Exchange Rate Dynamics under Financial Market Frictions*

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Abstract

This paper extends Dornbusch's overshooting model by proposing a *generalized interest parity condition* (GIP), which captures a sluggish adjustment on the asset market. The exchange rate model under the GIP is able to reproduce the delayed overshooting and the hump-shaped response to monetary shocks of both nominal and real exchange rates. Furthermore, we present empirical results for OECD member countries which fit the theoretical predictions.

Keywords: Exchange rates; Interest rate parity; Overshooting; Purchasing power parity puzzle; Monetary policy

JEL classification: E52; F31; F41; F47

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1 Introduction

Dornbusch (1976), one of the most influential papers in international macroeconomics, presents the first model to incorporate sticky prices in an open macroeconomics model with rational expectations. According to the model, the real exchange rate should depreciate after a monetary expansion, returning to its equilibrium value over time. As for the nominal exchange rate, its initial depreciation should overshoot its long-run value, so that we would observe a nominal appreciation over the equilibrium path toward its long-run value. The model, thereby, explains the excess volatility of nominal exchange rates.

Empirical studies, however, have found exchange rate patterns conflicting with Dornbusch's predictions. According to these findings, the peak response of exchange rates to a monetary shock occurs with a delay of several months, so that both nominal and real exchange rates present a hump-shaped pattern after monetary shocks (Eichenbaum and Evans, 1995; Cheung and Lai, 2000; Kim and Roubini, 2000; Faust and Rogers, 2003; Kim, 2005; Steinsson, 2008; Scholl and Uhlig, 2008; Kalyvitis and Skotida, 2010). This result is referred in the literature as *delayed overshooting*.

Dornbusch's model relies on the uncovered interest parity (UIP) condition, which states that interest rate differentials across countries should be equal to expected currency depreciation. In reality, however, interest rate differentials are poor predictors of exchange rate behavior, which constitutes the *forward premium puzzle* (for a survey, see Lewis, 1995). Actually, most theoretical analyses in international macroeconomics assumes the validity of UIP, despite the overwhelming empirical evidence against it. Assumptions do not need to be literally true, but there is a problem when an unrealistic assumption hides mechanisms that are essential to the understanding of the issue at question. That seems to be the case here.

We propose an extension of Dornbusch (1976) in which we allow departures from UIP. More specifically, we propose a *generalized interest parity condition*, according to which excess returns in asset markets adjust sluggishly to shocks. As a result, both nominal and real exchange rates have a delayed peak response to monetary shocks, while the response dynamics also presents a hump-shaped initial response followed by a prolonged convergence period. Hence, we are able to reconcile the model with the data.

Futhermore, our model offers predictions on the response of excess returns in the assets market to monetary shocks. Such predictions are not possible with the original Dornbusch model, since it assumes that UIP is valid at all times. We investigate empirically the response of excess returns to monetary shocks, and we find that monetary shocks have a positive impact on excess returns for some countries and negative for others. We argue that this difference in responses is compatible with the observed differences in income elasticity of money demand, as predicted by our theoretical model.

A number of papers have proposed theoretical explanations for the delayed overshooting. Landry (2009) incorporates a state-dependent pricing rule in an otherwise standard new open macroeconomics model to obtain a delayed exchange rate overshooting. On a different line, Andersen and Beier (2005) and Gourinchas and Tornell (2004) assume imperfect information on whether the monetary shocks are permanent or transitory. They generate not only delayed exchange rate overshooting but also ex-post departures from UIP due to persistent forecast errors. In Bacchetta and Wincoop (2010) these empirical regularities are explained by infrequent foreign currency portfolio decisions. However, none of these papers are able to explain simultaneously nominal and real exchange rate movements.

We propose a simple model where we assume sluggish adjustment of prices and of return on financial assets, and we use it to investigate the paths of exchange rates and excess returns in the assets market following a monetary shock. In this paper we choose not to develop microfundation in order to keep the simplification spirit of Dornbusch's model and to better understand the intuition of our results. Microfoundations for our assumptions can be found in the literature. The new open macroeconomics models offer micro-foundations for price rigidities (Lane, 2001, offers an early survey of this literature, following the seminal paper of Obstfeld and Rogoff, 1995). As for departures from the UIP, undelying explanation are based on either imperfect information on the nature of the shocks, as in Andersen and Beier (2005) and Gourinchas and Tornell (2004), or on infrequent portfolio decisions, as in Bacchetta and Wincoop (2010).

Section 2 presents some stylized facts to motivate this study. In section 3 we introduce the new assumption of sluggish adjustment on the asset market, captured by the *generalized interest parity* condition, and incorporate it to the Dornbusch (1976) framework. Section 4 analyzes the effects of monetary shocks and describes the empirical predictions of the model, while some empirical evidence for the model is presented in section 5. Finally, section 6 concludes the paper.

2 Stylized Facts

The two main assumptions of the theoretical model proposed in this paper are the sluggish adjustment of prices and of excess returns of assets. We then start by looking at the pattern of departures from purchasing power parity and from interest rate parity conditions.

2.1 Purchasing power parity

There is a vast empirical literature documenting the behavior of real exchange rate (RER) over time (see Froot and Rogoff, 1995, Rogoff, 1996, Sarno and Taylor, 2002, and Taylor and Taylor, 2004). On the one hand, RERs tend to converge to purchasing power parity (PPP) at very low speeds. On the other hand, short run deviations from PPP are large and volatile. As Rogoff (1996) points out, these two characteristics of RER are hard to reconcile. Usual explanations for RER changes cannot account for both of them simultaneously.

One explanation relies on nominal shocks in an economy with sticky prices. Price rigidity would prevent prices from adjusting instantaneously to nominal shocks, so that RERs would absorb the shocks. The effect would die out with the gradual adjustment of prices. The problem with this explanation is that it does not account for the low speed of convergences to PPP. Price stickiness would have to be more long lasting than the time required for sources of rigidity such as menu cost, imperfect information or fixed wage contracts.

Alternatively, *equilibrium* RERs may change as a response to real shocks to the economy, such as terms of trade shocks or changes in international interest rates. In this case RER changes could have a longer lasting effect. However, in order to explain the high RER volatility in the short run, real shocks would have to be unrealistically frequent and large.

Cheung and Lai (2000) compute the adjustment dynamics of the real exchange rates through impulse response analysis of four European countries, including France, Germany, Italy and U.K., vis-à-vis the U.S. for the period from April 1973 to December 1996. They find that the impulse responses of real exchange rates have similar patterns: (i) they are all hump-shaped; (ii) the shock amplification period lasts for 1 to 3 months only; and (iii) the adjustment occurs afterwards, and it takes more than one year. In addition, they point out that the initial amplification of shock response, albeit it is over a very short time, is related to the half-life estimation. The large amplified initial response can produce a long half-life estimation and generate the slow adjustment even when PPP deviations are corrected at a relatively fast speed. It is important to note that this non-monotonic response of the real exchange rates is not consistent with monotonic price-adjustment behavior in Dornbusch-type sticky-price models.

2.2 Interest rate parity

It is a well-known stylized fact that there are large deviations from UIP (Hodrick, 1987; Froot and Thaler, 1990; Lewis, 1995). Some researchers report that monetary policy shocks generate deviations from the UIP that are several times larger than the resulting interest rate differential (Eichenbaum, 1995; Cushman and Zha, 1997; Kim and Roubini, 2000). In other words, excess returns are larger than interest rate differentials. Excess returns ER_{t+1}, defined as the difference between the expected return on domestic assets and on foreign assets, can be written as:

$$ER_{t+1} \equiv e_{t+1} - e_t - (i_t - i_t^*) \tag{1}$$

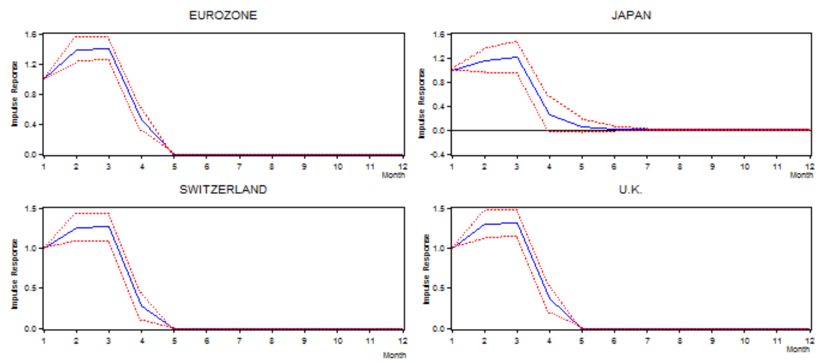
where e_t is the nominal exchange rate in period t, and i_t and i_t^* are the domestic and foreign interest rates, respectively.

We estimate impulse response functions on excess return, in the same manner as Cheung and Lai (2000) on the RER. Figure 1 presents the impulse responses on excess return of four currencies, including those of Eurozone, Japan, Switzerland and the United Kingdom, vis-à-vis the US. We use monthly data of average exchange rates and 3-month short term interest rates, for the period from January 2001 to December 2010.[1] All four excess return data are found to be stationary.

As depicted in Figure 1, we identify the following features: (i) impulse responses are all hump-shaped; (ii) the response to shocks amplifies over the first three months; and (iii) they damp out in 15 to 20 months. In fact, we compute these impulse responses to all the OECD member countries and we obtain the same results. Surprisingly, the pattern of impulse responses shown in Figure 1 is very similar to the RER adjustment dynamics reported by Cheung and Lai (2000). We use this finding to motivate our assumption in the theoretical model

[1] For Japan we have a slightly shorter period, from July 20002 to December 2010.

Figure 1: Adjustment dynamics of excess return.



developed in the next section regarding the evolution of excess returns on the assets market.

3 Theoretical Framework

We follow the structure of Dornbusch (1976) model, adding it to an alternative assumption to the UIP. More specifically, in our model economy there is sluggish adjustment both in the goods and in the asset markets. We start with the description of the asset market, and then describe the goods market, the money market, and finally the equilibrium.

3.1 The Asset Market

Most international macroeconomics models assumes free capital mobility, perfect substitutability between domestic and foreign assets, and no information problem or other sources of frictions in international financial markets. In such an environment, domestic and foreign assets should yield the same return at all times, that is, the UIP is valid and excess return in equation (1) equals zero. Empirical studies indicate that, although departures from UIP are common, excess returns do tend to be zero in the long run. We capture this empirical result by assuming a sluggish adjustment of excess returns. More specifically, we assume that excess return adjusts slowly towards the parity condition according to the following transition path:

$$ER_{t+1} = \lambda ER_t, \tag{2}$$

where a portion λ, $\lambda \in [0, 1]$, of current excess returns persists in the following period. Note that excess returns after k periods will be $\lambda^k ER_t$, so it will tend to be zero in the long run .

A larger λ means a more sluggish adjustment towards UIP. $(1-\lambda)$ can then be interpreted as the adjustment speed of excess return. We do not offer here micro-foundations for this slow adjustment of excess return. Possible explanations could be related to imperfect information on whether shocks are temporary or permanent, as suggested by Andersen and Beier (2005) and Gourinchas and Tornell (2004), or infrequent portfolio decisions, as shown in Bacchetta and Wincoop (2010).

We define $\tilde{e}_t$ as the exchange rate level that would render the UIP valid, and we call it IPER (interest rate parity exchange rate). According to this definition. the IPER $\tilde{e}_t$ shoud equal:

$$\tilde{e}_t \equiv e_{t-1} + \left(i_{t-1} - i^*_{t-1}\right). \tag{3}$$

Note that the gap between the actual exchange rate and the IPER, $e_t - \tilde{e}_t$, corresponds to the excess return in equation (1). Hence, equation (2) can be rewritten as:

$$e_{t+1} - \tilde{e}_{t+1} = \lambda \left(e_t - \tilde{e}_t\right), \tag{4}$$

or, substituting $\tilde{e}_{t+1}$ is the equation above by definition (3), we get:

$$e_{t+1} - e_t = \lambda \left(e_t - \tilde{e}_t\right) + \left(i_t - i^*_t\right) \qquad \text{(GIP)} \tag{5}$$

We denote equation (5) the *generalized interest parity* (GIP) condition, which allows for sluggish adjustment of excess return. Compared to the traditional UIP condition, the GIP condition has the additional term $\lambda(e_t - \tilde{e}_t)$, which captures the persistent component of past excess returns. The UIP can be seen as a special case of GIP, where $\lambda = 0$.

Note that, according to (4), we have that $\underset{k\to\infty}{lim} \left(e_{t+k} - \tilde{e}_{t+k}\right) = \underset{k\to\infty}{lim} \lambda^k \left(e_t - \tilde{e}_t\right) = 0$, that is, in the long run equation (5) boils down to the traditional interest parity condition. In the short run, however, there is some persistence of excess returns.

3.2 The Goods Market

Following Dornbusch (1976), we assume that there is slack capacity in the economy so that its activity level is demand determined. Aggregate demand for domestic output, y_t^d, is assumed to be an increasing function of the real exchange rate, q_t, and it is equal to its "natural" rate, $\bar{y}$, when the RER is at its equilibrium level, $\bar{q}$. That is:

$$y_t^d = \bar{y} + \delta \left(q_t - \bar{q} \right), \ \delta > 0. \tag{6}$$

where the real exchange rate is defined as:

$$q_t \equiv e_t + p_t^* - p_t, \tag{7}$$

where p_t and p_t^* are domestic and foreign prices, respectively. p_t^* is assumed to be constant.

If prices were fully flexible, the RER would be at its equilibrium level at all times, $q_t = \bar{q}$, and, consequently, output would remain at its natural level. However, we assume that prices are sticky in the short-run. We follow the price adjustment rule suggested by Mussa (1982), according to which price adjusts under the influence of following two forces. On the one hand, it adjusts to gradually eliminate the excess demand, and, on the other hand, it responds to changes in its own equilibrium path, as in:

$$p_{t+1} - p_t = \varphi \left(y_t^d - \bar{y} \right) + \left(\tilde{p}_{t+1} - \tilde{p}_t \right), \tag{8}$$

where $\tilde{p}_t$ represents the price level compatible with the long run equilibrium both in goods and in asset market, given the state of the economy at time t. In terms of our model, this means the price level that renders the RER equals to its equilibrium level $\bar{q}$, given the IPER, that is, the nominal exchange rate compatible with the UIP. Hence:

$$\tilde{p}_t \equiv \tilde{e}_t + p_t^* - \bar{q}. \tag{9}$$

By substituting the definition of equilibrium prices, equation (9), with the price adjustment, equation (8), and using the aggregate demand, equation (6), we get the price adjustment path:

$$p_{t+1} - p_t = \varphi\delta \left(q_t - \bar{q} \right) + \tilde{e}_{t+1} - \tilde{e}_t. \tag{10}$$

Note that the second term of the price adjustment path (10), the change in IPER, would be simply the nominal exchange rate devaluation in a model with no frictions in the asset market. The reason being that, in that case, the actual nominal exchange rate is the one consistent with UIP. Here, this is not necessarily true. An excess return caused by a shock in the economy will persist over time, so that the nominal exchange rate will no longer be the one that yields UIP.

By subtracting the term $(e_{t+1} - e_t)$ from both sides of equation (10), using equation (4) and (7), we get the equilibrium path for the RER:

$$q_{t+1} - q_t = -\varphi\delta\left(q_t - \bar{q}\right) - (1 - \lambda)\left(e_t - \tilde{e}_t\right) \tag{11}$$

Under UIP, we have that $q_{t+1} - q_t = -\varphi\delta(q_t - \bar{q})$, and shocks to RER should damp out monotonically over time, given that $\varphi\delta < 1$. Nevertheless, as we have seen in the previous section, empirical findings unveil non-monotonic dynamic responses of the RER (Cheung and Lai, 2000). The adjustment term $(1 - \lambda)\left(e_t - \tilde{e}_t\right)$ in equation (11), which does not exist if we assume the UIP condition, is a possible answer to such non-monotonic responses. Hence, the sluggish adjustment on the asset market is reflected on the RER path. According to this term, a positive excess return on foreign assets, that is, an actual nominal exchange rate more devalued than the IPER, would cause an appreciation of the RER. This means that sluggish adjustment on the asset market increases the short-term volatility and the adjustment time of the RER.

3.3 The Money Market

Money market equilibrium requires that money demand equals its supply. As usually seen in the literature, we assume that money demand is a negative function of interest rates and positive function of real income. The equilibrium condition in the money market is then given by:

$$m_t - p_t = -\eta i_t + \phi y_t \tag{12}$$

where m_t represents nominal money supply.

Substituting the interest rate in equation (12) for the GIP condition, equation (5), (6), and (12) can be rewritten as:

$$m_t - e_t + q_t = -\eta \left[e_{t+1} - e_t - \lambda \left(e_t - \tilde{e}_t \right) \right] + \phi\delta \left(q_t - \bar{q} \right)$$

where international prices and interest rates are assumed constant for simplicity. Furthermore, units are chosen so that $p^* = i^* = \overline{y} = 0$. Finally, rewriting the equation above we get the following equation:

$$e_{t+1} - e_t = \frac{e_t}{\eta} + \lambda \left(e_t - \tilde{e}_t \right) - \frac{\left(1 - \phi\delta \right) q_t}{\eta} - \frac{\phi\delta\bar{q} + m_t}{\eta} \tag{13}$$

Note that, compared to the traditional Dornbusch model, equation (13) includes a new term: $\lambda(e_t - \tilde{e}_t)$. Hence, in our model the sluggish adjustment of excess return on the asset market is reflected on the paths of both nominal and real exchange rates, in equations (13) and (11), respectively.

3.4 Equilibrium

We have a system of two first-order difference equations, for q and e in equations (11) and (13), respectively, and the convergence path of excess return in equation (4).

The economy is in a steady state when nominal and real exchange rates are stationary, that is, when $q_{t+1} - q_t = e_{t+1} - e_t = 0$. From equation (11), we then have that, in steady state:

$$q_t = \bar{q} - \frac{1 - \lambda}{\varphi\delta} \left(e_t - \tilde{e}_t \right), \tag{14}$$

and from equation (13), we have:

$$e_t = \frac{1 - \phi\delta}{1 + \eta\lambda} q_t + \frac{1}{1 + \eta\lambda} \left(\phi\delta\bar{q} + m_t \right) + \frac{\eta\lambda}{1 + \eta\lambda} \tilde{e}_t. \tag{15}$$

Finally, the nominal exchange rate must equal the IPER in a steady state, so that excess return is zero:

$$e_t = \tilde{e}_t. \tag{16}$$

Combining equations (14), (15) and (16), we have that, in steady state:

$$\bar{e} = \bar{m} + \bar{q},$$
$$\tilde{e} = \bar{e} \text{ and}$$
$$\bar{p} = \bar{m}.$$

Figure 2: Exchange rates dynamics

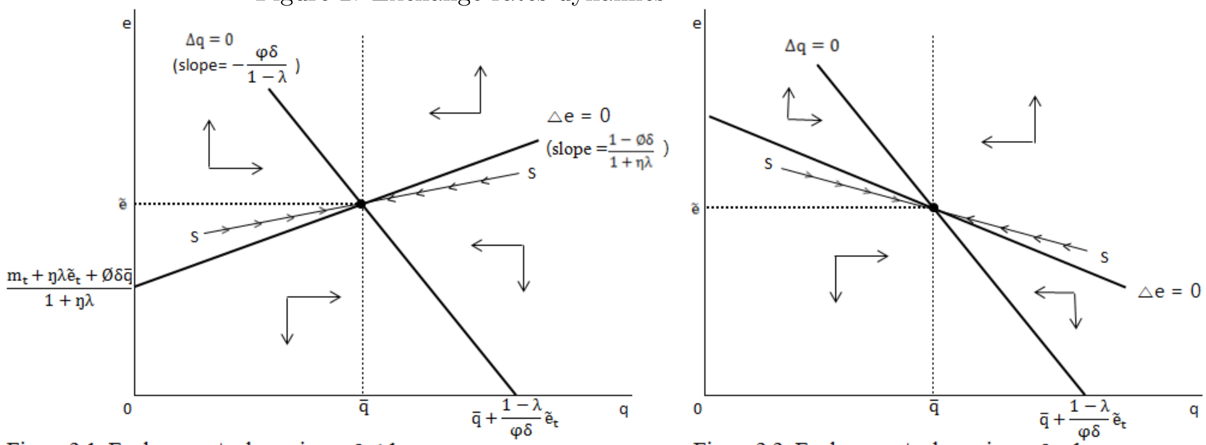


Figure 2.1 Exchange rate dynamics : $\varnothing\delta < 1$

Figure 2.2 Exchange rate dynamics : $\varnothing\delta > 1$

Figures 2.1 and 2.2 depict the system dynamics, based on equations (11) and (13). The system has a unique path that converges to the steady state, saddle path SS. The locus for stationary RER, defined in equation (14), is represented by the downward sloping $\triangle q = 0$ schedule in both figures. As for the nominal exchange rate, the set of points in which it is stationary may form either upward or downward sloping curve, depending on the sign of $1 - \phi\delta$, as indicated in equation (15). Figure 2.1 represents the case where $\phi\delta < 1$, which defines the upward-sloping line $\triangle e = 0$, whereas the opposite case is in Figure 2.2. In both schedules, the $\triangle e = 0$ line intercepts the vertical axis at $e = \frac{1}{1+\eta\lambda}(\phi\delta\bar{q} + m_t + \eta\lambda\tilde{e}_t)$.

Note that the $\triangle q = 0$ and $\triangle e = 0$ schedules are drawn for a given value of $\tilde{e}_t$, which is not necessarily its long-run equilibrium value $\tilde{e} = \bar{e} = \bar{m} + \bar{q}$. Hence, these schedules shift as $\tilde{e}_t$ approaches its equilibrium value. The steady state point lies at the intersection of the $\triangle q = 0$ and $\triangle e = 0$ lines for $\tilde{e} = \bar{m} + \bar{q}$.

Higher persistence of excess returns λ (see equation (2)) generates a steeper $\triangle q = 0$ schedule and a flatter $\triangle e = 0$ one. Note that in the case of no persistence of excess returns, i.e. for $\lambda = 0$, we recover Dornbusch (1976) model: both the $\triangle e = 0$ and $\triangle q = 0$ schedules would coincide with the one from the original Dornbusch model, since the IPER and the actual nominal exchange rates would be equal at all times, $\tilde{e} = e$.

4 Monetary Shocks

In this section, we investigate the adjustment dynamics of exchange rates in response to monetary shocks. As we have seen in the previous section, our assumption of sluggish adjustment of excess returns plays a key role in both nominal and real exchange rate dynamics. Although the long-run steady state equilibrium is exactly the same as Dornbusch (1976) model, the short-term dynamics is fairly different. To help with intuition, we start with a graphical description of the effect of a monetary shock. We then show the dynamics through a numerical simulation of the model. We separate the analysis for the two possible cases for the slope of the $\triangle e = 0$ schedule: $\phi\delta < 1$ or $\phi\delta > 1$. Notice that $\phi\delta$ measures the indirect impact of the RER on money demand, through its impact on output.

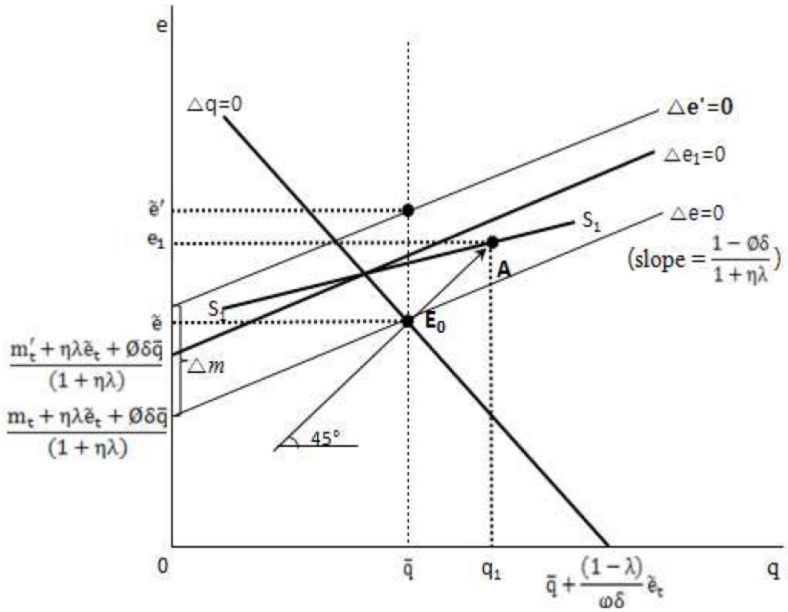
4.1 Exchange rate overshooting case: $\phi\delta < 1$

In Figure 3, the initial point E_0 is the original steady state where $\bar{e} = \bar{q} + \bar{m}$ and $\tilde{e} = \bar{e}$. The $\triangle e = 0$ schedule is upward sloping given that $\phi\delta < 1$. This assumption means that the money demand is not too responsive to output (low ϕ) and aggregate demand is not very sensitive to RER changes (low δ). This corresponds to the case of exchange rate overshooting in response to monetary shocks.

Suppose that an unanticipated expansionary monetary shock hits the economy, so that the money supply jumps once and for all to $\bar{m}'$, so that $\triangle m \equiv \bar{m}' - \bar{m} > 0$. Immediately, the $\triangle e = 0$ schedule shifts upward to $\triangle e_1 = 0$, consistent with the new money supply. From equation (15), we note that the upward-shift of the $\triangle e = 0$ schedule, given by $\frac{\triangle m}{1+\eta\lambda}$, is smaller than the monetary shock $\triangle m$, as shown in Figure 3. The higher the persistence rate of excess returns λ, the smaller the initial shift of this curve is.

Meanwhile, the $\triangle q = 0$ schedule does not shift immediately, since $\tilde{e}_t$ has been determined at time $t-1$ and the money supply has no direct effect on that schedule. Thus the real and nominal exchange rates jumps to the point A in Figure 3, which is on the 45° arrow at the intersection of the new saddle path S_1S_1. Note that this is not the actual path towards the new long-run equilibrium. This saddle path is the one corresponding to the exchange rates dynamics for a given value of the IPER $\tilde{e}_t$, which also adjusts along the path to

Figure 3: Monetary shock: initial response ($\phi\delta < 1$)



the new equilibrium. Hence, as the nominal exchange rate approaches the IPER, the position of the two stationary curves and the corresponding the saddle path shift over time.[2]

Figure 4 shows the next steps in the adjustment dynamics towards the long run equilibrium. The nominal exchange rate devaluation from $\bar{e}$ to e_1 causes a devaluation of the IPER for the next period (see equation (3)). Both the $\triangle e = 0$ and the $\triangle q = 0$ schedules shift upwards in proportion to $\tilde{e}_t$, causing further devaluation of the real and nominal exchange rates. The upward shift continues during the asset market adjustment. Note that there is a delayed overshooting of the nominal exchange rate: the initial exchange rate devaluation is lower that the final devaluation in the long-run, but the devaluation continues to surpass its long-run value. The upward-shifting stops when it reaches the saddle path $S'S'$, in which the IPER is equal to its long-run steady state value, which is, $\tilde{e}' = \bar{m}' + \bar{q}$. The devaluation then stops and the exchange rate appreciates to converge to the new steady state E_1 along the saddle path $S'S'$.

[2]Note that the position of the stationary curves shifts over time, as well as the saddle path. The intention of the analysis we make here is just to build some intuition about the problem. The simulation results in Figure 5 confirm the exchange rate path we propose here.

Figure 4: Monetary shock: adjustment dynamics ($\phi\delta < 1$)

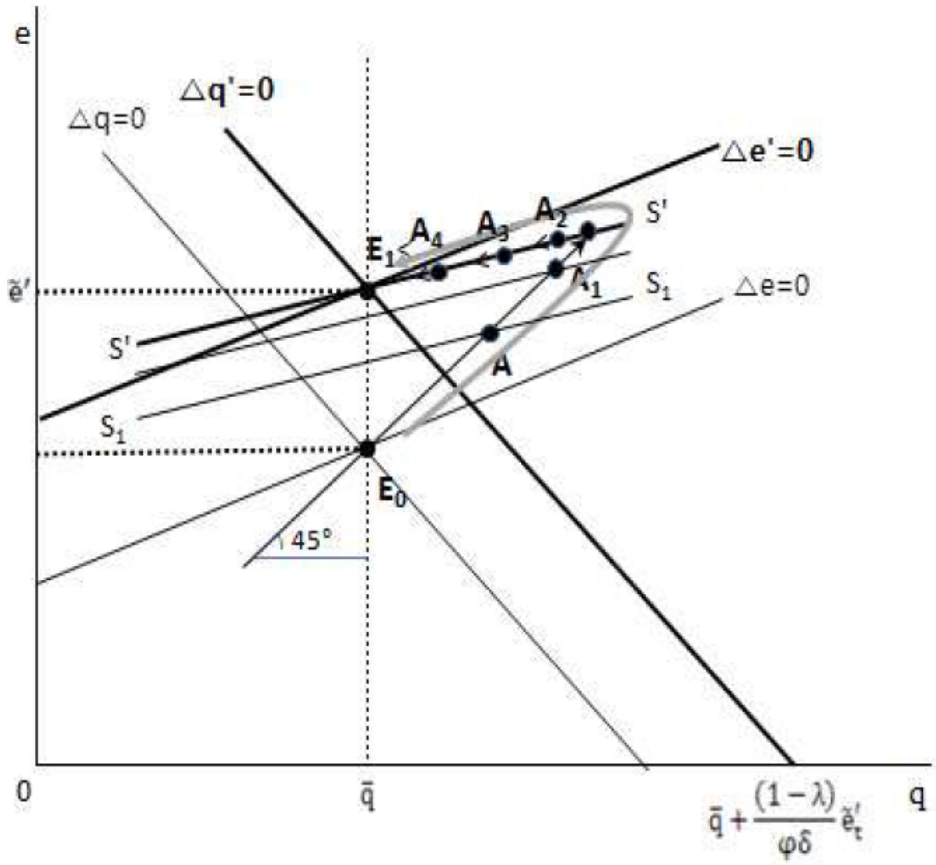


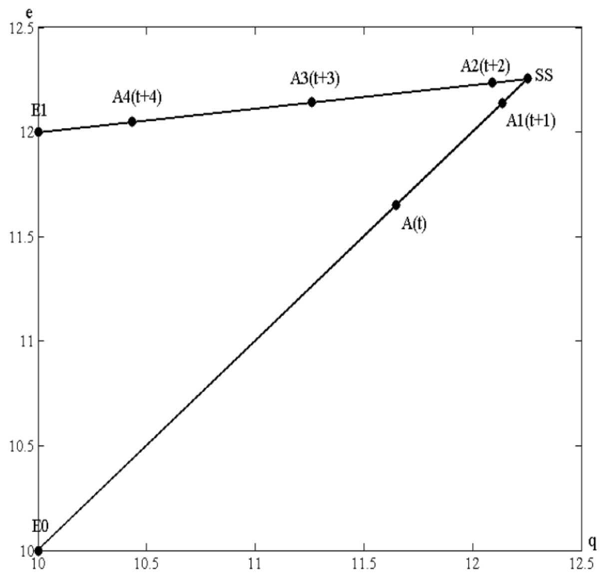
Figure 5 presents a numerical simulation of the model. The parameters used for the simulation are presented in Table 1. As we see in the figure, in response to an expansionary monetary shock on the initial steady state E_0, the exchange rate jumps immediately to $A(t)$, which is lower than its long-run steady state level. It then continues to increase to $A_1(t+1)$ along the 45º line. Eventually the nominal exchange rate overshoots its long run value E_1. Note that this delay in the peak response to the shock is compatible with the empirical findings in the literature. After reaching the saddle path SS, it starts to appreciate to converge on new steady state, and finally arrives at E_1. From the initial point E_0 to the new steady state E_1, the adjustment time takes five periods in this simulation.

The RER, on its turn, has an initial depreciation at the moment of the

Table 1: Parameter values for $\phi\delta < 1$

	Parameter	Value
Persistence of excess return	λ	0.7
Real exchange rate elasticity of domestic output	ϕ	0.8
Income elasticity of money demand	δ	1.0
Interest elasticity of money demand	η	0.5
Price adjustment to the excess demand	φ	0.8

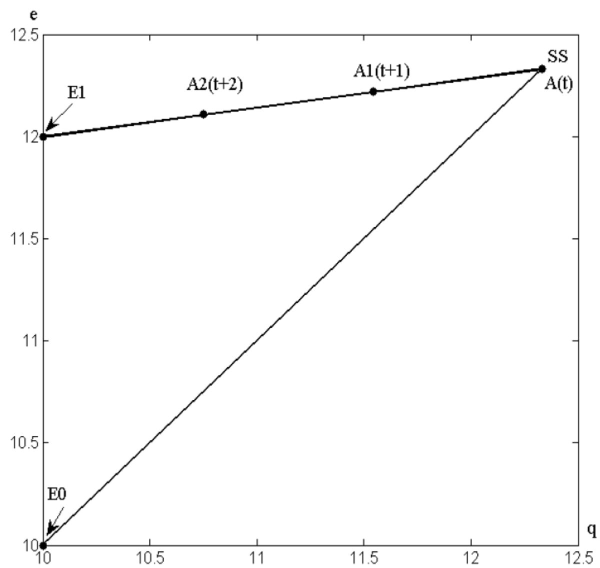
Figure 5: Simulation: expansionary shock ($\phi\delta < 1$)



shock, and then it continues depreciating during the adjustment period in the asset market. Here, also, there is a delay in its peak response to the monetary shock. After the adjustment in the asset market is completed, the RER begins to appreciate and subsequently returns to its long term equilibrium value $\bar{q}$.

For the sake of comparison, we present the simulation for Dornbusch model in Figure 6. All the conditions are the same as those of Figure 5, except for the persistence rate λ which is set to zero to be consistent with the UIP assumption. In response to the expansionary shock in money supply, the exchange rate immediately jumps up to the new saddle path $A(t)$, with an immediate overshooting. It then starts appreciating along the saddle path to converge to its long-run steady state value, and finally reaches the new steady state $E1$. From

Figure 6: Simulation Dornbusch model: expansionary shock ($\phi\delta < 1$)



the initial point $E0$ to the steady state $E1$, the economy takes three periods.

4.2 Exchange rate undershooting case: $\phi\delta > 1$

Figure 7 describes the effect of an expansionary monetary shock under the assumption that $\phi\delta > 1$, which means an amplified impact of RER on aggregate demand. In the original Dornbusch model with no frictions in the asset market, there was undershooting of the exchange rate in this case.

The $\triangle e = 0$ schedule is downward sloping and its slope is steeper than the saddle path. When an expansionary monetary shock hits the economy, the exchange rate, which was initially in steady state E_0, jumps up to A immediately but does not reach the new saddle path $S'S'$ due to the sluggish adjustment on the asset market. It continues depreciating until reaching the saddle path $S'S'$, in which the exchange rate is equal to the IPER, i.e. $e = \tilde{e}$. At that point, the RER is still more appreciated in comparison to the new steady state level, that is, there is no overshooting. The upward shifting of both the $\triangle e = 0$ and $\triangle q = 0$ schedules stop at the intersection of the new saddle path $S'S'$ and the exchange rate converges to the new steady state E_1 along the $S'S'$. The nominal exchange rate dynamics does not overshoot with respect to its new steady state value.

Figure 7: Monetary shock: adjustment dynamics ($\phi\delta > 1$)

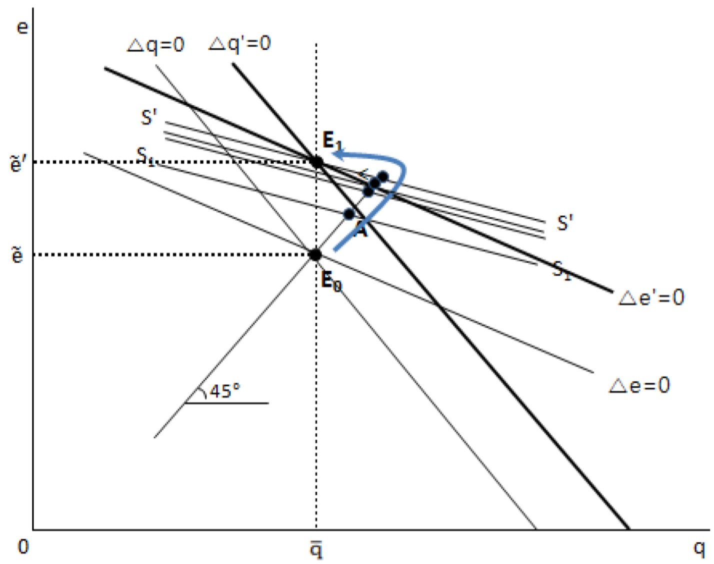


Table 2: Parameter values for $\phi\delta > 1$

	Parameter	Value
Persistence of excess return	λ	0.6
Real exchange rate elasticity of domestic output	ϕ	1.3
Income elasticity of money demand	δ	1.2
Interest elasticity of money demand	η	0.2
Price adjustment to the excess demand	φ	0.8

As for the RER, it follows a pattern similar to the previous case: its peak response to the monetary shock is delayed. There is an initial devaluation at the moment of the shock. The RER continues devaluing while asset market adjusts, and then it appreciates to go back to its steady state value.

Figure 8 presents the result of the numerical simulation of this case, for the parameter values in Table 2. As we can see from the figure, the nominal exchange rate dynamics depreciates monotonically towards its long-run steady state value, while the RER depreciates initially and continues to depreciate for a couple of periods, and then appreciates until reaching its long-run value. Hence, the RER has a non-monotonic response to the monetary shock, just as in the previous case.

Figure 8: Simulation: expansionary monetary shock ($\phi\delta > 1$)

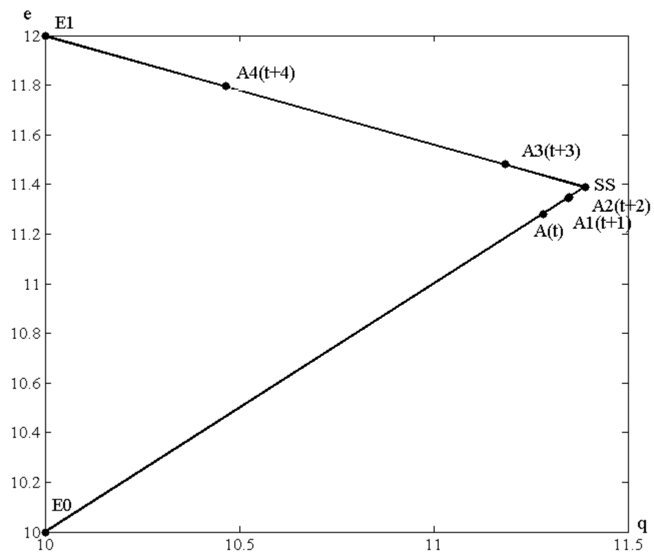


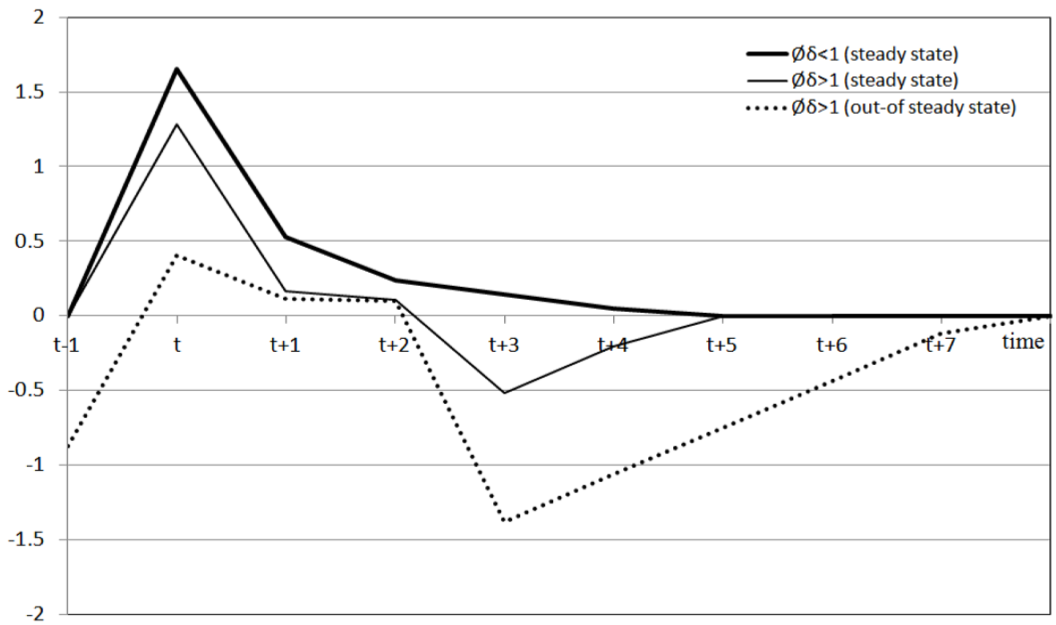
Figure 4.2 simulation : Expansionary Monetary Shock

4.3 Empirical Predictions

Sections 4.1 and 4.2 describe the adjustment dynamics of exchange rates in response to monetary shocks. In sum, the empirical predictions from the model are the following. For the overshooting case, i.e. $\phi\delta < 1$, the model predicts, for both real and nominal exchange rates, (i) a delayed peak response to monetary shocks; (ii) a non-monotonic path towards the long-run equilibrium, since they have depreciating periods followed by appreciating ones. As for the undershooting case, when $\phi\delta > 1$, we have the same type of pattern as the one described above for the RER, that is, (i) a delayed peak and (ii) non-monotonic response to monetary shocks. As for the nominal exchange rate, its response is monotonic, with no overshooting.

Besides the predictions on real and nominal exchange rate dynamics, our model makes also predictions regarding the dynamics of excess returns of foreign assets. Note that Dornbusch model has nothing to say in this respect, since it assumes UIP. Figure 9 presents dynamics of excess return in response to an expansionary monetary shock. The thick solid line represents the excess return for the overshooting case where $\phi\delta < 1$, whose exchange rate paths are depicted in Figure 5. The excess return jumps at the moment of the monetary expansion, and then it decreases continually until reaching zero at $t + 5$ when

Figure 9: Excess return dynamics



the economy reaches a new steady state. Over the whole transition path to the new equilibrium, the excess return is positive and decreases.

The thin solid line in Figure 9 depicts the excess return dynamics in the undershooting case where $\phi\delta > 1$, for which the exchange rate paths are in Figure 8. The excess return initially jumps as in the previous case, and then starts to decrease. The interesting feature of this case is that there is an *overshooting of excess return*: it decreases greatly that it becomes negative in the path to the new steady state. It then increases gradually back to zero when the economy reaches the steady state.

We also compute the excess return dynamics when the economy is initially out of the steady state, which is represented in the dotted line. We consider the situation where the economy is hit by a new monetary expansion when it is still on the transition path from the previous monetary expansion, for the case with $\phi\delta > 1$. Hence, we take an initial point with negative excess return. After the initial jump provoked by the new monetary expansion, excess return start to decrease and becomes negative. The lenght of time to reach a new steady state is considerably longer: eight periods $(t + 8)$, compared to five periods $(t + 5)$ in the cases starting from a steady state point.

Overall, excess return initially jumps in response to a monetary shock and then decreases. It is always positive on the transition path in the overshooting case where $\phi\delta < 1$, whereas it becomes negative at some point for the opposite case, with $\phi\delta > 1$.

5 Empirical Evidence

We now investigate the relation between excess returns and monetary shocks for OECD member countries. We choose OECD countries since they have open capital markets and constitute a more homogenous group of countries, whose assets should be closer substitutes compared with those from developing countries, for instance.

5.1 Methodology and Data

We use monthly average exchange rates, short-term interest rates (3-month) and central bank target rates for the period from January 2001 to December 2010. The data set is from the OECD statistics, International Financial Statistics of the International Monetary Funds and individual central banks.[3]

We compute excess return as follows:

$$ER_{t+3} = e_{t+3} - e_t - (i_t - i_t^*), \tag{17}$$

where a 3-month lag for exchange rates is applied to be compatible with the 3-month interest rate used for short-term interest rate. Excess returns are computed to each country vis-à-vis the US. We have a total of eighteen individual countries plus the Eurozone. The excess return data series pass unit root tests, so they seem free from non-stationarity issues.

We regress the excess return on monetary shocks, as in:

$$ER_t = \alpha_0 + \alpha_1 MS_t + \mu_t \tag{18}$$

where MS_t represents monetary shocks and μ_t are idiossincratic shocks. The monetary shock is defined as the change in monetary policy over the previous

[3] For Chile, Japan and Mexico we have slightly shorter periods: 01/2001 to 06/2008 for Chile, 07/2002 to 12/2010 for Japan, and 03/2008 to 12/2010 for Mexico. Also, we use treasury bill rates for Hungary and money market rates for Turkey.

three months. We capture it by the difference between the central bank target rate at period t and the average target rate over the previous three months, that is:

$$MS_t = -\left[i_t - \frac{1}{3} \sum_{\tau=-3}^{-1} i_\tau \right].$$

Note that we change the sign of the interest rate change, so that a monetary expansion appears as a positive value for the variable MS.

In regression (18), a positive sign for parameter α_1 means that positive excess returns are associated to expansionary monetary shocks. Conversely, a negative sign for α_1 implies negative excess return after a monetary shock. According to our predictions in Figure 9, a positive estimated value for α_1 would correspond to the overshooting case of $\phi\delta < 1$, while a negative estimated value would refer to the non-overshooting case of $\phi\delta > 1$.

5.2 Empirical Results

Table 3 presents the result of regression (18). We divide the countries into three groups according to the sign of the estimated coefficient of excess returns α_1, as shown in the first column of the table. For countries in Group I (Australia, Canada, Eurozone, Korea, New Zealand, Norway, Sweden and UK), the estimated value of coefficient α_1, presented on the forth column of the table, is found to be positive and significant. The coefficient is negative for countries in Group II (Chile, Denmark, Hungary, Iceland and Japan). Finally, excess returns are not significantly correlated to monetary shocks for countries in Group III (Czech Republic, Israel, Mexico, Poland, Switzerland and Turkey).

For a closer look at the data, we divided the periods into those with no change in monetary policy, those under expansionary monetary shocks and those under contractionary monetary policy. We then computed the average excess return across these different periods, as reported in Table 4. The average excess return when there is no change in monetary policy, presented in column A of the table, can be considered as the average risk premium for the country, compared to the US. Column B presents average excess return under expansionary monetary shocks, while the difference between these average excess returns and the ones in normal times is presented in column (B-A). We can see from the table that, when hit by an expansionary monetary shock, countries in Group I tend to have higher excess returns while those in Group II tend to be lower. For monetary

Table 3: Estimation results: Excess Returns

Table 3. Excess Return = α_0 + α_1(Monetary Policy Change Index)

(Monthly data, Jan 2001~Dec 2010, OLS estimation)

Group	Country	α_0	α_1	R^2	Ø
A	Australia	-0.045 ***	11.510 ***	0.323	1.056
		(-8.31)	(7.50)		
	Canada	-0.017 ***	6.023 ***	0.207	1.181
		(-4.50)	(5.55)		
	EU	-0.016 ***	5.076 **	0.039	1.070
		(-3.18)	(2.19)		
	Korea	-0.021 ***	14.981 ***	0.227	1.130
		(-4.32)	(5.89)		
	New Zealand	-0.053 ***	7.665 ***	0.230	0.537
		(-9.75)	(5.94)		
	Norway	-0.029 ***	2.978 **	0.037	0.821
		(-4.85)	(2.13)		
	Sweden	-0.009	2.837 **	0.050	0.990
		(-1.54)	(2.49)		
	UK	-0.024 ***	8.190 ***	0.352	0.930
		(-6.06)	(8.00)		
B	Chile	-0.021 ***	-2.802 ***	0.145	2.130
		(-4.15)	(-4.38)		
	Denmark	-0.012 **	-3.458 **	0.043	1.560
		(-2.45)	(-2.30)		
	Hungary	-0.065 ***	-2.460 ***	0.062	1.764
		(-9.17)	(-2.80)		
	Iceland	-0.066 ***	-3.844 ***	0.175	1.774
		(-8.67)	(-5.00)		
	Japan	0.009 *	-36.230 ***	0.179	1.750
		(1.88)	(-4.67)		
C	Czech Republic	-0.024 ***	3.242	0.014	0.710
		(-3.76)	(1.27)		
	Israel	-0.022 ***	0.718	0.012	1.125
		(-5.20)	(1.17)		
	Mexico	-0.033 **	-3.628	0.045	4.079
		(-2.13)	(1.20)		
	Poland	-0.050 ***	-1.034	0.005	2.142
		(-5.77)	(-0.74)		
	Switzerland	0.000	-0.854	0.003	1.495
		(-0.04)	(-0.56)		
	Turkey	-0.258 ***	0.210	0.000	1.000
		(-6.88)	(0.10)		

Note: *t*-statistics in parenthesis. *significant at 90%,**significant at 95%,***significant at 99%
Ø income elasticity of money demand (*See Appendix 2*)

Source: OECD. IMF. Central banks

contractions, presented in columns C and (C-A), the results are exactly the opposite: Group I countries have lower excess returns and Group II countries higher ones during monetary contraction. These averages are consistent with the estimation results in Table 3.

According to our analytical prediction in the previous section, countries in Group I should be in the overshooting case $\phi\delta < 1$, whereas those in Group II should be in the non-overshooting case $\phi\delta > 1$. Ideally, we would like to check both the income elasticity of money demand ϕ and the RER elasticity of domestic output δ if this is actually the case. However, accurate estimates of RER elasticity of output are not available. We do find in the literature estimates of income elasticity of money demand, and we report them in the last column of Table 3.[4] We observe that the values for the income elasticity of money demand ϕ of Group I countries are all smaller than those of Group II countries. Moreover, the reported values of Group II countries are all lager than 1.5.

As for Group III countries, with estimates of α_1 not significantly different from zero, we can find some interesting features. Czech Republic, Israel and Turkey have positive estimates for α_1 (although not statistically significant) and they also have small value of ϕ, just as Group I countries. Conversely, Mexico, Poland and Turkey have negative estimates of α_1, and they present higher values of ϕ, just as Group II countries. We conjecture that Group III countries may have similar patterns as those of Group I and Group II.

In sum, the empirical results for the OECD member countries are consistent with our predictions.

6 Conclusion

We extend Dornbusch's exchange rate overshooting model, by allowing a sluggish adjustment of excess returns in the assets market is a similar fashion to the sluggish adjustment of prices. More specifically, we replace the uncovered interest parity conditions by a *generalized condition*, according to which assets present excess returns after a shock that gradually dispear over time.

[4] Brouwer and Subbaraman, 1993; Atta-Mensah, 2004; Greiber and Setzer, 2007; Lee, 1995; Cassino and Misich, 1997; Eitrheim, 1998; Lybeck, 1975; Fisher, Hudson and Pradhan, 1993; Bahmani, 2010; Butter and Dijken, 1997; Dritsakis, 2011; Cornelius, 1990; Fujiki, Hsiao and Shen, 2002; Komárek and Melecký, 2001; Offenbacher and Kamel, 2007; Arrau and Gregorio, 1993; Bahmani-Oskooeea, Kutanb and Xic, 2013; Fischer, 2006; Saatçioğlu and Korap, 2007

Table 4: Average excess returns across periods

Table 4. Exchange Rate Gap ; e - ẽ

(Monthly data, Jan. 2001~Dec. 2010)

Group	Country	Average		Monetary policy change					Frequency		CAI[1)]
				No change	Expansionary		Contractionary		Expan-sionary	Contrac-tionary	
				A	B	(B-A)	C	(C-A)			
A	Australia	-0.042	***	-0.047	0.025	(0.072)	-0.070	(-0.023)	20	36	9
A	Canada	-0.012	***	-0.018	0.017	(0.035)	-0.027	(-0.009)	24	18	6
A	EU	-0.013	***	-0.016	0.038	(0.054)	-	-	7	0	
A	Korea	-0.017	***	-0.024	0.071	(0.095)	-0.022	(0.001)	9	6	19
A	New Zealand	-0.049	***	-0.056	0.013	(0.069)	-0.067	(-0.011)	15	19	14
A	Norway	-0.027	***	-0.028	-0.023	(0.005)	-0.026	(0.002)	18	20	16
A	Sweden	-0.008		-0.010	0.019	(0.029)	-0.015	(-0.005)	9	9	10
A	UK	-0.016	***	-0.023	0.027	(0.050)	-0.037	(-0.015)	19	10	2
B	Chile	-0.022	***	-0.016	-0.041	(-0.024)	-0.015	(0.002)	31	42	25
B	Denmark	-0.014	***	-0.014	-0.027	(-0.013)	0.011	(0.026)	24	12	12
B	Hungary	-0.068	***	-0.066	-0.075	(-0.009)	-0.058	(0.008)	40	16	33
B	Iceland	-0.070	***	-0.070	-0.111	(-0.041)	-0.019	(0.051)	25	21	24
B	Japan	0.009	*	0.010	-0.087	(-0.097)	0.056	(0.046)	2	2	18
C	Czech Republi	-0.022	***	-0.024	-0.019	(0.004)	-0.011	(0.013)	20	11	38
C	Israel	-0.021	***	-0.025	-0.026	(-0.001)	-0.011	(0.014)	47	36	22
C	Mexico	-0.040	***	-0.029	-0.055	(-0.026)	-0.085	(-0.056)	7	3	49
C	Poland	-0.047	***	-0.049	-0.043	(0.006)	-0.050	(-0.002)	30	10	44
C	Switzerland	-0.001	***	-0.003	0.000	(0.003)	0.020	(0.023)	10	10	7
C	Turkey	-0.257	***	-0.262	-0.219	(0.043)	-0.155	(0.107)	12	1	62

Source: OECD, IMF, Central banks

Note: *significant at 90%,**significant at 95%,***significant at 99%

1) Capital Access Index (2001~2009), *Milken Institute*

We show that, with this modification, the model better fits empirical evidence. We are able to explain the delayed overshooting and the hump-shaped response of nominal and real exchange rates to monetary shocks.

We estimate the reponse of excess returns of financial assets for OECD member countries, and our results are compatible with our theoretical predictions. More specifically, we show that, for countries with smaller income elasticity of money demand, excess returns respond positively to monetary shocks, whereas for countries with higher elasticity excess returns decrease with a positive monetary shock.

References

[1] Alvarez, F., Atkeson. A. Kehoe, P. J., (2007) "If Exchange Rates Are Random Walks, Then Almost Everything We Say about Monetary Policy Is wrong," *The American Economic Review*, Vol 97, No.2 (May), pp. 339-345

[2] Andersen, T. M., Beier, N. C., (2005) "International transmission of transitory and persistent monetary shocks under imperfect information," *Journal of International Economics*, Elsevier, vol. 66(2), pp. 485-507

[3] Arrau, P., Gregorio, J. de, (1993) "Financial Innovation and Money Demand: Application to Chile and Mexico," *The Review of Economics and Statistics*, Vol. 75, No. 3

[4] Atta-Mensah, J., (2004) "Money Demand and Economic Uncertainty," Working Paper 2004-25*, Bank of Canada*

[5] Bahmani-Oskooeea, M., Kutanb, A. M., Xic, D., (2013) "The Impact of Economic and Monetary Uncertainty on the Demand for Money in Emerging Economies," *Submitted to Applied Economics*

[6] Bahmani. S., (2010) "Openness and the speed of adjustment in the money market," *Journal of Economic and Finance* 34

[7] Brouwer, G. de, Ng, I., Subbaraman, R., (1993) "The Demand for Money in Australia: New Tests on an Old Topic," *Research Discussion paper*, Reserve Bank of Australia

[8] Butter F. A. G. den, Dijken, S. van, (1997) "The Information Contents of Aggregated Money Demand in the EMU," *Open economies review,* Volume 8, No. 3

[9] Cassino, V., Misich, P., (1997) "Forecasting the demand for currency," *Reserve Bank of New Zealand*, *Reserve Bank Bulletin*, Vol. 60, No. 1

[10] Cheung,Y-W., Lai, K. S., (2000) "On the purchasing power parity puzzle," *Journal of International Economics,* 52, pp. 321-330

[11] Cornelius, P. K., (1990) "Monetary Indexation and Revenues from Money Creation: The Case of Iceland," *Staff Papers - International Monetary Fund*, Vol. 37, No. 4

[12] Cushman, D.O., Zha, T., (1997) "Identifying monetary policy in a small open economy under flexible exchange rates," *Journal of Monetary Economics*, Vol. 39, pp. 433-448

[13] Dornbusch, R., (1976) "Expectation and Exchange Rate Dynamics," *Journal of Political Economy*, Vol. 84, No. 6, pp.1161-1176,

[14] Dritsakis, N., (2011) "Demand for Money in Hungary: An ARDL Approach," *Review of Economics and Finance*, No. 5

[15] Eichenbaum, M., Evans, C., (1995) "Some empirical evidence on the effects of shocks to monetary policy on exchange rates," *Quarterly Journal of Economics*, 110, pp. 975-1010

[16] Eitrheim, O., (1998) "The demand for broad money in Norway, 1969-1993," *Central Bank of Norway, Empirical Economics,* 23

[17] Engel, C., (1996) "The Forward Discount Anomaly and the Risk Premium: A survey of Recent evidence," *Journal of Empirical Finance*, Vol. 3, pp.123-192

[18] Faust, J., Rogers, J. H., (2003) "Monetary policy's role in exchange rate behavior," *Journal of Monetary Economics*, 50, pp. 1403-1424

[19] Fischer, A. M., (2006) "Measuring Income Elasticity for Swiss Money Demand: What do the cantons say about financial innovation?" *Swiss National Bank working paper*

[20] Fisher, P., Hudson S., Pradhan, M., (1993) "Divisia Measures of Money: An Appraisal of Theory and Practice," *Working Paper* No. 9, The Bank of England

[21] Frankel, J., Poonawala, J., (2010) "The Forward market in emerging currencies: Less biased than in major currencies," *Journal of International Money and Finance,* Vol. 29, pp. 585-598

[22] Frankel, J., Rose, A., (1996) "A panel project on purchasing power parity: mean reversion within and between countries," *Journal of International Economics,* Vol. 40, pp. 209-224

[23] Froot, K. A., Rogoff, K., (1995) "Perspectives on PPP and Long-run Real Exchange Rates," In Rogoff, K., Grossman, G. (Eds.). *Handbook of International Economics*. North Holland: Amsterdam. Frankel, J.A. and Rose, A.K

[24] Froot, K. A., Thaler, R., (1990) "Anomalies: Foreign Exchange," *Journal of Economic Perspectives*, 4, pp. 179-192

[25] Fujiki, H., Hsiao, C., Shen, Y., (2002) "Is There a Stable Money Demand Function under the Low Interest Rate Policy? A panel Data Analysis," *Monetary and Economic Studies, Bank of Japan*

[26] Gourinchas, P-O, Tornell, A., (2004) "Exchange rate puzzles and distorted beliefs," *Journal of International Economics*, Elsevier, vol. 64(2), pp. 303-333

[27] Greiber, C., Setzer, R., (2007) "Money and housing – evidence for the euro area and the US," *Deutsche Bundesbank Discussion Paper* No. 12

[28] Hodrick, R. J., (1987) *The Empirical Evidence on the Efficiency of Forward and Futures Foreign Exchange Markets*, Chur: Harwood,

[29] Kalyvitis, S., Skotida, I., (2010) "Some empirical evidence on the effects of U.S. monetary policy shocks on cross exchange rates,"

The Quarterly Review of Economics and Finance, Elsevier, vol. 50(3), pp. 386-394

[30] Kim, S., Roubini, N., (2000) “Exchange rate anomalies in the industrial countries: a solution with a structural VAR approach,” *Journal of Monetary Economics* 45, pp. 561-586

[31] Kim, S. (2005) Monetary Policy, Foreign Exchange Policy, and Delayed Overshooting,” *Journal of Money, Credit and Banking*, Blackwell Publishing, vol. 37(4), pages 775-82.

[32] Komárek, L., Melecký, M., (2001) “Demand for Money in the Transition Economy: The case of the Czech Republic 1993–2001,” *Warwick Economic Research Papers*, No. 614

[33] Lewis, K., (1995) “Puzzles in International Financial Markets,” in *Handbook of International Economics*, Vol.3, G. Grossman and K. Rogoff, eds., North Holland

[34] Lybeck, J. A., (1975) “Issues in the Theory of the Long-Run Demand for Money,” *The Swedish Journal of Economics*, Vol. 77, No. 2

[35] Landry, A., (2009) “Expectations and Exchange Rate Dynamics: A State-Dependent Pricing Approach,” *Journal of International Economics*, 78, pp. 60-71

[36] Lane, P. R., (2001) “The new open economy macroeconomics: a survey,” *Journal of International Economics*, Elsevier, vol. 54(2), pp 235-266

[37] Lee, T. H., Chung, J. C., (1995) “Further Results on the Long-run Demand for Money in Korea: A Cointegration Analysis.” *International Economic Journal*, 9 (3), pp 103-113

[38] Meese, R. A., Rogoff, K., (1983) “Empirical Exchange Rate Models of Seventies, Do they fit out of sample?” *Journal of International Economics*, 14, pp.3-24

[39] Mussa, M. (1982) “A Model of Exchange Rate Dynamics,” *Journal of Political Economics*, Vol. 90, No.1, pp. 74-104

[40] Obstfeld, M., Rogoff, K., (1984) "Exchange Rate Dynamics with Sluggish Prices under Alternative Price-Adjustment Rules," *International Economic Review*, Vol. 25, No. 1, pp. 159-174

[41] Obstfeld, M., Rogoff, K., (1995) "Exchange Rate Dynamics Redux," *Journal of Political Economy*, Vol. 103, pp. 624-60

[42] Obstfeld, M., Rogoff, K., (1996), *Foundations of International Macroeconomics*. The MIT Press

[43] Offenbacher, E., Kamel, T., (2007) "The Demand for Money in Israel: 1990-2006", *Discussion papers, Apr.,* Bank of Israel

[44] Rogoff, K., (1996) "The Purchasing Power Parity Puzzle," *Journal of Economic Literature* Vol. 34, No. 2, pp. 647-668

[45] Rogoff, K., (2002) "Dornbusch's overshooting model after twenty-five years," *IMF Working Paper*, Vol. 49

[46] Saatçioğlu C., Korap, L., (2007) "Turkish money demand, revisited: some implications for inflation and currency substitution under structural breaks," *Boğaziçi Journal, Review of Social, Economic and Administrative Studies*, Vol. 21, No. 1-2

[47] Sarno, L., Taylor, M. P., (2002) "Purchasing Power Parity and the Real Exchange Rate," *International Monetary Fund Staff Papers.* 49:1, pp. 65–105.

[48] Scholl, A., Uhlig, H., (2008) "New Evidence on the Puzzles: Results from Agnostic Identification on Monetary Policy and Exchange Rates," *Journal of International Economics*, 76, pp. 1-13.

[49] Steinsson, J., (2008) "The Dynamic Behavior of the Real Exchange Rate in Sticky Price Models," *The American Economic Review*, American Economic Association, Vol. 98, No. 1, pp. 519-533

[50] Taylor, M. P., Taylor, A. M., (2004) "The Purchasing Power Parity Debate," *Journal of Economic Perspectives*, 8, pp. 135-158