

IMF Working Paper

The Effects of Capital Controls on Exchange Rate Volatility and Output

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Abstract

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This paper extends the Dornbusch model of overshooting exchange rates to discuss both exchange rate and output effects of capital controls that involve additional costs for international asset transactions. We show that, on the one hand, such capital controls have the merit of reducing the volatility of exchange rates following a monetary shock. On the other hand, the implementation increases exchange rate volatility in the short run and induces costs for the real sector in the form of lower equilibrium output levels.

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I. INTRODUCTION

The turbulence in world financial markets in the 1990s has reanimated the interest in capital controls as a means to reduce the volatility of capital flows and exchange rate movements. These controls can come in different forms that can be distinguished, for example, by whether they are imposed on capital inflows or outflows, by what type of assets they are applied to and by whether they involve price controls, quantity restrictions or outright prohibitions (Eichengreen, 1999; Neely, 1999; Ariyoshi et al., 2000).²

In this paper, we focus on measures that make capital movements more costly. These measures are also referred to as price controls and mainly include taxes on certain international asset transactions, taxes on returns to international investment, and mandatory reserve requirements. The impact effect of such measures on the profitability of capital flows is similar to a tax.³ A price control often discussed in this context is a tax on each foreign exchange transaction and is associated with James Tobin (1974). He suggested levying a tax on all spot transactions involving the conversion of one currency into another. If the Tobin tax cannot be evaded it adds to the costs of foreign exchange trading and is expected to reduce the volume of short-term capital flows that are often considered destabilizing. In a fixed exchange rate system, such destabilization takes the form of volatility of foreign exchange reserves, while it takes the form of pronounced exchange rate fluctuations in a flexible exchange rate system. The idea of taxing foreign exchange transactions has lately also been discussed in the context of the new financial architecture: a number of politicians and several economists regard a measure that increases the costs of international capital flows as being part of a global approach to stabilize the international monetary and financial system (e.g., Blecker, 1999).⁴ Recently, the Tobin tax was even put on the agenda of a meeting of EU finance ministers.

There are two important questions associated with any capital control. First, can the measure be evaded? Second, can the measure indeed accomplish what it should do, i.e., reduce the volatility of capital flows and exchange rates or foreign exchange reserves and are there any undesirable indirect effects?

² Bird and Rajan (2000) also give a comprehensive overview regarding the different forms of capital as well as exchange rate controls.

³ Ariyoshi et al. (2000) distinguish administrative or direct controls and market-based or indirect controls. While the former comprise outright prohibitions and discretionary approval for certain cross-border capital movements, the latter aim at discouraging capital movements through cost-increasing measures. Such measures are the focus of this paper.

⁴ Empirical studies on the factors associated with capital controls include Alesina, Grilli, and Milesi-Ferretti (1994) and Grilli/Milesi-Ferretti (1995).

At least for the Tobin tax, the first question is broadly discussed in the literature and the conclusion is that it can be evaded relatively easily if one country or a few countries impose it.⁵ The discussion is less conclusive for other price controls. The second question, i.e., the question about the effects of capital controls, is the focus of this paper. We limit the discussion to the forms of capital controls that can be modeled as price controls. While several studies are rather descriptive pointing to the potential negative side effects of capital controls and the reduction of risk sharing and technology transfer (Krugman, 1998), most studies focus on the empirical evidence of the effects of capital controls (Edwards, 1998; Johnston/Tamirisa, 1998; Reinhart/Smith, 1998). By contrast, the theoretical literature on capital control effects is rather limited. One of the few theoretical analyses of the effects of a tax on foreign exchange transactions is presented by Frankel (1996). He uses a simple static monetary model with long-term oriented investors and short-term oriented speculators. Although he does not present a complete formal model, he describes the effects of capital controls as a reduction in the influence of short-term speculators on the exchange rate. Therefore, he concludes that a tax on foreign exchange transactions indeed reduces the variability of the exchange rate. Buch/Heinrich/Pierdzioch (1998) introduce a Tobin tax into the Dornbusch (1976) overshooting model and show that a Tobin tax reduces exchange rate volatility.

In this paper, we take the view that the financial sector and the real sector of an economy cannot be separated. Rather, there are spillover effects from financial markets to the real sector. We examine the effects of capital controls by combining a monetary model of exchange rate determination and a simple theory of real capital stock formation. We also take into account the cost of capital movements and market microstructure aspects of the foreign exchange market. We argue that the implementation of capital controls affects the interest rate because a more restrictive exchange and payment system changes the perception of the market about the risks of domestic assets. This induces higher interest rates and lowers investment, income, and growth in the long run.

The paper is organized as follows. In Sections II and III, we explain the structure of the model and its dynamics. Section IV studies the long-run effects of capital controls implemented in form of price controls. Section V examines the impact effect, the subsequent adjustment process to the new steady state, and the effects on exchange rate volatility. Section VI presents some empirical evidence and Section VII contains the summary and conclusions.

II. THE STRUCTURE OF THE MODEL

In order to examine the effects of capital controls we confine the analysis to price controls or indirect controls that make capital movements more costly and which, therefore, have the same impact effect as a tax. Hence, we do not examine outright prohibitions or

⁵ For an overview see Haq et al. (1996) and Raffer (1998).

quantity controls that cannot be modeled as a tax. We choose the generalization of assuming a price control in order to keep the analytics of the model at a manageable level. We start from a modified Dornbusch overshooting model for a small open economy. Like Buch/Heinrich/Pierdzioch (1998), we take into account the microstructure of the foreign exchange market and distinguish different types of traders. In addition, we introduce real capital and, thus, include important features of the supply side of the economy.

We start from a situation in which an economy has a flexible exchange rate system and has experienced high exchange rate volatility in the past. Such volatility could be the effect of monetary disturbances on the supply or the demand side but, in any case, is regarded as undesirable by the country. Therefore, capital controls are contemplated in order to reduce the observed exchange rate volatility. We first model the goods market and assume that there is a sluggish adjustment of the domestic price level (p) to an excess of aggregate demand in the goods market. Price changes (\dot{p}) are a function of excess demand in the goods market:

$$(1) \quad \dot{p} = \phi(y^D - y^S),$$

where y^D and y^S denote aggregate demand and aggregate supply, respectively. The parameter ϕ , which reflects the speed of adjustment, is assumed to be positive. In general, we use a lower case letter to denote the logarithm of a variable and a Greek letter to denote elasticity or semi-elasticity.

Aggregate demand rises when the domestic currency depreciates in real terms or when the interest rate declines. With h , e , and r representing a constant, the log of the nominal exchange rate (expressed as the price of the foreign currency in domestic currency units), and the interest rate, respectively, aggregate demand can be written as

$$(2) \quad y^D = h + \delta(e - p) - \gamma r; \quad \delta, \gamma > 0,$$

where δ and γ are the elasticities of aggregate demand with respect to the real exchange rate and the interest rate, respectively. We assume that the foreign price level is equal to unity.

In order to make aggregate supply endogenous, we use a fairly simple aggregate supply function that hinges on two assumptions. First, aggregate supply only depends on the capital stock and is, thus, equal to the natural level of output or production capacity. Second, the capital stock is a decreasing function of the interest rate and adjustment is instantaneous. Denoting the capital stock by c and using b and v as a constant and the interest elasticity of the capital stock, respectively, equation (3) describes the capital stock adjustment⁶

⁶ One can think of other justifications of the applied capital stock function. For example, one could assume that capital depreciates completely each period and, thus, equation (3) describes the investment process. In this case, the question of capital stock adjustment does not arise. For the qualitative results of our analysis, the equality of desired and actual capital
(continued...)

$$(3) \quad c = b - v r \quad \text{with} \quad v > 0.$$

Aggregate supply is given by equation (4), in which we use a constant technology parameter f and denote the production elasticity of the capital stock by β . This gives

$$(4) \quad y^s = f + \beta c \quad \text{with} \quad \beta > 0.$$

We now turn to the money market. Money market equilibrium requires that real money supply ($m-p$) is equal to real money demand. Using the traditional assumption that money demand is an increasing function in production and a decreasing function of the interest rate, the equilibrium condition for the money market can be written as

$$(5) \quad m - p = \kappa y^s - \lambda r \quad \text{with} \quad \kappa, \lambda > 0.$$

The parameters κ and λ are the production elasticity and the interest elasticity of money demand, respectively. The domestic interest rate is linked to the foreign interest rate through uncovered interest parity, in which E denotes the expectation operator:

$$(6) \quad E(\dot{e}) = r - \tau - \pi(\tau) - r^* \quad \text{with} \quad \pi_\tau > 0.$$

In this modified uncovered interest parity condition, we introduce the effects of capital controls on the yield of domestic assets by including two different terms. A first term, τ , represents the tax rate or the tax equivalent of the capital control that the government levies on capital inflows. We do not distinguish between different types of capital controls, but assume that the capital control works like a tax. This could be a Tobin tax, a tax on returns to international investment, a mandatory reserve requirement, or a tax on profits of international investment. As a tax, τ reduces the revenue from holding domestic assets. For simplicity, we ignore the effects of the use of the tax proceeds. A second term, $\pi(\tau)$, reflects the assumption that investors take into account a higher risk premium π if the government implements capital controls. For example, an investor could associate the introduction of a capital control with higher-than-anticipated macroeconomic imbalances or the expectation that the government could implement additional measures in the future that would reduce the profitability of the investment. This is in line with the argument of Goldstein (1995) who points out that capital controls can increase the perception of risk among international investors. Sometimes, such capital controls imposed by one country could even change the perception of risk for countries with similar macroeconomic conditions as highlighted by the IMF (1998): "The introduction by Malaysia in early September of exchange and capital controls may also turn out to be an important setback not only to that country's recovery and

stock is not a crucial assumption. Incorporating an adjustment process would only affect the quantitative but not the qualitative results.

potentially to its future development, but also to other emerging market economies that have suffered from heightened investors fears of similar actions elsewhere.”

One may argue that there could be a reduction on the risk premium for the domestic currency if indeed the capital control leads to a decline in exchange rate volatility. However, we assume this particular effect does not dominate but, rather, that it is more than offset by the perception of additional uncertainty about future economic policies. Hence, we assume that the risk premium is an increasing function in τ . Equation (6) shows that a differential between the domestic interest rate (r) and the foreign interest rate (r^*) adjusted for the tax (τ) and the risk premium (π) must equal the expected change of the exchange rate ($E(\dot{e})$).

We now turn to some market microstructure features of the foreign exchange markets. Specifically, we distinguish two types of foreign exchange traders, fundamentalists and chartists.⁷ Fundamentalists are assumed to have rational expectations. Since the model does not include any stochastic elements, fundamentalists always anticipate exchange rate movements correctly. Chartists or technical traders are assumed to have a short-term investment horizon and tend to undertake destabilizing speculation. This means that they expect a deviation of the exchange rate from its fundamental value (\bar{e}) to increase over time. For example, if the exchange rate exceeds its fundamental value, chartists expect the exchange rate to be even higher in the future and, therefore, contribute to further deviations of the exchange rate from the fundamental value. Our specification implies that chartists know the fundamental value of the exchange rate, but they do not think that the exchange rate moves into the direction of this value during the investment period they have in mind.

Exchange rate expectations of the market are a weighted average of the expectations of the two different groups of foreign exchange market participants. This is described by equation (7) in which w represents the weight with which fundamentalists' expectations enter market expectations:

$$(7) \quad E(\dot{e}) = w\dot{e} + (1-w)\alpha(e - \bar{e}) \quad \text{with} \quad \alpha = \alpha(\tau) \text{ and } \alpha_{\tau} < 0.$$

The term α represents the elasticity of exchange rate expectations of chartists with respect to deviations of the exchange rate from its fundamental value. The higher α is, the higher the aggressiveness with which the chartists' expectations react to a deviation of e from \bar{e} . We follow the suggestion of Frankel (1996) and assume that the relative responsiveness

⁷ A number of studies have confirmed the empirical relevance of the hypothesis regarding the heterogeneous composition of dealers on foreign exchange markets, e.g., Allen and Taylor (1990, 1992) and Frankel and Froot (1988, 1990). For recent empirical evidence on this issue, cf. Menkhoff (1997, 1998), Lui and Mole (1998), Cheung and Chinn (1999a, 1999b), Cheung and Wong (2000), and Oberlechner (2001).

of chartists' depends negatively on the magnitude of τ .⁸ This means that an increase in the tax rate reduces the response of technical traders to expected exchange rate changes. One could imagine that combining the expectations of the two groups of speculators to form the market expectation takes the following form: Fundamentalists and chartists report their expectations to a bank manager who then bases his own portfolio decisions on a weighted average of the two expectations as described in equation (7). This hypothesis is used, for example, by Frankel and Froot (1988).⁹

III. THE DYNAMICS OF THE SYSTEM

In order to examine the dynamic characteristics of the model, we begin the analysis by using the capital stock function (3) in equation (4). This yields the following equation for aggregate supply

$$(8) \quad y^s = f + \beta b - \beta v r .$$

To simplify this expression, we define $a \equiv f + \beta b > 0$ and $\rho \equiv \beta v > 0$. Equation (8) can then be written as

$$(9) \quad y^s = a - \rho r .$$

This expression can be used in the condition for money market equilibrium. Combining equations (5) and (9) and solving for the interest rate yields

$$(10) \quad r = \frac{1}{\kappa\rho + \lambda} p + \frac{\kappa a - m}{\kappa\rho + \lambda} .$$

We can now derive a more detailed expression for the price adjustment process. We substitute equations (2) and (9) for aggregate demand and aggregate supply in equation (1) and use the expression of equation (10) for the interest rate. This gives:

⁸ Alternatively, the effect of τ on exchange rate expectations could be modeled by assuming that the tax rate τ changes the weight of the two groups of foreign exchange market participants. In this case, an increase in τ would increase w .

⁹ Note that in the steady state the expected exchange rate change is zero and, thus, neither chartists nor fundamentalists have any incentive to take positions in the foreign exchange market. Several authors have used the Frankel-Froot setup in different analyses, e.g., Morales (1998).

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

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

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

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

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

Solving for the change in the exchange rate, we get

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

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

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

the dynamic system can conveniently be written as¹⁰

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

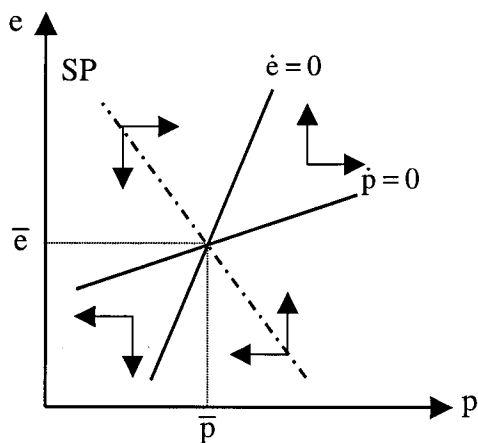
¹⁰ The equilibrium exchange rate level \bar{e} is derived later in equation (24).

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

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

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.

Price and exchange rate levels located to the right and below the $\dot{e} = 0$ schedule indicate that the domestic interest rate is higher than the equilibrium level and, thus, lead to an increase in the exchange rate. Correspondingly, combinations of price and exchange rate levels located to the left or above the $\dot{e} = 0$ schedule lead to a decline in the exchange rate. This is indicated by the vertical arrows in Figure 1.

The $\dot{p} = 0$ schedule represents all combinations of the exchange rate and the price level for which the goods market is in equilibrium, i.e., aggregate demand equals aggregate supply. The slope can be derived from the system (16) as

$$(18) \quad \left. \frac{de}{dp} \right|_{\dot{p}=0} = \frac{\phi\delta\kappa\rho + \phi\delta\lambda + \phi\gamma - \phi\rho}{\phi\delta(\kappa\rho + \lambda)} = 1 + \frac{\gamma - \rho}{\delta(\kappa\rho + \lambda)}$$

Since the numerator of the fraction on the right hand side of equation (18) can either be positive or negative, the sign of the slope is ambiguous. If the interest elasticity of the demand for goods is larger than the interest elasticity of the supply of goods, i.e., $\gamma > \rho$, the $\dot{p} = 0$ schedule is upward sloping. However, if the interest elasticity of the supply becomes very large and the value of the fraction on the right hand side of equation (18) is negative and larger than unity in absolute terms, the $\dot{p} = 0$ schedule is downward sloping. The intuition behind the ambiguity of the slope of $\dot{p} = 0$ schedule can be explained as follows: a rise in the price level will reduce the demand for domestic goods for two reasons (i) the rise in the price level leads to a real appreciation and a decline in net export demand; and (ii) the higher price level increases the interest rate that, in turn, reduces the demand in the goods market. Due to the fact that the higher interest rate will also lower the supply of goods, a rise in the price level could lead to either an excess supply or an excess demand for domestic goods. If

$$(19) \quad \delta(\kappa\rho + \lambda) + \gamma > \rho,$$

a rise in the price level leads to a stronger decline in demand compared to the decline in supply. As a result, an excess supply is induced that requires a higher exchange rate (depreciation of the domestic currency) in order to generate a balanced goods market and vice versa. In the following analysis, we assume that the two factors inducing the change in demand exert a stronger effect on the goods market equilibrium than the interest effect does on production capacities, i.e. relation (19) holds. This implies that the $\dot{p} = 0$ schedule is upward sloping but, at the same time, we assume that it is flatter than the $\dot{e} = 0$ schedule. Price and exchange rate levels located to the right and below (left and above) the $\dot{p} = 0$ schedule represent an excess supply (excess demand) of goods. This, in turn, will lead to a decline (increase) in the price level. This is indicated by the horizontal arrows in Figure 1. The steady state values of the exchange rate and the price level are denoted by \bar{e} and \bar{p} , respectively.

Since the $\dot{e} = 0$ schedule is assumed to be steeper than the $\dot{p} = 0$ schedule, we first derive the following expressions from equations (17) and (18):

$$(20) \quad \frac{1}{\theta w} > \frac{\delta(\kappa\rho + \lambda) + \gamma - \rho}{\delta}.$$

Multiplying both sides of this inequality by $\theta w \delta$ and using the definition in (15) yields after some rearranging

$$(21) \quad \delta > (1 - w)\alpha[\delta(\kappa\rho + \lambda) + \gamma - \rho].$$

We can use this to determine the stability characteristics of the system (16). Denoting the coefficient matrix of the price level and the exchange rate in system (16) by A , the determinant is

$$(22) \quad \det(A) = \frac{\theta\phi(-\rho + \delta\kappa\rho + \delta\lambda + \gamma)}{\kappa\rho + \lambda} - \frac{\phi\delta}{w(\kappa\rho + \lambda)}.$$

Since $\theta \equiv (1 - w)w^{-1}\alpha$, the determinant of the system is unambiguously negative if $\delta > (1 - w)\alpha[\delta(\kappa\rho + \lambda) + \gamma - \rho]$. This inequality holds as long as the $\dot{e} = 0$ schedule is steeper than the $\dot{p} = 0$ schedule that was assumed above. A negative determinant implies that there is one negative and one positive eigenvalue. In this case the system is saddlepathstable. In Figure 1, the SP schedule shows the saddle path;¹¹ the slope of the saddlepath is negative, as shown in Appendix II.

IV. A COMPARATIVE STATIC ANALYSIS OF THE EFFECTS OF A CAPITAL CONTROL

We now examine the effects of introducing a capital control that functions as a tax on capital inflows. We capture in the model the two features of any policy measure that aims at regulating international trade in assets as follows: there is a direct effect and at least one potential indirect effect. The direct effect is the cost of the tax that may, after all, not be very high. The indirect effect, which is crucial for our results, is the fact that any type of restriction raises the risk of domestic assets and will, therefore, be reflected in an increase in the domestic interest rate compared to the world market. We start from an initial equilibrium in which $\tau=0$ and assume that the government introduces a capital control to reduce the importance of short-term oriented chartists in the foreign exchange market and, thereby, decrease exchange rate volatility, which the economy experienced in the past. Although the tax or the tax equivalent is assumed to be imposed only on capital inflows, it could also be

¹¹ The case of a positive determinant could be in line with two positive or two negative eigenvalues. As we show in Appendix I, the smaller eigenvalue is always negative. Hence, we can rule out an explosive behavior of the system. Since the determinant is negative, we can also rule out complex roots.

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

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

equation (16) transforms into

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

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

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

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

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

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

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

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

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

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

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

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

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

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

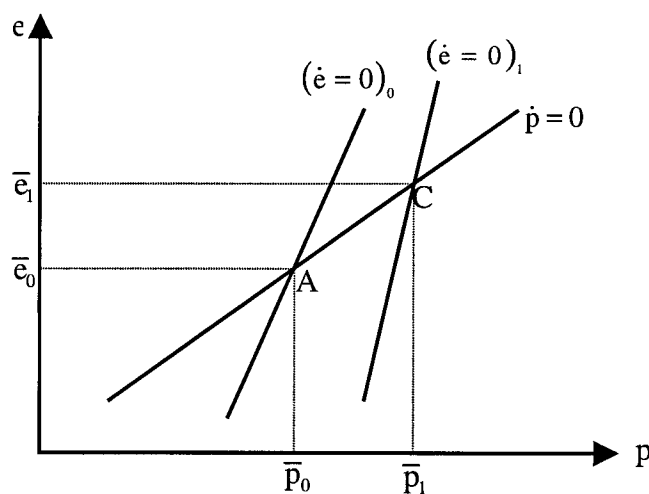
$$(31) \quad \frac{dy}{d\tau} = -\rho(1 + \pi_\tau) < 0.$$

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



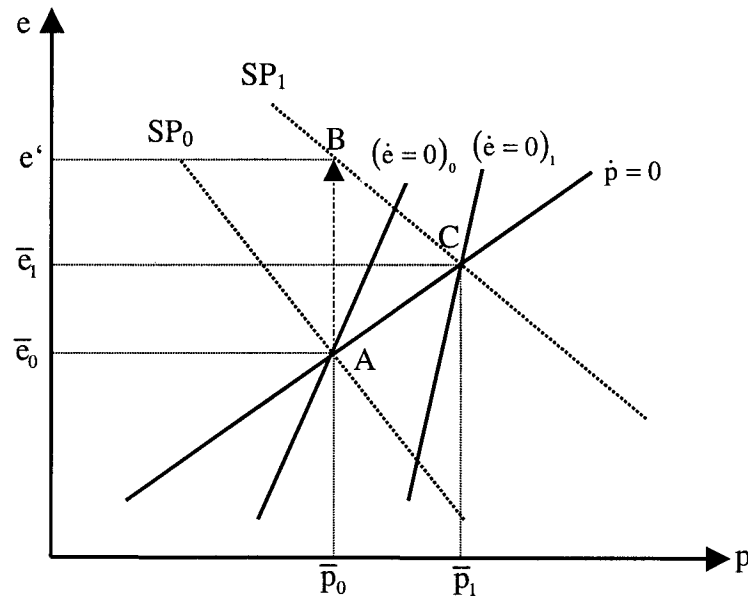
Hence, the new steady state (\bar{p}_1, \bar{e}_1) is in point C and we can conclude that the capital control leads to higher prices, a depreciation of the domestic currency, and lower output in the new steady state. The real exchange rate effect is ambiguous.

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

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 (\bar{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

parity, has to be less high. Hence, the economy adjusts along the saddlepath SP_1 to the new steady state in point C.

The time paths of key economic variables of the model are shown in Figure 4. The exchange rate shows the traditional overshooting characteristic. The price level initially remains unchanged and gradually increases to its new long-run equilibrium. Similarly, the domestic interest rate rises during the adjustment process. The lower right-hand diagram in Figure 4 shows that demand for domestic goods increases immediately the government implements the capital control. This is the consequence of the real depreciation that results from the nominal depreciation and the unchanged domestic price level. Aggregate supply initially remains unchanged. As prices adjust and the interest rate increases, both aggregate demand and supply decline. The new equilibrium output level is below the initial level, since the tax on capital flows together with the induced rise in the risk premium leads to a rise in the interest rate. Thus, the model emphasizes a negative supply side effect induced by the capital control.

We now turn to the question of how exchange rate volatility is affected by the tax. As explained before and shown in Figure 3, the saddle path is flatter with a capital control. Since prices cannot adjust in the short-run, any shock to the economy shifts the economy to the new saddlepath and the adjustment is borne exclusively by a change in the exchange rate. A flatter saddlepath reduces the exchange rate overshooting following a shock. For example, a monetary expansion, which shifts both the $\dot{e} = 0$ schedule and the $\dot{p} = 0$ schedule to the right so that the new steady state moves outward along the diagonal line, leads to a smaller immediate overshooting of the exchange rate.

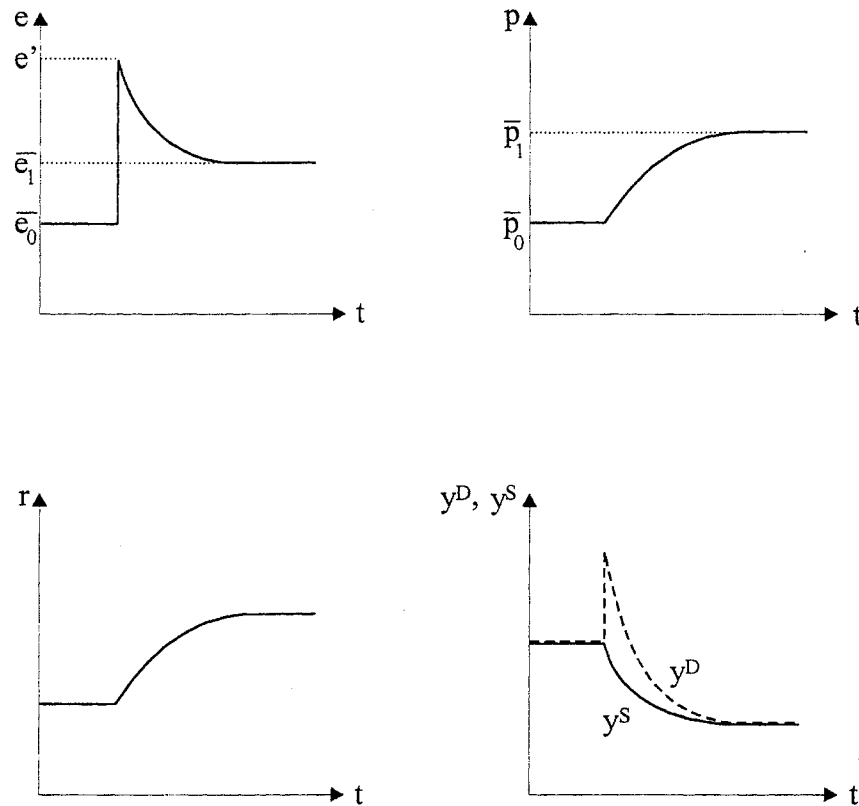
Therefore, we can conclude that a tax on capital flows indeed reduces exchange rate volatility. The crucial mechanism through which this is achieved is the effect that the tax has on the behavior of chartists. The tax reduces the responsiveness of chartists to a change in the exchange rate. As the tax involves higher transaction costs, technical traders respond less sensitively to exchange rate changes. Therefore, their destabilizing influence on the exchange rate is reduced.

Although the capital control reduces exchange rate volatility, this policy instrument does not involve a "free lunch." The price of reduced exchange rate volatility is a lower level of output because a country that uses capital controls may be considered as a country with higher risk and, thus, experiences a decline in investment.

VI. SOME EMPIRICAL EVIDENCE

Is there empirical evidence that supports our model and its implications? As it is not possible to empirically test the model directly, we examine whether some crucial hypotheses and implications of the model are consistent with the stylized facts and with empirical studies that examine the effects of capital controls on specific financial variables like the exchange rate and the interest rate.

Figure 4. The Dynamic Adjustment of the Key Economic Variables

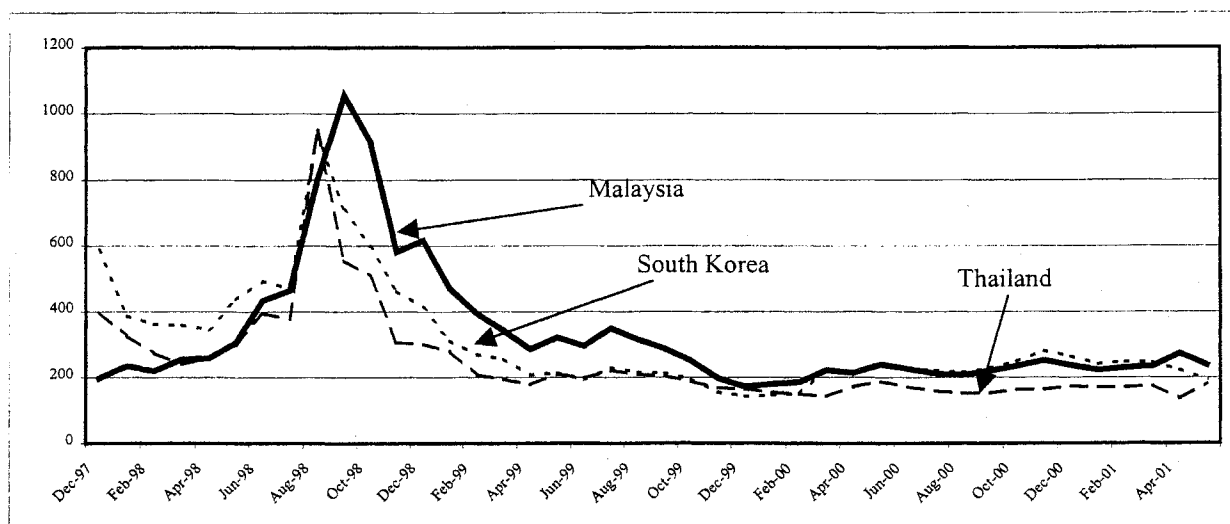


The most prominent recent example of a country using capital controls in order to reduce external imbalances and volatility is Malaysia. In September of 1998, the government responded to the adverse affects of the Asian crisis by announcing a policy package designed to insulate monetary policy from external volatility. Among other measures, the authorities pegged the ringgit to the U.S. dollar and imposed exchange and capital controls. In particular, they restricted the repatriation of portfolio investment and prohibited offshore trading of the ringgit. In February 1999, the Malaysian government significantly reduced existing capital controls and phased out the previously imposed restrictions by February 2000 (Box 1).

In order to investigate whether the capital controls introduced by Malaysia increased the risk premium on investment in Malaysia, we compare the interest rate spread of sovereign bonds in Malaysia, Thailand, and Korea. These three countries were often considered emerging economies of comparable development levels. Korea did not use any capital controls as a policy measure in its adjustment to the Asian crisis. Thailand resorted to

some capital controls but they were milder than in Malaysia. Until Malaysia introduced capital controls, the interest rate spread of Malaysian sovereign bonds was below the Korean spread and usually also below the level of Thailand (Figure 5). However the Malaysian spread increased to a higher level than in the other two countries immediately after the implementation of the capital controls.¹⁴

Figure 5. Sovereign Bond Spreads over U.S. Treasury (end-of-period)



Source: J.P. Morgan Chase, EMBI Global Sovereign Spreads.

When the Malaysian controls were eased in February 1999, the sovereign bond spread was still above the levels of Thailand and Korea, but in the following months this spread narrowed to a level comparable to those of Thailand and Korea. This observation suggests that investors tended to associate a relatively higher risk with Malaysian assets at least until the controls were removed.¹⁵ A higher risk perception for Malaysian assets is also supported by an example reported by Kochhar et al. (1999). According to their portrait of the Malaysian economic developments, Morgan Stanley announced in 1998 that Malaysia had been taken out permanently from its developed country stock index and the previous inclusion of Malaysia in this index was an aberration. As a consequence, Kochhar et al. presume that this may even have a permanent effect on the volume of foreign direct investment in Malaysian financial markets, even if this country should be included in the

¹⁴ Dornbusch (2001) gives a similar interpretation.

¹⁵ Of course, capital controls are only one factor in explaining risk premia. Therefore, it would require a more profound analysis to come to a comprehensive conclusion.

Box 1. Malaysia: Capital Controls and Exchange Restrictions

September 1–2, 1998

1. Malaysia fixed the exchange rate at RM 3.80 per U.S. dollar.
2. Prior approval was required for nonresidents to be able to buy or sell ringgit forward.
3. All sales of ringgit assets were required to be transacted through approved domestic intermediaries. This effectively shut down the operation of the offshore ringgit market.
4. Nonresidents were required to obtain BNM approval to convert ringgit held in external accounts into foreign currency, except for the purchase of ringgit assets in Malaysia or for the purposes of conversion and repatriation of sale proceeds of investment made by foreign direct investors.
5. Settlements of imports and exports became required to be settled in foreign currency. However, free exchange was maintained for all current account transactions in addition to supply of trade credit to nonresident exporters of Malaysian goods.
6. Credits to External Accounts were limited to sale of foreign currency; ringgit instruments, securities, or other assets in Malaysia; salaries; wages; rentals commissions; interest; profits; or dividends.
7. Debits to External Accounts were restricted to settlement for purchase of ringgit assets and placement of deposits; payment of administrative and statutory expenses in Malaysia; payment of goods and services for use in Malaysia; and granting of loans and advances to staff in Malaysia.
8. Domestic nationals were forbidden to export more than RM 10,000 during any travels abroad. Foreign nationals were forbidden to export more than RM 1,000 upon leaving Malaysia.
9. After September 1, 1998, nonresident sellers of Malaysian securities were required to hold on to their ringgit proceeds for at least 12 months before repatriation was to be allowed.
10. Ban on the provision of domestic credit to nonresident correspondent banks and stock broking companies.

February 15, 1999

1. As of February 15, 1999, the yearlong moratorium on repatriation of investments was replaced with a graduated tax. All capital having entered Malaysia before February 15, 1999, were subject to the following levies on the capital being removed:
 - 30 percent if repatriated within the first 7 months after entering Malaysia;
 - 20 percent if repatriated between 7 and 9 months after entry;
 - 10 percent if repatriated between 9 and 12 months of entering; and
 - no levy if repatriated after one year of entry.
2. For funds entering Malaysia after February 15, 1999, capital was free to enter and leave without taxation; however, profits were taxed at the rate of 30 percent if repatriated within one year of entry and 10 percent if repatriated after one year of entry.

Source: Kaplan/Rodrik (2001), p. 36.

emerging market index again. Liu (2000) finds no immediate effect of the Malaysian capital controls on foreign direct investment flows into Malaysia but stresses that there could be significant indirect effects adversely affecting foreign direct investment. Specially, foreign investors could face higher administrative costs associated with additional verification and approval procedures and perceive investment policy regimes unpredictable. According to Liu's analysis, this factor could increase the perception of Malaysia's country risk in international financial markets.

Some of the studies on the effectiveness of capital controls can be used to compare the results regarding the effects on exchange rate volatility. Usually, such studies focus on one specific country. Edison/Reinhart (2000) compare the effectiveness of the capital controls implemented by Malaysia and Thailand during the 1997–1998 period. They conclude that the capital controls implemented in Thailand were not successful but, at the same time, did not cause counterfactual effects either. By contrast, their conclusion with respect to Malaysia was that the capital constraints implemented there may have eased the recovery of the economy by increased interest rate and exchange rate stability.¹⁶

Valdes-Prieto/Soto (1998) investigated the Chilean unremunerated reserve requirement (URR), a selective capital control implemented in June 1991.¹⁷ Their estimates show that “substitution from the exempt short-term flows compensated reductions in taxed short-term flows, so the Chilean URR did not discourage total net short-term credit inflows to the private sector.” Valdes-Prieto/Soto conclude that this would imply that this control failed to contribute to monetary autonomy. Laurens/Cardoso (1998) also examined the case of Chile and found that the interest rate differential between Chile and the United States increased due to higher interest rates in Chile after the introduction of the capital controls. In contrast to Valdes-Prieto/Soto (1998), Laurens/Cardoso (1998) acknowledge that the URR “has a limited capacity to generate autonomy for implementing monetary policy.”

The steady state effect of capital controls on output as discussed in Section IV implies that restrictions on international capital flows harm the real economy by creating a higher

¹⁶ It is still disputed whether or not this helped Malaysia to recover fast. Kaplan and Rodrik (2001) use a time-shifted difference estimation technique to quantify the relative performance of the policy of Malaysia and the policy of Korea and Thailand. They find that Malaysia recovered faster from the crisis. Nevertheless, the authors do not want to rule out that the implementation of capital controls could have some adverse effects on investment in the long run, especially if one considers that foreign direct investment played an important role in Malaysia's successful economic development before the Asian crisis. They stress that the controls are too recent to ascertain with any degree of certainty their long-term consequences.

¹⁷ Note, however, that the Chilean URR was applied only to capital imflows during a period of a surge of capital inflows, which affected Chile as well as other emerging countries, and that it was taken away after the surge subsided.

risk premium and ultimately lower investment and, as a consequence, a lower capital stock and a lower output level. Several papers argue along these lines but there is hardly any hard evidence for this result. This has to do with the difficulty to indeed isolate the effects of capital controls on the real sector of the economy. However, an interesting study is the one of Gruben/McLeod (1998). They found that capital controls generally influenced growth negatively. Their study of Asian and Latin American countries concluded, "if a government decides to use capital controls to reduce volatility ... the price is some growth."

VII. SUMMARY AND CONCLUSIONS

The model presented in this paper suggests that capital controls have important indirect effects on financial markets and on output. Our analysis implies that a capital control that can be modeled as a tax on capital flows can indeed reduce exchange rate volatility following different types of shocks, but, at the same time, two additional effects occur. First, since the tax leads to a new steady state of the economy, its implementation initially triggers exchange rate volatility, including overshooting, which is the phenomenon it tries to curtail. Second, capital controls increase the risk premium of domestic assets so that the domestic interest rate rises and the incentives to invest in the capital stock of the economy decrease.

Although the model does not include growth, our results can also be interpreted in an environment of economic growth. In this case, capital controls exert negative effects on growth because they induce a dampening effect on investment activity. Policymakers in deciding about the appropriateness of capital controls need to weigh the negative growth effect of this policy against a possible positive effect of reduced exchange rate volatility.

The model captures several effects of a capital control and is in line with the empirical findings, but the analysis is not without limitations. Two of them stand out. First, the use of the tax proceeds is not taken into account. While generating revenue is not the purpose of the capital control, some capital controls imply higher government revenue. Thus, their spending can have positive effects on the real sector of the economy. In this case, this effect could mitigate the negative output effects described by the model. Second, as the capital control examined in this paper is assumed to be very general, the effects of more specific controls only, for example, imposed on certain asset transactions could be different from our results. However, this does not imply that the results of more specific controls would be more advantageous as other negative effects like specific substitution effects could occur that may even add more negative side effects.

REFERENCES

- Alesina, A., V., Grilli and G. M. Milesi-Ferretti (1994), "The Political Economy of Capital Controls," in *Capital Mobility: The Impact on Consumption, Investment, and Growth*, L. Leiderman and A. Razin, eds., Cambridge: Cambridge University Press, pp. 289–321.
- Allen, H., and M. P. Taylor (1990), "Charts, Noise and Fundamentals" in the London Foreign Exchange Market, *Economic Journal*, Supplement 100, iss. 400, pp. 49–59.
- (1992), "The Use of Technical Analysis in the Foreign Exchange Market," *Journal of International Money and Finance*, Vol. 11(3), pp. 304–314.
- Ariyoshi, A., K. Habermeier, B. Laurens, I. Ötoker-Robe, J.I. Canales-Kriljenko and A. Kirilenko (2000), "Capital Controls: Country Experiences with Their Use and Liberalizations," *IMF Occasional Paper* 190, Washington, D.C.
- Bird, G., and R.S. Rajan (2000), "Restraining International Capital Movements, What does it Mean?" Centre for International Economic Studies (CIES); *University of Adelaide Policy Discussion Paper* No. 0014.
- Blecker, R. A. (1999), "Taming Global Finance: A Better Architecture for Growth and Equity," Washington D.C. Economic Policy Institute.
- Buch, C. M., R. Heinrich, and C. Pierdzioch (1998), "Taxing Short-Term Capital Flows—An Option for Transition Economies?" Institute for World Economics, *Discussion Paper* 321.
- Cheung Y.-W. and C. Y.-P. Wong (2000), "A Survey of Market Practitioners' Views on Exchange Rate Dynamics," *Journal of International Economics*, Vol. 51(2), pp. 401–419.
- Cheung, Y.-W. and M. D. Chinn (1999a), *Macroeconomic Implications of the Beliefs and Behavior of Foreign Exchange Traders*. Working Paper of the University of California Santa Cruz.
- , (1999b), *Traders, Market Microstructure and Exchange Rate Dynamics*. Working Paper of the University of California Santa Cruz.
- Dornbusch, R. (1976), "Expectations and Exchange Rate Dynamics," *Journal of Political Economy*, Vol. 84(6), pp. 1161–1176.
- (2001), "Malaysia: Was it Different?" in *Preventing Currency Crises in Emerging Markets*, conference held January 11–13, 2001 (S. Edwards and J. Frankel, eds.), forthcoming from The University of Chicago Press.

- Edison, H. J, and C. M. Reinhart (2000), "Capital Controls During Financial Crises: The Case of Malaysia and Thailand," *Board of Governors of the Federal Reserve System International Finance Discussion Paper*, Number 662.
- Edwards, S. (1998), "Capital Flows, Real Exchange Rates and Capital Controls: Some Latin American Experiences," *NBER Working Paper* 6800.
- Eichengreen, B. (1999), *Toward a New International Financial Architecture: A Practical Post-Asia Agenda*, Institute for International Economics, Washington D.C.
- Frankel, J. (1996), "How Well Do Foreign Exchange Markets Work: Might a Tobin Tax Help?" in *The Tobin Tax: Coping with Financial Volatility*, Haq, M. ul, I. Kaul and I. Grunberg, eds., Oxford: Oxford University Press, pp. 41–81.
- Frankel, J., and K. Froot (1988), "Chartists, Fundamentalists and the Demand for Dollars," *Greek Economic Review*, Vol. 10, pp. 49–102.
- (1990), "Chartists, Fundamentalists and Trading in the Foreign Exchange Market," *American Economic Review, Papers and Proceedings*, Vol. 80, pp. 181–85.
- Goldstein, M. (1995), *Coping with Too Much of a Good Thing: Policy Responses for Large Capital Inflows to Developing Countries*, Institute for International Economics, Washington D.C.
- Grilli, V. and G.M. Milesi-Ferretti (1994), "Economic Effects and Structural Determinants of Capital Controls," *IMF Staff Papers*, Vol. 42, pp. 517–551.
- Gruben, W.C. and D. McLeod (1998), "Capital Flows, Savings, and Growth in the 1990s," *The Quarterly Review of Economics and Finance*, Vol. 38(3), pp. 287–302.
- Haq, M. ul, I. Kaul and I. Grunberg (1996), eds., *The Tobin Tax: Coping with Financial Volatility*, Oxford: Oxford University Press.
- International Monetary Fund (IMF) (1998), *World Economic Outlook* (October).
- Johnston, B. R. and N. T. Tamirisa (1998), "Why Do Countries Use Capital Controls?" *IMF Working Paper* 98/181, Washington D.C.
- Kaplan, E., and D. Rodrik (February 2001), "Did the Malaysian Capital Controls Work?" *NBER Working Paper* 8142.
- Kochhar, K., S. Roger, D. Tzannines, B. Johnston, M. Moore, and I. Otker-Robe (1999), "Malaysia: Selected Issues," *IMF Staff Country Report* 99/86, Washington D.C.
- Krugman, P. (1998), *An Open Letter to Prime Minister Mahathir*, September 1, 1998, <http://web.mit.edu/krugman/www/mahathir.html>.

- Laurens, B., and J. Cardoso (1998), "Managing Capital Flows—Lessons from the Experience of Chile," *IMF Working Paper 98/168*, Washington, D.C.
- Liu, O. (2000), "Malaysia fashions own path to recovery, looks to strengthen growth," in *IMF Survey*, Vol. 29(17); pp. 282–284, International Monetary Fund.
- Lui, Y., and D. Mole (1998), "The use of fundamental and technical analyses by foreign exchange dealers: Hong Kong evidence," *Journal of International Money and Finance* 17, pp. 535–545.
- Menkhoff, L. (1997), "Examining the Use of Technical Currency Analysis," *International Journal of Finance and Economics*, Vol. 2(4), pp. 307–318.
- (1998), "The Noise Trading Approach—Questionnaire Evidence from Foreign Exchange," *Journal of International Money and Finance*, Vol. 17(3), pp. 547–564.
- Morales, A. (1998), "Exchange Rate Uncertainty in Money-Based Stabilization Programs," *IMF Working Paper 98/3*, Washington D.C.
- Neely, C. J. (1999), "An Introduction to Capital Controls," *Federal Reserve Bank of St. Louis Review*, Vol. 81(6), pp. 13–30.
- Oberlechner, T. (2001), "Importance of Technical and Fundamental Analysis in the European Foreign Exchange Market," *International Journal of Finance & Economics*, Vol. 6(1), pp. 81–93.
- Raffer, K. (1998), "The Tobin Tax: Reviving a Discussion," *World Development*, Vol. 26(3), pp. 529–538.
- Reinhart, C., and R. T. Smith (1998), "Too Much of a Good Thing. The Macroeconomic Effects of Taxing Capital Inflows," in *Managing Capital Flows and Exchange Rates: Perspectives from the Pacific Basin*, R. Glick, ed., Cambridge: Cambridge University Press, pp. 436–464.
- Tobin, J. (1974), *The New Economics One Decade Older. The Eliot Janeway Lectures on Historical Economics in Honor of Joseph Schumpeter*, Princeton: Princeton University Press.
- Valdes-Prieto, S., and M. Soto (1998), "The Effectiveness of Capital Controls: Theory and Evidence from Chile," *Empirica*, Vol. 25(2), pp. 133–64.

CALCULATION OF THE EIGENVALUES OF THE DYNAMIC SYSTEM

Before calculating the slope of the saddlepath, we assess the stability of the system. We, therefore, derive the eigenvalues and the corresponding eigenvectors of the system given in equation (16). The saddlepath is defined as the eigenvector that refers to the negative eigenvalue. The eigenvalues are the roots of the characteristic equation of (16). For simplicity we set

$$(32) \quad \eta = \frac{\phi\delta\kappa\rho + \phi\delta\lambda + \phi\gamma - \phi\rho}{\kappa\rho + \lambda}.$$

As we assumed that $\delta(\kappa\rho + \lambda) + \gamma > \rho$, we always get $\eta > 0$. Hence the characteristic equation of (16) can be written as

$$(33) \quad \det \begin{pmatrix} -\eta - x & \phi\delta \\ \frac{1}{w(\kappa\rho + \lambda)} & -\theta - x \end{pmatrix} = (-\eta - x)(-\theta - x) - \frac{\phi\delta}{w(\kappa\rho + \lambda)} = 0.$$

Rearranging equation (33) gives

$$(34) \quad (\theta\eta) + (\eta + \theta)x + x^2 - \frac{\phi\delta}{w(\kappa\rho + \lambda)} = 0.$$

Solving (34) for x yields

$$(35) \quad x_{1/2} = -\frac{\theta}{2} - \frac{1}{2}\eta \pm \sqrt{\frac{1}{4}(\eta + \theta)^2 + \frac{\phi\delta}{w(\kappa\rho + \lambda)} - \eta\theta}.$$

After some manipulations, we derive the roots as

$$(36) \quad x_{1/2} = -\frac{\theta}{2} - \frac{1}{2}\eta \pm \sqrt{\left(\frac{\theta}{2} - \frac{1}{2}\eta\right)^2 + \frac{\phi\delta}{w(\kappa\rho + \lambda)}}.$$

Since the value of the expression under the root is unambiguously positive and the determinant is negative, we get one positive and one negative eigenvalue. Hence, the system is saddlepathstable.

THE IMPACT OF A VARIATION OF THE CAPITAL CONTROL ON THE SLOPE OF THE SADDLEPATH

To capture the slope of the saddlepath, we derive the eigenvector that corresponds to the negative eigenvalue x_2 obtained in Appendix I. Since the eigenvector is not uniquely determined, we can normalize the first component of the eigenvector to unity. Using this normalization, the second component (g) will be uniquely resolved. The following equation sets up the condition that has to be fulfilled by the eigenvector:

$$(37) \quad \begin{pmatrix} -\eta - x_2 & \phi\delta \\ \frac{1}{w(\kappa\rho + \lambda)} & -\theta - x_2 \end{pmatrix} \begin{pmatrix} 1 \\ g \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}.$$

To calculate the value of g , we only need to take into account one of the two equations of system (37) because the two equations are linear dependent. Using the second equation, which is

$$(38) \quad \frac{1}{w(\kappa\rho + \lambda)} - g(\theta + x_2) = 0,$$

we derive the following expression

$$(39) \quad g = \frac{1}{w(\kappa\rho + \lambda)(x_2 + \theta)}.$$

After inserting x_2 and combining the θ expressions, we get

$$(40) \quad g = \frac{1}{w(\kappa\rho + \lambda) \left[\frac{\theta}{2} - \frac{1}{2}\eta - \sqrt{\left(\frac{\theta}{2} - \frac{1}{2}\eta\right)^2 + \frac{\phi\delta}{w(\kappa\rho + \lambda)}} \right]}.$$

The expression in brackets is negative because $\frac{\theta}{2} - \frac{1}{2}\eta < \sqrt{\left(\frac{\theta}{2} - \frac{1}{2}\eta\right)^2 + \frac{\phi\delta}{w(\kappa\rho + \lambda)}}$.

Therefore, the value of g is negative, too. Hence, we conclude that the slope of the saddlepath is also negative.

To calculate the impact of a capital control, which functions as a tax, on the slope of the saddlepath, we first use equation (15) in equation (40) and get

$$(41) \quad g = \frac{1}{w(\kappa\rho + \lambda) \left(\frac{(1-w)w^{-1}\alpha}{2} - \frac{1}{2}\eta - \sqrt{\left(\frac{(1-w)w^{-1}\alpha}{2} - \frac{1}{2}\eta \right)^2 + \frac{\phi\delta}{w(\kappa\rho + \lambda)}} \right)}$$

Differentiation with respect to τ yields the slope of the saddlepath as

$$(42) \quad \frac{\partial g}{\partial \tau} = -w(\kappa\rho + \lambda) \frac{\frac{(1-w)\alpha_\tau}{2w} \left[1 - \frac{\left(\frac{\theta}{2} - \frac{\eta}{2} \right)}{\sqrt{\left(\frac{\theta}{2} - \frac{\eta}{2} \right)^2 + \frac{\phi\delta}{w(\kappa\rho + \lambda)}}} \right]}{\left[w(\kappa\rho + \lambda) \left(\frac{\theta}{2} - \frac{\eta}{2} - \sqrt{\left(\frac{\theta}{2} - \frac{\eta}{2} \right)^2 + \frac{\phi\delta}{w(\kappa\rho + \lambda)}} \right) \right]^2}$$

Since $\frac{\theta}{2} - \frac{\eta}{2} < \sqrt{\left(\frac{\theta}{2} - \frac{\eta}{2} \right)^2 + \frac{\phi\delta}{w(\kappa\rho + \lambda)}}$, the bracket in the nominator is positive.

Under consideration of the minus sign and the fact that $\alpha_\tau < 0$, the value of $\partial g/\partial \tau$ is always positive. This means that the slope of the saddlepath becomes flatter when the government implements a capital control.