WP/01/187
Correction 1

IMF Working Paper

January 2, 2002

Subject: **The Effects of Capital Controls on Exchange Rate Volatility and Output**

CORRIGENDUM

The attached pages 9, 14, 15, and 16 of WP/01/187 (November 2001) are being reissued to correct a printing error.

Att: (4)

Other Distribution:
Department Heads
Division Chiefs

(11) $$\dot{p}=\phi\left[\delta(e-p)+h-\gamma\left(\frac{1}{(\kappa\rho+\lambda)}p+\frac{\kappa a-m}{(\kappa\rho+\lambda)}\right)-a+\rho\left(\frac{1}{(\kappa\rho+\lambda)}p+\frac{\kappa a-m}{(\kappa\rho+\lambda)}\right)\right].$$

To generate an expression for price changes as a function of the price level and the nominal exchange rate, we rearrange equation (11) and get

(12) $$\dot{p}=\frac{-\phi\delta(\kappa\rho+\lambda)+\phi(\rho-\gamma)}{\kappa\rho+\lambda}p+\phi\delta e+\phi h-\frac{\phi\gamma\kappa+\phi\lambda}{\kappa\rho+\lambda}a+\frac{\phi\gamma-\phi\rho}{\kappa\rho+\lambda}m.$$

The second variable that is crucial for the dynamics of the system is the nominal exchange rate. In order to derive a corresponding expression for changes in the exchange rate as we did for the price level, we first use equation (10) for the domestic interest rate in equation (6) and then equate equations (6) and (7). Rearranging gives for the contribution of fundamentalists to the market expectations

(13) $$w\dot{e}=-(1-w)\alpha(e-\bar{e})+\frac{1}{\kappa\rho+\lambda}p+\frac{\kappa a-m}{\kappa\rho+\lambda}-\tau-\pi(\tau)-r^*.$$

Solving for the change in the exchange rate, we get

(14) $$\dot{e}=\frac{1}{w(\kappa\rho+\lambda)}p-(1-w)w^{-1}\alpha e+(1-w)w^{-1}\alpha\bar{e}+\frac{\kappa a-m}{w(\kappa\rho+\lambda)}-(\tau+\pi(\tau)+r^*)w^{-1}.$$

The dynamics of the model are described by system of ordinary differential equations (12) and (14). Defining

(15) $$\theta\equiv(1-w)w^{-1}\alpha>0,$$

the dynamic system can conveniently be written as[10]

(16) $$\begin{pmatrix}\dot{p}\\ \dot{e}\end{pmatrix}=\begin{pmatrix}\dfrac{-\phi\delta\kappa\rho-\phi\delta\lambda+\phi(\rho-\gamma)}{\kappa\rho+\lambda} & \phi\delta\\ \dfrac{1}{w(\kappa\rho+\lambda)} & -\theta\end{pmatrix}\begin{pmatrix}p\\ e\end{pmatrix}+\begin{pmatrix}\phi h-\dfrac{\phi\gamma\kappa+\phi\lambda}{\kappa\rho+\lambda}a+\dfrac{\phi\gamma-\phi\rho}{\kappa\rho+\lambda}m\\ \theta\bar{e}+\dfrac{\kappa a-m}{w(\kappa\rho+\lambda)}-\left[\tau+\pi(\tau)+r^*\right]w^{-1}\end{pmatrix}.$$

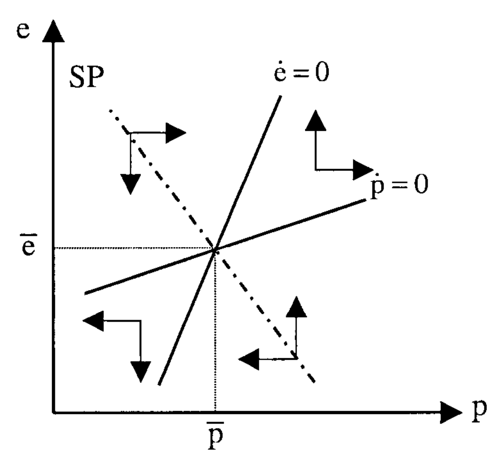
[10] The equilibrium exchange rate level $\bar{e}$ is derived later in equation (24).

The dynamics of the model are illustrated in Figure 1. The $\dot{e}=0$ schedule visualizes all combinations of the exchange rate and the price level that imply stationarity of the exchange rate. The slope of the $\dot{e}=0$ schedule, which can be derived from the system (16), is

$$\left.\frac{de}{dp}\right|_{\dot{e}=0}=\frac{1}{\theta w(\kappa\rho+\lambda)}>0. \tag{17}$$

As all values in the denominator of the fraction in equation (17) are positive, the slope of the $\dot{e}=0$ schedule is unambiguously positive. The economic intuition of the slope of the $\dot{e}=0$ schedule is as follows. In the traditional Dornbusch model—the one where only rational agents exist—the $\dot{e}=0$ schedule would be a vertical line. In our modified framework, we have to take into account that exchange rate expectations of the market are also influenced by chartists. At a given equilibrium exchange rate level $(\bar{e})$ an under–valuation of the domestic currency $(e-\bar{e}>0)$ leads to further depreciation expectations in the chartist group.

Figure 1. The Dynamics of the Model



Starting from a point on the $\dot{e}=0$ schedule, a rise in the price level reduces real money supply and induces an increase in the domestic interest rate that makes domestic assets more attractive. In this case, uncovered interest parity requires the market to expect a depreciation of the domestic currency. This expectation is generated if the exchange rate is higher, because this induces chartists to expect a further depreciation. Therefore, the exchange rate has to increase, so that the chartist forms depreciation expectation for the domestic currency. Hence, the $\dot{e}=0$ schedule has a positive slope.

interpreted as levied on both inflows and outflows.[12] We begin the analysis by examining the comparative statistics. The stationary point has to satisfy the condition that in equation (16) $\dot{e} = \dot{p} = 0$. Using the simplification

$$\eta = \frac{\phi\delta\kappa\rho + \phi\delta\lambda + \phi\gamma - \phi\rho}{\kappa\rho + \lambda}, \tag{23}$$

equation (16) transforms into

$$\begin{pmatrix} 0 \\ 0 \end{pmatrix} = \begin{pmatrix} -\eta & \phi\delta \\ \dfrac{1}{w(\kappa\rho+\lambda)} & -\theta \end{pmatrix} \begin{pmatrix} \bar{p} \\ \bar{e} \end{pmatrix} + \begin{pmatrix} \phi h - \dfrac{\phi\gamma\kappa + \phi\lambda}{\kappa\rho+\lambda} a + \dfrac{\phi\gamma - \phi\rho}{\kappa\rho+\lambda} m \\ \theta\bar{e} + \dfrac{\kappa a - m}{w(\kappa\rho+\lambda)} - \dfrac{\tau + \pi(\tau) + r^*}{w} \end{pmatrix} \tag{24}$$

basis, we can derive the long run price and exchange rate levels as

$$\begin{pmatrix} \bar{p} \\ \bar{e} \end{pmatrix} = \begin{pmatrix} -\kappa a + m + (\kappa\rho+\lambda)(\tau + \pi(\tau) + r^*) \\ \dfrac{1}{\delta}\left(\dfrac{\gamma\kappa + \lambda}{\kappa\rho+\lambda} a - \dfrac{\gamma - \rho}{\kappa\rho+\lambda} m - h \right) + \dfrac{\eta}{\phi\delta}\left(-\kappa a + m + (\tau + \pi(\tau) + r^*)(\kappa\rho+\lambda) \right) \end{pmatrix}. \tag{25}$$

Differentiating the first equation of (25) with respect to τ yields the change in the steady state value of the price level due to the implementation of the capital control

$$\frac{d\bar{p}}{d\tau} = (\kappa\rho+\lambda)(1+\pi_\tau) > 0. \tag{26}$$

Thus, the introduction of a tax on capital flows leads to a price increase in the new steady state. This price increase is stronger the higher the income and interest elasticity of money demand and the higher the interest elasticity of production are.

In order to see what effects the capital control exerts on the steady state value of the exchange rate, we differentiate the equation for $\bar{e}$ as given in (25) with respect to τ and get

$$\frac{d\bar{e}}{d\tau} = \frac{\eta(\kappa\rho+\lambda)}{\phi\delta}(1+\pi_\tau) > 0. \tag{27}$$

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[12] Alternatively, we could also assume that $\tau/2$ is imposed on international asset transactions in each direction. In principle, this would not change the results of our analysis.

The exchange rate effect is unambiguously positive, since we assume—as explained in Section II—that $\delta(\kappa\rho+\lambda)+\gamma>\rho$. This implies that the implementation of the capital control leads to a nominal depreciation of the home currency. Combining equations (26) and (27) shows that the effect of the Tobin tax (or any other capital control working like a tax) on the real exchange rate is

$$(28) \qquad \frac{d(\bar{e}-\bar{p})}{d\tau}=\frac{\gamma-\rho}{\delta}(1+\pi_\tau).$$

Its sign, therefore, depends on the relative size of the interest elasticity of demand (γ) and supply (ρ) in the goods market. Since the before-mentioned restriction on the parameter values can be consistent with $\gamma>\rho$, $\gamma=\rho$, and $\gamma<\rho$, the real exchange rate effect is ambiguous. If γ is fairly large, i.e., the rise in the interest rate reduces demand in the goods market by more than supply, this requires a real depreciation of the home currency to clear the goods market.

In order to investigate the effect of the capital control on production and income, we use equation (6) to derive

$$(29) \qquad \frac{dr}{d\tau}=1+\pi_\tau.$$

This means that, with given exchange rate expectations, a rise in the tax rate increase the domestic interest rate proportionally. Using equation (9) this decreases income and production capacities by

$$(30) \qquad \frac{dy}{d\tau}=-\rho\frac{dr}{d\tau}.$$

Since we examine steady states we do not need to distinguish between aggregate demand and supply. We therefore drop the superscript from the variable y. Combining equations (29) and (30) yields

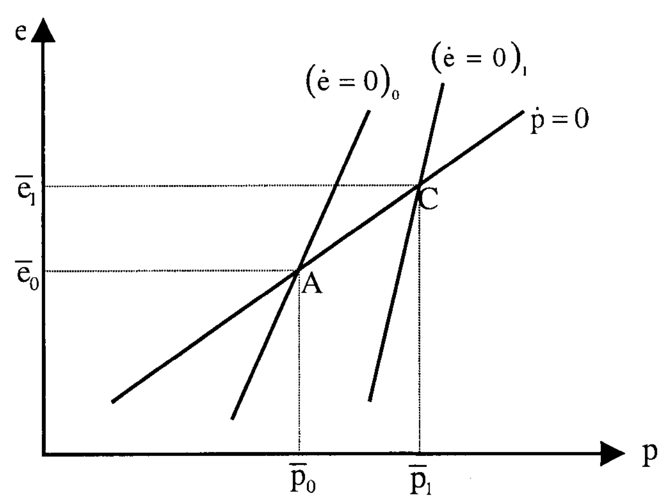
$$(31) \qquad \frac{dy}{d\tau}=-\rho(1+\pi_\tau)<0.$$

Hence, the implementation of the tax will lead to a decline in economic activity. This is the result of the induced increase in the domestic interest rate that reduces the equilibrium capital stock and, thus, production capacities.

The effects of the capital control on the steady state are illustrated in Figure 2. The tax shifts the $(\dot{e}=0)_0$ schedule to the right to $(\dot{e}=0)_1$, as can be derived from equation (14). Simultaneously, the introduction of a tax on capital inflows changes the slope of the $\dot{e}=0$

schedule. This can be derived from equations (15) and (17) taking into account that the tax reduces α, i.e., the aggressiveness of the chartists' expectations to exchange rate deviations from the fundamental value. The higher slope results from the fact that a higher price level together with the accompanying increase in the interest rate requires an expectation of depreciation for uncovered interest parity to hold. At a given equilibrium level $(\bar{e})$ the exchange rate has to increase even further than before, to generate a higher gap between e and $\bar{e}$ because chartists do not respond anymore as aggressively to the disequilibria on the foreign exchange market. Therefore, the slope of the $\dot{e} = 0$ schedule has to increase.

Figure 2. The Effects of a Tax on Capital Inflows on the Steady State



Hence, the new steady state ($\bar{p}_1$, $\bar{e}_1$) is in point C and we can conclude that the capital control leads to higher prices, a depreciation of the domestic currency, and lower output in the new steady state. The real exchange rate effect is ambiguous.

V. The Dynamic Adjustment Following the Implementation of A Capital Control

In this section, we examine the adjustment process from the initial equilibrium to the new steady state following the implementation of the tax on capital inflows. The adjustment is illustrated in Figure 3. From the previous section, we know that given the initial steady state in A, the new steady state is in C. Since the $\dot{e} = 0$ schedule becomes steeper, the new saddlepath is flatter than in the initial equilibrium.[13]

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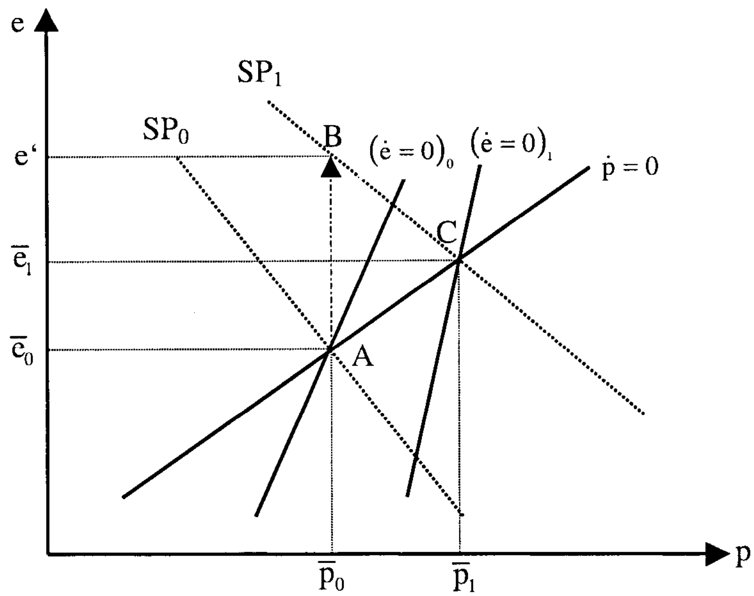
[13] In Appendix II we present a formal analysis of the effect of the Tobin tax on the slope of the saddlepath.

Figure 3. The Adjustment Process Following the Implementation of a Tax on Capital Inflows



The new saddlepath helps us determine the impact effect of the capital control and the subsequent adjustment to the new steady state. Just like in the Dornbusch model, there is no impact effect on the price level, as prices adjust only over time. The implementation of a tax on capital inflows leads to an immediate decline in the attractiveness of domestic assets because it reduces both the risk-adjusted revenue as well as the after tax interest revenue. Uncovered interest parity can only continue to hold if an expectation of appreciation for the domestic currency prevails. This implies that the depreciation of the domestic currency overshoots. In Figure 3, this moves the system from A to B, i.e., the exchange rate increases in the short run to e' and, hence overshoots its new long-term value ($\overline{e}_1$). In B, chartists expect that the gap between the realized exchange rate and its fundamental value will increase further in the future. In other words, in this situation chartists have depreciation expectations. By contrast, fundamentalists take this behavior into account and compensate the irrational beliefs. This process implies that the impact effect of the implementation of the Tobin tax (or any other capital control working like a tax) exhibits indeed overshooting characteristics. It also highlights that the overshooting of the exchange rate has to be higher in a system with chartists than in a system without them.

In the medium term, prices adjust because of the induced disequilibrium in the goods market. The depreciation increases demand for domestic goods that leads to an excess demand in the goods market and a subsequent gradual rise in the price level. When prices in the goods market rise, the domestic interest rate increases and the exchange rate consistent with short-term equilibrium in the foreign exchange market, i.e., with uncovered interest