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Limited Participation and Exchange Rate Dynamics: Does Theory Meet the Data?

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Abstract

Meese and Rogoff [1983] show that macroeconomic models “of the Seventies” fail to outperform the random walk exchange rate forecasts. Macroeconomics thus provide useless information as far as out-of-sample exchange rate forecasting is concerned. However, since Meese and Rogoff’s seminal paper, advances have been made in the theoretical modeling of international macroeconomic dynamics. New Open Economy Macroeconomics, developed in the wake of Obstfeld and Rogoff [1995]’s work, show that intertemporal general equilibrium models capture international stylized facts. In particular, Hairault, Patureau, and Sopraseuth [2002] have shown that a small open economy model based on credit market frictions successfully accounts for exchange rate volatility. This paper aims at assessing the empirical performances of this model. First, the model statistically matches a large set of features observed in the data, in addition to exchange rate dynamics. Credit market frictions are found to be critical in making the model consistent with the data. Secondly, we find that, in the recent period only, the limited participation model succeeds in outperforming the random walk exchange rate forecasts in the medium run.

JEL Classification : F32, F41

Keywords : New Open Economy Macroeconomics, Simulated Method of Moments, Exchange Rate Forecasts

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1 Introduction

Meese and Rogoff [1983] have demonstrated that macroeconomic models of the Seventies were unable to beat the random walk out-of-sample forecasts of nominal exchange rates. The poor forecasting performance of macroeconomic models led economists such as Frankel and Rose [1995] to assert that

“There is remarkably little evidence that macroeconomic variables have consistent strong effects on floating rates [...]. Such negative findings have led the profession to a certain degree of pessimism vis-à-vis the exchange rate research”.

We disagree with this over - pessimistic view on the relevance of fundamentals based models in the study of nominal exchange rate fluctuations. Indeed, this paper proposes a macroeconomic model that is able to beat the random walk forecast in the medium run. Since Meese and Rogoff [1983]’s paper, substantial advances have been made in the econometric modeling of exchange rate behavior. Several authors successfully provided more accurate nominal exchange rate forecasts than the naive random walk using cointegration (MacDonald and Taylor [1994]) or non linear dynamics (Clarida, Sarno, Taylor, and Violente [2003], Kilian and Taylor [2003]). However, these approaches lack structural models to rationalize the underlying mechanisms at the heart of nominal exchange rate dynamics. This paper is an attempt to fill this gap.

From a theoretical point of view as well, progress has been made in the field of macroeconomic modeling. In particular, the last decade has witnessed a dramatic change in international macroeconomics with the development of the “New Open Economy Macroeconomics” (NOEM). This approach, exemplified by Obstfeld and Rogoff [1995], lays stress on the introduction of market imperfections into dynamic general equilibrium models based on rational optimizing agents. This literature demonstrates that monetary shocks are able to capture essential features of exchange rate dynamics. In particular, models in which firms choose their prices in the buyer’s currency account for the observed exchange rate volatility (Chari, Kehoe, and McGrattan [2002], see Lane [2001] for a survey).

An alternative way of explaining exchange rate dynamics focuses on Dornbusch [1976]’s overshooting model. This is the route pursued by Hairault, Patureau, and Sopraseuth [2002] who develop a limited participation model in a small economy framework. In this setting, an expansionary monetary shock generates a persistent decrease in the nominal interest rate (liquidity effect). When uncovered interest rate parity holds, this liquidity effect implies a nominal exchange rate overshooting. The small open economy model based on credit market frictions is shown to quantitatively match the observed exchange rate standard deviation.

The proliferation of models extending Obstfeld and Rogoff [1995]’s framework demonstrates the vividness of this literature. Nevertheless, in spite of the outpouring theoretical literature developed in

the wake of Obstfeld and Rogoff [1995]’s paper, little is known about the empirical performances of such models. Indeed, even if authors compare simulated moments with their empirical counterparts (Chari, Kehoe, and McGrattan [2002], Hairault, Patureau, and Sopraseuth [2002]), this procedure does not provide a statistical criterion for assessing the overall goodness of fit of the model. Recent attempts have therefore been made to fill the gap between theory and data. In closed economy models, Ireland [2001], Smets and Wouters [2002], Collard, Fève, Langot, and Perraudin [2002], among others, use estimation procedures to assess the empirical accuracy of dynamic general equilibrium models. In line with this approach, this paper implements estimation techniques to gauge the goodness of fit of a New Open Economy model.

Furthermore we assess the forecasting performances of a NOEM model. As mentioned by Diebold [1998], the estimation procedure is then all the more necessary as

“If Dynamic Stochastic General Equilibrium Models are to be used for forecasting, econometric analysis is desirable for at least two reasons. First, forecasting is intimately concerned with the quantification of uncertainties that produce forecast errors. Accurate assessment of such uncertainties is key, for example, for producing credible forecast confidence intervals. Calibration methods, unlike probabilistic econometric methods, are ill-suited to the task. Second, simply using a priori reasonable parameter values [...] is not likely to produce accurate forecasts”.

We subscribe to Diebold [1998]’s point of view. Structural estimation is a pre-requisite to the assessment of the predictive power of our theoretical model. In line with Meese and Rogoff [1983], we assess the out-of-sample exchange rate forecast accuracy of the model against those of the random walk.

DelNegro and Obiols-Homs [2003], Lubik and Schorfheide [2003] and Bergin [2003] preceded us in this attempt to assess the empirical goodness of fit of NOEM models. In particular, as the NOEM literature develops competing extensions of Obstfeld and Rogoff [1995]’s model (price rigidities versus wage rigidities, local currency pricing versus producer currency pricing), Bergin [2003]’s main concern is to identify the specification that is supported by data. In a general equilibrium model based on wage and/or price rigidities, he shows that price stickiness of the local variety is the critical type of friction supported by the data. Bergin [2003]’s paper opens the route to a rigorous testing of the empirical relevance of New Open Economy models.

We extend Bergin [2003]’s paper with two respects. First, while Bergin [2003] is most interested in discriminating between different kind of frictions, our paper focuses on frictions on the credit market (Hairault, Patureau, and Sopraseuth [2002]), thereby extending to an open economy framework models developed by Christiano [1991] and Fuerst [1992]. The estimation procedure suggests that this model

is statistically supported by the data. In addition, credit market frictions are found to be critical in making the model consistent with the observed time series. However, even though the model is designed to capture the propagation mechanisms of monetary policy, the monetary disturbances are not the primary force behind the aggregate dynamics.

Secondly, with regards to out-of-sample nominal exchange rate forecasts, consistently with Bergin [2003]’s findings, the theoretical model does not provide more accurate one-step ahead exchange rate forecast than the random walk. Moreover, our paper stresses that forecasting performances should be based on a horizon longer than 1 period ahead. Indeed, we find that, in the recent years, the limited participation model outperforms the random walk in the medium run.

After presenting the limited participation model (section 2), the estimation procedure is described in section 3. Section 4 measures the empirical performances of the New Open Economy model. Our estimates are based on the Deutschmark-Dollar quarterly data, on the flexible exchange rate period 1971:1-1998:4. We then compare the out-of-sample exchange rate forecasts of the limited participation model to those of the random walk. Section 5 concludes.

2 The limited participation model

The theoretical framework to be estimated is a small open economy model characterized by market imperfections as in Hairault, Patureau, and Sopraseuth [2002]. Given the time-consuming estimation procedure, we discard the two-country setting widely used in the theoretical literature in order to lower the number of estimated structural parameters.

2.1 Timing of the period

The model consists of four types of economic agents (the consumer-household, the perfectly competitive good-producing firm, the financial intermediary and the central bank) and five markets (goods, labor, loanable funds, foreign assets and money markets) in a small open economy framework. The timing of decisions within a period can be separated in five steps:

- At the beginning of the period the monetary shock occurs: the monetary authorities inject liquidity into the loanable funds markets.
- The credit market opens and the firms determine their demand for loans. As in Dow [1995] they have to borrow funds to invest in physical capital. At the present moment, loan supply is already known given the household’s deposit choice made the last period and the central bank liquidity injection. The firms also determine their demand for labor and capital.

- In the third step transactions on the labor market and the goods market occur. Each firm sells its production to the local and foreign household.
- The household determines her contingent claims portfolio. Labor income is collected and loans are repaid to the financial intermediary for a net nominal interest rate R_t . The household receives interest payments on her deposits as well as dividend payments from the banks and the firms.
- At the end of the period the household chooses the amount of bank-deposit M_{t+1}^b to put in the banks the next period and the amount M_{t+1}^c of money-cash allowing consumption purchases the next period.

2.2 Household behavior

The representative household maximizes her expected intertemporal utility :

$$\bar{U}_0 = E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, L_t) \quad (1)$$

with C_t the consumption bundle and L_t the leisure. We assume logarithmic preferences on consumption and leisure

$$U(C_t, L_t) = \ln C_t + \gamma_L \ln L_t, \quad \gamma_L > 0$$

2.2.1 Allocation of resources

Each economy (home and foreign) is specialized in the production of a single good (H, F). Each variety is produced by an infinite number of firms which perfectly compete with each other. The domestic representative household consumes both types of goods, the consumption bundle C_t being defined as:

$$C_t = \left[\omega_t^{\frac{1}{\theta}} (C_{Ht})^{\frac{\theta-1}{\theta}} + (1 - \omega_t)^{\frac{1}{\theta}} (C_{Ft})^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}$$

with $\theta > 1$ the elasticity of substitution between domestic and foreign goods. Based on Stockman and Tesar [1995], ω_t is the stochastic relative weight of domestic goods whose law of motion is given by :

$$\ln \omega_{t+1} = (1 - \rho_\omega) \ln \omega + \rho_\omega \ln \omega_t + \varepsilon_{\omega,t+1} \quad (2)$$

with ω the mean of the process, $0 < \rho_\omega < 1$ the persistence parameter and ε_ω an *iid* white noise. The chosen specification for preferences implies that purchasing power parity does not hold (as long as ω is not constant and equal to 0.5). Since an extensive empirical literature¹ concludes to sharp deviations from PPP in the short run, these assumptions allow the model to better fit the data in the perspective of structural estimation. C_{Ht} denotes the consumption of the home-produced good and

¹See Rogoff [1996] for a survey.

C_{Ft} the consumption of imported goods. As in Blanchard and Kiyotaki [1987] the optimal allocation between goods yields the demand functions for domestic and foreign goods respectively:

$$\begin{aligned} C_{Ht} &= \omega_t \left[\frac{P_{Ht}}{P_t} \right]^{-\theta} C_t \\ C_{Ft} &= (1 - \omega_t) \left[\frac{P_{Ft}}{P_t} \right]^{-\theta} C_t \end{aligned}$$

with P_{Ht} the price for domestic good, P_{Ft} the price for imported goods expressed in domestic currency and P_t the home consumption price index. This leads to the following expression for the domestic consumption price index

$$P_t = \left[\omega_t (P_{Ht})^{1-\theta} + (1 - \omega_t) (P_{Ft})^{1-\theta} \right]^{\frac{1}{1-\theta}}$$

We assume that the law of one price holds, therefore it comes that $P_{Ft} = e_t P_t^*$ with P_t^* the foreign consumption price index². Besides, as in Kollmann [2001], we assume that foreign inflation $\pi_t^* = \frac{P_t^*}{P_{t-1}^*}$ is a stochastic process that evolves according to :

$$\ln \pi_{t+1}^* = (1 - \rho_{\pi^*}) \ln \pi^* + \rho_{\pi^*} \ln \pi_t^* + \varepsilon_{\pi^*, t+1} \quad (3)$$

with π^* the mean of the process, $0 < \rho_{\pi^*} < 1$ the persistence parameter and ε_{π^*} an *iid* white noise.

2.2.2 Intertemporal program

We introduce money by assuming that the household faces a cash-in-advance constraint on her consumption purchases:

$$P_t C_t \leq v_t M_t^c \quad (4)$$

with z_{vt} a velocity shock, supposed to follow an autoregressive process according to

$$\ln v_{t+1} = (1 - \rho_v) \ln v + \rho_v \ln v_t + \varepsilon_{v, t+1} \quad (5)$$

with v the mean of the process, $0 < \rho_v < 1$ the persistence parameter and ε_v an *iid* white noise. The velocity shock is interpreted as a shock to money demand introduced for instance by Ireland [2002].

As in Andolfatto and Gomme [2000], we consider that in the current period the household chooses the amount of deposits she wants to put into the bank the next period. Thus at the end of period t , the household chooses the amount M_{t+1}^c of money available for consumption purchases (money-cash) in period $t + 1$ and the amount M_{t+1}^b of money put into the bank (money-deposit) in period $t + 1$. Because of adjustment costs on money-holdings, at period t , when the household chooses her amount

²We also suppose that the price of goods exported by the foreign country (P_{Ft}^*) is equal to the foreign consumption price index P_t^* , consistent with our assumption of small open economy.

of money-cash M_{t+1}^c and her complement (the amount of money-deposit M_{t+1}^b), she takes into account the fact that changing her money holdings M_{t+1}^c is costly: it takes time to reorganize the flow of funds. We assume that the time spent on reorganizing the flow of funds Ω_t is given by:

$$\Omega_t = \frac{\xi}{2} \left(\frac{M_{t+1}^c}{M_t^c} - g \right)^2 \quad (6)$$

with $\xi > 0$, the scale parameter on adjustment costs. In the long run steady state, $\frac{M_{t+1}^c}{M_t^c}$ is equal to g . Then both the level of Ω_t and its derivative with respect to $\frac{M_{t+1}^c}{M_t^c}$ equate zero in steady state. Changing M_t^c is costly (in terms of time) with a marginal cost being an increasing function of the parameter ξ . As the time endowment is normalized to unity, leisure time L_t is given by the following equation:

$$1 = H_t + L_t + \Omega_t$$

The household maximizes her expected flow of utility (equation (1)) subject to the cash-in-advance constraint (equation (4)) and the budget constraint :

$$\begin{aligned} & M_{t+1}^c + M_{t+1}^b + e_t B_{t+1} + P_t C_t \\ \leq & M_t^c + P_t w_t (1 - L_t - \Omega_t) + R_t M_t^b + e_t i_t^F B_t + D_t^f + D_t^b \end{aligned} \quad (7)$$

where w_t denotes the real wage, D_t^f and D_t^b the profits of the firm and of the bank respectively, which are returned as dividends to the household at the end of the period. The return of the bank deposits (at the end of the period) is given by the nominal interest rate R_t . The household also saves by holding foreign assets. International financial markets are incomplete and, each period the household buys B_{t+1} foreign asset holdings issued by the rest of the world and denominated in foreign currency. As a result the nominal exchange rate e_t (the price of foreign currency in terms of domestic currency) intervenes in the budget constraint. The foreign financial asset yields the no-risk nominal interest rate i_{t+1}^F the next period (assumed to be constant).

2.3 Firms

The production technology is given by a Cobb-Douglas function:

$$Y_t = A_t K_t^\alpha H_t^{1-\alpha} \quad (8)$$

where $\alpha \in [0, 1]$. The technological shock A_t follows a first-order autoregressive process according to :

$$\ln A_{t+1} = (1 - \rho_a) \ln A + \rho_a \ln A_t + \varepsilon_{a,t+1} \quad (9)$$

with A the mean of the process, $0 < \rho_a < 1$ the persistence parameter and ε_a an *iid* white noise.

The objective of the representative firm is to maximize the discounted stream of dividends payments where the dividends are discounted by its value to the owner of the firm (the consumer). Consequently, it chooses between paying the dividends to the household at the end of the period and investing them in physical capital. The discounted rate that captures this decision is the ratio of the multipliers associated with the budget constraint of the household ($\beta \frac{\lambda_{t+1}}{\lambda_t}$), since that ratio reflects the consumer's variation in wealth. Profits from sales are received by the firm at the end of the period. Hence, at the beginning of the period, the firm has to borrow funds from the bank to invest in physical capital. The cost of borrowing is the nominal interest rate R_t , which equates the rate of return on the household bank deposits.

The program of the firm is then:

$$V(K_t) = \underset{\{H_t, K_{t+1}\}}{Max} \left\{ D_t^f + E_t \left[\beta \frac{\lambda_{t+1}}{\lambda_t} \right] V(K_{t+1}) \right\} \quad (10)$$

with the instantaneous profit function given by:

$$D_t^f = P_{Ht} Y_t - P_t \omega_t H_t - P_t R_t I_t - P_t \frac{\Psi_I}{2} \frac{(K_{t+1} - K_t)^2}{K_t} \quad (11)$$

given the law of motion of the physical capital stock:

$$I_t = K_{t+1} - (1 - \delta) K_t \quad (12)$$

$\delta \in]0, 1[$ denotes the depreciation rate of capital stock. We suppose the investment bundle has the same structure than consumption:

$$I_t = \left[\omega_t^{\frac{1}{\theta}} (I_{Ht})^{\frac{\theta-1}{\theta}} + (1 - \omega_t)^{\frac{1}{\theta}} (I_{Ft})^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}$$

The representative firm faces adjustment costs on capital that we assume to be quadratic, scaled by the parameter Ψ_I . Adjustment costs are to be paid in terms of consumption bundle:

$$CA_t^K \equiv \frac{\Psi_I}{2} \frac{(K_{t+1} - K_t)^2}{K_t} = \left[\omega_t^{\frac{1}{\theta}} (CA_{Ht}^K)^{\frac{\theta-1}{\theta}} + (1 - \omega_t)^{\frac{1}{\theta}} (CA_{Ft}^K)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}$$

We therefore get that the domestic demand functions for the domestic and foreign goods respectively are

$$\begin{aligned} D_{Ht} &= \omega_t \left[\frac{P_{Ht}}{P_t} \right]^{-\theta} D_t \\ D_{Ft} &= (1 - \omega_t) \left[\frac{P_{Ft}}{P_t} \right]^{-\theta} D_t \end{aligned}$$

with D_t aggregate demand : $D_t = C_t + I_t + CA_t^K$.

The firms sell their amount of production to domestic agents and to the foreign country, that is

$$Y_t = D_{Ht} + X_t$$

with X_t foreign demand for the domestic good, given by the following equation:

$$X_t = \left[\frac{P_{Ht}}{e_t P_t^*} \right]^{-\theta} \chi$$

with χ a foreign demand term assumed to be constant.

2.4 The central bank

Each period, an amount of money Θ_t is injected into the loanable funds market. The money stock evolves according to:

$$M_{t+1} = M_t + \Theta_t \tag{13}$$

with the monetary injection defined as :

$$\Theta_t = (g_t - 1)M_t \tag{14}$$

Substituting equation (14) in equation (13), we obtain :

$$M_{t+1} = g_t M_t \tag{15}$$

The monetary authority conducts monetary policy by gradually adjusting the short-term nominal interest rate R_t in response to deviations of output, inflation and money growth from their steady-state values Y , π and g according to the policy rule

$$\ln \frac{R_t}{R} = \rho_r \ln \frac{R_{t-1}}{R} + \rho_\pi \ln \frac{\pi_t}{\pi} + \rho_y \ln \frac{Y_t}{Y} + \rho_g \ln \frac{g_t}{g} + \varepsilon_{R,t+1} \tag{16}$$

Parameters ρ_y and ρ_π are strictly positive if the central bank is willing to stabilize inflation and output, with inflation defined as $\pi_t = \frac{P_t}{P_{t-1}}$. The serially uncorrelated innovation ε_R is normally distributed with mean zero and standard deviation σ_R . As discussed in Clarida, Gali, and Gertler [1998], the OECD central banks have a tendency to smooth interest rates (which implies $0 < \rho_r < 1$). Besides, we allow the monetary authority to react to the current money growth factor as in Ireland [2001] and Kim [2000]. The *ex-ante* specification for the monetary rule is more general than Taylor [1993]'s, but the estimation procedure will allow us to go further into the analysis of the Bundesbank behavior, since the reaction function parameters will be estimated.

2.5 The financial intermediary

The financial intermediary accepts deposits from the household (M_t^b) at period $t - 1$ which are repaid at the end of period t at the interest rate R_t . The bank also receives cash injections Θ_t from monetary authorities. The bank resources are loaned to the firm. The end-of-period profit is redistributed to the household in the form of dividends. The asset balance of the bank leads to :

$$P_t I_t = M_t^b + \Theta_t \quad (17)$$

where $P_t I_t$ are loans made to the firm. At the end of the period, the dividends of the bank are

$$D_t^b = R_t P_t I_t - R_t M_t^b \quad (18)$$

Since we model a small open economy, output and assets domestic aggregate quantities are equilibrium quantities at the given foreign price level P^* and the given nominal foreign interest rate i^F . That is, on the foreign assets market the domestic household can carry out any foreign asset she is willing to hold given the foreign interest rate, being only constrained by her budget constraint. We thus infer from the budget constraint (7) and the market equilibria that the household's foreign asset holdings evolve as:

$$e_t B_{t+1} - e_t (1 + i_t^F) B_t = P_{Ht} Y_t - P_t D_t \quad (19)$$

This equation reflects the equilibrium of the balance of payments of the home economy. The small country trades with the rest of the world, depending on the levels of the home production and absorption. If domestic production exceeds absorption ($P_{Ht} Y_t - P_t D_t > 0$), the trade balance is positive while the capital account is negative: the household sells the production surplus abroad and increases her holding of foreign assets. In contrast, if domestic production cannot satisfy the domestic demand for goods, the economy has to import goods from the rest of the world and finance its trade deficit by borrowing from abroad.

2.6 Limited participation and exchange rate dynamics

The first order conditions on foreign asset B_{t+1} and bank deposit M_{t+1}^b are given by

$$\begin{aligned} e_t \lambda_t &= \beta E_t (\lambda_{t+1} e_{t+1} i_{t+1}^F) \\ \lambda_t &= \beta E_t (\lambda_{t+1} R_{t+1}) \end{aligned}$$

where λ_t denotes the Lagrangian multiplier associated with the budget constraint (7). Log-linearizing both conditions around the steady state yields the uncovered nominal interest rate parity:

$$\frac{R}{1+R} E_t \hat{R}_{t+1} - \frac{i^F}{1+i^F} E_t \hat{i}_{t+1}^F = E_t \hat{e}_{t+1} - \hat{e}_t \quad (20)$$

where $\hat{x}_t \equiv \frac{x_t - x}{x}$ stands for the deviation of x_t from its steady state value x . Equation (20) explains the joint dynamics of nominal exchange rate and interest rate. Hairault, Patureau, and Sopraseuth [2002] show that this small open economy model captures nominal exchange rate volatility. The intuition behind this result is similar to Dornbusch [1976]'s. Following a monetary expansion, the domestic interest rate persistently declines due to frictions on the credit market. As the foreign interest rate i^F is constant, the interest rate spread turns out to be negative (in favor of foreign assets). Given the uncovered interest rate parity, this negative interest rate differential results in an anticipated appreciation of the currency, which generates an immediate depreciation of the nominal exchange rate beyond its new steady state value. Hairault, Patureau, and Sopraseuth [2002] show that the nominal exchange rate obtained from the model simulated with exogenous monetary shocks displays a volatility that is close to the one observed in the data. Hairault, Patureau, and Sopraseuth [2002] conclude that the nominal exchange rate overshooting improves our understanding of exchange rate dynamics. However, the authors do not provide a statistical criterion for assessing the overall goodness of fit of their model. The next section aims at filling this gap.

2.7 Equilibrium

The equilibrium is characterized by the set of prices $\Omega_t^P = \{w_t, R_t, P_t, P_{Ht}, e_t\}_{t=0}^\infty$ and the set of quantities³

$$\begin{aligned}\Omega_t^C &= \left\{ C_t, H_t, B_{t+1}, M_{t+1}^b, M_{t+1}^c, M_{t+1} \right\}_{t=0}^\infty \\ \Omega_t^Q &= \left\{ Y_t, H_t, K_{t+1} \right\}_{t=0}^\infty\end{aligned}$$

such as :

- given the set of prices Ω^P , the vector of exogenous foreign variables $\{i^F, P^*, \chi\}$, the vector of exogenous shocks $\{A, \varepsilon_R, \omega, v\}$, the set of quantities Ω^C maximizes the expected intertemporal utility of the household subject to equations (4) and (7),
- given the set of prices Ω^P , the vector of exogenous foreign variables $\{i^F, P^*, \chi\}$, the vector of exogenous shocks $\{A, \varepsilon_R, \omega, v\}$, the set of quantities Ω^Q maximizes the profits of the representative firm subject to equations (8) and (12),
- given the sets of quantities Ω^C and Ω^Q and given the vector of exogenous foreign variables $\{i^F, P^*, \chi\}$, the vector of exogenous shocks $\{A, \varepsilon_R, \omega, v\}$, the set of prices Ω^P ensures that the labor market, the loanable funds market, the goods market, the money market and the current account are cleared.

³For sake of simplicity, we do not distinguish notations of supply variables from demand variables on all markets.

3 The structural estimation procedure

To estimate theoretical models we could rely on two techniques. The first one, based on maximum likelihood, is used for instance by Ireland [2001] and Bergin [2003]. The second procedure is the simulated method of moments (SMM hereafter) developed by Duffie and Singleton [1993] and Ingram and Lee [1991]. The purpose of this method, implemented for example by Collard, Fève, Langot, and Perraudin [2002], is to estimate the deep parameters of a theoretical model so as to statistically reproduce some moments from observed data with the corresponding moments obtained on simulated data. We chose to resort to the SMM. Indeed, maximum likelihood is particularly needed when one wants to explore the statistical relevance of two *nested* models, which is not the purpose of our paper. Moreover, the SMM provides a wide range of statistical indicators to measure the goodness of fit of the model. Maximum likelihood also gauges the match between the model and the data by comparing the likelihood from the model to that of an unconstrained VAR. We feel that SMM, with its string of test statistics, describes more accurately the specific dimensions in the data reproduced by the model. In this section, we present the SMM, the data and the moments used for the estimation.

3.1 The simulated method of moments

Consider the following dynamic structural model:

$$\begin{cases} \mu_0(z_t, z_{t-1}, u_t, \varphi_1) = 0 \\ r_0(u_t, u_{t-1}, \varepsilon_t, \varphi_2) = 0 \end{cases}$$

with $\{z_t\}_{t=1}^{t=T}$ the set of observed endogenous variables, $\{u_t\}_{t=1}^{t=T}$ and $\{\varepsilon_t\}_{t=1}^{t=T}$ the sets of unobservable variables and $\varphi = \{\varphi_1, \varphi_2\}$ the set of q unknown structural parameters. $\{\varepsilon_t\}_{t=1}^{t=T}$ is an *iid* process whose distribution is supposed to be known. In our setting, z_t includes the set of following variables $\{C_t, I_t, Y_t, TB_t, M_t, P_t, e_t, R_t\}$ (where TB_t stands for trade balance), u_t is the set of stochastic variables $\{A_t, \omega_t, v_t, \pi_t^*, \varepsilon_{Rt}\}$ associated with innovations $\varepsilon_t = \{\varepsilon_{at}, \varepsilon_{\omega t}, \varepsilon_{vt}, \varepsilon_{\pi^* t}, \varepsilon_{Rt}\}$.

The structural model is estimated through the simulated method of moments. This method dwells on a simple estimation criterion (a quadratic function) that depends on a set of p moments ($p \geq q$) calculated both on the observed data and their theoretical counterparts : the idea is to find the value for the q structural parameters that minimizes the distance between the set of p moments calculated on observed data and the same set of p moments estimated on the simulated theoretical series.

The method is implemented as follows. Suppose that the structural model is the “true” data generating process. Under this assumption, the data simulated from the model for the true set of deep parameters φ_0 and one draw s of structural innovations (noticed $\{z_t^s(\varphi_0)\}_{t=1}^{t=T}$) display the same properties as the observed data thus verifying:

$$E[m(z_t^s(\varphi_0))] = E[m(z_t)] \quad (21)$$

Nevertheless we only dispose of $M_T(\cdot)$, the empirical counterpart of this moment condition, that is calculated both on the observed data and their theoretical counterparts and defined as:

$$M_T(x) = \frac{1}{T} \sum_{t=1}^T m(x_t)$$

The principle of the method can be summarized as follows:

$$\begin{array}{ccc} M_T(z) & \xrightarrow{p} & E[m(z_t)] (= E[m(z_t^s(\varphi_0))]) \\ \uparrow & & \uparrow \\ M_T(z^s(\varphi)) & \xrightarrow{p} & E[m(z_t^s(\varphi))] \end{array}$$

As $M_T(\cdot)$ converges in probability to $E[m(\cdot)]$, and according to equation (21), obtaining an inference on φ_0 consists in finding the value of deep parameters φ such that the simulated set of moments $M_T(z^s(\varphi))$ calculated from the structural model is the closest as possible (along a particular metric) to $M_T(z)$ calculated once for all on the observed data.

The estimation procedure consists of the following steps.

1. From the data, we compute the moments (variance, autocorrelations, cross-correlations) that capture the joint dynamics of all time series in our sample.
2. The structural model is solved. The solution method relies on log-linearization around the steady state and implementing Blanchard and Kahn [1980]'s procedure. Hence for fixed initial conditions z_0 and u_0 and S draws $\{\varepsilon_t^1\}_{t=1}^{t=T}, \dots, \{\varepsilon_t^S\}_{t=1}^{t=T}$ in its known distribution⁴, we simulate S unique particular paths for variables of interest $\{z_t^1(\varphi)\}_{t=1}^{t=T}, \dots, \{z_t^S(\varphi)\}_{t=1}^{t=T}$ through $r_0(\cdot)$ and $\mu_0(\cdot)$ for a particular set of structural parameters φ^5 .
3. We then average the moments chronicle calculated on simulated data noted:

$$M_T^S(z(\varphi)) = \frac{1}{S} \sum_{s=1}^S M_T(z^s(\varphi))$$

4. The SMM estimator $\widehat{\varphi}_T(W)$ is the value of φ that renders $M_T^S(z(\varphi))$ (the set of moments computed on simulated data) as close as possible to $M_T(z)$ (the set of moments computed on observed data). The distance between $M_T^S(z(\varphi))$ and $M_T(z)$ is measured according to some metric W . The SMM estimator $\widehat{\varphi}_T(W)$ is then defined as:

$$\widehat{\varphi}_T(W) = \arg \min_{\varphi} g(\varphi)' W g(\varphi)$$

⁴We suppose that the innovations are *iid* gaussian. These draws are remained identical along the estimation procedure.

⁵ S is greater than 1 in order to reduce the inaccuracy of estimations due to the fact that we resort to simulations (see Gregory and Smith [1993]).

with $g(\varphi) = [M_T(z) - M_T^S(z(\varphi))]$ and W a positive semi-definite matrix converging to a deterministic matrix. An estimate of the metric W is required for the computation of $\widehat{\varphi}_T(W)$. Ingram and Lee [1991] derived the optimal value W^* for the metric

$$W^* = \left[\left(1 + \frac{1}{S}\right) \Omega \right]^{-1}$$

that depends on the variance-covariance matrix of moments estimated on observed data and based on the Generalized Method of Moments since this method implies that :

$$\sqrt{T}(M_T(z) - E[m(z_t)]) \xrightarrow{L} N(0, \Omega)$$

A convergent estimation of the optimal metric, noted \widehat{W}_T^* , requires a correction for autocorrelation and/or heteroskedasticity for the estimation of Ω . We retain the parametric VARHAC correction proposed by Den Haan and Levin [2000]⁶. This metric is computed once and for all in step 1.

Steps 2 through 4 are repeated until a value of the estimated parameters $\widehat{\varphi}_T(\widehat{W}_T^*)$ (noted $\widehat{\varphi}_T^*$) minimizes the objective function. To minimize the SMM criterion, we use the downhill simplex method (Nelder and Mead [1965]). This method requires only function evaluations, not derivatives as gradient-based methods like BFGS, Newton, etc...

In order to measure the goodness of fit of our SMM results, the econometric literature provides three indicators.

- In order to test the significance of the structural parameters, we rely on the following test statistic, that is based on the asymptotic distribution of $\widehat{\varphi}_T^*$:

$$\sqrt{T}(\widehat{\varphi}_T^* - \varphi_0) \rightarrow N \left(0, \left[1 + \frac{1}{S}\right] \left[\frac{\partial g(\varphi)'}{\partial \varphi} W^* \frac{\partial g(\varphi)}{\partial \varphi'} \right]^{-1} \right)$$

whose asymptotic variance matrix is easily obtained from numerical derivatives of $g(\varphi)$ and from convergent estimation of W^* .

- In order to gauge the overall match between the model and the data, Gouriéroux, Monfort, and Renault [1993] derived a simple diagnostic test inspired from the over-identification test *à la* Hansen [1982]. Hence, the statistics

$$\Psi(\widehat{\varphi}_T^*) = T \left[1 + \frac{1}{S}\right]^{-1} [g(\widehat{\varphi}_T^*)]' \widehat{W}_T^* [g(\widehat{\varphi}_T^*)]$$

⁶ Alternative corrections are available in the econometric literature. In order to choose the appropriate correction method, we implemented the following counterfactual experiment. First, suppose that the Data Generating Process is the theoretical model. We then generate fake data with the model. We estimate the structural parameters through SMM. Only the VARHAC correction recognized the complete match between the data (generated by the model by assumption) and the simulated data (also generated by the model through SMM) and leads to the global acceptance of the structural model.

tests the global adequacy of the moments computed on simulated data to the moments computed on observed data set ⁷ and is asymptotically $\chi^2(p - q)$ distributed.

- This test of global adequacy is completed by a test of goodness of fit of each moment estimated on the simulated data set to its empirical counterpart. This statistics stems from Collard, Fève, Langot, and Perraudin [2002] who adapt the Gallant and Tauchen [1996] statistics developed in the framework of the Efficient Method of Moments to the Simulated Method of Moments. The test statistics is such that

$$\left\{ \text{diag} \left\{ \Omega - \frac{\partial g(\varphi)}{\partial \varphi'} \left[\frac{\partial g(\varphi)'}{\partial \varphi} W^* \frac{\partial g(\varphi)}{\partial \varphi'} \right]^{-1} \frac{\partial g(\varphi)'}{\partial \varphi} \right\} \right\}^{-\frac{1}{2}} \sqrt{T} g(\varphi)$$

is then asymptotically $N(0, 1)$ distributed.

Finally, we will test restrictions on the value of some deep parameters. In order to gauge the statistical relevance of such assumptions, we will resort to restriction tests. A simple test of m restrictions on the structural parameters can then be implemented when computing the estimation of the structural model under the null, $\widehat{\varphi}_T^{0*}$. Gouriéroux, Monfort, and Renault [1993] show that:

$$\Psi(\widehat{\varphi}_T^{0*}) - \Psi(\widehat{\varphi}_T^*)$$

is asymptotically $\chi^2(m)$ distributed.

3.2 What dimensions in the data should the model fit?

As Fève [1997] recalls, the SMM dwells on the ability of the structural model to match a large set of moments. The SMM estimates are then such that the model matches the short run behavior of 8 German time series ranging from 1971:1 to 1998:4. Quarterly time series are taken from the OECD BSDB database. The data consist of the real GDP (Y) and the real investment (I) for the business sector, the real private consumption (C), the trade balance for goods and services (in volume, deflated by the mean of output calculated on the period TB/\bar{Y}), the monetary aggregate ($M1$), the consumer price index (P), the nominal exchange rate of the Deutschemark *vis-à-vis* the US dollar (E) and the gross nominal short-run interest rate (R). With the exception of investment and consumption, all time series are included in the database chosen by Bergin [2003]. We add investment since the liquidity effect inherent to the limited participation model modifies investment dynamics. Moreover, consumption is included in order to gauge the accuracy of the model with regards to other standard business cycle features such as consumption dynamics.

⁷This statistics is also an indicator of the robust estimation of the model. Indeed, Dridi and Renault [2001] demonstrate that an estimation that passes the over-identification criterion is robust to the mis-specification of the structural model.

All data except the nominal interest rate are seasonally adjusted. The sample period includes the German reunification, we then eliminate outliers corresponding to this exogenous event that the model will not be able to capture⁸. The moments are then calculated on time series taken in logarithm (except trade balance) and detrended using Hodrick and Prescott [1997]’s methodology with the adjustment parameter set to 1600⁹.

Which moments should the model match? The theoretical model must replicate a set of moments that characterize key features of the data. The latter can be captured by variances, autocorrelations and instantaneous as well as dynamic correlations across variables. However, a model can hardly mimic all observed moments for all time series. We use unconditional moments that encompass as many features in the data as possible in order to avoid too much arbitrariness. We then adopt a pragmatic approach by selecting 57 moments among a large set of empirical features, that our model can fit. We also include in these 57 moments the ones “naturally” imposed by the underlying theory (the moments related to exchange rates for instance). In this latter case we therefore do not exclude from the criterion the moments that are not *in fine* well statistically matched.

The set of moments used for estimation includes variances, autocorrelations as well as instantaneous and dynamic cross-correlations between the eight series and they are presented in table 1¹⁰. All moments are not centered such that each moment does not depend on the others, which eases the estimation procedure. At the end of the estimation process, the observed selected moments have to be sufficiently well reproduced by the model to be accepted by the over-identification test *à la* Hansen.

3.3 Which structural parameters to estimate?

As the estimation procedure requires parsimony in the number of estimated deep parameters, we first select among the whole set of structural parameters to be estimated. It is widely understood that the estimation result is conditional on the choice of calibrated values (Bergin [2003]). Given that point and to avoid arbitrariness as much as possible, we adopt the following reasoning with regards to the choice of the parameters to be estimated. First, our dataset does not deliver enough relevant information to obtain reliable estimates for all parameters. Besides, some parameters (such as the capital depreciation rate, the share of capital in production, etc...) are commonly pinned down by the Real Business Cycle literature. The calibration of these parameters is then based on standard values, which allows to estimate the sub-set of parameters whose value is not so well-established in the literature.

⁸We take the original series into growth rates. These series are then centered and normalised. For these series we consider as outlier an observation that does not lay in the interval [-3,3], as in Millard, Scott, and Sensier [1997]. The corresponding point in the serie taken in growth rate is therefore replaced by averaging the closest growth rates. Finally we rebuild the series in level. Every series in volume are at least concerned by an outlier due to German reunification.

⁹Lower cases denote variables taken in logarithm and \hat{x} denotes the HP-filter cyclical component of variable x .

¹⁰In the table, the number on the right of each moment represents its reference number. It will serve to identify it in the figures 1 and 2 that present the quality of fit in section 4.1.

Table 1: Which moments to match?

Variance		Autocovariance		Covariance(0)		Covariance(1)			
$\sigma^2(\widehat{e})$	1	$Cov_{-1}(\widehat{e})$	20	$Cov(\widehat{e}, \widehat{i})$	7	$Cov(\widehat{e}, \widehat{c}_{-1})$	26	$Cov(\widehat{m}_1, \widehat{c}_{-1})$	39
$\sigma^2(\widehat{y})$	2	$Cov_{-1}(\widehat{y})$	21	$Cov(\widehat{e}, \widehat{c})$	8	$Cov(\widehat{e}, \widehat{p}_{-1})$	27	$Cov(\widehat{p}, \widehat{e}_{-1})$	40
$\sigma^2(\widehat{i})$	3	$Cov_{-1}(\widehat{i})$	22	$Cov(\widehat{e}, \widehat{p})$	9	$Cov(\widehat{e}, \widehat{TB}_{-1})$	28	$Cov(\widehat{p}, \widehat{i}_{-1})$	41
$\sigma^2(\widehat{c})$	4	$Cov_{-1}(\widehat{c})$	23	$Cov(\widehat{e}, \widehat{TB})$	10	$Cov(\widehat{y}, \widehat{e}_{-1})$	29	$Cov(\widehat{p}, \widehat{c}_{-1})$	42
$\sigma^2(\widehat{p})$	5	$Cov_{-1}(\widehat{p})$	24	$Cov(\widehat{y}, \widehat{i})$	11	$Cov(\widehat{y}, \widehat{i}_{-1})$	30	$Cov(\widehat{p}, \widehat{TB}_{-1})$	43
$\sigma^2(\widehat{TB})$	6	$Cov_{-1}(\widehat{TB})$	25	$Cov(\widehat{y}, \widehat{c})$	12	$Cov(\widehat{y}, \widehat{p}_{-1})$	31	$Cov(\widehat{TB}, \widehat{e}_{-1})$	44
$\sigma^2(\widehat{r})$	48	$Cov_{-1}(\widehat{r})$	50	$Cov(\widehat{y}, \widehat{m}_1)$	13	$Cov(\widehat{i}, \widehat{e}_{-1})$	32	$Cov(\widehat{TB}, \widehat{y}_{-1})$	45
$\sigma^2(\widehat{m}_1)$	54	$Cov_{-1}(\widehat{m}_1)$	55	$Cov(\widehat{y}, \widehat{p})$	14	$Cov(\widehat{i}, \widehat{c}_{-1})$	33	$Cov(\widehat{TB}, \widehat{c}_{-1})$	46
				$Cov(\widehat{i}, \widehat{c})$	15	$Cov(\widehat{i}, \widehat{p}_{-1})$	34	$Cov(\widehat{TB}, \widehat{p}_{-1})$	47
				$Cov(\widehat{i}, \widehat{p})$	16	$Cov(\widehat{c}, \widehat{e}_{-1})$	35	$Cov(\widehat{r}, \widehat{e}_{-1})$	51
				$Cov(\widehat{c}, \widehat{p})$	17	$Cov(\widehat{c}, \widehat{i}_{-1})$	36	$Cov(\widehat{e}, \widehat{r}_{-1})$	52
				$Cov(\widehat{c}, \widehat{TB})$	18	$Cov(\widehat{c}, \widehat{p}_{-1})$	37	$Cov(\widehat{m}_1, \widehat{e}_{-1})$	56
				$Cov(\widehat{p}, \widehat{TB})$	19	$Cov(\widehat{c}, \widehat{TB}_{-1})$	38	$Cov(\widehat{e}, \widehat{m}_{1-1})$	57
				$Cov(\widehat{r}, \widehat{e})$	49				
				$Cov(\widehat{m}_1, \widehat{e})$	53				

Furthermore, we focus our attention on the parameters that we assume to be critical in matching the selected moments. The sub-set of parameters we estimate thus includes the parameters for adjustment costs on money holdings and capital (ξ and Ψ_I respectively), the coefficients of the monetary rule and the processes of shocks. The rest of the structural parameters is calibrated to standard values found in the literature. Table 2 sums up the calibrated parameters values.

Table 2: Parameters Values

α	β	δ	θ	ω	A	v	H	b	π	π^*	i^F	γ_X	γ_P
0.42	0.988	0.025	1.00001	0.75	1	1	0.2	0.05	1.0083	1.0126	1.08	1.0058	1.0079

The model is estimated on a quarterly basis. The calibration on German data draws on Kollmann [2001]. α is set to 0.42. Aggregate data suggest a quarterly capital depreciation rate of about 2.5%, thus δ is set to 0.025. The subjective discount factor β is set at $\beta = 0.988$ implying a real interest rate equal to 1.2% per quarter. The elasticity of substitution between goods is set to be almost 1, a value lower than Backus, Kehoe, and Kydland [1995]'s ($\theta = 1.5$) but comforted by our preliminary attempts to estimate this value which robustly converges to the calibrated value. The parameter ω is set so that the steady state imports to GDP ratio is 25% consistent with German data. The steady-state values for the technological level and the velocity shock are set equal to 1. The value for γ_L is determined given the calibrated value for H meaning that 80% of time is devoted to non-working

activities. The parameter b represents the steady-state indebtedness flow which is set 5% of GDP. This value is consistent with the average trade balance over GDP ratio over the whole period 1971:1-1998:4. Finally, the parameters γ_X and γ_P stand for the deterministic trend in output and prices respectively that we determine by a simple regression based on corresponding German quarterly data. As well the values for π , π^* and i^F correspond to the means of German inflation, US inflation and US short-term nominal interest rates (OECD BSDB database, quarterly basis) on the period 1971:1-1998:4.

The 15 other parameters of the model are to be estimated through the Simulated Method of Moments. Section 4 reports the empirical performances of the limited participation model.

4 Empirical performances of the liquidity model

The standard evaluation method of business cycles models derives their *ex-post* performances by comparing the second-order moments of the theoretical series to those of the corresponding business cycle series. First, the SMM technique allows to provide a statistical support to this methodology. Furthermore, uncertainty concerning the “true” values of structural parameters is taken into account since the SMM produces some statistical framework to test their significance. In addition, our paper goes one step further by allowing the analysis of the performances of a New Open Economy Macroeconomy model from an *ex-ante* perspective by measuring out-of-sample forecast accuracy.

4.1 Estimation results over the whole sample

4.1.1 How well does the model fit the data?

Table 3 reports the estimation results of the limited participation model over the whole period 1971:1-1998:4. Column 2, labelled “Estimation 1”, displays the estimation of the 15 parameters not previously calibrated. The global adequacy of the model is captured by the Hansen statistic. For the model to be accepted by the data, the previous statistic has to be inferior to the critical value of a $\chi^2(p - q)$, p being the number of moments to match (57) and q the number of estimated structural parameters (15). The p -value (10.08%) shows that the liquidity model is globally accepted by the data.

Column 2 shows that 3 estimated parameters are close to zero: the reaction function to output in the interest rate rule ρ_y , the persistence parameter in the foreign inflation rate shock ρ_{π^*} and the velocity shock ρ_v . In addition, the preference shock ρ_ω seems to be characterized by a very persistent behavior: ρ_ω is very close to 1. We then restrict these parameters to the values found in estimation 1 (bold characters in table 3)¹¹. We then test the statistical significance of such restrictions. Results are reported in column 3 “Estimation 2”. The restriction test statistic (54.3593) is such that we strongly

¹¹The values for ρ_{π^*} and ρ_v have been constrained to 0.0001 and the value for ρ_ω to 0.999 for technical reasons. Indeed, as pointed out by Bergin [2003], some regions of the parameter space do not imply a well defined equilibrium within the model. Namely, autoregressive coefficients of shocks have to be strictly greater than zero and strictly less than unity.

accept the null hypothesis that $\rho_y = \rho_{\pi^*} = \rho_v = 0$ and $\rho_\omega = 1$. Moreover, the goodness of fit of the model is even more statistically satisfactory with a p -value of 18.61%.

Table 3: Estimation results, Germany 1971:1-1998:4

Parameters		Estimation 1	Estimation 2
Adjustment costs on money holding	ξ	7.9659	8.4474 (1.654)
Adjustment costs on capital	Ψ_I	1.5144	1.7554 (0.764)
Taylor rule :			
- weight on output	ρ_y	$2.54 \cdot 10^{-5}$	0
- weight on lagged R	ρ_r	0.5105	0.5180 (2.993)
- weight on inflation	ρ_π	0.0678	0.0639 (1.042)
- weight on money growth	ρ_g	0.4223	0.4204 (3.450)
Technological shock :			
- persistence	ρ_a	0.9810	0.9812 (48.703)
- volatility	σ_a	0.0078	0.0078 (9.707)
Foreign Inflation shock :			
- persistence	ρ_{π^*}	$9.52 \cdot 10^{-6}$	0
- volatility	σ_{π^*}	0.0478	0.0485 (9.082)
Taylor Rule shock :			
- volatility	σ_R	0.0014	0.0015 (2.145)
Taste shock :			
- persistence	ρ_ω	0.99999477	1
- volatility	σ_ω	0.0126	0.0129 (15.560)
Money demand shock :			
- persistence	ρ_v	0.00000000	0
- volatility	σ_v	0.0055	0.0055 (5.862)
Hansen statistic			
	$\Psi(\widehat{\varphi}_T^*)$	54,0405 $\chi^2(42)$	54,3593 $\chi^2(46)$
	p -value	0.1008	0.1861
Restriction test		-	0.3188 $\chi^2(4)$
	p -value	-	0.9885

The results are obtained with $H = 50$. Figures between parenthesis are t -stats (column 3).

In column 3, we report the significance of each estimated parameter: the t -statistic is displayed between parenthesis below the estimated value. All parameters are statistically significant, except the adjustment cost on capital Ψ_I and the response of the monetary authorities to inflation ρ_π . Nevertheless, a restricted version of the model with $\rho_\pi = \Psi_I = 0$ does not pass the restriction test: the corresponding p -value equates 4%. Furthermore, column 3 displays that the adjustment cost on

money holdings ξ is only significant at a 10% level. Nevertheless a restricted version of the model with $\xi = 0$ is not supported by the data since, in this case, the model is strongly rejected (with a corresponding p -value of the test equal to $4.47 \cdot 10^{-8}$).

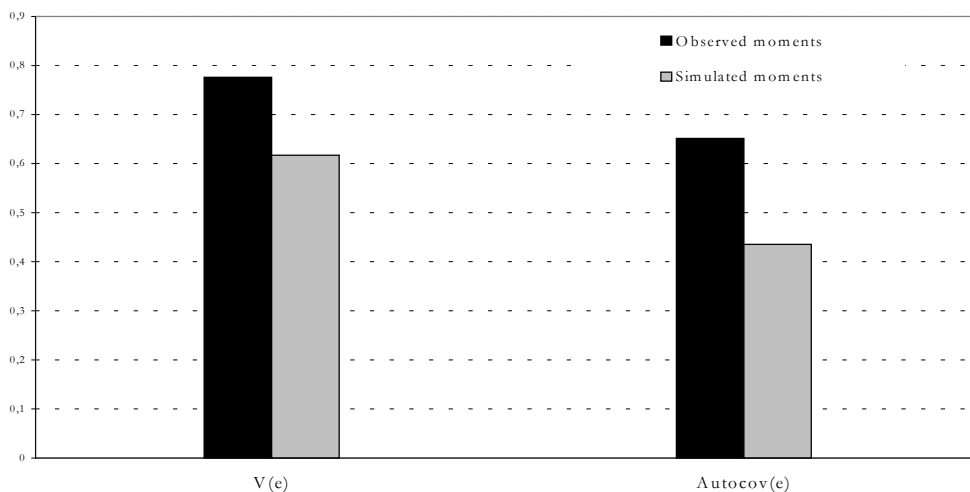
Column 3 of table 3 presents a parsimonious estimation of the limited participation model that is globally accepted by the data. The estimated values for the technological process and the adjustment cost on capital are consistent with the values found in the business cycle literature. In contrast, the values for the persistence of foreign inflation and velocity shocks are surprisingly low and even negligible. The SMM delivers a proper estimation of the German monetary policy rule. It confirms the presence of interest rate smoothing behavior for the Bundesbank even if lower than the estimates of 0.91 found by Clarida, Gali, and Gertler [1998]. Our estimation also highlights the conservative behavior of the Bundesbank as the interest rate reacts to monetary variables (inflation and monetary growth) while it is not sensitive to output fluctuations. The key mechanism of the model relying on the adjustment cost on money holdings ξ is significant. The estimation procedure suggests that such credit market frictions are critical in reproducing some dimensions of data. However, the estimation results are somewhat disappointing with regards to the role of monetary shocks. While the model is designed to capture the effects of monetary policy, the relative variances of the exogenous shocks suggest that the monetary shock is not the primary driving force behind the aggregate dynamics (as compared to the preference shock ω_t *à la* Stockman and Tesar [1995]).

As a first attempt to gauge the quality of fit, figures 1 and 2 present the empirical moments and their simulated counterparts (in figure 2 each moment is designed by its reference number, see table 1). First note that these numbers are variances, covariances computed on times series that are not centered while usually standard errors and correlations are presented in the literature. Therefore, they cannot be directly compared to the values commonly found in the international business cycle literature.

As we pay a particular attention to the exchange rate behavior, we choose to present the variance and autocovariance of the nominal exchange rate on a separate figure (figure 1). It reveals that the model is able to account for a substantial part of the variance of the nominal exchange rate (with a variance of 0.62 versus 0.77 in the data) as well as accounting for its persistence (with a theoretical autocovariance around 0.44 compared to 0.65 in the data). Figure 2 suggests that the model successfully matches the empirical properties of selected data. A first glance at the quality of estimation is rather satisfactory, since the scale and sign of empirical moments are well reproduced by the model for a large number of them.

The test *à la* Gallant and Tauchen that measures the goodness of fit of each moment confirms the quality of the estimation. Indeed figure 3 displays Gallant and Tauchen [1996]'s statistics that tests

Figure 1: Exchange rate moments : observed versus simulated



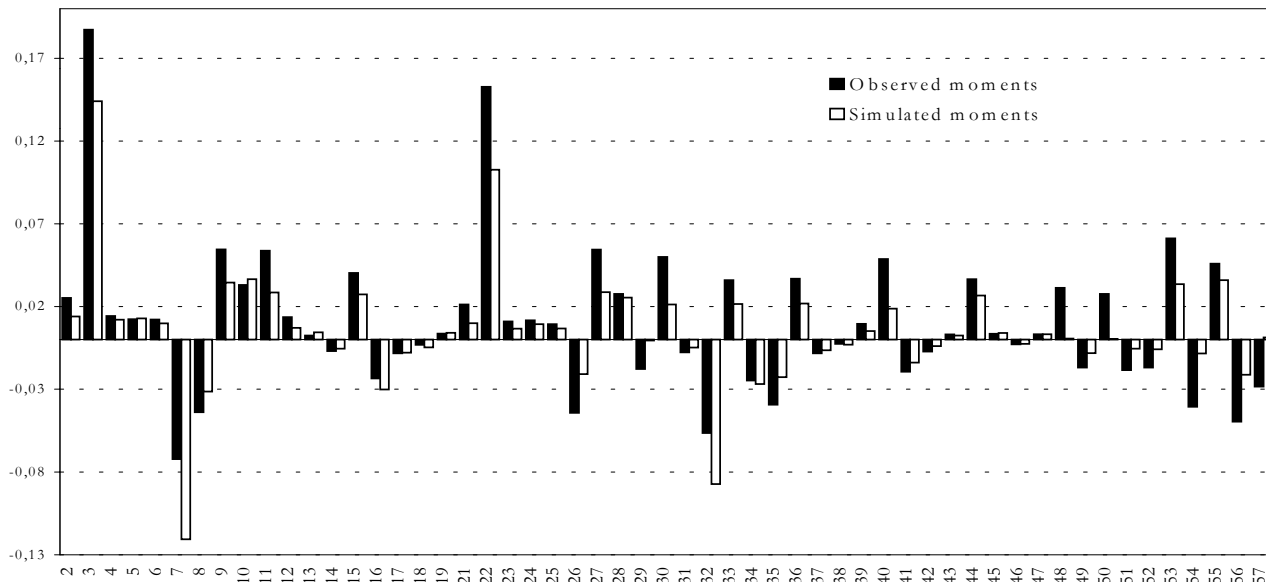
as the null hypothesis the equality between each simulated moment with its corresponding empirical counterpart.

It reveals that only 3 out of the 57 observed moments are not significantly well reproduced by the model at the level of 5%, that are the persistence of output and the variance and persistence of the interest rate. Yet these moments are significantly well reproduced at the level of 1%.

Figure 3 shows the quality of our estimation, since the model is able to match a vast majority of moments. Moreover, the limited participation model is able to reproduce the exchange rate dynamics: the statistics *à la* Gallant and Tauchen relative to the variance and autocovariance of the exchange rate is far below the critical value as well as the sub-set of covariances between the exchange rate and the other variables.

The structural estimation of the limited participation model over the whole period delivers an interesting message that contrasts with Frankel and Rose [1995]’s pessimistic view with regards to the ability of macroeconomic models to explain exchange rate movements. The limited participation model is found to generate a substantial part of the cyclical properties of the exchange rate. Furthermore, the SMM enables us to assert that such moments are significantly well reproduced by the model. Finally, credit market frictions are found to be critical in making the model consistent with the data, which gives support to the stress on market imperfections at the heart of the NOEM literature. Next section presents the dynamics of the model in terms of impulse response functions before we turn to exchange rate forecasts.

Figure 2: Simulated versus observed moments : Does the model fit the data?



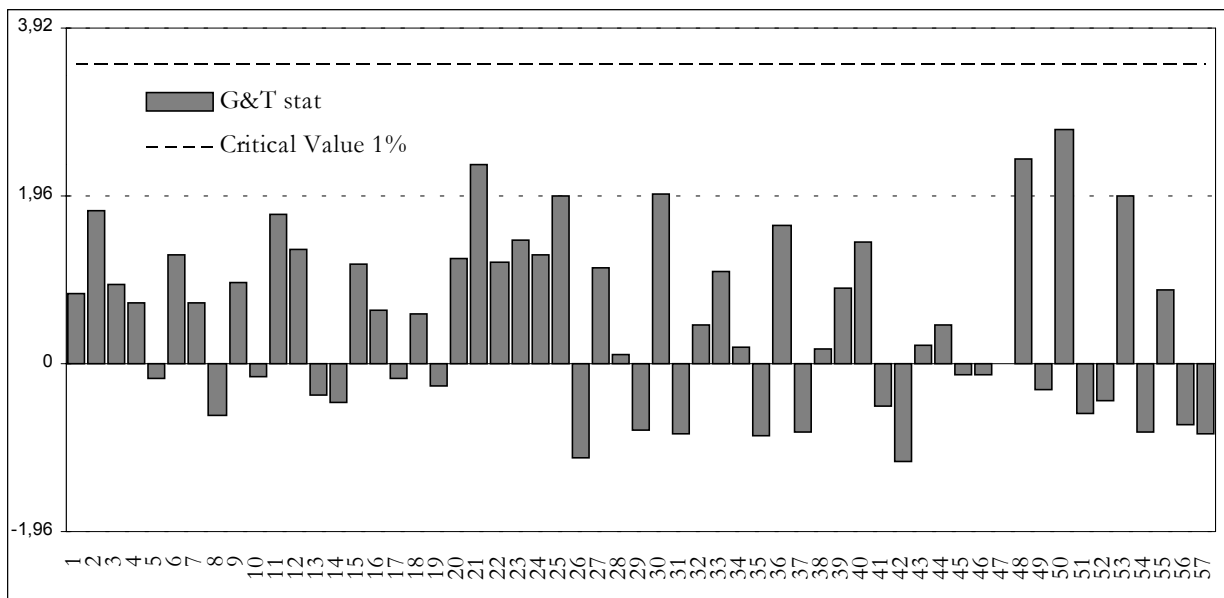
4.1.2 Impulse response functions

This section describes the dynamics for some key variables following technological and monetary shocks. We therefore evaluate whether the liquidity model is able to generate the dynamics implied by both shocks so as to mimic the one identified in the data (the VAR literature has largely documented the impulse response functions to such shocks, as in Eichenbaum and Evans [1995], Clarida and Gali [1994]). As the heart of the model lies in the interactions between monetary shocks and credit market frictions, we naturally check that the model, with the set of estimated parameters over the whole period, generates a nominal exchange rate overshooting following monetary shocks, in line with Dornbusch [1976]’s intuition. We also present impulse response functions to technological shocks as such effects are well-established in the business cycle literature.

Dynamics following a technological shock We report the impulse response functions of three key variables of the model, namely the nominal exchange rate, the nominal interest rate and domestic output following a 1% increase in the technological growth rate. Figure 4 displays the dynamics of the exchange rate and the nominal interest rate.

As shown by figure 4, the nominal exchange rate depreciates on impact to monotonically converge to its new steady state level. The nominal interest rate immediately jumps beyond its reference level to further decline. Nevertheless, it remains persistently higher than its initial level.

Figure 3: Gallant and Tauchen statistics : How well does the model fit the data?



The interest rate response mainly stems from the behavior of the monetary growth factor (equation (16)). Indeed, the estimation procedure results show that the monetary authorities react to an increase in g by raising the nominal interest rate. As the technological change yields a positive wealth effect for the household, consumption persistently increases (beyond its steady state level) and the demand for money (M_{t+1}^c) thus rises. The endogenous monetary factor g therefore increases (equation 15) and the inflation-adverse central bank raises the interest rate.

The joint dynamics of both e and R is consistent with the uncovered interest rate parity: the persistent increase in the domestic interest rate has to be offset by an expected depreciation of domestic currency. As expectations are rational, the nominal exchange rate depreciates on impact and goes on depreciating to its new long-run level.

Figure 5 presents the output impulse response function. As the technological shock raises the factor marginal productivity, investment and employment (not displayed here)¹² increase with the shock, so does domestic output on impact. As the effects of the shock vanishes, output monotonically decreases. The incomplete asset market structure implies that temporary shocks have permanent effects on real variables. The positive technological shock results in a permanent increase of domestic output beyond its initial steady state level.

¹²Investment still increases with the technological shock despite the raise in the nominal interest rate. The positive effect of the shock, through capital marginal productivity, dominates the negative effect of the raise of the borrowing cost.

Figure 4: Dynamics following a technological shock

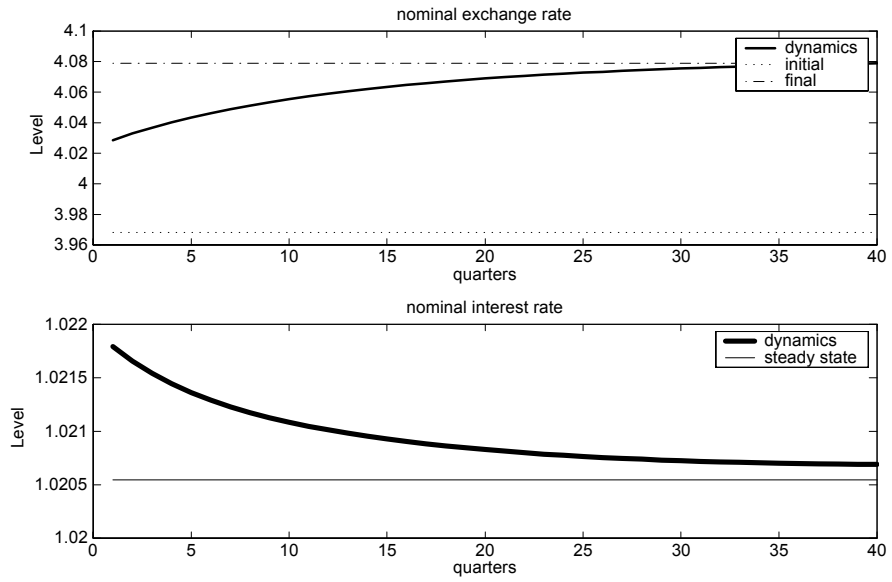


Figure 5: Output dynamics following a technological shock

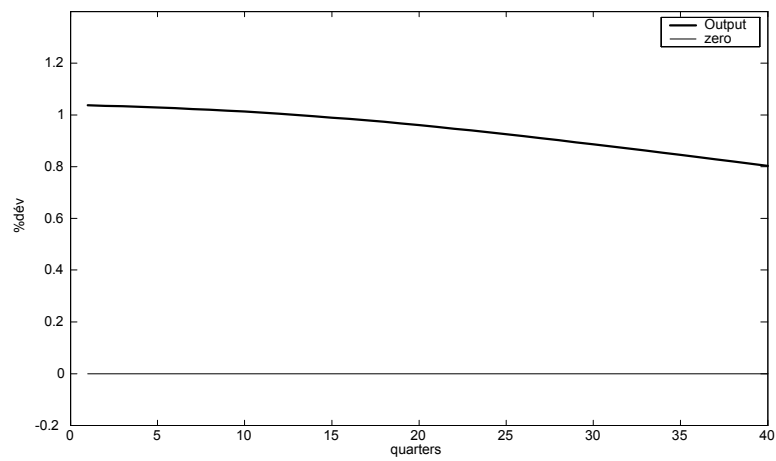
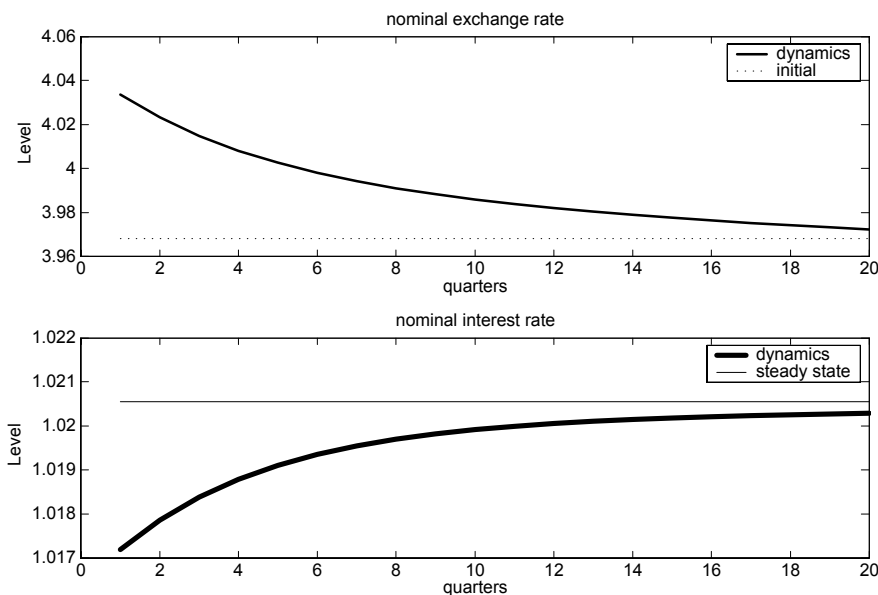


Figure 6: Dynamics following a monetary shock



Dynamics following a positive monetary shock We now evaluate the dynamics of some key variables in the model following a positive money supply shock (*i.e.* a 1% *decrease* in the interest rate innovation ε_R). As the limited participation model implies a particular investment dynamics, we present the impulse response functions of the nominal interest rate R , the nominal exchange rate e , domestic output Y and investment I .

Figure 6 displays the response of the nominal variables e and R . The dynamics of the nominal interest rate follows the Taylor rule (equation (16)). Since the estimated value of ρ_π is rather small, the central bank is more focused on smoothing the interest rate and reacting to the money growth factor g , both elements contributes to the persistence of the liquidity effect.

- Indeed, first, following the decrease in the nominal interest rate, the Bundesbank operates a smooth adjustment ($\rho_r = 0.518$)
- Furthermore, adjustment costs scaled by ξ limit the increase in money holdings that could counteract the persistent decline in the nominal interest rate. For, in the period of the monetary shock, the household chooses the amount of money that she wants to consume tomorrow (M_{t+1}^c). After the occurrence of the money shock, the agent anticipates inflation : the household wants to preserve her consumption in the future by increasing today the amount of nominal money balances. However, it is costly for the household to raise the ratio $\frac{M_{t+1}^c}{M_t^c}$ dramatically. Changing M_{t+1}^c deprives the agent of time available for leisure or labor. With larger adjustment costs, it is more expensive to modify money holdings today and the household will rather wait. As a result,

in the first period, the household raises the amount of money-cash M_{t+1}^c by a small amount. Adjustment costs on money holdings limit changes in M_{t+1}^c for consumption purchases thereby slowing down the rise in g . The latter could increase the nominal interest rate R through the Taylor rule, thus reducing the magnitude of the liquidity effect. In a nutshell, adjustment costs scaled by ξ contributes to the persistent fall of the nominal interest rate.

The analysis of impulse response functions is consistent with the estimation findings. SMM indeed indicates that interest smoothing (ρ_r) as well as credit market frictions (though ξ) are statistically significant, thus playing a critical role in making the model close to the data.

The nominal exchange rate dynamics stems from the interest rate response combined with uncovered interest rate parity. The persistent decline in the interest rate results in a negative interest rate spread that is offset by an expected appreciation of the nominal exchange rate. On impact the nominal exchange rate depreciates with the monetary shock. The immediate depreciation is then followed by an appreciation given uncovered interest rate parity. In the spirit of Dornbusch [1976], the limited participation model generates a nominal exchange rate overshooting. The impulse response functions of the nominal interest rate and the nominal interest rates are consistent with the empirical implications of monetary innovations as identified through alternative VAR specifications (Christiano, Eichenbaum, and Evans [1997] in a closed-economy context, Kalyvitis and Michaelides [2001], Kim and Roubini [2000] and Schlagenhauf and Wrase [1995] in a multi-country setting).

Figure 7 displays the output impulse response function while figure 8 presents the investment dynamics. On impact the output response turns out to be negative. This comes from the decline in employment (not displayed here), the capital stock being fixed the first period. With the monetary shock, the household escapes the inflationary tax by consuming less to rather have leisure time: Employment decreases and so does output. Nevertheless, the output response becomes positive a few periods after the shock since the rise in capital (associated with the investment boom) compensates for the decline in labor.

Indeed as shown in figure 8, investment reacts positively to the monetary shock. Since the cost of borrowing persistently remains below the reference level, firms are enticed to invest more. Schlagenhauf and Wrase [1995] and Christiano and Eichenbaum [1992] identify the output impulse response function following a monetary expansion in the G7 countries. They show that for all countries output initially declines to further increases six or nine months after the shock. Figure 7 reveals that the theoretical response function for output is consistent with such findings.

The limited participation model is thus able to mimic the empirical effects of monetary and technological shocks. The next step is then to evaluate the performances of the liquidity model in terms of out-of-sample exchange rate forecasts. Next section presents the method and the forecasting results.

Figure 7: Output dynamics following a monetary shock

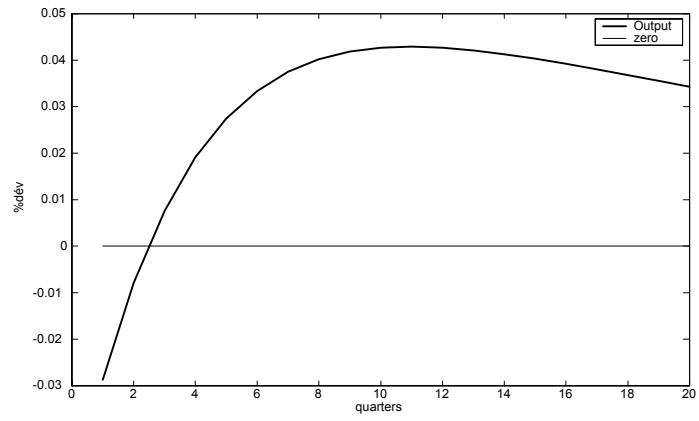
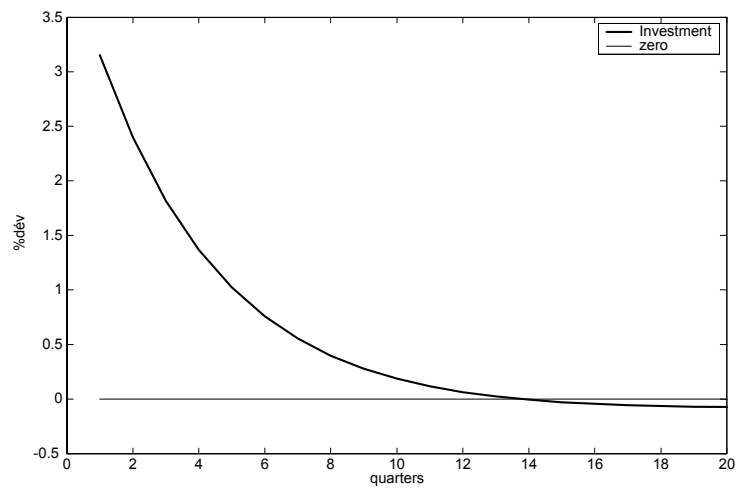


Figure 8: Investment dynamics following a monetary shock



4.2 Out-of-sample exchange rate forecasts : the limited participation model versus the random walk

Following Meese and Rogoff [1983], this section compares the forecasting performances of our theoretical model against those of the random walk. Table 4 reports the root mean square errors (RMSE) from the liquidity model and the random walk. The figures in this table are obtained in order to mimic a real-time forecasting exercise: after estimating the model from 1971:1 through 1994:2, the estimated parameters are plugged into the liquidity model to compute out-of-sample forecasts for the level of exchange rate, with one-step ahead forecast for 1994:3, two-step-ahead forecast for 1994:4, and so on. The model is then re-estimated with data from 1971:1 through 1994:3 before computing forecasts from that date at all horizons. Continuing in this manner allows to generate one-step ahead forecasts from 1994:3 through 1998:4, two-step ahead forecast from 1994:4 through 1998:4, and so on.

In order to mimic real-life out-of-sample forecasting experiment, each period, structural shocks are estimated up to the date of forecast. Estimated disturbances are then plugged into the structural model to yield nominal exchange rate forecasts in level. Appendix A provides a full description of the data used in this exercise.

Moreover, we chose 1994:2 as a starting date for the forecasting exercise in order to have enough points in the sample to implement the estimation procedure. In addition, if we start estimating the model before 1994:2, the match between the model and the data is not significant enough. The model is actually supported by the data from 1994:2 on. We then report in table 4 the RMSEs of the model when the estimation procedure runs from 1994:2 on.

To compare the RMSEs, table 4 reports Diebold and Mariano [1995]'s statistics that is used to test the null hypothesis of equal accuracy across models. Let $d_t^h = \left(err_{t,h}^{LIQ} \right)^2 - \left(err_{t,h}^{RW} \right)^2$ a measure of the forecast performance from the model (*LIQ*) relative to that of the random walk (*RW*) at horizon h , where $\{err_t^y\}_{t=1}^T$ is a series of h -step ahead forecast error, with $y = \{LIQ, RW\}$. Let d^h denotes the sample mean of $\{d_t^h\}_{t=1}^T$. Diebold and Mariano [1995] show that, under the null hypothesis, $\bar{d}^h = 0$, the test statistics

$$\zeta^h = \frac{d^h}{\sigma_{d^h}}$$

follows a normal distribution, where σ_{d^h} denotes the standard error of d^h . A consistent estimate of σ_{d^h} is obtained using the method of Newey and West [1987]. Negative values of ζ^h indicates that the theoretical model beats the random walk. In contrast, positive values of ζ^h means that the random walk produces more accurate out-of-sample forecasts than the liquidity model.

Table 4 reports forecasting performances when implemented from 1994:2 on. The forecasting exercise leads to mixed results. As the values of the Diebold and Mariano [1995]'s statistic are positive

Table 4: Forecast Accuracy (** denotes 5% level significance)

Horizon h	1994:4		
	RMSE RW	RMSE LIQ	ζ^h
1	0.0252	0.0502	0.983
2	0.0386	0.0614	0.9894
3	0.0526	0.0747	0.8799
4	0.0646	0.086	1.0886
5	0.0727	0.094	1.0047
6	0.082	0.1009	0.9874
7	0.0908	0.1093	1.0637
8	0.0977	0.1124	0.7865
9	0.1044	0.1148	0.7625
10	0.1072	0.1133	0.4221
11	0.1091	0.113	0.2337
12	0.1083	0.1096	0.076
13	0.102	0.0969	-0.3327
14	0.0918	0.0878	-0.2438
15	0.0733	0.0552	-2.3833**
16	0.0559	0.0439	-2.2765**

from a 1 to 12 quarters ahead, it tends to favor the random walk against the liquidity model. Nevertheless at no horizon the random walk significantly yields better forecasts than the structural model. Moreover, the 15 and 16 quarters ahead forecasts from the model significantly outperforms the random walk. This result provides some evidence in favor of the superior predictive power of the limited participation model against the naive random walk in the medium run. Nevertheless in the short run the model does not yield more accurate forecasts than the random walk. While we expected the model to outperform the naive approach, we can only conclude that it does not make worse.

5 Conclusion

This paper follows the route open by Bergin [2003] to explore the empirical dimensions of NOEM models. Rather than focusing on monopolistic competition models with price and wage stickiness estimated by Bergin [2003], we assess the empirical goodness of fit of the limited participation model.

First, we find that the limited participation model is statistically supported by the data. Credit market frictions are critical in the ability of the model to match the observed time series. From that point of view, the estimation results confirm our initial intuition that credit market frictions are a key ingredient in exchange rate dynamics. However, they remain somewhat disappointing since monetary shocks do not seem to be the primary driving force behind the aggregate dynamics.

With regards to exchange rate forecasts, we show that in the recent years, the model succeeds in outperforming the random walk in the medium run. The results of this paper suggest that fundamentals based models do provide an empirically relevant tool for understanding exchange rate dynamics. Nevertheless the limited participation model does not yield more accurate forecasts than the random walk in the short run. Combining the limited participation assumption to short run rigidities (price rigidities, pricing-to-market) might help us overcome this shortcoming. This is left for further research.

References

- ANDOLFATTO, D., AND P. GOMME (2000): “Monetary Policy Regimes and Beliefs,” Working Paper 9905R, Federal Reserve Bank of Cleveland.
- BACKUS, D., P. KEHOE, AND F. KYDLAND (1995): “International Business Cycles: Theory versus Evidence,” in *Frontiers of Business Cycle Research*, ed. by T. Cooley. Princeton University Press.
- BERGIN, P. (2003): “Putting the New Open Economy Macroeconomics to a Test,” *Journal of International Economics*, 60(1), 3–34.
- BLANCHARD, O., AND C. KAHN (1980): “The Solution of Linear Difference Models under Rational Expectations,” *Econometrica*, 48(5), 666–689.
- BLANCHARD, O., AND N. KIYOTAKI (1987): “Monopolistic Competition and the Effect of Aggregate Demand,” *American Economic Review*, 77(4), 647–666.
- CHARI, V., P. KEHOE, AND E. MCGRATTAN (2002): “Can Sticky Price Models Generate Volatile and Persistent Real Exchange Rates?,” *Review of Economic Studies*, 69(3), 533–563.
- CHRISTIANO, L. (1991): “Modeling the Liquidity Effect of a Money Shock,” *Federal Reserve Bank of Minneapolis Quarterly Review*, 15, 3–34.
- CHRISTIANO, L., AND M. EICHENBAUM (1992): “Some Empirical Evidence on the Liquidity Effect,” in *Political Economy, Growth and Business Cycle*, ed. by Z. Cukierman, Z. Hercowitz, and L. Leiderman. MIT Press.
- CHRISTIANO, L., M. EICHENBAUM, AND C. EVANS (1997): “Sticky Price and Limited Participation Models of Money: A Comparison,” *European Economic Review*, 41, 1201–1249.
- CLARIDA, R., AND J. GALI (1994): “Sources of Real Exchange Rate Fluctuations: How Important Are Nominal Shocks?,” *Carnegie Rochester Conference Series on Public Policy*, 41, 1–56.
- CLARIDA, R., J. GALI, AND M. GERTLER (1998): “Monetary Policy Rule in Practice: Some International Evidence,” *European Economic Review*, 42, 1033–1067.

- CLARIDA, R. H., L. SARNO, M. P. TAYLOR, AND G. VIOLENTE (2003): “The Out-of-Sample Success of Term Structure Models as Exchange Rate Predictors : A Step Beyond,” *Journal of International Economics*, 60(1), 61–83.
- COLLARD, F., P. FÈVE, F. LANGOT, AND C. PERRAUDIN (2002): “A Structural Model of U.S. Aggregate Job Flows,” *Journal of Applied Econometrics*, 17(3).
- DELNEGRO, M., AND F. OBIOLS-HOMS (2003): “The Impact of U.S. Monetary Policy Shocks on Mexico : A Structural Analysis,” Discussion paper.
- DEN HAAN, W., AND A. LEVIN (2000): “Robust Covariance Matrix Estimation with Data-Dependent VAR Prewhitening Order,” Discussion Paper Technical Working Paper nr255, National Bureau of Economic Research.
- DIEBOLD, F., AND R. MARIANO (1995): “Comparing Predictive Accuracy,” *Journal of Business and Economic Statistics*, 13, 253–263.
- DIEBOLD, F. X. (1998): “The Past, Present and Future of Macroeconomic Forecasting,” *Journal of Economic Perspectives*, 12, 175–192.
- DORNBUSCH, R. (1976): “Expectations and Exchange Rate Dynamics,” *Journal of Political Economy*, 84, 1161–1176.
- DOW, J. (1995): “The Demand and Liquidity Effects of Monetary Shocks,” *Journal of Monetary Economics*, 36, 91–115.
- DRIDI, R., AND E. RENAULT (2001): “Semiparametric Indirect Inference,” mimeo, CREST - INSEE.
- DUFFIE, D., AND K. SINGLETON (1993): “Simulated Moments Estimation of Markov Models of Asset Prices,” *Econometrica*, 61(4), pp. 929–952.
- EICHENBAUM, M., AND C. EVANS (1995): “Some Empirical Evidence on the Effect of Shocks to Monetary Policy on Exchange Rates,” *Quarterly Journal of Economics*, 110, 974–1009.
- FÈVE, P. (1997): “Les Méthodes D’étalonnage Au Regard de L’économétrie,” *Revue économique*, 48(3), pp.629–638.
- FRANKEL, J., AND A. ROSE (1995): “Empirical Research on Nominal Exchange Rates,” in *Handbook of International Economics*, ed. by G. Grossman, and K. Rogoff, chap. 33, pp. 1689–1729. Elsevier Science.
- FUERST, T. (1992): “Liquidity, Loanable Funds, and Real Activity,” *Journal of Monetary Economics*, 29, 3–24.

- GALLANT, A., AND G. TAUCHEN (1996): “Which Moments to Match?,” *Economic Theory*, 12, 657–681.
- GOURIEROUX, C., O. MONFORT, AND E. RENAULT (1993): “Indirect Inference,” *Journal of Applied Econometrics*, 8, S85–S118.
- GREGORY, A., AND G. SMITH (1993): “Statistical Aspects of Calibration in Macroeconomics,” in *Handbook of Statistics*, vol. 11, chap. 25. Maddala, G.S. and Rao, C.R. and Vinod, H.D.
- HAIIRAULT, J., L. PATUREAU, AND T. SOPRASEUTH (2002): “Overshooting and the Exchange Rate Disconnect Puzzle: A Reappraisal,” *Journal of International Money and Finance*, forthcoming.
- HANSEN, L. (1982): “Large Sample Properties of Generalized Method of Moments Estimators,” *Econometrica*, 50(4), 1029–1054.
- HODRICK, R., AND E. PRESCOTT (1997): “Post War US Business Cycles: an Empirical Investigation,” *Journal of Money, Credit and Banking*, 29, 1–16.
- INGRAM, B., AND B. LEE (1991): “Simulation Estimation of Time- Series Models,” *Journal of Econometrics*, 47, 197–205.
- IRELAND, P. (2001): “Sticky-Price Models of the Business Cycle : Specification and Stability,” *Journal of Monetary Economics*, 47, 3–18.
- (2002): “Money’s Role in the Business Cycle,” *Journal of Money, Credit and Banking*, forthcoming.
- KALYVITIS, S., AND A. MICHAELIDES (2001): “New Evidence on the Effects of US Monetary Policy on Exchange Rates,” *Economics Letters*, 71.
- KILIAN, L., AND M. P. TAYLOR (2003): “Why Is It so Difficult to Beat the Random Walk Forecast of Exchange Rates?,” *Journal of International Economics*, 60(1), 85–107.
- KIM, J. (2000): “Constructing and Estimating a Realistic Optimizing Model of Monetary Policy,” *Journal of Monetary Economics*, 45, 329–359.
- KIM, S., AND N. ROUBINI (2000): “Exchange Rate Anomalies in the Industrial Countries : A Solution with a Structural VAR Approach,” *Journal of Monetary Economics*, 45, 561–586.
- KOLLMANN, R. (2001): “The Exchange Rate in a Dynamic-Optimizing Current Account Model with Nominal Rigidities: a Quantitative Investigation,” *Journal of International Economics*, 55, 243–262.

- LANE, P. (2001): “The New Open Economy Macroeconomics: A Survey,” *Journal of International Economics*, 54, 235–266.
- LUBIK, T., AND F. SCHORFHEIDE (2003): “Do Central Banks Target Exchange Rates? A Structural Investigation,” mimeo.
- MACDONALD, R., AND M. TAYLOR (1994): “The Monetary Model of the Exchange Rate : Long Run Relationship, Short Run Dynamics and How to Beat the Random Walk,” *Journal of International Money and Finance*, 13(3), 276–290.
- MEESE, R., AND K. ROGOFF (1983): “Empirical Exchange Rate Models of the Seventies: Do They Fit Out of the Sample?,” *Journal of International Economics*, 14, 3–24.
- MILLARD, S., A. SCOTT, AND M. SENSIER (1997): “The Labour Market over the Business Cycle: Can Theory Fit the Facts?,” *Oxford Review of Economic Policy*, 13(3), 70–92.
- NELDER, J. A., AND R. MEAD (1965): “A Simplex Method for Function Minimization,” *Computer Journal*, 7, 308–313.
- NEWKEY, W., AND K. WEST (1987): “A Simple Positive Semi-Definite Heteroskedasticity and Autocorrelation Consistent Covariance Matrix,” *Econometrica*, 55(3), 703–708.
- OBSTFELD, M., AND K. ROGOFF (1995): “Exchange Rate Dynamics Redux,” *Journal of Political Economy*, 103(3), 624–660.
- ROGOFF, K. (1996): “The Purchasing Power Parity Puzzle,” *Journal of Economic Literature*, 34, 647–668.
- SCHLAGENHAUF, D., AND J. WRASE (1995): “Liquidity and Real Activity in a Simple Open-economy Model,” *Journal of Monetary Economics*, 35(3), 431–461.
- SMETS, F., AND R. WOUTERS (2002): “Monetary Policy in an Estimated Stochastic Dynamics General Equilibrium Model of the Euro Area,” Federal reserve bank of san francisco proceedings, Federal Reserve Bank of San Francisco.
- STOCKMAN, A., AND L. TESAR (1995): “Tastes and Technology in a Two-country Model of the Business Cycle: Explaining International Comovements,” *American Economic Review*, 85(1), 168–185.
- TAYLOR, J. (1993): “Discretion Vs. Policy Rules in Practice,” *Carnegie-Rochester Conference Series on Public Policy*, 39, 195–214.

A Estimates of structural shocks when forecasting the nominal exchange rate

In order to mimic real-time out-of-sample forecasting experiment, each period, the structural shocks are estimated up to the date of forecast. Estimated disturbances are then plugged into the structural model to yield nominal exchange rate forecasts in level. All time series stem from quarterly OECD BSDB data base. For all shocks, structural disturbances ε_{vt} , $\varepsilon_{\omega t}$, ε_{at} and ε_{π^*t} in equations (3)-(5) are measured in the following way:

- Technological shocks are estimated using Solow residuals with data on capital, output and labor.
- The computation of velocity disturbances is based on the cash in advance constraint (equation (4)) with German quarterly data on money (M1 aggregate), private consumption and consumer price index.
- Foreign price shocks are calculated thanks to the deflator of German imports.
- The computation of the preference shock is based on the first-order condition of the household program (not presented in the main part of the paper). The standard household arbitrage between domestic and foreign goods determines the domestic demand for foreign goods, given their relative price, the elasticity of substitution between goods, aggregate demand and the preference shock :

$$D_t^F = (1 - \omega_t) \left[\frac{P_{Ft}}{P_t} \right]^{-\theta} D_t$$

To extract the series for ω_t we take this condition that we apply to the following series: The goods and services imports series in volume for Germany for D_t^F , its deflator for P_t^F , the German consumer price index for P_t , and private consumption plus business sector investment series for aggregate demand D_t . We also use the estimate of θ over the whole period. We then take the log of the so-built time series.

For all shocks, we use equations (5) through (3) with the estimated persistence parameters (ρ_v , ρ_ω , ρ_a and ρ_{π^*}) to infer the structural disturbances ε_{vt} , $\varepsilon_{\omega t}$, ε_{at} and ε_{π^*t} . Finally, the shock on the Taylor rule comes from equation (16) in which we plug data on output, money growth, consumer price index and interest rate.

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