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THE LONG-RUN STABILITY OF A SMALL, OPEN ECONOMY UNDER CRAWLING PEG REGIME

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The paper analyses the long-run (steady-state) output and price stability of a small, open economy which adopts a "crawling-peg" type of exchange-rate regime in the presence of various kinds of random shocks. Analytical and simulation results suggest that with the exception of money demand shocks, an exchange rate policy which involves a relatively higher rate of indexation of the exchange rate to price level is likely to lead to the worsening of price stability for all types of shocks. On the other hand, the impact of adopting such a policy on output stability depends on the type of the shock; for policy shocks to the exchange rate and shocks to output demand, output stability is worsened whereas for the shocks to risk premium of domestic assets, supply price of domestic output and the wage rate, better output stability is achieved in the long run.

Keywords: open economy, crawling-peg, exchange rate, stability, random shocks

JEL classification index: F41

1. INTRODUCTION

The debate about the choice of the "optimal exchange rate regime" has gained new momentum particularly after the East Asian crisis that started in 1997. As recently emphasised and shown by Jadresic et al. (1999), Sebastian and Savastano (1998), the key insight emerging from the ongoing debate is the idea that due to the differences in levels of economic and financial development, no single exchange rate regime is optimal for all the countries, and the regime that is optimal for a particular country may change over time. Furthermore, a growing number of economists have started considering the extreme form of "pure floating" exchange rate regime as undesirable because of the evidence that assets markets in general, and the foreign exchange markets in particular, are driven by herd behaviour rather than rational expectations. This kind of market behaviour makes

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it extremely difficult for the economic mechanism under "pure floating" to hold the exchange rate close to a level consistent with the fundamentals (Williamson, 1999).

The opposite of pure floating is "pure fixed rates" whose operational success critically depends, among other factors, on the willingness of the country in question to adopt currency board like institutional arrangements that will assure continued credibility of the fixed rate commitment (Williamson, 1999). This argument is of particular relevance for countries, which do not have the fiscal and monetary discipline, and therefore frequently resort to money printing to finance fiscal deficits. The end result of sustained money financing of fiscal deficits is inflation, which erodes the international competitiveness of exports and inevitably leads to rising current account deficits and falling foreign exchange reserves of the Central Bank.

One of the preferred regimes by the policymakers to reduce the risk of such overvaluation of the currency and its likely adverse consequences has generally been the "crawling peg" regime. Under this regime, the usual practice has been the backward indexation of the exchange rate to domestic price level. Depending on the choice of the policymaker about the degree of indexation (or the rate of crawl), the exchange rate is devalued at periodic intervals proportionately, or less than proportionately, to a given rate of past inflation. However, the past experience of the countries which adopted the crawling peg regime suggest that policymakers who consider the changes in current account balance, the foreign exchange reserves and the rate of accumulation of stock of external debt as unsustainable, may, from time to time, undertake a larger devaluation than what the policy rule would require. Such unanticipated policy behaviour suggests that crawling peg regimes, in practice, have both systematic and non-systematic policy components. The latter component acts like a random (policy) shock for the economy and the long-run stability consequences of such an unanticipated policy behaviour are usually not carefully evaluated and taken into account.

The recent East Asian crisis has shown how a crisis in one country can easily spread to other countries (particularly through the erratic behaviour of international investors), which may not have immediate problems in fundamentals of their economies. Usually the contagion effects work through the financial variables such as increases of the interest rate (caused by rapid increase in risk premiums), and declines in stock prices and currency values (Stiglitz, 1999). This financial turmoil may lead to deflationary business conditions with devastating real effects, which may last for years (Tobin, 1999). Furthermore, the tightening of monetary policy (in response to the financial crisis) as recommended by the World Bank, and carried out by most countries during the early phases of a financial crisis, could have potentially caused magnified contractionary effects on domestic output through the supply-side and demand-side effects of the rapid increase in interest rates.

The demand-side effects of higher interest rates on new investments have been found to be particularly significant for small and mid-sized firms, which find themselves unable to borrow from commercial banks (even at the new higher interest rates) due to the reduced supply of loans to such firms whose creditworthiness decreases as the falling stock prices (partly caused by rising interest rates) reduce the asset values and the net worth of these firms (Ferri and Kang, 2000). Despite the fact that the possible direct supply-side (cost) effects of higher interest rates on firms, which particularly depend on loans from the commercial banks for their working capital needs was pointed out by Taylor (1983), no effort has been made to include such effects in traditional open economy macro-models. This is one of the reasons for the inability of these models to explain adequately what happened during and after the East Asian crisis, leading some analysts to suggest that understanding the crisis fully will require a new generation of analytical models (Asian Development Bank, 1999).

The present study is not an attempt to explain either the roots or the dynamics of a similar crisis that can emerge in different countries and spread to others. Rather it is a modest attempt to analyse the long-run stability properties of adopting a crawling peg regime using a model which incorporates some of the stylised facts of the East Asian crisis, particularly regarding the nature of the shocks, and supply-side effects of higher interest rates. The fact that the exchange rate regime of approximately 30 of the developing countries in the world is crawling peg regime, underlines the policy significance of the issue raised above (Jadresic et al., 1999).

In particular, an attempt has been made to analyse the impact of adopting a relatively higher rate of crawl (or higher degree of indexation of the exchange rate to domestic price level) on the long-run (steady-state) stability of the output and the price level for a variety of shocks, which include shocks to output demand, money demand, supply price of domestic output, wage level, risk premium on domestic assets and the policy shocks to the exchange rate. Analytical results suggest that the long-run stability of price level is unambiguously negatively affected by adopting an exchange rate policy which involves higher rate of crawl for all types of shocks except for money demand shocks, which have neither price nor output effects under either a strictly fixed or a crawling peg regime, latter of which is also a variant of fixed rate regimes. On the other hand, the analytical results in relation to the long-run output stability are ambiguous for shocks to risk premium. However, when the main sources of macroeconomic instability are the shocks to the supply price of domestic output and the wage level, higher rate of crawl unambiguously improves the long-run stability of output, whereas the same policy worsens the output stability in case of output demand shocks and policy shocks to the exchange rate. Simulation of analytically ambiguous results for risk-premium shocks show that (for a large majority of alternative combinations of plausible parameter values) an increase in the rate of crawl is likely to generate better output stability in the long run.

The model of the small, open economy, which is used to analyse the issues discussed above, is specified in the second section of the paper. Analysis of the comparative static results regarding the likely impact of increasing the rate of crawl on the long-run equilibrium (steady-state) variances of output and price level is presented in section three. In section four, we numerically simulate the ambiguous analytical results for a variety of combinations of plausible parameter values and discuss the exceptional cases. The last section summarises the results and discusses their policy implications.

2. THE MODEL OF THE SMALL, OPEN ECONOMY

The model of the small, open economy which captures the crawling peg kind of exchange-rate policy and some of the stylised facts (particularly regarding the supply-side effects of rising interest rates and various types of shocks) that emerged from the East Asian crises, is described below by equations (1)–(6).

$$y_t = a_1 (e + p^* - p)_t + a_2 (i)_t + a_3 (y^*)_t + u_t \qquad (1)$$

$$a_1 > 0,\ a_2 < 0,\ a_3 > 0$$

$$(m - p)_t = b_1 (y)_t + b_2 (i)_t + \varepsilon_t \qquad (2)$$

$$b_1 > 0,\ b_2 < 0$$

$$p_t = c_1 (e + p^*)_t + c_2 (y)_t + c_3 (w)_t + c_4 (i)_t + v_t \qquad (3)$$

$$c_1 > 0,\ c_2 > 0,\ c_3 > 0,\ c_4 > 0$$

$$w_t = w^*_t + k_t \qquad (4)$$

$$i_t = i^*_t + \delta_t \qquad (5)$$

$$e_t = \alpha p_{t-1} + z_t \qquad (6)$$

$$0 \leq a \leq 1$$

Where for $\forall_t$, $u \sim N(0, \sigma_u^2),\ \in\ \sim N(0, \sigma^2 \in)$

$v \sim N(0, \sigma_v^2),\ k \sim N(0, \sigma_k^2)$

$\delta \sim N(0, \sigma_\delta^2),\ z \sim N(0, \sigma_z^2)$

σ^2 stands for the variance of the corresponding random shock and covariance of each possible pair of u, $\in$, v, k, δ and z is assumed to be 0.
y = output of the small, open economy
e = exchange rate – expressed as the units of the small economy's currency per unit of the currency of the large economy.
y^* = output of the large economy (which is the main trading partner of the small economy)
p = price level of the small economy
i = nominal interest rate of the small economy
m = money supply of the small economy
i^* = nominal interest rate of the large economy
p^* = price level of the large economy
w = wage rate of the small economy
w^* = predetermined component of the wage rate of the small economy
$\in$ = random shock to money demand
u = random shock to output demand
v = random shock to price level
k = random shock to wage rate
δ = random shock to risk premium
z = random policy shock to the exchange rate
α = degree of indexation of the exchange rate to domestic price level or the rate of crawl.

All of the above variables except the interest rate are expressed in natural logarithm.

Equations (1) and (2) represent the goods market and money market equilibrium conditions. The price adjustment behaviour of domestic producers is specified by equation (3), which captures the assumptions that in addition to labour input, producers use imported goods (from the large economy) as an input in the production process and furthermore, the changes in interest rate directly affect the cost of production. This latter aspect of the supply-side behaviour of the economy reflects the assumption that firms use loans from the commercial banking system to finance their working capital needs (which include regular payments to the labour, raw material and energy suppliers) and therefore, a given increase in interest rates will lead to a direct increase in production costs. Equation (4) captures the assumption that wages are predetermined in the beginning of each period and can deviate from this predetermined level (w_t^*) only in case of an unanticipated shock. The (uncovered) interest parity equation (5) shows that domestic interest rate can deviate from the foreign interest rate by an amount of risk premium, which is assumed to be only, on average, zero. In other words, we assume that for investors, the "degree of substitutability" of domestic and foreign bonds can change unpredictably as a result of "news" that may be totally unrelated to the fundamentals of the economy (as observed during East Asian Crisis) which, in turn, makes risk premium required by investors a random variable (Stiglitz, 1999). The statistical analysis of the data about the risk premium revealed that investors' "preference for risk" changes collectively from "risk loving" to "risk aversion" as a result of news about the financial developments in a certain country (Persaud, 1998). We explain the nature of the uncovered interest parity equation that we used in our model in more detail in Appendix 1 to the paper. Equation (6) attempts to capture the real world behaviour of policymakers who have adopted crawling peg regimes. The value of α (policy parameter) represents the rate of crawl (degree of indexation) of the exchange rate in relation to the domestic price level. In the beginning of each period the exchange rate is readjusted based on the past period's value of the price level and the policy choice of the rate of crawl, and it is kept fixed at this target level throughout the whole period.

However, as Dornbusch (1991) points out, if the Central Bank reserves have fallen to critical levels or the accumulated stock of external debt has reached such levels, which may result in actual or potential debt servicing problems, central authorities may be forced to undertake a large devaluation despite the fact that the exchange rate might have been devalued in proportion to the price level in the past. Such unanticipated devaluations (or revaluations) represent policy shocks to the economy and the non-systematic component (z_t) of the exchange rate policy attempts to capture this dimension of the real world policy behaviour. As McKinnon (1999) shows when the "decision making horizon" of investors is short, the policy shocks will have zero covariance with shocks to risk premium. This is because under those circumstances, investors simply assume that a non-systematic change in the exchange rate (even though possible in the long-run) will not happen in the time interval corresponding to their decision-making horizon.

3. ANALYSIS OF THE LONG-RUN MACROECONOMIC STABILITY PROPERTIES OF THE CRAWLING PEG REGIME

The macroeconomic stability of an economy in the long-run particularly depends on the stability of its output and the price level, which have been traditionally measured in terms of the magnitudes of their respective variances around their long-run equilibrium (or the steady-state) values. In the light of this, the aim of this section is to analyse the likely impact of choosing a relatively higher rate of indexation (or rate of crawl) of the exchange rate to domestic price level on the magnitudes of output and price variances that would result in the presence of each type of shock separately. If adopting a relatively higher rate of crawl leads to a larger variance of output (or the price level) in the presence of a certain type of shock, this naturally implies the worsening of the long-run stability of output (or the price level) when the main source of macroeconomic instability is that specific type of shock.

In what follows, using the reduced form of the long-run equilibrium (steady-state) solution of the model (which is stated in Appendix 2 to the paper), we first present the analytical expressions representing the steady-state variances of both output and the price level for each type of shock and analyse the sensitivity of each variance to an increase in the rate of crawl.

3.1. Stability in the presence of output demand shocks

The variances of output and the price level are given below by equations (7) and (8).

$$\sigma_y^2 = \left(\frac{1+c_1\alpha}{q}\right)^2 \sigma_u^2 , \tag{7}$$

where, $q = 1 + a_1c_2 - a\,(c_1 + a_1c_2)$ throughout the rest of the paper.

$$\sigma_p^2 = \left(\frac{c_2}{q}\right)^2 \sigma_u^2 \ . \tag{8}$$

To see the impact of increasing the rate of crawl on output and price stability, we take the derivatives of (7) and (8) with respect to α. Equations (9) and (10) capture these effects:

$$\frac{\partial\sigma_y^2}{\partial\alpha} = \frac{2(1-c_1\alpha)[-c_1q+(c_1+a_1c_2)(1-c_1\alpha)]\sigma_u^2}{q^3} > 0 \tag{9}$$

$$\frac{\partial\sigma_p^2}{\partial\alpha} = \frac{2c_2^2(c_1+a_1c_2)\sigma_u^2}{q^3} > 0 \tag{10}$$

As equations (9) and (10) show, increasing the rate of crawl (of the exchange rate) unambiguously leads to the worsening of both output and price stability.

This result can be explained as follows: a given positive shock to output demand (such as an unanticipated fiscal expansion or an investment boom) is expansionary for output, and therefore it positively affects the price level causing both variables to deviate from their long-run equilibrium (steady-state) values. With a higher rate of crawl, currency is devalued by a larger magnitude in response to the initial increase in the price level. This, in turn, means a relatively larger increase in both output and the price level in the subsequent period, making the total amount of deviation of both variables from their initial equilibrium values relatively bigger than it would be in the presence of a lower rate of crawl.

In what follows, we examine the consequences of adopting a crawling peg regime in the presence of output demand shocks (which can take the form of an investment or a consumption boom or a fiscal expansion) on the balance of payments stability: any one of these shocks will lead to deterioration of the current account balance. For example, an unanticipated fiscal expansion will be expansionary for output and therefore lead to an increase in the price level. While the expansion in output will increase imports, the increase in price level (through its expenditure-switching effect) will not only increase imports but also reduce exports, leading to a reduction in current account balance. However, this worsening of the overall balance of payments is partly or more than offset by the improvement in the capital account balance, which takes place as a result of capital inflows generated by the upward pressure on domestic interest rate throughout the adjustment process in the impact period. As output expands and the price level increases following a positive shock to output demand, demand for money will increase putting an upward pressure on domestic interest rate and therefore lead to capital inflows from the large economy. On the other hand, the presence of a crawling-peg type of exchange rate regime means that the exchange rate is devalued in the beginning of the next period (in response to the increase in price level in the impact period), which is expected to lead to an improvement in the balance of payments. Therefore, even if the net effect (of a given positive shock to output demand) on the balance of payments happens to be negative in the impact period, the presence of a crawling peg regime with a relatively high rate of crawl, could reduce the potentially adverse effects of such shocks on the balance of payments stability.

3.2. Stability in the presence of money-demand shocks

As shown elsewhere in the literature, a fixed exchange rate regime (whether it is pure fixed rates or crawling-peg kind of regime) can perfectly insulate a small, open economy from the adverse price and output effects of shocks to domestic demand for money (Fischer, 1986 and Husted and Melvin, 1998). This insulation is achieved by printing enough money to meet the rising demand for it caused by a positive shock to money demand, which prevents the appreciation of the exchange rate and keeps it at its target level. Our reduced form solution of the model captures the same result showing that there are no price and output effects of shocks to domestic demand for money, and therefore, the steady-state variances of both variables are zero. In other words, when the main source of macroeconomic instability is money demand shock, a crawling peg regime (which is a variant of fixed rates) can provide perfect stability for both output and the price level.

However, it is worth noting that even in the absence of price and output effects, such shocks can potentially lead to balance of payments instability due to the capital inflows or outflows that they generate. For example, when there is a positive shock to domestic demand for money, this creates upward pressure on domestic interest rate, which leads to capital inflow causing a surplus on the capital account balance and an improvement in the overall balance of payments. In case of a negative shock to money demand, the result would be a capital account deficit and deterioration of the balance of payments and the corresponding fall in the stock of foreign currency reserves of the Central Bank.

3.3. Stability in the presence of price-level shocks

The steady-state variances of output and price level, when the main source of macroeconomic instability is shock to supply price of domestic output, are given below by equations (11) and (12)

$$\sigma_y^2 = \left(\frac{\alpha_1(\alpha - 1)}{q}\right)^2 \sigma_v^2 \tag{11}$$

$$\sigma_p^2 = \left(\frac{1}{q}\right)^2 \sigma_v^2 \tag{12}$$

Taking derivatives of both (11) and (12) with respect to α yield the following:

$$\frac{\partial \sigma_y^2}{\partial \alpha} = \left[\frac{2\alpha_1^2(\alpha - 1)(q + (c_1 + a_1 c_2)(\alpha - 1))}{q^3}\right]\sigma_v^2 < 0 \tag{13}$$

$$\frac{\partial \sigma_y^2}{\partial \alpha} = \left[\frac{2(c_1 + a_1 c_2)}{q^3} \right] \sigma_v^2 < 0 \tag{14}$$

As the above results show, an exchange rate policy which involves higher rate of crawl of the currency, while unambiguously improving the long-run stability of output, definitely worsens the long-run price stability in the presence of price-level shocks. This suggests that policymakers face a trade-off in adopting such an exchange-rate policy when the dominant source of macroeconomic uncertainty originates from price-level shocks; higher rate of crawl leads to superior output stability but this is achieved only at the expense of worsened price stability in the long run.

This result can be explained as follows: a given positive shock to supply price of domestic output is contractionary for output since it raises the relative price of domestic goods vis-à-vis the foreign goods. However, in the subsequent period, the devaluation of domestic currency in response to the increase in price level partly offsets the initial contractionary effect. With a higher rate of crawl, the amount of subsequent devaluation is bigger, which in turn, makes the net contractionary output effect of the initial price-level shock smaller. In other words, with bigger value of α, the absolute magnitude of deviation of output from its steady-state value is smaller. However, in the presence of imported inputs, the same policy leads to relatively larger increase in domestic price level due to the cost-raising effect of a given devaluation.

The result regarding the trade-off between output and price stability in the presence of price-level shocks seems to suggest that there is some robustness in terms of model specification. This is motivated by the earlier findings of Dornbusch (1980), who obtained the same result in a model which assumes perfect substitutability of domestic and foreign goods and of Çıftçioğlu (1995) who obtained the same result in a short-run dynamic model.

On the other hand, the presence of a crawling-peg type of exchange rate regime unambiguously helps to reduce the adverse effects of price-level shocks on the balance of payments stability: a given positive shock to supply price of domestic output leads to appreciation of real exchange rate (meaning an increase in the relative price of domestic good), which worsens the current account balance. However, this negative effect on balance of payments would be partly (or more) offset by the upward pressure on domestic interest rate (caused by the inflationary effect of the shock), which generates incipient capital inflow.

The devaluation that takes place in the next period (in response to the increase in the price level in the impact period) tends to positively affect the current account balance and therefore reverse the likely negative impact effect of a given positive price-level shock on the balance of payments. In this sense, the presence of a crawling-peg type of exchange-rate regime is likely to promote the balance of payments stability when the main source of macroeconomic instability is shock to supply price of domestic output.

3.4. Stability in the presence of wage shocks

Analytical expressions representing the steady-state variances of output and the price level in the presence of wage shocks are given below by equations (15) and (16).

$$\sigma_y^2 = \left(\frac{a_1 c_3(\alpha - 1)}{q}\right)^2 \sigma_k^2 \tag{15}$$

$$\sigma_p^2 = \left(\frac{c_3}{q}\right)^2 \sigma_k^2 \tag{16}$$

Taking derivatives of (15) and (16) with respect to α yield the following:

$$\frac{\partial \sigma_y^2}{\partial \alpha} = \left[\frac{2a_1^2 c_3^2 (\alpha - 1)(q + (c_1 + a_1 c_2)(\alpha - 1))}{q^3}\right] \sigma_k^2 < 0 \tag{17}$$

$$\frac{\partial \sigma_p^2}{\partial \alpha} = \left[\frac{2c_3^2 (c_1 + a_1 c_2)}{q^3}\right] \sigma_k^2 > 0 \tag{18}$$

As the equations (17) and (18) show, a relatively larger value of α leads to lower output instability but only at the expense of larger price instability. Considering the fact that an unanticipated shock to the wage rate essentially increases the unit cost of production like any other type of price level shocks which directly affect the cost of production, the analysis of this policy trade-off is similar to that of the price-level shocks explained previously. As the work of Hausmann et al. (1999) suggests, increasing global integration of factor markets (along with goods markets) means that output demand shocks impinging on foreign labour-importing countries, will lead to fluctuations in the demand for labour from labour-exporting countries causing unanticipated random shocks for the labour market conditions and therefore for the prevailing wage rate in such economies. This point is a reminder of the necessity for policymakers to be conscious of the stability effects of adopting a crawling peg regime in the presence of not only domestic shocks but also foreign shocks impinging on other economies.

3.5. Stability in the presence of shocks to risk premium

As the recent East Asian and the earlier Mexican crisis of 1995 have both shown that, even the "news" about the possible crisis in one country can easily spread to other countries particularly through capital flows. For example, the Mexican crisis of 1995, which resulted in an unanticipated devaluation of the Mexican peso and a dramatic drop in Mexican stock prices made international investors to re-evaluate the risks of their portfolio investments in other developing countries. The end result of this "contagion effect" was the dramatic increase in required risk premiums for the securities of developing countries, and as a result, their financial markets were also hit by declining values due to rapid outflow of foreign capital. This drop in the value of developing country securities following the Mexican crisis is often referred to as the "Tequila Effect" (Husted and Melvin, 1998). It seems that very few of the developing countries can be immune from the potential adverse effects of the volatility in risk premium of domestic assets caused by unanticipated changes in the degree of optimism or pessimism of investors. The growing global integration of financial markets naturally made the stability of open economies more vulnerable to the effects of random fluctuations in investors' preferences regarding risk.

Equations (19) and (20) represent the steady-state variances of output and the price level that would result when the main sources of macroeconomic instability are the shocks to risk premium:

$$\sigma_y^2 = \left(\frac{s}{q}\right)^2 \sigma_\delta^2 \tag{19}$$

Where $s = a_1 c_4(\alpha - 1) + a_2(1 - c_1\alpha)$

$$\sigma_p^2 = \left(\frac{a_2 c_2 + c_4}{q}\right)^2 \sigma_\delta^2 \tag{20}$$

Taking derivatives of (19) and (20) with respect to the value of α yield the following:

$$\frac{\partial \sigma_y^2}{\partial \alpha} = \left[\frac{2s\left(\left(a_1c_4 - a_2c_1\right)q + \left(c_1 + a_1c_2\right)s\right)}{q^3} \right] \sigma_\delta^2 = ? \tag{21}$$

$$\frac{\partial \sigma_p^2}{\partial \alpha} = \left[\frac{2\left(a_2c_2 + c_4\right)^2 \left(c_1 + a_1c_2\right)}{q^3} \right] \sigma_\delta^2 > 0 \tag{22}$$

As equations (21) and (22) suggest, while an increase in the rate of crawl unambiguously leads to the worsening of price stability, its impact on output stability is ambiguous. The numerical simulations carried out in the next section suggest that an increase in the value of α is likely to reduce the magnitude of the output instability. However, in two of the cases examined, the opposite was found to be true. In one case the interest rate effect on the production costs is relatively small. This is due to the fact that with a sufficiently small interest rate effect on production costs, the net effect of higher interest rates on price level might be negative, as the negative effect operating through contractionary demand-side effect will more than offset the positive supply-side effect. Under these circumstances, a positive shock to risk premium negatively affects both output and the price level in the impact period. However, this means that in the subsequent period, the exchange rate is appreciated leading to a further contraction in output. Furthermore, in the presence of a higher rate of crawl, the magnitude of this subsequent appreciation is bigger, which in turn makes the overall amount of deviation of output from its steady-state value relatively larger.

In what follows we explain the intuition behind the basic results as captured by equations (21) and (22) in some detail: a given positive shock to risk premium (for domestic bonds) leads to an increase in the required rate of return on domestic bonds, for the existing stock of such bonds to be held willingly in domestic and international investors portfolios. In other words, for equilibrium in financial markets, interest rate on domestic bonds must rise. Given our assumption that changes in the domestic interest rate directly affects the supply price of domestic output through its effect on production costs, a positive shock to risk premium, which unambiguously leads to contraction in output, may or may not lead to an increase in the price level. In other words, its impact on the price level is ambiguous since there are two opposite effects; while its direct cost raising supply-side effect (which operates through the interest cost of working capital needs of domestic firms) is inflationary, the negative effect operating through the contraction in aggregate demand is deflationary.

If the net effect of a positive shock to risk premium on the price level is positive (numerically negative) in the impact period, the exchange rate is devalued (revalued) in the next period. However this ambiguity about the nature of the policy response, resulting from the ambiguity of the nature of the price effect in the impact period, implies corresponding ambiguity of the effect of adopting an exchange-rate policy with a relatively higher rate of crawl, on the long-run output stability. An exchange-rate policy which involves a relatively higher rate of crawl inevitably means a relatively higher rate of devaluation (revaluation) in the next period, in response to a given increase (decrease) in domestic price level in the impact period. If the currency is devalued, this exerts an expansionary effect on net exports (trade balance) and therefore reduces the size of the overall (negative) deviation of output from its initial (long-run) equilibrium. And in the presence of a relatively higher rate of crawl, the magnitude of this subsequent devaluation (which takes place in case of a positive price effect in the impact period) will be relatively larger, leading to a relatively smaller deviation of output from its long-run equilibrium (steady-state) level. However, both this expansionary effect on aggregate demand and the direct cost raising supply-side effect of a relatively larger devaluation lead to a relatively larger increase in the price level following the impact period. This, in turn, makes the overall deviation of the price level from its initial long-run equilibrium level relatively larger. Therefore, in a case where the net price effect of a given positive shock to risk premium is positive in the impact period, an exchange-rate policy, which involves relatively larger rate of crawl, will tend to improve the long-run stability of output but only at the expense of worsened price stability. On the other hand, if the impact effect of a given positive shock to risk premium on price level is negative, the same exchange-rate policy results in a relatively bigger revaluation of the domestic currency in the next period. This leads to further contraction in output (through the real appreciation it causes) and an additional reduction in the price level both through its contractionary relative-price effect on trade balance and the reduction it brings about in the cost of imported inputs. Under these circumstances, the presence of a relatively larger rate of crawl of the exchange rate may lead to the worsening of both (long-run) output and price stability since the overall (negative) deviation of both output and the price level from their respective long-run equilibrium levels increases.

On the other hand, the implications of adopting a crawling peg regime on the balance-of-payments stability in the presence of shocks to risk premium will depend on the relative size of the "opposing effects" on capital accounts and the current account balances. A positive shock to risk premium for domestic bonds immediately leads to capital outflow and therefore causes an increase in the domestic interest rate by an amount equivalent to an increase in the risk premium. At the same time, due to the assumption that the exchange rate is adjusted only at the beginning of each period (based on the rate of crawl) and kept fixed throughout the rest of the period, as capital flows out of the country, the Central Bank will have to sell foreign currency (from the stock of its reserves) in order to prevent depreciation of the currency. In other words, the impact effect of a higher risk premium is the emergence of a capital account deficit and the consequent fall in the stock of foreign currency reserves of the Central Bank. However, this deficit on the balance of payments (due to deterioration of the capital account balance) may worsen or improve depending on the direction of the price effect of a given shock in the impact period. If the net price effect is negative so that relative price of domestic goods is reduced, the positive effect of contraction in national income on trade balance (which operates through lower imports) is further strengthened leading to surplus in the current account balance. In this case, the overall balance of payments may or may not be in deficit and therefore the stock of reserves of the Central Bank may or may not fall in the impact period.

However, if the net price effect is positive (which may take place if the interest-rate effect on the production costs is relatively high), the consequent real appreciation may more than offset the positive effect of contraction in output on the current account balance leading to an overall deficit in the current account balance, which further worsens the overall deficit in the balance of payments. If the existing stock of foreign currency reserves of the Central Bank is not adequate, it is highly likely that the exchange rate regime may collapse. On the other hand, even if the net price effect in the impact period is negative, so that the current account unambiguously improves, the appreciation of the currency in the next period due to crawling peg regime may lead to additional balance-of-payments instability by worsening the current account balance. Therefore, for crawling peg regime (with the kind we assumed in our model) to be operative, we need to assume that, either the balance-of-payments deficit that may emerge in response to a risk-premium shock will not be large in magnitude and/or the stock of foreign currency reserves of the Central Bank is adequate to deal with such unexpected balance-of-payments instability.

3.6. Stability in the presence of policy shocks

Output and price variances in the presence of policy shocks are given below by equations (23) and (24).

$$\sigma_y^2 = \left(\frac{a_1 (1 - c_1)}{q} \right)^2 \sigma_z^2 \tag{23}$$

$$\sigma_p^2 = \left(\frac{a_2 c_2 + c_1}{q} \right)^2 \sigma_z^2 \tag{24}$$

Taking derivatives of (23) and (24) yield the following:

$$\frac{\partial \sigma_y^2}{\partial \alpha} = \left[\frac{2a_1^2 (1 - c_1)^2 (c_1 + a_1 c_2)}{q^3} \right] \sigma_z^2 > 0 \tag{25}$$

$$\frac{\partial \sigma_p^2}{\partial \alpha} = \left[\frac{2(c_1 + a_1 c_2)^3}{q^3} \right] \sigma_z^2 > 0 \tag{26}$$

The signs of both derivatives are unambiguously positive: a given increase in the value of α leads to increases in the steady-state variances of both output and the price level. In other words, when the main source of macroeconomic instability is the policy shock to the exchange rate itself, a relatively larger rate of crawl of the exchange rate results in the worsening of both output and the price stability in the long run.

The above result can be attributed to the fact that if there is a sudden unanticipated devaluation in the middle of the period during which the exchange rate was supposed to be kept fixed which it may be due to the external debt servicing problems and/or the unsustainability of the current account deficit, this positively affects both output and the price level. In the beginning of next period, the increase in the price level necessitates further devaluation of the exchange rate (whose magnitude depends on the rate of crawl) causing further deviation of both output and the price level from their initial steady-state equilibrium values. And this deviation naturally happens to be larger if the subsequent devaluation is relatively larger, which is the case in the presence of a relatively larger rate of crawl.

The consequences of such an unanticipated devaluation on the balance-of-payments stability in the presence of a crawling peg regime can be summarised as follows: in the impact period during which the policy shock (let's say devaluation) takes place, current account balance first improves. However, expansionary and inflationary effects of a given devaluation on the trade balance partly offsets this initial positive effect on the balance of payments. The subsequent devaluation that takes place in the next period (in response to the inflationary effect in the impact period) leads to further improvement in the current account balance and therefore in the overall balance of payments. On the other hand, it is worth noting that positive output and price effects of the initial and the subsequent devaluations put upward pressure on the domestic interest rate (by increasing domestic demand for money), which causes incipient capital inflow and forces the Central Bank to buy foreign currency in exchange of domestic currency to prevent appreciation of domestic currency. However, improvement in the capital account balance means further improvement in the overall balance of payments leading to an increase in the stocks of foreign currency reserves of the Central Bank. Naturally, a policy shock in the form of revaluation (appreciation) of the currency would have opposite effects and therefore could potentially lead to a balance-of-payments deficit. This might be destabilising for a crawling peg regime, where the stock of foreign currency reserves at the Central Bank is below a certain critical level necessary to deal with the emerging deficit.

4. NUMERICAL ANALYSIS

In this section, using plausible parameter values, we try to see the likely qualitative effect of an increase in the rate of crawl on the long-run stability of output in the presence of random shocks to risk premium, which was shown to be ambiguous. We first use a set of base values for the structural parameters of the model to sign this effect captured by equation (21) and then test the robustness of the result to varying parameter values by experimenting with alternative cases. Each case involves changing the value of only one of the parameters and keeping the values of the rest, the same as their base values. In what follows, we first present the base values and the resulting numerical estimate for the expression representing the impact of an increase in the rate of crawl on output variance:

Base Values

$a_1 = 0.4$	$a_2 = -0.2$	$a_3 = 0.2$
$b_1 = 1$	$b_2 = -0.1$	
$c_1 = 0.3$	$c_2 = 0.2$	$c_3 = 0.5$
$\alpha = 0.5$	$c_4 = 0.1$	

Using the above values in equation (21) we obtain :

$$\frac{\partial \sigma_y^2}{\partial \alpha} = -0.009\,\sigma_\delta^2$$

The above result suggests that when the main source of macroeconomic instability is a shock to risk premium, the presence of relatively larger rate of crawl is likely to reduce the long-run instability of output. To test the robustness of this result to varying parameter values, we experiment with alternative cases, the results of which are presented below:

Simulation Cases		$\partial\sigma_y^2/\partial\alpha$
Case 1:	$a_1 = 0.6$	$-0.013\ \sigma_\delta^2$
Case 2:	$a_1 = 0.2$	$-0.004\ \sigma_\delta^2$
Case 3:	$c_4 = 0.0$	$0.005\ \sigma_\delta^2$
Case 4:	$c_4 = 0.2$	$-0.027\ \sigma_\delta^2$
Case 5:	$a_2 = -0.1$	$-0.007\ \sigma_\delta^2$
Case 6:	$a_2 = -0.3$	$-0.009\ \sigma_\delta^2$
Case 7:	$a = 0.1$	$-0.007\ \sigma_\delta^2$
Case 8:	$a = 1.0$	$-0.014\ \sigma_\delta^2$
Case 9:	$c_1 = 0.5$	$-0.008\ \sigma_\delta^2$
Case 10:	$c_1 = 0.1$	$-0.009\ \sigma_\delta^2$
Case 11:	$c_2 = 0.8$	$0.006\ \sigma_\delta^2$
Case 12:	$c_2 = 0.1$	$-0.013\ \sigma_\delta^2$
Case 13:	$b_1 = 0.7$	$-0.009\ \sigma_\delta^2$
Case 14:	$b_1 = 0.5$	$-0.009\ \sigma_\delta^2$
Case 15:	$b_2 = -0.2$	$-0.009\ \sigma_\delta^2$

The simulation results presented above suggest that as long as the elasticity of the price level to interest rate is not very small and/or, the elasticity of the price level to output (which is a proxy for the pressure of aggregate demand) is not very large, an increase in the rate of crawl will result in better long-run output stability in the presence of shocks to risk premium. This, in turn, means that similarly to the cases of shocks to the wage rate and the supply price of output, policymakers who intend to adopt a crawling peg regime with a relatively high rate of crawl will face a trade-off between achieving better stability of output and accepting the worsening of price stability in the long run.

5. CONCLUSIONS

In this last section, we first present a summary of the basic results of the paper in relation to the impact of adopting an exchange-rate policy with a relatively higher rate of crawl on the long-run macroeconomic stability of a small, open economy and then discuss their policy implications:

The impact of increasing the rate of crawl
on the long-run macroeconomic stability

Type of shock	Output stability	Price stability
Output-demand	–	–
Money-demand	None	None
Price-level	+	–
Wage-rate	+	–
Risk-premium	? (+)*	–
Policy	–	–

* The likely effect obtained from simulations.

As the above table shows, increasing the rate of crawl of the exchange rate, worsens the long-run price stability in all types of shocks examined except the money-demand shocks. These have neither price nor output effects under a crawling peg regime, which is a variant of a fixed exchange-rate regime. On the other hand, the consequences of such a policy on the long-run stability of output depend on the type of the shock. In case of output-demand shocks and policy shocks to the exchange rate, a relatively higher rate of crawl worsens not only the price stability, but also the output stability. In the case of price-level shocks and the shocks to the wage rate, the same policy yields superior outcomes for the long-run stability of output. In the presence of random shocks to risk premium, even though the qualitative nature of the impact of the same exchange-rate policy on the output stability is ambiguous, the simulation results suggest that its impact is likely to be positive, similar to the case of price level and wage shocks.

One important feature of both the East Asian crisis (of 1997) and the earlier Mexican crisis (of 1995), was the high speed at which the crisis that started in one country spread to other countries, particularly through the erratic shift in investors preferences; after facing losses in one country investors rushed to sell off their assets in other countries even when there were no signs of weakness in the fundamentals of those economies. It seems that investors' preferences can collectively and unpredictably shift from "risk loving" to "risk aversion" leading to random fluctuations in the risk premium for domestic assets. In addition, as it has happened in the past, countries which have adopted fixed rates or crawling peg kind of exchange rate regimes had to devalue their currencies in magnitudes well above what the ongoing crawling rate would require. Such unanticipated devaluations (or revaluations) have been carried out even in the absence of an apparent financial crisis. However, whatever are the short-term goals of the policymakers in undertaking these deliberate exchange-rate movements, it is clear that such policy shocks themselves become a source of macroeconomic uncertainty and their long-run stability consequences need to be carefully evaluated. Our analysis suggests that a relatively higher degree of indexation of the exchange rate (to price level) is likely to worsen both output and price instability that may be caused by such non-systematic policy shocks.

One other consideration that emerged from the East Asian crisis was the significant role that the rapid rise in interest rates played, both on the demand and the supply sides of the economy, particularly for the small and medium-sized firms, which financed both their new capital investment and working capital needs from the commercial banks. By incorporating this interest rate effect (on the supply side) as well as the wide variety of shocks that were mentioned above, we tried to add additional realism to the basic structure of our model. The policy messages of the basic insights of the model are particularly relevant for the policymakers who are concerned about the increased financial volatility generated by the rapid integration of domestic capital markets with the global markets. In other words, the recent experience of emerging markets suggests that the financial volatility caused by unpredictable changes in investors' risk preferences are likely to be a significant source of macroeconomic uncertainty for most of the developing countries. In such countries, where the exchange rate regime is the crawling peg regime, policymakers can reduce the long-run instability of employment and real gross domestic product by adopting a relatively higher rate of crawl of the exchange rate over time, but only at the expense of worsened price stability. However, as the simulation results discussed in the previous section show, if the effect of the interest rate (and/or aggregate demand) on the price level is sufficiently small (large), policymakers can reduce the long-run instability in both output and the price level, by choosing a relatively low rate of adjustment of the exchange rate to past price changes.

In addition to shocks to risk premium, the volatility observed in crude oil (petroleum) prices in recent years seem to suggest that supply shocks to the price level can continue to be an important source of instability for most economies. Our results suggest that in the presence of such supply shocks, policymakers who prefer to have better price stability in the long-run instead of output stability, should try to maintain relatively stable exchange rates by choosing a relatively low rate of crawl.

APPENDIX 1

The uncovered interest parity relationship captured by equation (5) of the small, open economy model specified in section two, assumes that under conditions of perfect mobility of capital when domestic and foreign financial markets are in equilibrium, the domestic interest rate on domestic-currency-denominated bonds will deviate from the foreign interest rate on similar, foreign-currency-denominated bonds by an amount given by the risk premium (on domestic bonds). This amount was assumed to be a normal random variable with zero mean and constant variance. In this form, the interest parity equation that we used, is a version that corresponds to the monetary regimes under which the exchange rate is expected to be kept fixed over the duration of maturity time of the financial assets in question. In our model we implicitly assume that the only available assets for domestic and foreign investors are domestic and foreign bonds with one-period to maturity. On the other hand, the exchange-rate rule specified in equation (6) assumes that the exchange rate is adjusted at the beginning of each period and kept at the same level (unless there is a policy originated shock) until the end of that period. Given the assumption that policy shock is a white noise, expected value of the exchange rate until the end of each period is equal to the value announced by the policymakers in the beginning of the period in question. In this sense, the expected change of the exchange rate is zero until the end of the maturity time of both types of bonds. In other words, investors will expect to be able to convert the gross monetary returns from foreign (or domestic) bonds to the domestic (or foreign) currency at the same exchange rate, which was prevailing when they purchased the bonds in the beginning of each period.

APPENDIX 2

The reduced form of the steady-state solution of the small, open economy model that we used in the paper is given below by equations (27), (28) and (29) which capture the reduced form expressions for the three endogenous variables (y, p and m) of the model:

$$y = a_1 (\alpha - 1) (D + c_2 A)/E + A \tag{27}$$

$$m = [M (p^* + z) + T (i^* + \delta) + N (a_3 y^* + u) + R (w^* + k) + Qv]/E + \varepsilon \tag{28}$$

$$p = [D + c_2 A]/E \tag{29}$$

Where A, D, E, M, T, N, R and Q are as follows:

$$A = a_1 p^* + a_2 i^* + a_3 y^* + a_1 z + a_2 \delta + u$$

$$D = c_1 p^* + c_3 w^* + c_4 i^* + c_1 z + c_3 k + c_4 \delta + v$$

$$E = (1 - c_1 \alpha) + a_1 c_2 (1 - \alpha)$$

$$M = a_1 b_1 (1 - c_1) + (c_1 + a_1 c_2)$$

$$T = [a_1(b_1 c_4 - b_2 c_2) - c_1 (a_2 b_1 + b_2)] \alpha + a_2(b_1 + c_2) + c_4(1 - a_1 b_1) + b_2(1 + a_1 b_2)$$

$$N = b_1 (1 - c_1 \alpha) + c_2$$

$$R = c_3 [a_1 b_1 (\alpha - 1) + 1]$$

$$Q = a_1 b_1 (\alpha - 1) + 1$$

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