma_{y,y}^2, \sigma_{m,y,y}^2 \right) \) depending only on their own lags and lags of \( \varepsilon_{m,y}^2, \varepsilon_{y,y}^2, \varepsilon_{m,y,y}^2 \), respectively). These restrictions are made only to avoid the numerical difficulties that would arise when estimating an over-parametrized model.

I use an alternative VARMA(1, 1) representation of the GARCH (1, 1) model. Let us considerer the 3 x 1 stochastic vector:

\[
\xi_t = \text{vech} \left( \varepsilon_t, \varepsilon_t' \right) - \text{vech} \Sigma_t
\]  

(24)

Where \( \text{vech} \left( \varepsilon_t, \varepsilon_t' \right) = \left( \varepsilon_{m,y}^2, \varepsilon_{m,y,y}^2, \varepsilon_{y,y}^2 \right)' \), \( \text{vech} \Sigma_t = \left( \sigma_{m,y}^2, \sigma_{m,y,y}^2, \sigma_{y,y}^2 \right)' \) and \( \xi_t \) is a white noise process.

Substituting (24) in (23) and rearranging:

\[
\begin{pmatrix}
- B - I & \sum & 0 \\
0 & - B - I & \sum \\
0 & 0 & - B - I
\end{pmatrix}
\begin{pmatrix}
\varepsilon_{m,y}^2 \\
\varepsilon_{m,y,y}^2 \\
\Sigma_{y,y}^2
\end{pmatrix} =
\begin{pmatrix}
\mu_1 \\
\mu_2 \\
\mu_3
\end{pmatrix} +
\begin{pmatrix}
\mu_1 \\
\mu_2 \\
\mu_3
\end{pmatrix} +
\begin{pmatrix}
B \\
B \\
B
\end{pmatrix}
\begin{pmatrix}
\varepsilon_{m,y}^2 \\
\varepsilon_{m,y,y}^2 \\
\Sigma_{y,y}^2
\end{pmatrix}
\]  

(25)

in which the presence of the sum \( a_{ii} + g_{ii} \) allows us to design a direct test for stationarity in variance, \( |a_{ii} + g_{ii}| < 1 \) [Bollerslev (1986)].

Conditional variances for the money supply and the industrial production depend on their own innovations, while their conditional covariance depends on innovations in both variables. Conditional heteroskedasticity seems to be present in all countries, although not all coefficients seem to change over time. As suggested by the previous tests, we estimated heteroskedastic effects for the money supply in France and the UK and the covariance between the money supply and the industrial production in France. However, I also obtain a statistically significant autoregressive structure for the conditional covariance between both variables in Spain and Germany. No conditional heteroskedasticity in the variances of the money supply or the industrial production was found for these two countries.
### Table 1
Least squares estimation of the risk premium associated to macroeconomic uncertainty.
Full sample: 1986:02-1998:04

\[
RP_{i,t} = \ln \left( \frac{S_{i,t}}{F_{i,t}} \right) = \alpha_i + \sigma\sigma_{i,t-1} + \alpha_i\sigma\sigma_{i,t-1}^2 + \alpha_i\sigma\sigma_{i,t-1}^3 + \alpha_i\sigma\sigma_{i,t-1}^4 + \alpha_i\sigma\sigma_{i,t-1}^5 + \alpha_i\sigma\sigma_{i,t-1} + \varepsilon_i
\]

<table>
<thead>
<tr>
<th></th>
<th>ESP/DEM</th>
<th>FRF/DEM</th>
<th>GBP/DEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-0.0017</td>
<td>-0.0032*</td>
<td>-0.0090</td>
</tr>
<tr>
<td></td>
<td>(-1.03)</td>
<td>(-1.88)</td>
<td>(-1.40)</td>
</tr>
<tr>
<td>(RP(-1))</td>
<td></td>
<td></td>
<td>0.1430*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(1.87)</td>
</tr>
<tr>
<td>(\hat{\sigma}_{y,m}^2)</td>
<td>0.0047</td>
<td>0.0089*</td>
<td>0.0232</td>
</tr>
<tr>
<td></td>
<td>(0.48)</td>
<td>(1.76)</td>
<td>(1.33)</td>
</tr>
<tr>
<td>(\hat{\sigma}_{x,m}^2)</td>
<td>-0.0541*</td>
<td>0.0432*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-2.80)</td>
<td>(1.98)</td>
<td></td>
</tr>
<tr>
<td>(\hat{\sigma}_{y}^2)</td>
<td>0.0442</td>
<td>-0.0126</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.83)</td>
<td>(-0.19)</td>
<td></td>
</tr>
<tr>
<td>(\hat{\sigma}_{m}^2)</td>
<td></td>
<td>0.0216</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.23)</td>
<td></td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.053</td>
<td>0.051</td>
<td>0.044</td>
</tr>
<tr>
<td>Adj. (R^2)</td>
<td>0.040</td>
<td>0.031</td>
<td>0.018</td>
</tr>
<tr>
<td>COR(1)</td>
<td>0.37</td>
<td>0.32</td>
<td>0.96</td>
</tr>
<tr>
<td>COR(12)</td>
<td>0.73</td>
<td>0.16</td>
<td>0.56</td>
</tr>
<tr>
<td>ARCH(6)</td>
<td>0.63</td>
<td>0.02</td>
<td>0.47</td>
</tr>
</tbody>
</table>

Notes:
(a) t-statistics in parentheses.
(b) \(\sigma_{y,m}^2 = \text{var} \{ \log (x_{m,i}) \} \) \(\sigma_{x,m}^2 = \text{cov} \{ \log (x_{m,i}) \log (\rho_{i,m}) \} \) for \(i=FR, SP, UK\)
(c) An asterisk denotes a coefficient significant at the 10% level
(d) \(RP(-1)\) denotes the lagged risk premium
(e) P-value of Breusch-Godfrey test statistic for residual serial correlation up to lag order \(p\).
(f) Autoregressive conditional heteroskedasticity test. ARCH(6) is the p-value of LM test statistic.

### Table 2(a)
Least squares estimation of the risk premium associated to preference uncertainty.

\[
RP_{i,t} = \gamma_i + IR_{SPR} + IR_{SPR2} + \varepsilon_i
\]

<table>
<thead>
<tr>
<th></th>
<th>ESP/DEM</th>
<th>FRF/DEM</th>
<th>GBP/DEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-0.0061*</td>
<td>-0.0016</td>
<td>0.0242</td>
</tr>
<tr>
<td></td>
<td>(-1.83)</td>
<td>(-1.46)</td>
<td>(1.25)</td>
</tr>
<tr>
<td>(IR_{SPR})</td>
<td>0.4651*</td>
<td>0.8758*</td>
<td>-1.5313</td>
</tr>
<tr>
<td></td>
<td>(1.81)</td>
<td>(1.87)</td>
<td>(-0.80)</td>
</tr>
<tr>
<td>(IR_{SPR2})</td>
<td>-10.017*</td>
<td>-101.11*</td>
<td>6.3577</td>
</tr>
<tr>
<td></td>
<td>(-2.33)</td>
<td>(-2.84)</td>
<td>(0.13)</td>
</tr>
<tr>
<td>Taste Uncertainty</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R^2</td>
<td>0.022</td>
<td>0.002</td>
<td>0.022</td>
</tr>
<tr>
<td>Adj. R^2</td>
<td>0.109</td>
<td>0.192</td>
<td>0.109</td>
</tr>
<tr>
<td>COR(1)</td>
<td>0.87</td>
<td>0.24</td>
<td>0.53</td>
</tr>
<tr>
<td>COR(12)</td>
<td>0.90</td>
<td>0.59</td>
<td>0.30</td>
</tr>
<tr>
<td>ARCH(6)</td>
<td>0.16</td>
<td>0.64</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Notes:
(a) t-statistics in parentheses.
(b) P-value of F-statistic for the null hypothesis: \(H_0: \gamma_1 = \gamma_2 = 0\).
(c) P-value of Breusch-Godfrey test statistic for residual serial correlation up to lag order \(p\).
(d) Autoregressive conditional heteroskedasticity test. ARCH(6) is the p-value of LM test statistic.
(e) An asterisk denotes a coefficient significant at the 10% level
Table 3
Least squares estimation of the risk premium equation (a)


\[
RP_{t+1} = \beta_0 + \beta_1 IR_{t+1} + \beta_2 IR_{t-1} + \beta_3 \sigma_{t+1}^2 + \beta_4 \sigma_{t-1}^2 + \beta_5 \gamma_{t+1}^2 + \beta_6 \gamma_{t-1}^2 + \beta_7 \gamma_{t+1} \gamma_{t-1}^2 + \beta_8 \gamma_{t+1} \gamma_{t-1}^2 + \epsilon_{t+1}
\]

<table>
<thead>
<tr>
<th></th>
<th>ESP/DEM(40)</th>
<th>FRF/DEM</th>
<th>GBP/DEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-0.0080</td>
<td>-0.0063</td>
<td>0.0074</td>
</tr>
<tr>
<td>(</td>
<td>(-1.62)</td>
<td>(-0.05)</td>
<td>(0.14)</td>
</tr>
<tr>
<td>IR_SPR</td>
<td>0.4970*</td>
<td>1.0438*</td>
<td>-1.4011</td>
</tr>
<tr>
<td>(</td>
<td>(1.88)</td>
<td>(2.00)</td>
<td>(-0.68)</td>
</tr>
<tr>
<td>IR_SPR2</td>
<td>-0.866*</td>
<td>-9.427*</td>
<td>-1.5623</td>
</tr>
<tr>
<td>(</td>
<td>(-2.22)</td>
<td>(-2.56)</td>
<td>(-0.03)</td>
</tr>
<tr>
<td>(\hat{\sigma}_{m}^2)</td>
<td>0.0121</td>
<td>0.0096</td>
<td>0.0263</td>
</tr>
<tr>
<td>(</td>
<td>(0.86)</td>
<td>(1.11)</td>
<td>(1.31)</td>
</tr>
<tr>
<td>(\hat{\sigma}_{y}^2)</td>
<td>0.0152</td>
<td>0.0469</td>
<td></td>
</tr>
<tr>
<td>(</td>
<td>(0.39)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\sigma_{m}^2)</td>
<td>-0.0061</td>
<td>-0.32</td>
<td>0.16095</td>
</tr>
<tr>
<td>(</td>
<td>(-0.32)</td>
<td></td>
<td>(1.31)</td>
</tr>
<tr>
<td>(\sigma_{y}^2)</td>
<td>0.0176</td>
<td></td>
<td>0.0164</td>
</tr>
<tr>
<td>(</td>
<td>(0.23)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taste Uncertainty(60)</td>
<td>0.076</td>
<td>0.040</td>
<td>0.1564</td>
</tr>
<tr>
<td>Fundamental Uncertainty(60)</td>
<td>0.636</td>
<td>0.666</td>
<td>0.42</td>
</tr>
<tr>
<td>R²</td>
<td>0.160</td>
<td>0.249</td>
<td>0.195</td>
</tr>
<tr>
<td>Adj. R²</td>
<td>0.089</td>
<td>0.167</td>
<td>0.103</td>
</tr>
<tr>
<td>COR(1)</td>
<td>0.76</td>
<td>0.25</td>
<td>0.36</td>
</tr>
<tr>
<td>COR(12)</td>
<td>0.91</td>
<td>0.31</td>
<td>0.33</td>
</tr>
<tr>
<td>ARCH(6)</td>
<td>0.21</td>
<td>0.76</td>
<td>0.40</td>
</tr>
</tbody>
</table>

Notes:
(a) t-statistics in parentheses.
(b) \(\sigma_{x}^2 = \text{var}(\log(x_{i,t}))\) \(\sigma_{x,y} = \text{cov}(\log(x_{i,t}),\log(y_{i,t}))\) for \(i=FR, SP, UK\)
(c) P-value of F-statistic for the null hypothesis: \(H_0: \beta_1 = \beta_2 = 0\).
(d) P-value of F-statistic for the null hypothesis: \(H_0: \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0\).
(e) P-value of Breusch-Godfrey test statistic for residual serial correlation up to lag order \(p\).
(f) Autoregressive conditional heteroskedasticity test. ARCH(6) is the p-value of LM test statistic.
(g) An asterisk denotes a coefficient significant at the 10% level.

Figure 1
Interest rate swap spreads (IR_SPR) and observed risk premium (RP\(_{t+1}\))

![Figure 1](image_url)
Figure 2

Observed risk premium vs. fitted risk premium, macroeconomic and preference uncertainty (a)(b)(c)


Notes:
(a) Left column: Observed exchange risk premium versus the fitted value from the model in Table 4
(b) Middle column: Observed exchange risk premium versus macroeconomic uncertainty contribution
(c) Right column: Observed exchange risk premium versus preference uncertainty contribution

Figure 3

Probability indicator for Spain, France and the United Kingdom

Figure 4
Scatter diagrams: fitted risk premium (horizontal axis) vs. observed risk premium, macroeconomic and preference uncertainty contribution \(^{(a,b,c)}\).


<table>
<thead>
<tr>
<th>FITTED VS. OBSERVED</th>
<th>FITTED VS. MACR. UNCERT.</th>
<th>FITTED VS. PREF. UNCERT.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ESP/DEM</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correlation(^{(d)})</td>
<td>0.40</td>
<td>0.58</td>
</tr>
</tbody>
</table>

| FRF/DEM             |                          |                          |
| Correlation\(^{(d)}\) | 0.35                     | 0.32                     | 0.70                     |

| GBP/DEM             |                          |                          |
| Correlation\(^{(d)}\) | 0.41                     | 0.19                     | 0.85                     |

Notes:
(a) Left column: observed risk premium versus the fitted risk premium from the model in Table 4
(b) Middle column: Macroeconomic uncertainty contribution versus the fitted risk premium
(c) Right column: Preference uncertainty contribution versus the fitted risk premium
(d) Correlation between variables in scatter diagrams