Exchange Rates, Macroeconomic Fundamentals and Risk Aversion

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Abstract

This paper shows that under absence of arbitrage opportunities the exchange rate reacts to restore equilibrium in international bond markets. The key factors determining its value are the difference between realized and implicit interest rate differentials, the underlying risk premium in bond markets and changes in market expectations on the long run exchange rate. The application of this model to the macroeconomy reveals the importance of the risk premium for setting monetary policy. We find that a relative increase/decrease in the risk premium between foreign and domestic debt markets increases/decreases the influence of foreign monetary policy for shifting real output.

Key words: Foreign exchange markets, International bond markets, Risk premium, Uncovered interest parity condition.

JEL Classification: C22, F31

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1 Introduction

The exchange rate is an important macroeconomic instrument fundamental to analyze the relation between macroeconomic variables such as interest rates, changes in money supply, real output, prices, or the balance of payments, across countries. The exchange rate can also be considered as an asset traded in financial markets, see Hansen and Hodrick (1983), Fama (1984), Obstfeld and Rogoff (1996), Bansal (1997), Backus, Foresi and Telmer (2001) or more recently Ang and Chen (2010). This implies that its price dynamics are determined by future market expectations on macroeconomic fundamentals, but also under no-arbitrage conditions, by the relation between international asset markets and the effects of perceived risks on these markets by international investors.

This paper studies exchange rate determination as the result of the interaction between financial and macroeconomic variables between open economies. Our model is based on rational expectations and absence of arbitrage opportunities. The model explicitly considers the effect of a time-varying term that measures departures from market efficiency in the foreign exchange market and from the Expectations Hypothesis in international bond markets. This term is identified with the presence of investors’ risk aversion to international asset markets. This approach is motivated by portfolio balance theories; portfolio balance theorists argue that risk aversion is the predominant motive in investors’ choice between domestic and foreign currency securities. This implies that assets in different markets are not perfect substitutes since investors require a risk premium for investing on the risky market.

The conclusion of our model is that the exchange rate is mainly forward looking. Its dynamics, prompted by the occurrence of shocks to the open economy in equilibrium are determined by changes in market expectations on the long run exchange rate, changes in the risk premium in debt markets and the foreign exchange market, and changes between the international yield curve and the actual observed differential in interest rates. Related to this
is our finding that the forward premium is given by the sum of a shock to the international bond market and a shock to the risk premium on the foreign exchange market. Our model also rationalizes the existence of carry trade strategies by describing the conditions under which these strategies are profitable. These conditions are, mainly, the level of interest rate differentials between economies in the previous period, the risk aversion underlying in international debt markets and the magnitude of the shock to these markets.

To study the implications of our model for exchange rate determination in the real economy, we follow the existing literature by considering simple versions of the monetary model that link interest rates to the rest of economic fundamentals. One of the main contributions of our theory is to reveal the importance of the risk premium observed in asset markets for setting monetary policy. The paper shows that the effects of unanticipated movements in monetary policy with the aim of shifting real output demand differ depending on the extent of relative risk aversion in debt markets. The larger the existence of risk aversion in the foreign debt market the most effective that country’s monetary policy is in boosting real output. On the other hand, if the risk aversion is to the domestic debt market the effects of monetary policy for shifting foreign output are diminished by the existence of a risk premium in the domestic market that makes domestic investment more attractive compared to investment on the foreign short term bond market. As a by-product of this analysis we show that the overshooting phenomenon predicted by the monetary model with sticky prices also depends on the underlying risk premium, and in contrast to Dornbusch (1976) model, it can be solely explained by a temporary increase in money supply.

The closest contributions to this work are Obstfeld and Rogoff (1996), that observe that the nominal exchange rate is an asset, and hence, propose asset pricing models for exchange rate determination based on future market expectations; Engel and West (2005) that study the forecasting ability of present value models and link them to macroeconomic fundamentals such as interest rates, money supply, real output or expected inflation; Engle, Mark and West
(2007) that also present evidence that exchange rates are primarily determined by changes in expectations and show that these series incorporate news about future macroeconomic fundamentals; and finally, Chen and Tsang (2010) that discuss an empirical model for exchange rate determination based on macro-finance fundamentals. In their model the exchange rate is the result of the interactions between the risk premium on international bond markets and the foreign exchange market. The Nelson-Siegel (1987) latent factor model extracted from cross-country yield curves is used to capture expectations about future economic conditions and systematic risks in the currency markets. Other related papers as Bansal (1997), Graveline (2006) or Ang and Chen (2010) amongst others, focus on econometric specifications of the dynamics of the yield curve and the foreign exchange rate with the aim of forecasting currency returns. In contrast to these papers we do not explore econometric methodologies to fit real data and leave possible empirical representations of our model for future research.

The article is structured as follows. Section 2 sets the theoretical framework by introducing the equilibrium conditions in asset markets and deriving the pricing formula for the exchange rate for departures from this short run equilibrium. Section 3 extends this theory to analyze exchange rate determination as a result of simultaneous equilibrium in the monetary and output markets. The section also explores the effect of macroeconomic policies affecting money supply, interest rates and prices on the determination of the exchange rate. Section 4 concludes.

2 Theoretical Framework

We assume two open economies, domestic and foreign, with a floating exchange rate system between their currencies. Interest rates are determined from the interaction between financial and macroeconomic factors and in particular from the clearing of domestic and foreign zero-rate bond markets. In this model supply and demand forces eliminate instantaneously
the existence of arbitrage opportunities in asset markets (international debt markets and foreign exchange market). Investors operating on these markets hold rational expectations with respect to the future performance of assets. There is perfect capital mobility between economies implying an infinite free flow of capital to take advantage of investment opportunities arising in both debt markets. Prices fully reflect available information implying market efficiency but make allowance at the same time for the presence of a risk premium derived from investors’ risk aversion. We assume three periods $0 < t < T$, time 0 corresponds to the current period, time $t$ denotes the future short term and time $T$ the future long term. We identify the long run exchange rate with an exchange rate where both foreign and domestic economies are in equilibrium; no shocks to the system happen at time $T$.

The notation is the following. Let $i_{0,t}$ and $i_{0,t}^*$ be domestic and foreign interest rates outstanding between period 0 and $t$, continuously compounded; $S_t$ is the spot nominal exchange rate defined as units of foreign currency per unit of domestic at time $t$ and $F_{t,T}$ is the corresponding forward price determined at time $t$. An increase in $S$ means an appreciation of the domestic currency. The expressions in small letters are logs of spot and forward prices. The expression $E_0s_t = E[s_t|\mathcal{I}_0]$ denotes the expectation of the log of the spot exchange rate conditional on the information set $\mathcal{I}_0$; this set contains all the information available at time 0. The tilde symbol denotes differences between variables measured for the foreign and domestic markets, e.g, $\tilde{i}_{0,t} = i_{0,t}^* - i_{0,t}$.

Equilibrium in the foreign exchange market is given in the short run by

$$E_t s_T - s_t = \tilde{i}_{t,T} + \varepsilon_t,$$  \hspace{1cm} (1)

and in the long run by

$$E_0 s_T - s_0 = \tilde{i}_{0,T} + \varepsilon_0,$$  \hspace{1cm} (2)

with $\varepsilon_0$ and $\varepsilon_t$ time-varying risk premiums that measure the level of international investors’
risk aversion to the foreign currency compared to the domestic currency at periods 0 and \( t \), respectively. This condition is the so-called risk-adjusted uncovered interest parity condition and accommodates the presence of a time-varying risk premium in efficient markets. The existence of this term is widely documented in the literature on the term structure of interest rates, see Campbell and Shiller (1991), Fama and Bliss (1987), Diebold, Rudebusch and Aruoba (2006) or Cochrane and Piazzesi (2005), amongst others; or on empirical statistical tests of the unbiasedness of the forward exchange premium, see for example Fama (1984), or discussions in Domowitz and Hakkio (1985), Cumby (1988), Frankel (1982a and 1982b), Frankel and Froot (1989), or more recently Obstfeld and Rogoff (2003) or Bekaert, Wei and Xing (2007).

The assumption of no-arbitrage in financial markets implies no-arbitrage in the foreign exchange market. The no-arbitrage condition is

\[
f_{0,t} = s_0 + \tilde{i}_{0,t},
\]

with \( f_{0,t} \) the forward exchange rate. The no-arbitrage condition corresponding to the international debt market is

\[
\tilde{i}_{0,T} = \tilde{i}_{0,t} + \tilde{i}_{t,T},
\]

with \( \tilde{i}_{t,T} = i_{t,T}^f - i_{t,T}^d \) the differential in implicit forward rates obtained from the corresponding foreign and domestic yield curves. This condition is also called international term structure of interest rates. Other related articles studying exchange rate dynamics from no-arbitrage arguments are Hansen and Hodrick (1983), Fama (1984), Backus, Foresi and Telmer (2001) or more recently Ang and Chen (2010).

Equilibrium in asset markets is completed by equilibrium on international debt markets. In equilibrium the domestic bond market is given by \( E_0i_{t,T} = i_{t,T}^f + \eta_0 \) with \( \eta_0 \) a time-varying term reflecting departures from the Expectations Hypothesis that for \( \eta_0 < 0 \) we
identify with the existence of a risk premium on the domestic long term bond market. More specifically, a negative $\eta_0$ indicates investors’ expectations on an increase in short-term domestic interest rates between $t$ and $T$. It also implies that the implicit forward interest rate can be interpreted as the maximum value at which investors are still willing to hold domestic long term bonds compared to domestic short term bonds. On the other hand, a positive $\eta_0$ indicates investors’ expectations on a decrease in short-term domestic interest rates between $t$ and $T$. In line with the Liquidity Preference Theory the implicit forward interest rate reflects the minimum value at which risk averse investors are still willing to hold short term investments in the domestic bond market compared to investing in the long term domestic bond. Assuming the same equilibrium condition for the foreign bond market we obtain the following expression for the differential in international interest rates in equilibrium;

$$E_0^\text{\text{	extasciitilde}}_{t,T} = i_{t,T} + \tilde{\eta}_0,$$  \hspace{1cm} (5)$$

where $\tilde{\eta}_0 = \eta_0^* - \eta_0$ reflects the net risk premium on the international bond market. The sign of this parameter is very important for determining investors’ sentiment on international debt markets. If $\tilde{\eta}_0 > 0$, the foreign short term bond offers a higher expected return than the corresponding domestic short term bond. This can be interpreted as a risk premium required by investors to invest in the foreign debt market. On the other hand, if this quantity is negative investors expect the domestic short term bond to be riskier and hence the expected excess return is offered by the domestic market. To show this we calculate the return that an international investor expects at time 0 from investing on the foreign debt market between $t$ and $T$. At time 0, she expects to invest $E_0s_t$ units of domestic currency that will yield a gross expected return of $\frac{E_0s_t(1 + E_0i_{t,T}^*)}{E_0s_T}$ in domestic currency. This strategy is expected to be more profitable than investing in the domestic bond market if the previous return is higher than $(1 + E_0i_{t,T})$ obtained from investing one unit of domestic currency in its own debt market at time $t$. Taking logs and using suitable approximations, the foreign strategy
is more profitable than the domestic one if

$$E_0(\tilde{i}_{t,T} - \Delta s_T) > 0$$  \hspace{1cm} (6)$$

with $\Delta s_T = s_T - s_t$. Now, applying (2) to $E_0s_T$ and $E_0s_t$ and using conditions (4) and (5) we observe that

$$E_0\Delta s_T = \tilde{i}_{t,T}^f.$$  \hspace{1cm} (7)$$

From (5), it follows that the term $\tilde{\eta}_0$ is the expected excess return from investing on the foreign bond compared to investing on the domestic bond. Further, taking expectations at time 0 in expression (2), we have

$$E_0\Delta s_T = \tilde{i}_{t,T}^f + \tilde{\eta}_0 + E_0\varepsilon_t.$$  \hspace{1cm} (8)$$

Expressions (7) and (8) show that under the risk-adjusted uncovered interest parity condition the best predictor of the risk premium on the foreign exchange market is the excess return expected in the international debt market, that is,

$$E_0\varepsilon_t = -\tilde{\eta}_0.$$  \hspace{1cm} (9)$$

Interestingly, we obtain a condition similar in spirit to UIP. Investors’ expectations on the exchange rate risk premium $\varepsilon_t$ are a consequence of the net risk premium realized in the international short term bond market. That is, investors expect a movement of the exchange rate risk premium at time $t$ that offsets the expected excess return realized in the corresponding international bond market. This movement on the expected foreign exchange risk premium also implies the expected overshooting of the forward exchange rate $f_{t,T}$ compared
to the long run exchange rate $s_T$, that is, if $\bar{\eta}_0 > 0$ it follows that

$$E_0 s_T < E_0 f_{t,T}.$$  

This condition follows from taking expectations at time 0 on the equilibrium condition $E_t s_T = f_{t,T} + \varepsilon_t$.

Bansal (1997) also studies the relationship between risk premiums on the foreign exchange market and bond markets. This author, however, relates the foreign exchange risk premium to differences in the market price of interest rate risk. Finally, it is interesting to observe that if the risk premiums from each debt market cancel out the Expectations Hypothesis is satisfied for the differential of interest rates. The international yield curve is an unbiased predictor of the actual interest rate differential and there is no expected excess return to be made a priori on debt markets.

To study the exchange rate under departures from asset market equilibrium we analyze the impact of a shock to the financial system on the international bond market. A similar analysis can be carried out by studying the impact of the shock to the foreign exchange market. The shock is defined as

$$\nu_t = \tilde{i}_{t,T} - \tilde{i}_{t,T} - \bar{\eta}_0.$$  

This condition together with the no-arbitrage conditions (3) and (4) yield

$$\nu_t = f_{0,t} - s_t - \Delta \varepsilon_t + \Delta E_t s_T - \bar{\eta}_0$$  

with $\Delta E_t s_T = E_t s_T - E_0 s_T$ and $\Delta \varepsilon_t = \varepsilon_t - \varepsilon_0$.

The shock at time $t$ not only reflects the difference between the spot and forward exchange rate but also changes in risk aversion and in market expectations. Rearranging this expression
we obtain the short run exchange rate as

\[ s_t = f_{0,t} - \Delta \epsilon_t + \Delta E_t s_T - \tilde{y}_0 - \nu_t. \]  \hspace{1cm} (12)

It is useful to write this expression in terms of the spread on international interest rate differentials:

\[ s_t = f_{0,t} - \Delta \epsilon_t + \Delta E_t s_T + \tilde{i}'_{t,T} - \tilde{i}_{t,T}. \]  \hspace{1cm} (13)

Expression (13) shows that the exchange rate is, as recent literature has highlighted, forward looking. This literature refers to models in which the exchange rate is primarily determined by changes on market expectations, see Engel, Mark and West (2007). These authors view the exchange rate as an asset price, and therefore, make use of asset pricing models to determine the exchange rate. In these models, see Obstfeld and Rogoff (1996), Engel and West (2005) or more recently Chen and Tsang (2010), the exchange rate is driven by a present discounted sum of expected future fundamentals. In our model, the exchange rate depends on the forward price, but more importantly, it depends on the difference between realized and implicit interest rate differentials, changes in investors’ risk aversion and in market expectations on the long run exchange rate. The difference between realized and implicit international interest rate differentials incorporates the effect of the shock to the international bond market that can potentially produce a change in market expectations on the equilibrium exchange rate and on the foreign exchange market risk premium. The next section analyzes the implications of the nature of the shock, whether it is monetary or to the real economy, in the determination of the exchange rate and real output.

Expression (13) also shows that the exchange rate can be decomposed in terms of the shock \( \nu_t \) and a shock \( \omega_t \) defined as the difference between \( \epsilon_t \) and \( E_0 \epsilon_t \). This term is assumed to be serially uncorrelated but potentially correlated to \( \nu_t \), and reflecting the transmission of shocks between asset markets. Replacing in the above expression and assuming for simplicity
that $\varepsilon_0 = 0$ we obtain

$$s_t = f_{0,t} - \omega_t + \Delta E_t s_T - \nu_t. \quad (14)$$

By definition, the shock $\omega_t$ has an effect on the expectations on the long run exchange rate. The shock $\nu_t$, on the other hand, does not necessarily produce changes in market expectations. In this case the shock is transitory, otherwise the shock is permanent. For the transitory shock equation (13) implies that

$$\Delta s_t = \tilde{\nu}_{0,t} + \tilde{\nu}_T^{t} - \tilde{\nu}_{t,T} - \Delta \varepsilon_t. \quad (15)$$

In a system that is away from equilibrium, but with equal initial cross-country interest rates, the dynamics of the exchange rate can be explained by unexpected differences on the international yield curve and changes on the foreign exchange market risk premium. In general, initial cross-country interest rates are different, leading to conclusions on the dynamics of the exchange rate not discussed in the literature so far. For example, the situation $\tilde{\nu}_{t,T} < \tilde{\nu}_T^{t}$ is very likely to produce a different effect when the forward price at time 0 is at a premium, $\tilde{\nu}_{0,t} > \tilde{\nu}_{0,t}$, than when the forward price is at a discount, $\tilde{\nu}_{0,t} < \tilde{\nu}_{0,t}$.

In particular, for a constant risk premium model (15) predicts a sure depreciation of the foreign currency in the former case and a possible appreciation in the latter, that depends on the relation between $\tilde{\nu}_{0,t}$ and $\tilde{\nu}_T^{t} - \tilde{\nu}_{t,T}$. Under the presence of risk aversion exchange rate movements are ambiguous and depend on the magnitude of the risk premium. A similar analysis follows for $\tilde{\nu}_{t,T} > \tilde{\nu}_T^{t}$. Bansal (1997), using an empirical specification of the exchange rate, obtains similar findings on the importance of the sign of interest rate differentials.

Expression (15) also rationalizes the existence of carry trade strategies. These strategies are given by short positions in the low interest rate country used to invest in the high interest rate country with the expectation of observing an appreciation in the latter currency. For the sake of exposition, assume that the high interest rate country is foreign. The above formula
predicts the profitability of these strategies when the shock to the international bond market produces an unanticipated increase in the realized interest rate differential large enough to offset the implicit interest rate differential at time \( t \) and the initial difference of interest rates at time 0. Otherwise, the foreign currency (high interest rate) will depreciate.

3 A Macroeconomic Approach to Exchange Rate Determination

The above model for exchange rate determination is based on no-arbitrage conditions and market efficiency. The key factors to determine the exchange rate are unexpected changes in interest rate differentials, the underlying risk premium and potential changes on market expectations on the long run exchange rate. This section studies the determination of the exchange rate from simultaneous equilibrium in the monetary and real output markets. The main difference with previous formulations on exchange rate determination is the expression for the short run exchange rate. In our study expression (13) replaces previous models considering the UIP as one of the building blocks for determining the exchange rate. In this way our model naturally considers the effect of macroeconomic policies producing departures from equilibrium in the determination of the exchange rate.

It is worth starting the section discussing our model for interest rate determination. The main theories entertained in the literature are the monetary approach and the Taylor rule. Central Banks usually follow Taylor rules to set nominal interest rates. In our model, international interest rates are, however, determined from equilibrium in international zero-rate bond markets. Although both rates are related it is well known that the base rate set by Central Banks is a lower bound of the corresponding market rate obtained from bond prices. Moreover, the former rate does not correspond to the return on a tradable asset and does not incorporate a risk premium; hence the limited use of our model to describe the
mechanism of macroeconomic variables using this theory.

To describe the monetary market, and as in Engel and West (2005), we follow the models of Frenkel (1976), Mussa (1976) and Bilson (1978), and the versions considering sticky prices introduced by Dornbusch (1976) and Frankel (1979). Both approaches assume that the real demand for money, the log of which is linear in the log of real income and interest rates, can be expressed as

\[ m_t - p_t = \phi y_t - \lambda i_{t,T} \]  \hspace{1cm} (16)

where \( m_t, p_t \) and \( y_t \) denote the logs of the nominal quantity of money, the price level, and real income outstanding between time \( t \) and \( T \); \( \phi > 0 \) and \( \lambda > 0 \) are tuning parameters of the model. In equilibrium in the monetary market we have that real money demand equals real money supply.

Equilibrium in output markets is obtained in this model when aggregate output demand is matched by aggregate real output supplied by both countries. Aggregate output demand is a positive function of disposable income in each country, investment and expenditure by each government. The real exchange rate also has a fundamental role in determining the economy that produces aggregate output. Thus, a depreciation of the real exchange rate implies, in general, an increase in real output by foreign. In what follows, we use \( y \) to denote both real output demand and supply and assume each output market is in equilibrium.

By taking expectations in expression (16) we observe that the risk premium \( \eta_0 \) underlying in the domestic bond market is a factor to consider by monetary authorities, along with the dynamics of prices, when designing their monetary offer. That is, if the goal is to determine a target of \( E_0 y_t = Y \) they need to supply an appropriate amount of money for the domestic economy to satisfy the following equation in equilibrium:

\[ E_0(m_t - p_t) = \phi Y - \lambda i_{t,T} + \lambda \eta_0. \]  \hspace{1cm} (17)
Thus, if $\eta_0 > 0$, domestic short term interest rates between $t$ and $T$ are expected to decrease implying risk aversion to the short term bond. Consequently, investors prefer to consume and increase domestic output demand rather than investing on the domestic bond market. On the other hand, if $\eta_0 < 0$ short term interest rates are expected to increase and the risk aversion is to the long term bond market. In order to increase output the domestic economy needs to supply an extra money supply to compete with the higher returns offered by the domestic long term bond.

An equation analogous to (16)-(17) and similar arguments hold for the foreign economy. For simplicity we assume that $\phi$ and $\lambda$ take the same values across countries. Using expressions (7) and (9), the difference in the expected real money demand between economies is

$$E_0(\tilde{m}_t - \tilde{p}_t) = \phi E_0\tilde{y}_t - \lambda E_0\Delta s_T - \lambda \tilde{\eta}_0. \quad (18)$$

In an open economy monetary policy cannot be taken independently of other countries’ monetary interventions. Thus, the previous equation shows that expectations on the return on the exchange rate between $t$ and $T$ and the existence of an expected excess return to be made on international bond markets have an influence on the expectations on real money demand differentials. In equilibrium, if $\tilde{\eta}_0 < 0$ the domestic debt market offers a higher expected return compared to the foreign market (the domestic market is seen as riskier). Thus, in order to boost foreign output the foreign monetary authority needs to supply an extra amount of money to compensate for the risk aversion to the domestic short term bond that makes domestic investment more attractive. On the other hand, if $\tilde{\eta}_0 > 0$ the effect on real output of an inflow of foreign money supply is augmented by the magnitude of the risk premium. In this case the foreign bond market offers an expected excess return compared to the domestic market. Investors are more willing to buy foreign currency creating pressures on foreign money demand and therefore boosting real output. The shift in money supply does not need to be as large as under risk neutrality to shift output.
To follow the structure of the previous section we now consider the exchange rate under departures from equilibrium due to the occurrence of shocks to the open economy. These shocks can be monetary (money expansions/contractions), fiscal (fiscal tightening, unexpected shifts in government expenditure) or to the real economy (movements in the real exchange rate). We discuss first the effect of fiscal and real shocks to output markets. In order to analyze the effect of these measures on the short run exchange rate we need to evaluate the effect of each policy not only on the foreign output market but also on the domestic output market. Thus, it is not clear, for example, that an increase in disposable income by foreign implies a boost of foreign real income. This will also depend on the real exchange rate that determines the relative attractiveness between domestic and foreign products. For these reasons we will not study further the effect of shocks to output markets on the exchange rate and assume that both domestic and foreign markets are in equilibrium. Hence, our interest is in studying the effect of monetary shocks on the short term exchange rate.

A monetary shock is defined as the difference between the existing real money demand at time $t$ and its conditional expectation. Using the previous expressions, and replacing in (10), we have

$$m_t - \bar{p}_t - E_0(m_t - \bar{p}_t) = \phi(y_t - E_0\bar{y}_t) - \lambda \nu_t,$$

that relates monetary shocks to those produced in international bond markets. Now, replacing in (13) we obtain the following decomposition of $s_t$:

$$s_t = \begin{cases} f_{0,t} - \Delta \varepsilon_t - \bar{\eta}_0 + \Delta E_t s_T & \text{financial factor} \\ \bar{\phi}(y_t - E_0\bar{y}_t) \quad & \text{real economy factor} \\ \lambda[(m_t - E_0\bar{m}_t) - (\bar{p}_t - E_0\bar{p}_t)] & \text{monetary factor} \end{cases}$$

with $\lambda = 1/\lambda$ and $\bar{\phi} = \phi/\lambda$.

The exchange rate can be decomposed into a financial factor given by the forward exchange rate, changes in the risk premium and in market expectations on the long run exchange rate; by a real factor given by the unexpected increase in real income differentials.
between economies, and a monetary factor that measures cross-country differences in the shock to the real money supply. This model not only describes the exchange rate in equilibrium but also provides the expression for the exchange rate after changes in monetary and real factors. Figure 1 describes graphically the dynamics of the exchange rate after an unexpected relative increase in foreign money supply compared to domestic. For simplicity, domestic macroeconomic variables are assumed to be fixed. The graph not only shows the contributions of each factor to determine the short run exchange rate but also the effect of the risk premium. The downward curves represent combinations of the exchange rate and output obtained from equilibrium in monetary markets. The upward curve describes combinations of the exchange rate and output obtained from equilibrium in output markets. The intersection of both curves describes the exchange rate when both monetary and output markets are in equilibrium. Under absence of risk aversion the increase in foreign money supply compared to domestic implies a new equilibrium at point 1 that yields a depreciation of the currency and more real output. Under risk aversion to the domestic bond market, \( \eta_0 < 0 \), the exchange rate depreciates less than before (see point 3 in Figure 1) and the output differential increases by a smaller amount. Finally, if the risk aversion is to the foreign bond market the increase in foreign money supply produces an extra shift in output beyond that produced under risk neutrality and a higher depreciation of the currency (see point 2 in Figure 1).
So far we have just analyzed the dynamics of the short run exchange rate. In order to study the exchange rate in the long run we need to study the dynamics of prices and their response to changes in macroeconomic conditions. In order to do this we divide the analysis into economies with flexible and sticky prices.

### 3.1 Flexible Prices

In the monetary models of Frenkel (1976), Mussa (1976) and Bilson (1978), prices adjust immediately to changes in money supply, producing in turn an immediate effect on the spot exchange rate. These models assume that the relative Purchasing Power Parity (PPP) condition holds; in our framework, this assumption implies the following:

\[
s_t = \tilde{p}_t + q_t \quad \text{and} \quad s_0 = \tilde{p}_0 + q_0
\]

with \( q_0 \) and \( q_t \) the real exchange rate before and after the shock at time \( t \), respectively.
Expressions (20) and (21) together explain the dynamics of the spot exchange rate:

\[ \Delta s_t = \frac{1}{1 + \lambda} \left[ \Delta E_t s_T - \Delta \varepsilon_t - \tilde{\eta}_0 - \tilde{\phi} (\tilde{y}_t - E_0 \tilde{y}_t) + \tilde{\lambda} (\tilde{m}_t - E_0 \tilde{m}_t) + \tilde{\lambda} \Delta q_t \right]. \]

A real depreciation of the foreign currency produces a depreciation of the nominal exchange rate. The effect of an increase in relative prices is mixed; it depends on the real exchange rate. Thus, if prices simply adjust to keep the real exchange rate constant, the demand for real output and market expectations on the long run exchange rate are likely to be unaffected by the increase in nominal money supply. The dynamics of the exchange rate are only due to monetary changes and differences in the foreign exchange risk premium:

\[ \Delta s_t = \frac{1}{1 + \lambda} \tilde{t}_{0,t} + \frac{\tilde{\lambda}}{1 + \lambda} (\tilde{m}_t - E_0 \tilde{m}_t) - \frac{1}{1 + \lambda} (\Delta \varepsilon_t + \tilde{\eta}_0). \]

Otherwise, if the price adjustment produces a depreciation of the real exchange there will be an increase in foreign real output implying pressures on the demand side of the foreign monetary offer. To reach equilibrium in the money market the foreign monetary authority will increase the money supply or increase interest rates. Whereas the former measure produces a depreciation of the foreign currency that offsets the appreciation due to a shift in output, the second measure produces a further appreciation as shown in (13). These measures also have an impact on investors’ market expectations on the long run exchange rate, and hence on the short run exchange rate.

Note that in the long run equilibrium there is no change on the macroeconomic variables, therefore, applying any of the above formulations for exchange rate determination we obtain \( s_T = f_{t,T} + \varepsilon_t \). Expression (13) shows that unless there are changes in market expectations on the long run exchange rate the forward rate does not vary, that is \( f_{t,T} = f_{0,T} \), and the long run exchange rate is not affected by the temporary increase in foreign money supply.
3.2 Sticky Prices

The monetary models of Dornbusch (1976) and Frankel (1979) differentiate between equilibrium in the short and long run. In the short run, the exchange rate adjusts due to equilibrium in asset markets. If the shock to the economy is permanent this produces a slow adjustment of prices that makes real money demand return to previous levels. Thus, an increase in foreign money supply by monetary authorities implies the overshooting of the exchange rate in the long run. Frankel (1979) refines this model by including the difference on expected inflation rates as an explanatory factor of the short run dynamics of the exchange rate. Model (20) is similar in spirit to Frankel’s approach; in our model it is unexpected inflation differentials what influences the dynamics of the spot exchange rate.

In our model, the short-run exchange rate in an economy with sticky prices is:

\[ s_t = s_0 + \tilde{i}_{0,t} + \Delta E_t s_T - \Delta \varepsilon_t - \tilde{\eta}_0 - \tilde{\phi}(\tilde{y}_t - E_0\tilde{y}_t) + \tilde{\lambda}(\tilde{m}_t - E_0\tilde{m}_t) + \varepsilon_t. \]

In the long run we assume that there are no surprises to the economic system, hence the random variables at time T coincide with their conditional expectations. Replacing in the previous expression evaluated at time T we obtain the long run exchange rate, that is given by

\[ s_T = s_t + i_{t,T} + \varepsilon_t. \]

Further, using (17) and (18) for domestic and foreign economies, it follows that

\[ \tilde{i}_{t,T} = \tilde{i}_{t,T} + \tilde{\eta}_0 - \tilde{\lambda}(\tilde{m}_t - E_0\tilde{m}_t) + \tilde{\phi}(\tilde{y}_t - E_0\tilde{y}_t) \]

and the long run exchange rate is

\[ s_T = s_t + \tilde{i}_{t,T} + \tilde{\lambda}(\tilde{m}_t - E_0\tilde{m}_t) + \tilde{\phi}(\tilde{y}_t - E_0\tilde{y}_t) + \omega_t. \]
with $\omega_t$ the surprise to the foreign exchange risk premium term at time $t$. Finally, if the unexpected increase in foreign money supply is temporary and $\varepsilon_0 = 0$, we can write the previous two expressions as

$$\Delta s_t = \tilde{i}_{0,t} + \tilde{\lambda}(\tilde{m}_t - E_0\tilde{m}_t) - \tilde{\phi}(\tilde{y}_t - E_0\tilde{y}_t) - \omega_t$$

$$\Delta s_T = \tilde{i}_{t,T} - \tilde{\lambda}(\tilde{m}_t - E_0\tilde{m}_t) + \tilde{\phi}(\tilde{y}_t - E_0\tilde{y}_t) + \omega_t.$$

These expressions show that the net effect of the unexpected increase in foreign money supply, after considering the effect of a potential increase in output and the variation to the risk premium, is an immediate depreciation of the spot exchange rate of same magnitude of the subsequent long term exchange rate appreciation. Thus, the key factors that determine the overshooting of the exchange rate in the long run is the difference between $\tilde{i}_{0,t}$ and $\tilde{i}_{t,T}$, and the magnitude of the shock to the monetary, output and foreign exchange market.

4 Conclusion

The exchange rate, modeled as a result of the interactions between international asset markets, is forward looking. In particular, our theoretical analysis of departures of the exchange rate from short run equilibrium highlights the importance of the occurrence of shocks to international debt markets and to investors’ risk aversion levels. These shocks can also produce a change in investors’ expectations on the long run exchange rate. These findings stress the difficulty of the forward exchange rate for obtaining accurate forecasts of the spot exchange rate and shed further light on the empirical failure of standard regression equations to test for the validity of UIP. Related to this is our finding that there exists an uncovered interest parity condition between the risk premiums in the international bond market and in the foreign exchange market. The best predictor of the risk premium on the long run exchange rate is the expected excess return on the international bond market.
Our theory on exchange rate determination has an immediate applicability to monetary policy. The paper shows that the effects of unanticipated movements in monetary policy differ depending on the underlying risk aversion on international asset markets. If there exists risk aversion to the foreign market foreign policies to boost output are more efficient and less costly in terms of inflationary monetary measures. On the other hand, if investors are risk averse to the domestic debt market foreign monetary policies need to be more proactive and include larger inflows of money supply to compete with the extra returns offered by the domestic market. These findings gain relevance in the current economic context where the effect of quantitative easing policies is controversial. A possible line of action would be to act on economic policies that ease the magnitude of the risk premium on asset markets.
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