WP/96/20

INTERNATIONAL MONETARY FUND

Research Department

The Sources of Macroeconomic Fluctuations in Developing Countries: Brazil and Korea

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February 1996

Abstract

This paper studies the sources of macroeconomic fluctuations in developing countries using a structural VAR approach. Identification of the sources is achieved using long-run restrictions derived from a theoretical model of a small open economy encompassing a large number of macroeconomic paradigms; the short-run dynamics are unrestricted. This framework is applied to Brazil and Korea. The results confirm that supply shocks are the main source of GDP fluctuations, even in the short run. Aggregate demand shocks are shown to be important in the short run in Brazil, but not in Korea. External shocks explain a small fraction of the variance of output, whereas the real exchange rate is driven mainly by fiscal shocks. Nominal shocks appear to have little impact on output and the real exchange rate.

JEL Classification Numbers:
C32, E32, F41

[1]We are grateful to Richard Agenor, Paul Cashin, David Coe, Don Mathieson, Se-Jik Kim, Gian-Maria Milesi-Ferreti, and Pierre Siklos for their comments. All remaining errors are our responsibility.

Contents

Summary

This paper focuses on the sources of macroeconomic fluctuations in small open economies. In addition to assessing the relative importance of domestic demand and supply shocks, the methodology allows an evaluation of the role of external shocks. To identify the sources of business cycles, a set of block exogeneity restrictions is added to the usual long-run restrictions that constrain the effects of aggregate demand and nominal shocks on the level of output. To justify the long-run restrictions as well as to interpret the empirical results, the paper models an economy that produces an exportable and a nontradable good using an imported intermediate input. This model incorporates the effect of oil price shocks, world output fluctuations, and structural reforms. The data determine the short-run dynamics without specifying such frictions as price rigidities, adjustment costs, and information restrictions that are responsible for keeping output within the production possibilities frontier. Thus, the empirical strategy encompasses a wide class of macroeconomic paradigms in a unified framework.

Because structural reforms are essentially supply shocks, while stabilization policies are basically demand shocks, the analysis contributes to the understanding of the output and real exchange rate effects of adjustment programs. In this vein, the empirical framework compares the performance of Brazil and Korea. These representative middle-income countries followed similar trade and macroeconomic policies until the end of the 1970s, but their policies took different directions in the 1980s.

The main results in this paper confirm, for small open economies, the stylized fact found for the U.S. economy: supply shocks tend to dominate output fluctuations even in the short run. In Brazil demand policies play an important role in explaining the short-run fluctuations of output and the real exchange rate, but in Korea the effects of these policies are negligible. Unlike other studies, this study finds that, controlling for domestic and supply shocks, external factors play a limited role. External factors tend to account for less than 20 percent of the fluctuations in GDP for both countries. Finally, although fiscal policy shocks appear to be the main driving force of real exchange rates, nominal shocks have almost no effect on these rates.

I. Introduction

The fact that output fluctuations can be due to demand shocks (i.e., monetary or fiscal policies) and/or supply shocks (i.e., productivity, labor supply, or structural reforms) is a basic proposition of macroeconomics. Although a strict demand versus supply dichotomy may not be entirely correct, it may still shed some light on what class or classes of models predict better the evolution of output.[1] In fact, recent developments in closed-economy macroeconomics have attempted to assess the relative importance of aggregate demand versus aggregate supply disturbances, and of nominal versus real shocks in the generation and propagation of business cycles.[2] Recently this framework has been extended to a large open economy setting, and to the study of the relative transmission properties of fixed and floating exchange rates, as well as the role of nominal shocks in real exchange rate fluctuations.[3]

In this paper, we focus on the sources of macroeconomic fluctuations in small-open economies, which in addition to assessing the relative importance of domestic demand and supply shocks, allow us to evaluate the role of external shocks. To identify the sources of business cycles, we add a set of block-exogeneity restrictions to the usual restrictions that constrain the effects of aggregate demand shocks on the level of output to be zero in the long run. To motivate the long-run restrictions as well as to interpret the empirical results, we consider an economy that produces an exportable and a nontradable good using an imported intermediate input. This model allows us to incorporate the effects of oil price shocks (in the spirit of Bruno and Sachs (1985)). We also control for the impact of world output as a stimulus to LDC economic cycles and to technological improvements through trade and investment. Trade policy in our model is shown to affect output and growth, as in Lee (1993), and is introduced to illustrate how structural reforms can affect output and the real exchange rate in the long run while inducing short-run fluctuations.

An interesting feature of the empirical methodology we use is that the short-run dynamics are determined by the data without specifying the particular frictions--price rigidities, adjustment costs, information restrictions, and so forth--that are responsible for keeping output inside the production possibilities frontier. Thus, our empirical strategy encompasses a wide class of macroeconomic paradigms. Output and the real exchange rate can deviate from their long-run levels due to both the transitional dynamics of capital accumulation following external shocks and/or structural reforms, as well as to the short-run real effects of monetary and fiscal policies.

Since structural reforms are essentially supply shocks, while stabilization policies are basically demand shocks, our analysis contributes

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[1]See Buiter (1987) and Plosser (1989).

[2]See Blanchard and Quah (1989), Shapiro and Watson (1988), King, Plosser, Stock, and Watson (1991), and Gali (1992).

[3]See Ahmed et al. (1993), Bayoumi and Eichengreen (1994), and Clarida and Gali (1994).

to the understanding of the output and real exchange rate effects of adjustment programs. Although stabilization policies are considered a necessary condition for growth, they may not be sufficient (Dornbusch (1990)). And, even though there exists some consensus on the positive effects of those policies on output growth in the medium and long run (Fischer (1993)), there is less consensus on the short-run effects. Most macroeconomic models predict negative output effects from contractionary macroeconomic policies, and there is indeed some empirical evidence on the initial recessionary effects of adjustment programs.[1] Similarly, although trade liberalization increases real income in the long run, the reallocation of resources may temporarily reduce real income.[2]

We use this empirical methodology to compare the performance of two relatively large middle-income countries, Brazil and Korea. These two countries provide an interesting case study because they followed similar trade and macroeconomic policies until the end of the 1970s, but their policies took different directions in the 1980s.

During the late 1960s and 1970s, Brazil and Korea grew at roughly 9 percent and were considered "miracles" of export-led growth. However, both countries reacted to the first oil shock with external financing and a return to import substitution policies.[3] Alongside domestic expansionary policies, both countries faced a slowdown in export growth, an appreciation of the real exchange rate, and an explosive increase in external debt in the second half of the 1970s. The need to adjust in both countries was apparent by early 1979. While Korea went ahead with a comprehensive stabilization program, Brazil "proclaimed a policy of fighting inflation by raising production,"[4] giving priority to expenditure and credit expansion to finance investment in the agricultural and energy sectors.[5]

The decisive response of the Korean authorities, which included a tightening of macro-policies and a gradual opening up of the economy, allowed the country to benefit from the improved external environment after 1984 (Chart 1). Although Brazil conducted an important external adjustment--primarily through large devaluations--the lack of persistent fiscal adjustment led to an acceleration of inflation, crowding out of private investment, and slow economic growth; despite strong export growth, GDP growth remained below 5 percent until 1985. In the second half of the 1980s, several heterodox stabilization plans were attempted, largely based on price and wage freezes. Because these efforts were not supported by sufficiently tight policies, they proved unsuccessful in controlling

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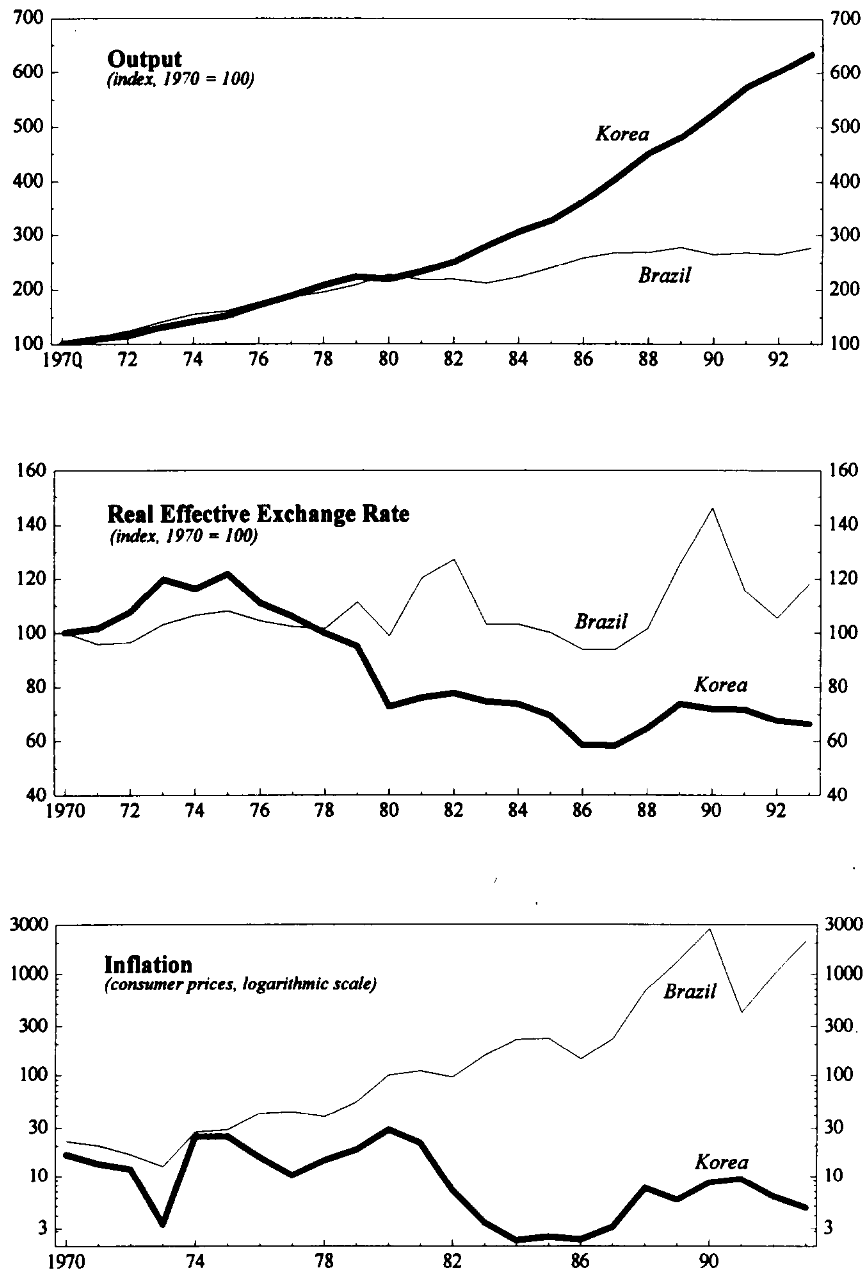
[1]See Khan (1990), and Summers and Pritchett (1993).
[2]See Mussa (1986) and Gavin (1991).
[3]See Cardoso (1991) and Corbo and Suh (1992).
[4]Maddison and Associates (1992), p.37.
[5]See Cardoso and Fishlow (1989).

Chart 1. Brazil and Korea: Selected Indicators, 1970-93



Source: IMF, World Economic Outlook data base.

inflation, which reached four-digit levels by 1989 and contributed to Brazil's weak economic performance.[1]

Previous comparisons of the Asian and Latin American experiences and/or individual studies of Brazil and Korea, quantify independently the impact of foreign shocks,[2] or the stance of macro policies,[3] or the sources of growth.[4] The empirical strategy developed in this paper also measures these shocks, but explicitly allows for their interaction in a unified framework. In doing so, the analysis loses some of the details of the structural differences that may affect their response to different shocks. One of the contributions of this paper is to determine which of these structural differences are relevant empirically as these differences may have offsetting effects on the macroeconomic performance.[5]

The paper is organized in five sections and an appendix. In the next section a dependent-economy model with imported intermediate inputs is presented and the long-run properties are derived. These long-run properties are used in Section III to develop our empirical strategy and account for the small open economy assumption. The empirical results are interpreted with the long-run model, and compared to previous studies in Section IV; the main findings are summarized in the concluding Section V. The appendix summarizes the properties of the model discussed in Section II, and provides supporting data in the accompanying tables and charts.

II. A Long-Run Model

A small open economy model is used to motivate the economic content of the long-run restrictions used in the empirical section of the paper. A description of the production and consumption structures allows us to discuss the long-run effects of different shocks and policies on output and the real exchange rate. To encompass a large number of macroeconomic paradigms, the short-run dynamics are left unrestricted and are determined by the data. In this vein, our model is augmented to incorporate nominal variables in a fairly general way.

1. Production

A small open economy that produces an exportable and a nontradable good is considered. The exportable sector uses capital (K) and labor (L_X) as well as an imported intermediate input (M) to produce an amount of gross output given by:

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[1]Since 1990, however, there has been an important turning point in economic strategy, with emphasis placed firmly on macroeconomic and market-oriented structural reforms. Sustained implementation of these policies should help Brazil to maintain low inflation on a durable basis and to sustain stronger growth in the medium term.

[2]See Sachs (1985), Corbo and Nam (1992), and Dornbusch and Park (1992).

[3]See Aghevli and Marquez-Ruarte (1985).

[4]See Pack and Page (1994), Young (1994), and Elias (1992).

[5]For instance, while in terms of GDP Korea's external debt was much larger than Brazil's--requiring a much larger adjustment to the drying out of external funds in the early 1980's--its larger degree of openness and more abundant human capital may have helped it to cope better to external shocks.

$$Q_{x_t} = A_{x_t}\left[K_t^{1-\alpha}L_{x_t}^{\alpha}\right]^{\mu}M_t^{1-\mu} = A_{x_t}V_{x_t}^{\mu}M_t^{1-\mu} \tag{1}$$

where V_x is a domestic value added index that can be written as a second tier function of primary factors K and L_x (see Bruno and Sachs (1985)), and A_x is the level of technology. A convenient way to summarize the production side is by means of a real value added function Y_x:

$$Y_{x_t}(P_{m_t};V_{x_t}) \equiv \max\left\{Q_{x_t} - P_{m_t}M_t\right\} \tag{2}$$

where P_m is the domestic price of intermediate inputs in terms of the exportable good--i.e., inclusive of the tariff. Optimal choices of intermediate inputs by exporters imply that GDP can be written as:

$$Y_{x_t} = \left[\mu(1-\mu)^{(1-\mu)/\mu}\right] A_{x_t}^{1/\mu}\ P_{m_t}^{(\mu-1)/\mu}\ V_{x_t} \tag{3}$$

To complete the supply side of the model we assume that production of the nontradable good uses only labor (L_n),

$$Q_{n_t} = Y_{n_t} = A_{n_t}L_{n_t}^{\beta} \tag{4}$$

Although somewhat restrictive, this specification captures the relative labor intensity of this sector and the fact that the share of intermediate inputs used in the nontradable sector is much smaller than the one used in the tradable sector. A more general specification could be allowed. However, if we were to add reproducible (or intersectorally mobile) capital in the nontradable sector, prices would be determined in the supply side.[1] The current specification allows for the existence of some nonreproducible factors (see Roldós (1995)) such that fiscal shocks can lead to a permanent real exchange rate appreciation.[2]

2. Consumption, relative prices and GDP

This economy is inhabited by an infinitely-lived household that maximizes the expected utility it obtains from the consumption of both exportable and nontradable goods, i.e., they

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[1]See for instance Guidotti (1988), Engle and Kletzer (1989), and Obstfeld (1989).

[2]Dornbusch (1989) sketches a model that stresses similar features as a useful paradigm for modelling real exchange rates in developing countries.

$$\max\ U_t = E_t \left\{ \sum_{j=0}^{\infty} \left(\frac{1}{1+\rho}\right)^{t+j} \left[\psi \log c_{x_t} + (1-\psi) \log c_{n_t}\right] \right\} \tag{5}$$

subject to flow and intertemporal budget constraints that depend on the kind of assets that are available. For simplicity, we assume that there are no changes in the net foreign asset position in the long run. This assumption is not unduly restrictive because the alternative assumption--free capital mobility--does not change the nature of the qualitative long-run results highlighted in this section.[1] Optimization in consumption and production yields the equality of marginal rates of substitution and transformation to the real exchange rate, Q, defined as the relative price of nontradables in terms of exportables, i.e.:

$$\frac{(1-\psi)\, c_x}{\psi\, c_n} = Q_t = \frac{(1-\psi)\, Y_x}{\psi\, Y_n (1-g)} \tag{6}$$

The right-hand side of the equality shows the ratio of exportable to nontradable output available to the private sector, where g is the ratio of government spending to nontradable goods production. We are assuming that government purchases are concentrated in nontradable goods, and are financed by lump sum taxes.

In order to discuss the effects of the different shocks and policies on total GDP, $Y_t = Y_x + QY_n$, we use the right-hand side equality of equation (6) to substitute for the real exchange rate and obtain:

$$Y_t = Y_{x_t} + Q_t Y_{n_t} = \mu (1-\mu)^{(1-\mu)/\mu} A_{x_t}^{1/\mu} P_{m_t}^{(\mu-1)/\mu} \left[1 + \frac{(1-\psi)}{\psi(1-g)}\right] \left(\frac{L_x}{K}\right)^{\alpha} K_t \tag{7}$$

The effects of the different shocks and policies on GDP are more apparent when we take logs of (7); lower case letters denote logs:

$$y_t = \nu + (1/\mu)\, a_{x_t} - \left(\frac{1-\mu}{\mu}\right) p_{m_t} + \log\left[1 + \frac{(1-\psi)}{\psi(1-g)}\right] + k_t + \alpha \log\left(\frac{L_x}{K}\right) \tag{8}$$

In the long run, the marginal productivity of capital equals the rate of time preference, and in turn this implies a constant level of the labor/capital ratio L_x/K, the last term of (8). Therefore, the long-run

[1] Moreover, both Brazil and Korea had some kind of capital controls during our sample period, and had limited access to foreign capital following the debt crisis--at least until the 1990s.

level of output depends on the level of the technology (a_x), the domestic price of imported intermediate inputs (p_m), fiscal policy (g), and the endogenous response of the capital stock (k).

We assume that a fraction δ of the technological progress generated in the industrial countries spills over to the small open economy under study. In particular, we postulate that $a_x = \delta y^*$, where y^* is output in the industrial countries and δ is an inverse measure of the barriers to technology adoption (Parente and Preston (1994)), related to the small country's degree of openness as well as the level of local human capital.[1]

As can be seen from (8), an increase in the price of intermediate inputs acts like negative Hicks-neutral technological progress, as demonstrated originally by Bruno and Sachs (1985). We can decompose the domestic price of inputs into its world price component, $p_m{*}$, and a tariff, τ. As shown by Lee (1993), higher trade taxes reduce the marginal product of capital and can lead to either a lower level of GDP or a lower growth rate. Although other structural reforms affect the supply side in a similar way, our discussion focuses on trade policies because these policies were markedly different in Brazil and Korea during the 1980s.[2]

The main effect of a fiscal expansion in this model is a change in the composition of demand--and hence of production--towards nontradable goods, with an ambiguous effect on total GDP. Although equation (8) suggests that an increase in government spending leads to a long-run increase in GDP, the reduction in the capital stock that follows makes this effect ambiguous. Furthermore, as pointed out by Ahmed, et al. (1993), in the long-run a fiscal expansion could also entail an increase in distortionary taxes that would tend to reduce total output. Given these ambiguities, we assume that the long-run impact of fiscal policy on GDP is small. More importantly, in connection with our empirical strategy, Blanchard and Quah (1989) demonstrate that the identification of the shocks is robust provided that the effect of fiscal policy on long-run output is small, relative to the long-run effect of other shocks.

The effect of fiscal policy on the real exchange rate can be inferred from equation (6). An increase in government spending leads to a real appreciation--an increase in Q--to accommodate the shift in the composition of aggregate demand.[3] Froot and Rogoff (1991) also prove this result in a similar setting. They claim that this result is very robust for a large

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[1]Theoretical models on international knowledge spillovers are summarized in Grossman and Helpman (1991); empirical evidence on these spillovers is found in Coe, Helpman, and Hoffmaister (1994).

[2]While Korea started a gradual but steady process of trade liberalization in the early 1980s, Brazil did not engage in such liberalization efforts until recently (see Corbo and Suh (1992) and Maddison and Associates (1992)).

[3]A complete derivation of this result is provided in the Appendix.

group of countries, and is supported by empirical evidence from both the Bretton Woods and EMS periods.[1] As shown in the Appendix, technological progress and reductions in intermediate input prices lead to real exchange rate appreciation.

3. Monetary and exchange rate policies

To allow nominal variables to be a source of short-run fluctuations in output and the real exchange rate, we need to introduce money explicitly. Money could be introduced in the utility function or via a cash-in-advance constraint. However, this is not necessary for our empirical strategy because we only need to impose long-run neutrality of money and/or the nominal exchange rate. The explicit modeling of money in our model would be complicated by the fact that both Brazil and Korea have had different exchange rate regimes during our sample period. At times these countries followed some form of real exchange rate targeting policy (see Calvo, Reinhart, and Végh (1994)), while at other times they used fixed rates to try to reduce inflation.[2]

However, in order to capture the role of nominal variables in the short run, the structural model includes a general unspecified equation for the evolution of the price level. The latter is determined by the response of the monetary authority to external shocks, fiscal, and trade policy, as well as by other exogenous nominal forces. Among those nominal forces, in Brazil one should consider nominal wages shocks given the widespread use of indexation practices.[3]

4. Short-run dynamics and long-run restrictions

Before imposing the long-run economic restrictions discussed above, we need to describe the stochastic structure of the exogenous variables and how they interact with the economic model to determine the short-run dynamics. Anticipating the fact that all endogenous variables have unit roots, we postulate that the exogenous variables in our model follow integrated processes summarized in the vector $\Delta z_t=B(L)\epsilon_t$, where $z_t'=[p^*_m, y^*, \tau, g, n]$ are the exogenous variables (n denotes the nominal variable), B(L) is a diagonal matrix of lag polynomials, and $\epsilon' = [\epsilon^o, \epsilon^*, \epsilon^\tau, \epsilon^f, \epsilon^n]$ are respectively the structural innovations to the price of inputs, world

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[1]However, if factors are completely mobile relative prices are completely determined by the supply side of the model, and the long-run real exchange rate is independent of fiscal policy.

[2]A remarkable feature of the Korean experience has been the relatively small variability of its real exchange rate (Kim and Leipziger (1993)). In our sample the coefficient of variation of the real exchange rate is 4.5 for Korea and 7.3 for Brazil.

[3]See De Gregorio, Giovannini, and Wolfe (1993) for a model where wage pressures derived from union behavior lead to a real exchange rate appreciation.

technology, domestic supply, fiscal and monetary/exchange rate policies. The ϵ's are assumed to be serially uncorrelated with mean zero and are mutually orthogonal, $E[\epsilon\epsilon'] = I$. The diagonal matrix B(L) would be an identity matrix if all exogenous variables were random walks, but we allow the exogenous variables to follow more general stochastic processes.

The structural vector autoregression model that we estimate in the next section summarizes both the extrinsic dynamics of the exogenous variables, as well as the intrinsic dynamics of our model. The structural VAR model is given by:

$$\begin{bmatrix} \Delta p^*_{m_t} \\ \Delta y^*_t \\ \Delta y_t \\ \Delta q_t \\ \Delta p_t \end{bmatrix} = A(L) \times \begin{bmatrix} \epsilon^o_t \\ \epsilon^*_t \\ \epsilon^T_t \\ \epsilon^f_t \\ \epsilon^n_t \end{bmatrix} \tag{9}$$

where the left-hand side contains the endogenous variables (domestic output, the real exchange rate, and the price level) and A(L) is a square matrix of lag polynomials. An element $a_{ij}(L)$ of this matrix denotes the response of the i^{th} variable to the j^{th} shock lagged L periods. This response depends both on the dynamics of the exogenous variables--B(L)--and the (unspecified) intrinsic dynamics of our model. The short-run movements of output and the real exchange rate can be interpreted as the transitional--equilibrium--dynamics of capital accumulation in response to the different shocks, or as the disequilibrium dynamics implicit in a model with wage/price stickiness. Rather than taking a stand on a particular macroeconomic paradigm, we let the data determine the short-run dynamics, implied by A(L).

The long-run restrictions derived from our model can be summarized by the A(1) matrix, which contains the long-run multipliers,

$$A(1) = \begin{bmatrix} a_{11}(1) & 0 & | & 0 & 0 & 0 \\ a_{21}(1) & a_{22}(1) & | & 0 & 0 & 0 \\ \hline a_{31}(1) & a_{32}(1) & | & a_{33}(1) & 0 & 0 \\ a_{41}(1) & a_{42}(1) & | & a_{43}(1) & a_{44}(1) & 0 \\ a_{51}(1) & a_{52}(1) & | & a_{53}(1) & a_{54}(1) & a_{55}(1) \end{bmatrix} \tag{10}$$

Equation (10) partitions the long-run effects into domestic and external components. The zeros in the north-eastern quadrant correspond to the small open economy assumption: the domestic shocks--supply, fiscal and monetary/exchange rate policies--do not affect world variables. The zeros in the south-eastern quadrant are the restrictions used to identify domestic supply and demand innovations: fiscal and nominal innovations do not affect output in the long-run, and nominal innovations do not affect the real exchange rate in the long-run.[1]

The non-zero elements of A(1) can be explicitly obtained from our long-run model and are used to interpret our empirical results, but are not used to restrict the empirical model. For instance, in the Appendix we show that the effect of a tariff reduction--a negative realization of ϵ^{τ}--on the long-run level of output is given by:

$$a_{33}(1) = -\left(\frac{1-\mu}{\alpha\mu}\right)\left(\frac{1}{L_x/L - L_n/L}\right) \tag{11}$$

suggesting that trade liberalization leads to an increase in GDP as long as the fraction of the labor force employed in the exportable sector is larger than that employed in the nontradable sector. Note that the size of the effect depends critically on the share of intermediate inputs in gross output (μ). Following the common practice of structural VAR, we do not use this "restriction" to estimate our model.

III. Estimation Strategy

The estimation strategy used to recover the innovations in our structural VAR model was proposed by Blanchard and Quah (1989), and Shapiro and Watson (1988), and avoids the arbitrary ordering restrictions of a

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[1]As noted above, the fiscal policy innovations can be identified approximately even if they effect output in the long-run, as long as this effect is relatively small compared to the impact of other shocks, see Blanchard and Quah (1989).

standard VAR model, because it identifies the structural innovations using the long-run restrictions from the theoretical model.[1] Our estimation strategy modifies the original structural VAR models to impose the small open economy assumption.

Blanchard and Quah (1989) show that the structural innovations are a linear transformation of the reduced-form innovations, and can be recovered once their contemporaneous effects matrix, A(0), is identified. Below we discuss the linear transformation, and the identification of A(0) using the long-run restrictions in equation (10).

The linear transformation needed to recover the structural innovations is apparent when we compare the structural model with the reduced-form version of the model. Consider the following restatement of the structural model given in equation (9):

$$\Delta x = \sum_{j=0}^{\infty} A(j)\epsilon_{-j} \tag{12}$$

where the ϵ's are the structural innovations defined above, and the A(j)'s are the sequence of square matrices summarized by A(L). The reduced form, or Wold representation, of the model is given by:

$$\Delta x = \sum_{j=0}^{\infty} C(j)\mu_{-j} \tag{13}$$

where the μ's are the reduced-form innovations with zero mean and $E[\mu\mu'] = \Omega$, the C(j)'s are a sequence of square matrices that represent the effect of μ lagged j periods, and C(0), the contemporaneous effect of μ, is an identity matrix. Note that the sequence of C(j) matrices can be obtained by inverting a standard VAR representation of Δx.

Comparing the structural model (12) to the reduced-form model (13), and recalling that C(0) = I, we have that $A(0)\epsilon = \mu$. More generally, $A(j)\epsilon_{-j} = C(j)\mu_{-j}$, implying that A(j) = C(j)A(0). Thus, the linear transformation needed to recover the structural model consists of post-multiplying the reduced-form model by A(0).

The structural model provides three types of restrictions that are used to identify A(0): (1) the orthogonality of the structural innovations, (2) the small open economy assumption, and (3) the long-run restrictions.

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[1]Ahmed et al. (1993), Bayoumi and Eichengreen (1994), and Clarida and Gali (1994) extend this framework to a large open-economy setting, which they apply to industrial countries.

By using these restrictions to identify A(0), we avoid the need to use the Choleski decomposition of Ω, to identify A(0).

The first type of restrictions stem from the assumption that the structural innovations are mutually orthogonal, implying that $A(0)A(0)' = \Omega$. This expression defines 15 nonlinear restrictions on A(0) of the form:

$$\omega_{ij} = \sum_{k=1}^{5} a(0)_{ik} a(0)_{jk} \quad . \tag{14}$$

The second type of restrictions is derived from the small open economy assumption, and correspond to the zeros in the north-eastern quadrant of equation (10). Ahmed and Park (1994) also use the small open economy assumption but fail to impose it in the short run, with two undesirable properties: (i) domestic shocks have short-run effects on world variables and, (ii) the external shocks for each individual country differ. To overcome this problem, we impose the small open economy restrictions in the short-run, by specifying the block exogeneity of ϵ^{o} and ϵ^{*}, or $a(j)_{ik} = 0$ for i= 1, 2 and k = 3, 4, 5 for j= 0, 1, 2, ..., ∞. These provide six additional restrictions to identify A(0), which are implemented by estimating a near-VAR model where the domestic variables are excluded from the oil price and world output equations. It is worth reiterating that our implementation of the small open economy assumption recovers the same external innovations--ϵ^{o} and ϵ^{*}--for both Brazil and Korea, which ensures the comparability of the external shocks in these economies.

The third type of restrictions is imposed on the long-run level of the endogenous variables x, and stem from our structural model; they correspond to the zeros in the south-eastern quadrant in equation (10).[1] They are used in the identification of A(0) as follows. Note that the A(j) matrices contain the effects of the structural innovations on the change of x, Δx, lagged j periods. The sum of all of the A(j) matrices--the sum of all the changes of x--will equal the long-run effect on the level of x. The zeros in the south-eastern quadrant of equation (10) imply that particular structural innovations have no long-run effects on the level of the endogenous variables. For example, the theoretical model suggests that nominal shocks--the fifth structural innovation--do not have long-run effects on the level of domestic output, the third variable. This restriction is summarized by the condition that $a(1)_{3,5} = \Sigma a(j)_{3,5}$ equals zero. In all, the theoretical model imposes four additional long-run restrictions on A(0), of the form:

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[1]In addition to these long-run restrictions, this third type of restrictions include the zero in the north-western quadrant of equation (10). This restriction is used to distinguish between intermediate input price innovations and world technological innovations.

$$0 = \sum_{j=0}^{\infty} a(j)_{ik} = \sum_{j=0}^{\infty} \sum_{h=1}^{5} c(j)_{ih} a(0)_{hk} \tag{15}$$

for i=1 and k=2, i=3 and k=4, 5, and i=4 and k=5.

Together, these three types of restrictions exactly identify A(0). Thus these restrictions cannot be tested empirically, but are assumed to be valid. The short-run small open economy assumption, however, is tested as discussed below.

IV. Empirical Analysis

The *data sources* for Brazil and Korea are provided first. Then, we check the validity of the *time series properties* implied by our structural VAR model, namely the stationarity of the variables included, and the lack of cointegration among the (log) level variables. Next, we discuss the *estimation* of the VAR model--the number of lags selected--and deal with heteroskedasticity and breaks in the time series. We also test the validity of the small open economy assumption by testing the implied near VAR structure. Finally, the estimated near VAR model with the long-run restrictions from the theoretical model, is used to calculate our main empirical results: the variance decompositions and the impulse response functions.

1. Data, time series properties, and estimation

a. Data sources

The sample used in the estimation consists of 68 quarterly observations from 1976:Q2 to 1993:Q2 for Brazil and Korea. All data used in this study come from the IFS tapes, with the exception of oil prices (average petroleum spot price) which were obtained from the Commodities and Special Studies Division of the Research Department of the IMF. Output for Korea and Brazil is GDP (line 99b). The real exchange rate has been calculated as the relative price of nontraded goods in terms of traded: $p_i / e_i P^*$, where p_i is the consumer price index (CPI: line 64) of Brazil or Korea, e_i is defined as the price of a U.S. dollar in domestic currency (line ae), and P^* is the producer price index (PPI: line 63) in the United States. Oil prices are deflated using P^*. Since a large share of both countries' exports are to the United States, world output is proxied by GDP in the United States (line 99b.r).

b. Time series properties

The modeling technique assumes that the series in the model are stationary, and that levels of these series are not cointegrated; these assumptions are supported by the data. Standard unit root tests were used to verify the stationarity of the series; to deal with seasonality, fourth-order log differences were taken. The unit root test results suggest that these differences are stationary--the null hypothesis of a unit root is rejected in all cases (Table A1). Johansen's eigenvalue and trace statistic maximum likelihood tests suggest that there is no evidence of cointegration--the null hypothesis of zero cointegration vectors (r=0) is not rejected (Table A1).

c. Estimation

The theoretical model does not provide a guide for the number of lags to include in the VAR model. Monte Carlo simulations (see Lutkepohl (1985)) suggest that asymptotically the Hannan-Quinn and the Schwarz tests correctly choose the lag length of a VAR model. For Brazil, these tests did not give an unambiguous answer: the Hannan-Quinn test suggests 2 lags, while the Schwarz test suggests 1 lag; for Korea both tests "weakly" suggest 1 lag over 2 lags (Table A2). Both models were estimated using 1 and 2 lags, but 2 lags were used for the results presented in this paper.[1]

Next, we turn to heteroskedasticity and breaks in the series (see Charts A1-A3). The volatility of many series appears to have changed in the mid-1980s: both intermediate goods inflation and Brazil's inflation rate appear to be more volatile in the second half of the 1980s, while world output growth and Korea's inflation and real exchange rate appear to be less volatile after the mid-1980s. Goldfeld-Quandt F tests are used to check for heteroskedasticity, setting the break in the fourth quarter of 1985.[2] These test results confirm the statistical significance of the changes noted above (Table A2). In addition, not only did the volatility of Korea's inflation rate decline, but so did its level; a significant break was found following the fixing of Korea's exchange rate in the second quarter of 1981.

Conditional on nonconstant variances and the break in Korea's rate of inflation, the near VAR specification implied by the small open economy assumption is tested; a likelihood ratio test supports this assumption (Table A2). Thus, a near VAR model is estimated for Brazil and Korea and use these models are used to compute the variance decompositions and impulse response functions from the structural innovations.[3]

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[1]For Brazil the model with one lag was not stable, and for consistency we used 2 lags for both countries. Note that for Korea, the Hannan-Quinn test statistics for 1 and 2 lags are very similar, thus "weakly" selecting 1 lag. Nonetheless, the qualitative results for Korea are not altered by using 2 lags instead of 1.

[2]Ahmed et al. (1993) follow a similar procedure to test for heteroscedasticity.

[3]See Table A3 for a summary of the estimation results.

2. Variance decompositions

The decomposition of the variance evaluates the relative importance of each of the structural innovations in the fluctuations of output, the real exchange rate, and inflation at different time horizons. Table 1 provides the estimates of the relative importance of each shock for Brazil and Korea.

The decomposition of the variance of output growth suggests that domestic shocks, ϵ^{τ}, ϵ^{f}, and ϵ^{n}, explain more than 80 percent of the long-run variation of output in both countries. External shocks, ϵ^{o} and ϵ^{*}, explain a relatively small portion of the movements of long-run output. This result contrasts with the analysis of Dornbusch and Park (1992), who assign a large weight to the favorable external environment in Korea's successful adjustment experience. The authors recognize, however, that their conclusion is based "on pieces of evidence, not on a constructive proof" (Dornbusch and Park, 1992, p. 68).

Despite the similar relative importance of external and domestic factors in explaining long-run output movements, the composition of these factors is quite different across these countries. For Brazil world output shocks (ϵ^{*}) are the relevant external shock, while for Korea oil shocks (ϵ^{o}) are the most important external shock. One possible explanation for the difference in external factors might be due to the similar evolution of oil and non-oil commodity prices during the mid-1980s (see Borensztein and Reinhart (1994)). This would tend to reinforce oil price effects for Korea because both types of goods are imported, while it tends to render them insignificant for Brazil due to Brazil's relatively larger fraction of commodity exports.

Even more striking are the differences between domestic sources of economic growth both in the short and long run. In the short run, fiscal innovations (ϵ^{f}) in Brazil explain a fairly large portion of output movements--respectively, 60 and 35 percent the first and second quarters--while in Korea these innovations explain only a small fraction of output movements. In the long run, however, both fiscal and supply side innovations are important factors in Brazil, while only supply side innovations are of any importance in Korea.

These results are suggestive of the sources of output fluctuations and the impact of external shocks in these countries. The widely-held view of the resilience of the Korean economy is supported by our empirical results--external shocks explain a small fraction of the output movements in Korea. Our results for the Brazilian economy suggest that external shocks explain a larger proportion of output movements, particularly in the short-run. More

Table. 1 Variance Decomposition of Domestic Variables[1]

(Standard errors in parenthesis)

	Brazil					Korea				
	External		Domestic			External		Domestic		
Quarters	ϵ^o	ϵ^*	ϵ^τ	ϵ^f	ϵ^n	ϵ^o	ϵ^*	ϵ^τ	ϵ^f	ϵ^n
	Percentage of the variance of domestic output growth due to:									
1	22.5 (12.8)	7.7 (8.8)	7.4 (10.7)	59.9 (15.2)	2.5 (3.3)	5.5 (19.4)	0.8 (6.9)	93.4 (20.8)	0.2 (9.9)	0.1 (3.0)
2	12.8 (8.3)	5.6 (5.9)	32.2 (15.1)	34.6 (12.6)	14.8 (9.7)	6.7 (19.0)	0.7 (6.8)	92.2 (20.3)	0.3 (9.7)	0.1 (3.0)
4	9.1 (6.1)	4.5 (4.2)	53.6 (14.3)	23.3 (9.1)	9.5 (7.2)	12.3 (18.8)	0.6 (6.7)	86.8 (20.1)	0.3 (9.6)	0.1 (3.0)
8	8.6 (5.7)	4.6 (4.0)	54.2 (14.5)	23.1 (9.5)	9.4 (7.5)	17.1 (18.6)	0.6 (6.6)	82.0 (19.9)	0.3 (9.3)	0.1 (2.8)
16	8.8 (5.7)	5.0 (4.2)	53.9 (14.6)	23.0 (9.5)	9.3 (7.4)	17.1 (19.3)	0.6 (6.4)	81.9 (20.2)	0.3 (8.3)	0.1 (2.2)
32	8.8 (5.7)	5.1 (4.2)	53.9 (14.6)	22.9 (9.5)	9.3 (7.3)	17.1 (21.9)	0.6 (6.3)	81.9 (21.8)	0.3 (7.6)	0.1 (1.7)
	Percentage of the variance of real exchange rate depreciation due to:									
1	10.1 (8.0)	3.2 (4.2)	55.6 (20.6)	30.3 (19.4)	0.7 (1.2)	18.4 (20.8)	0.5 (6.3)	27.8 (21.0)	53.3 (7.8)	0.0 (3.0)
2	9.3 (7.7)	3.3 (4.2)	54.8 (20.6)	31.5 (19.4)	1.1 (1.3)	22.8 (20.8)	0.3 (6.4)	27.5 (20.8)	49.4 (7.5)	0.0 (2.4)
4	8.8 (7.4)	3.6 (4.4)	53.4 (20.6)	33.2 (19.4)	1.0 (1.2)	30.2 (19.9)	0.3 (6.3)	25.0 (20.6)	44.5 (8.4)	0.0 (2.5)
8	8.9 (7.2)	4.0 (4.3)	53.2 (20.3)	32.7 (18.9)	1.3 (1.5)	35.9 (20.2)	0.8 (6.4)	21.7 (20.7)	41.5 (7.7)	0.0 (2.0)
16	9.0 (7.2)	4.1 (4.3)	53.0 (20.2)	32.5 (18.7)	1.4 (1.5)	37.3 (21.7)	1.0 (6.4)	21.2 (21.3)	40.5 (6.1)	0.0 (1.1)
32	9.0 (7.2)	4.1 (4.3)	53.0 (20.2)	32.5 (18.7)	1.4 (1.5)	37.3 (23.6)	1.0 (6.3)	21.2 (22.6)	40.5 (5.7)	0.0 (0.9)
	Percentage of the variance of domestic price inflation due to:									
1	2.7 (3.6)	5.5 (5.4)	10.0 (10.8)	7.2 (8.6)	74.6 (14.1)	20.7 (24.1)	0.1(13.1)	0.0 (26.1)	19.4(15.2)	59.9(14.8)
2	2.7 (3.5)	5.2 (5.1)	12.2 (11.5)	7.1 (8.3)	72.8 (14.3)	10.0 (20.2)	0.4 (7.8)	18.5 (22.2)	17.0(13.7)	54.1 (7.8)
4	3.1 (3.5)	5.3 (4.7)	14.0 (12.0)	7.6 (7.7)	69.9 (14.3)	51.5 (22.3)	0.1 (6.7)	26.3 (21.3)	6.4 (6.9)	15.7 (3.3)
8	3.4 (3.6)	5.9 (4.7)	15.0 (11.8)	7.9 (7.5)	67.8 (14.2)	66.8 (23.8)	0.1 (6.8)	24.7 (22.2)	3.4 (5.3)	5.0 (2.2)
16	3.6 (3.6)	6.0 (4.6)	15.2 (11.8)	7.9 (7.5)	67.3 (14.2)	65.7 (25.2)	0.3 (6.7)	25.6 (23.5)	4.0 (5.2)	4.4 (1.7)
32	3.6 (3.7)	6.1 (4.7)	15.2 (11.8)	7.9 (7.5)	67.3 (14.2)	65.5 (25.9)	0.3 (6.6)	25.7 (24.4)	4.1 (5.4)	4.4 (1.6)

[1]Based on the estimated near VAR model with two lags, summarized in Table A3. The innovations ϵ^o, ϵ^*, ϵ^τ, ϵ^f, and ϵ^n are respectively to intermediate inputs, world supply, domestic supply, fiscal and nominal policies. Approximate standard errors were computed by Monte Carlo Simulations, using 1000 replications. The standard errors provide a measure of the precision of the estimated variance decomposition; the ratio of the estimated variance decomposition to the standard errors are not distributed Student's t.

importantly, our results also suggest that fiscal shocks have been an important source of output fluctuations in Brazil, especially in the short run.

It is interesting to note that previous studies using structural VAR approaches for the U.S. economy have also found that a large fraction of output fluctuations--between two thirds to three quarters--are due to supply shocks, even in the short run.[1] This stylized fact is confirmed by our results from Korea where in both the short and long run, most of the fluctuation in output is attributed to supply shocks. The results for Brazil also show that more than half of GDP fluctuations are due to supply shocks in the medium to long run. However, in the very short-run, fiscal shocks are the dominant factor, and while their importance declines in the long-run they are still substantial after several years.

The decomposition of the variation of the real exchange rate confirms the importance of fiscal shocks on the real exchange rate found by Froot and Rogoff (1991), and suggests a slightly different behavior of the real exchange rate in Korea and Brazil. In Korea, movements of the real exchange rate are primarily associated with fiscal and oil price shocks. In Brazil, fiscal shocks are also important for the determination of the real exchange rate, but supply shocks have an even larger role.

It is interesting to note that nominal shocks have almost no effect on output and real exchange rates even in the short run. This contrasts with the evidence found by Clarida and Gali (1994) for the United States vis-à-vis Japan and Germany, which they interpret as providing support for the textbook Mundell-Fleming model.[2] However, our results would suggest that the usefulness of this model to interpret fluctuations in developing countries is limited.

The decomposition of the variation of inflation shows that nominal factors are the main source of variation of prices in Brazil; this is also true for Korea but only in the very short run. In the long run, intermediate input prices explain two thirds of Korea's inflation rate. This result is consistent with the findings of Corbo and Nam (1992), who also point out that the evolution of oil and raw material prices is quite important for the explanation of inflation in Korea, albeit using a very different methodology. The persistence of the importance of nominal shocks in Brazil is most likely due to the high degree of price indexation.

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[1]See Blanchard and Quah (1989), Shapiro and Watson (1988), and Gali (1992).

[2]It is worth noting, however, that they find little evidence of the role of nominal factors for Britain and Canada.

3. Impulse responses

Two interesting empirical findings stem from the impulse responses (Charts 2 and 3). First, the long-run effects of most innovations are consistent with our model. For example, in both Brazil and Korea a positive domestic supply shock (ϵ^{T}) expands output and lowers domestic prices; a positive oil shock (ϵ^{O}) has essentially the opposite effects. Furthermore, the few incorrectly signed long-run effects are not statistically important. Second, the dynamics of adjustment differ markedly between the two countries. In particular, the impulse responses suggest that most Korean variables adjust monotonically to their post-shock values, while the Brazilian variables display more complex dynamics.

In both countries, a positive supply shock--an import tariff reduction in our model, or more generally a structural reform that increases efficiency--leads to an expansion of output, but the adjustment process differs. In Korea output expands monotonically and quickly, with about half of the impact occurring in the first two quarters, while in Brazil output overshoots its long-run level after about one year of the shock (see the first panel of Charts 2 and 3).

Demand shocks (fiscal and monetary/exchange rate innovations) have markedly different effects on output in Brazil and Korea. On impact a fiscal expansion in Brazil has a strong effect on GDP, followed by a dampened cycle. This response is consistent with a Keynesian view of fiscal policy, as Brazil's efforts to consolidate its fiscal position were not sustained during our sample period.[1] Also note that monetary/exchange rate shocks have a contractionary effect in Brazil, as predicted by the contractionary devaluation literature.[2] Korea's output response suggests that demand policies had virtually no effect on output. This result is consistent with the expectational view of fiscal policy, and confirms the view that Korea's financial policies avoided major mistakes and allowed structural reforms and favorable external conditions to lead Korea out of the 1979-82 crisis.[3]

External shocks present two puzzling long-run results, although neither is statistically important. First, oil shocks have a small expansionary effect on Brazil's output. This could be associated with the deepening of import substitution policies and the development of a large energy-substitution program that followed the two major oil shocks in the 1970s

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[1]Giavazzi and Pagano (1990) compare the Keynesian view of fiscal contractions with the so-called German or expectational view (see also Bertola and Drazen (1993)). The latter stresses that the expectation of future fiscal consolidation offsets the initial contraction on output; evidence from Denmark and Ireland in the 1980s supports this view.

[2]See Edwards (1989), and Lizondo and Montiel (1989).

[3]For a complete discussion of the fiscal stance of Korea during the 1980's, see Aghevli and Marques Ruarte (1985) and Corbo and Nam (1992).

(see Madisson and Associates (1992)). It is important to note that in Brazil oil shocks explain only a very small fraction of the movements of output, so empirically this expansion is small. Second, technological shocks have a small contractionary effect on Korea's output. This result is puzzling, although we must note that technological shocks are not statistically important in Korea. This lack of empirical relevance is consistent with Young (1994) but surprising due to recent evidence suggesting that world technology spillovers are important (Coe, Helpman, and Hoffmaister (1994)).

In both countries, movements of the real exchange rate are mainly associated with fiscal shocks. As the theoretical model predicts, a positive fiscal shock appreciates the real exchange rate. In Korea the real exchange rate approaches its new level in a gradual and monotonic way, but in Brazil it overshoots the long-run level. A positive supply shock tends to appreciate the real exchange rate in Korea, as predicted by the theory. However, in Brazil the opposite result is obtained. Similarly, while an increase in oil prices leads to a real depreciation in Korea--as predicted by the model--the result is the opposite in Brazil.

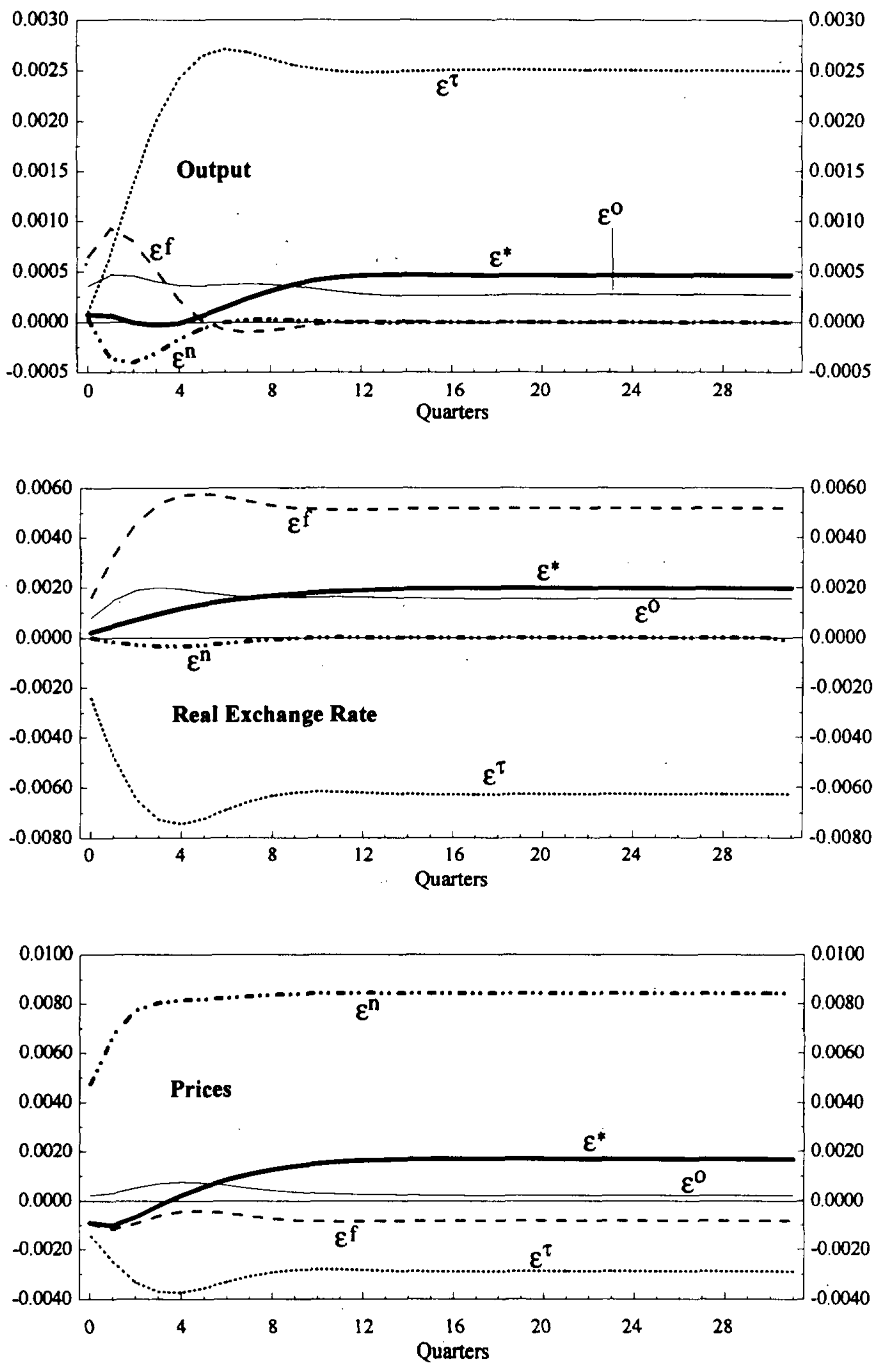
It is not surprising that the nominal innovation is the main determinant of the price level in Brazil and that more than 50 percent of the response happens in the first quarter. This is also true for Korea, but as the variance decompositions have already shown the price of intermediate inputs--oil and materials--determines the level of prices in the medium to long run.

V. Conclusions

The main results in this paper confirm for small open economies the stylized fact found for the U.S. economy: supply shocks tend to dominate output fluctuations even in the short run. However, in Brazil demand policies play an important role in explaining the short-run fluctuations of output, but in Korea the effects of these policies are negligible. The lack of a role for demand policies in Korea could be interpreted as supporting the view expressed in Dornbusch and Park (1992) and Corbo and Suh (1992): there was nothing extraordinary in Korea's macro-policies, except the lack of major policy mistakes, combined with the right structural reforms that allowed the country to take advantage of the favorable external environment and implement successful adjustment policies.

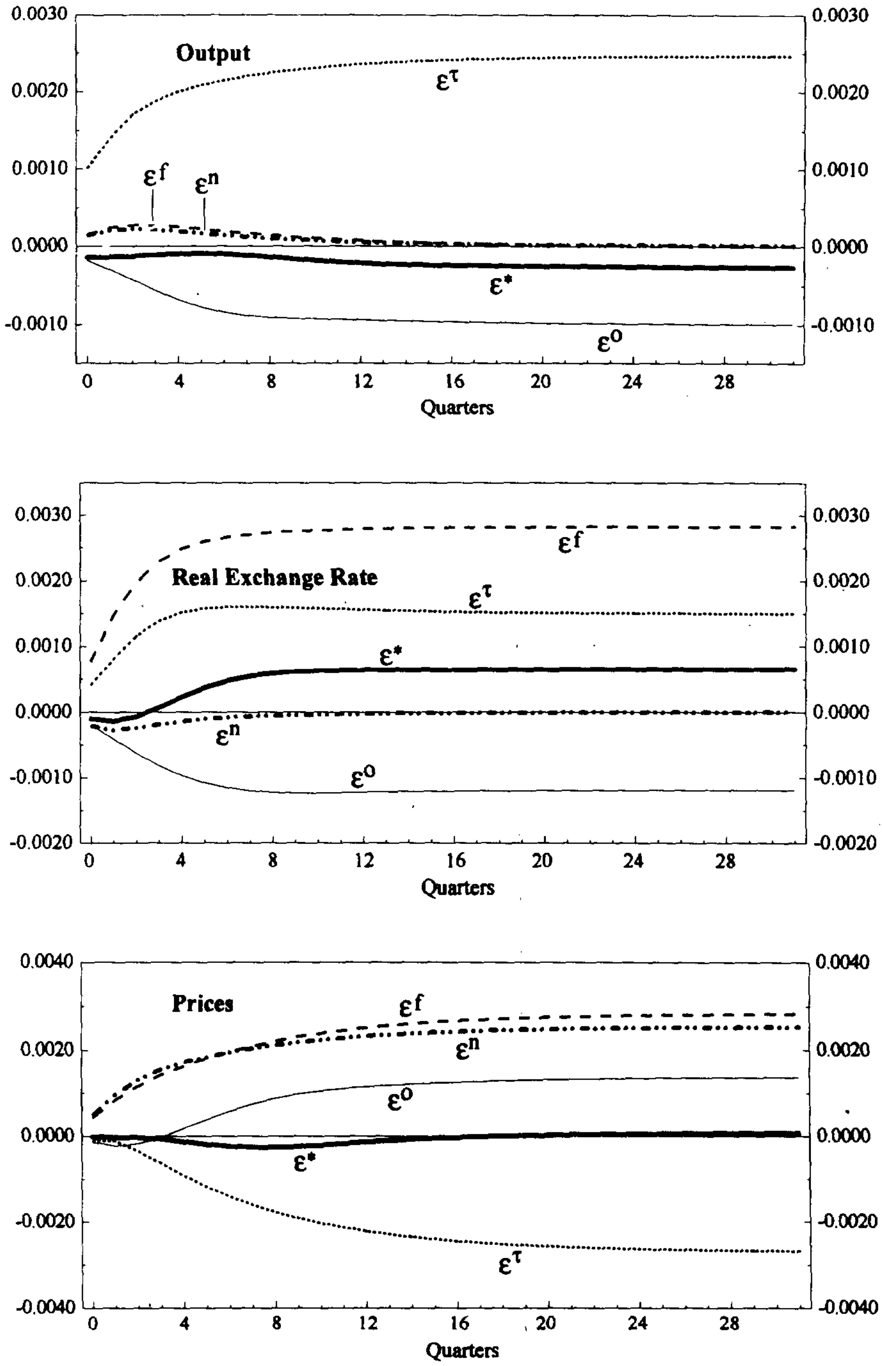
Contrary to other studies, we find that once we controlled for domestic demand and supply shocks, the role played by external factors is limited. External factors tend to account for less than 20 percent of output movements in both countries. However, this might not be true for other developing countries. In particular, terms of trade shocks are likely to play a substantive role in output movements in countries where the export base is concentrated in a few commodities (see Mendoza (1995)). We are currently researching this issue.

Chart 2. Brazil's Impulse Responses[1]



[1]The innovations ε^{o}, ε^{*}, ε^{τ}, ε^{f}, and ε^{n} are respectively to intermediate input prices, world supply, domestic supply, fiscal and nominal policies. The responses correspond to a one standard error shock to each of these innovations.

Chart 3. Korea's Impulse Responses[1]



[1]The innovations ε^o, ε^*, ε^τ, ε^f, and ε^n are respectively to intermediate input prices, world supply, domestic supply, fiscal and nominal policies. The responses correspond to a one standard error shock to each of these innovations.

Fiscal policy shocks appear to be the main driving force of real exchange rates. A fiscal expansion causes the real exchange rate to appreciate, with overshooting in the case of Brazil. It is interesting to note that nominal shocks have almost no effect on output and real exchange rates even in the short run. This contrasts with the evidence found by Clarida and Gali (1994) for the United States vis-à-vis Japan and Germany, which they interpret as providing support for the textbook Mundell-Fleming model. Our evidence suggests that the usefulness of the Mundell-Fleming model to interpret fluctuations in developing countries is limited, an issue that deserves more research.

Two shortcomings of the methodology used in this paper suggest issues for further investigation. First, the identification of nominal shocks requires that they have no long-run effect on output. If this were not the case, as seems plausible, especially in high inflation economies such as Brazil, our identification procedure could be allocating part of the role of nominal variables to the supply and/or fiscal shocks. The fact that nominal variables can have a direct effect on output and the real exchange rate--both in the short and long run--via factor supplies has been recently stressed in Roldós (1995). There is indeed some empirical evidence of these effects.[1] Second, the methodology used in this paper does not capture the effects of uncertainty and the variability of policies. A reduction of the rate of inflation can reduce uncertainty and also have long-run effects on capital formation, output and growth.

Nonetheless, the identification scheme used in this paper is approximately correct even when demand policies have long-run effects, as long as these effects are small (see Blanchard and Quah (1989)). For countries where this is true, this empirical methodology can prove useful to measure the relative importance of different sources of macroeconomic fluctuations.

[1]See De Gregorio (1993) and Fischer (1993). Further evidence of these effects is provided by the simulation exercises in Robelo and Vegh (1995) and Uribe (1995).

Long-Run Responses to Structural Innovations

The main comparative statics results for the economic model that motivates the long-run restrictions are derived below. The long-run properties of the model of Section II are summarized in the following system:

$$B(1-\alpha)\, l_x^{\alpha} = \rho \tag{A.1}$$

$$l_x K = [\psi\alpha/(1-\psi)\beta]\,(1-g)\,(L-l_x K) \tag{A.2}$$

where $B = \mu\, A_x^{1/\mu}\, [(1-\mu)\, p_m^{-1}]^{(1-\mu)/\mu}$ is a function of parameters and exogenous variables; we have used the fact that the real exchange rate is equal to

$$Q = \frac{B\alpha\, l_x^{(\alpha-1)}}{A_n\beta\,(L-l_x K)^{(\beta-1)}}. \tag{A.3}$$

An increase in government spending financed by lump sum taxes leads to a reduction in the capital stock and a real exchange rate appreciation:

$$d\log K = -\left(\frac{L_n}{L}\right)\left(\frac{g}{1-g}\right) d\log g \tag{A.4}$$

$$d\log Q = (1-\beta)\left(\frac{L_x}{L}\right)\left(\frac{g}{1-g}\right) d\log g \tag{A.5}$$

while the effect on total GDP measured in terms of tradables is positive, i.e.:

$$d\log Y = \left[\left(\frac{1-\psi}{1-\psi g}\right) - \frac{L_n}{L}\right]\left(\frac{g}{1-g}\right) d\log g \tag{A.6}$$

In their comprehensive study on industrialization and growth, Chenery, Robinson and Syrquin (1986) provide empirical estimates from developing countries for some of the parameter values involved in these exercises. From that source we consider a share of tradables in consumption $\psi = 0.48$, a share of the labor force employed in nontradables $L_n/L = 0.42$ and a share of labor in total value added $\beta = 0.60$. Using the average share of government spending in GDP for Brazil and Korea in 1980, g = 0.233, it can be shown that the impact of an increase in g on the real exchange rate is 40 percent larger than that on GDP which is positive, albeit small.

Using these same parameter values, it can be shown that a positive supply shock, an increase in B (due to technological progress, a reduction in the price of oil or trade liberalization) leads to an increase in K, Q and Y:

$$\mathrm{dlog}\,K = \left(\frac{1}{\alpha}\right)\left(\frac{1}{L_x/L - L_N/L}\right)\mathrm{dlog}\,B \qquad (A.7)$$

$$\mathrm{dlog}\,Q = \left(\frac{1}{\alpha}\right)\left[1 + (1-\beta)\left(\frac{L_x}{L_n}\right)\left(1 + \frac{1}{L_x/L - L_n/L}\right)\right]\mathrm{dlog}\,B \qquad (A.8)$$

$$\mathrm{dlog}\,Y = \left(\frac{1}{\alpha}\right)\left(\frac{1}{L_x/L - L_n/L}\right)\mathrm{dlog}\,B \qquad (A.9)$$

Taking into account the definition of B, the impact of external and supply shocks on output and the real exchange rate follows directly from Equations (A.8) and (A.9).

Table A1. Time Series Properties: Unit Root and Cointegration Tests 1/

	Brazil		Korea		World	
	Augmented Dickey-Fuller	Phillips-Perron	Augmented Dickey-Fuller	Phillips-Perron	Augmented Dickey-Fuller	Phillips-Perron
Unit Root Test 2/						
Δy	-3.19*	-3.33*	-4.03*	-5.99*	-3.91*	-2.27
Δq	-3.20*	-2.09	-3.98*	-2.59	...	...
Δp 3/	-3.37*	-2.83	-3.13	-2.03	-4.98*	-3.66*

Maximal Eigenvalue Test for Cointegration 4/

Hypothesis Null	Alternative	Brazil Test Statistics	Korea Test Statistics	World Test Statistics
r=0	r=1	25.15	21.13	...
r≤1	r=2	24.17	15.74	...
r≤2	r=3	10.33	11.54	...
r≤3	r=4	5.68	5.94	...
r≤4	r=5	3.17	1.34	...

Trace Statistic Test for Cointegration 4/

Hypothesis Null	Alternative	Brazil Test Statistics	Korea Test Statistics	World Test Statistics
r=0	r≥1	68.15	55.69	...
r≤1	r≥2	43.36	34.55	...
r≤2	r≥3	19.19	18.81	...
r≤3	r≥4	8.86	7.27	...
r≤4	r≥5	3.17	1.34	...

1/ Asterisks (*) denote rejection of the null hypothesis at 5 percent significance level.

2/ All tests were performed with a drift, unless otherwise specified. The number of lags included in the tests are determined by testing down from a maximum of four lags.

3/ For Brazil the data generating process (DGP) includes a drift and a time trend. For Korea the DGP includes a break from 1981:02 onwards. For the World the test refers to the oil price deflated by the cpi of the United States.

4/ The Johansen procedure was specified to include 3 lags in the levels, which is consistent with two lags in the difference specification used in the paper.

Table A2. Lag Length, Homoscedasticity and Near VAR Tests 1/

	Brazil		Korea	
	Schwarz	Hannan-Quinn	Schwarz	Hannan-Quinn
A. Lag Length Tests				
Number of Lags:				
1	-41.80*	-42.28	-46.89*	-47.38*
2	-41.70	-42.68*	-46.29	-47.27
3	-40.55	-42.03	-45.31	-46.80
4	-39.91	-41.90	-45.00	-47.00
5	-39.37	-41.88	-44.50	-47.03
6	-38.60	-41.64	-43.65	-46.71
B. Goldfeld-Quandt Tests for Homoskedasticity	Increased	Decreased	Increased	Decreased
Equation:				
Δp* F(23,30), F(30,32)	3.83*	0.26	5.83*	0.17
Δy* F(23,30), F(30,23)	0.18	5.47*	0.19	5.30*
Δy F(17,24), F(24,17)	1.34	0.75	1.56	0.64
Δq F(17,24), F(24,17)	1.87	0.53	0.44	2.27*
Δp F(17,24), F(24,17)	64.74	0.02	0.10	9.82*
C. Near Var Tests for Small Open Economy 2/				
χ^2_{12}	15.1		16.6	
marginal significance	0.2		0.2	

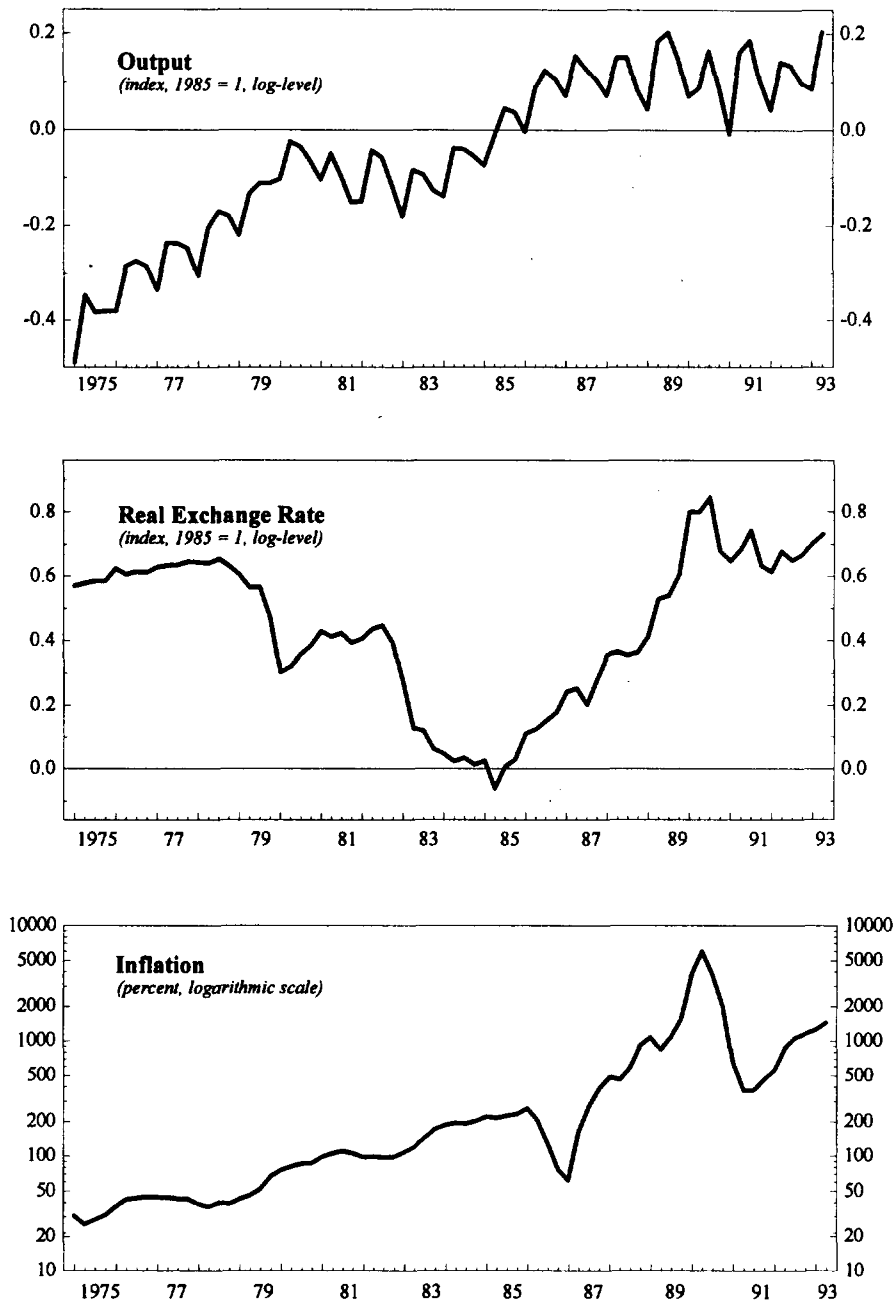
1/ In panel A, asterisks (*) denote the selection of lags; in other panels they denote rejection of null hypothesis at 5 percent significance level.
2/ Log Likelihood test with small sample correction as suggested by Sims (1980).

Table A3. Summary of Estimation Results: Models Estimated with 69 Observations from 1976:Q2-1993:Q2[1]

	Brazil					Korea				
	Δp_m^*	Δy^*	Δy	Δq	Δp	Δp_m^*	Δy^*	Δy	Δq	Δp
					Dependent Variables					
Coefficient of determination (R^2)	0.73	0.76	0.67	0.81	0.95	0.73	0.76	0.43	0.86	0.87
Adjusted R^2 ($\bar{R}^2$)	0.70	0.73	0.59	0.76	0.93	0.70	0.73	0.30	0.82	0.83
Standard error of estimate (*100)	0.14	0.31	0.94	3.76	6.63	0.14	0.31	1.32	1.08	0.82
F-test for the significance of regressors:[2]										
Δp_m^*	82.56*	0.76	0.03	2.20	0.36	82.59*	0.76	2.14	0.98	4.52*
Δy^*	0.37	88.74*	5.17*	0.53	6.29*	0.37	88.74*	0.37	1.34	0.06
Δy	...	...	25.74*	0.55	0.72	...	...	7.20*	0.45	3.42*
Δq	...	...	6.49*	50.26*	0.74	...	...	0.02	31.56*	0.29
Δp	...	...	4.14*	0.26	31.93*	...	...	0.28	1.05	81.27*
Contemporaneous covariance/ correlations of the reduced form innovations[3]										
Δp_m^*	1.30	...	...	...	...	1.31	...	...	...	...
Δy^*	-0.08	2.44	...	...	...	-0.08	2.49	...	...	...
Δy	0.35	0.07	7.51	...	...	-0.12	-0.09	1.05	...	...
Δq	0.18	0.06	0.35	29.41	...	-0.13	-0.07	0.30	8.22	...
Δp	0.05	-0.15	-0.12	0.08	50.89	-0.12	-0.01	0.00	0.18	6.39

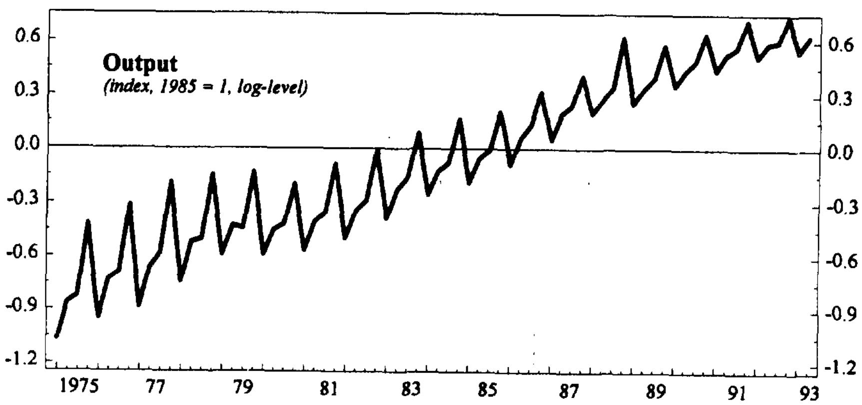
[1]The models include two lags and are estimated using weighted least squares; all equations contain seasonal dummies. A time trend is included in Brazil's inflation equation and a break is included in Korea's inflation equation.
[2]The null hypothesis states that both lags of the regressors are zero. Asterisks (*) denote a rejection of the null hypothesis at the 5 percent level.
[3]The variance of the reduced-form innovations multiplied by 10,000 are shown along the main diagonal. Correlations between these innovations are shown off the main diagonal.

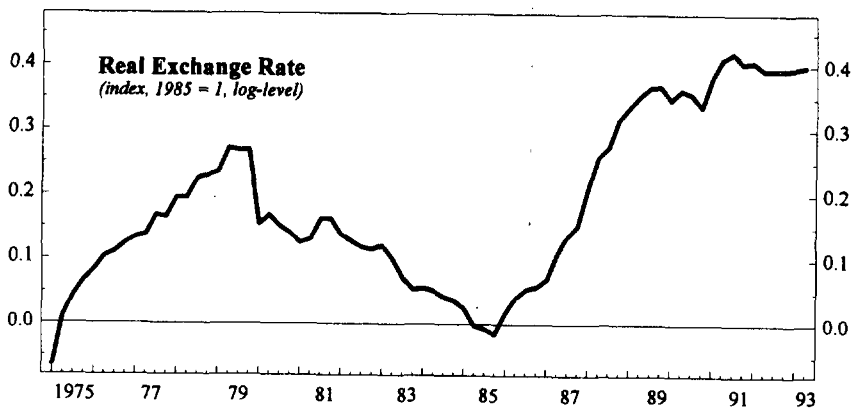
Chart A1. Brazil, 1975:Q1-93:Q2

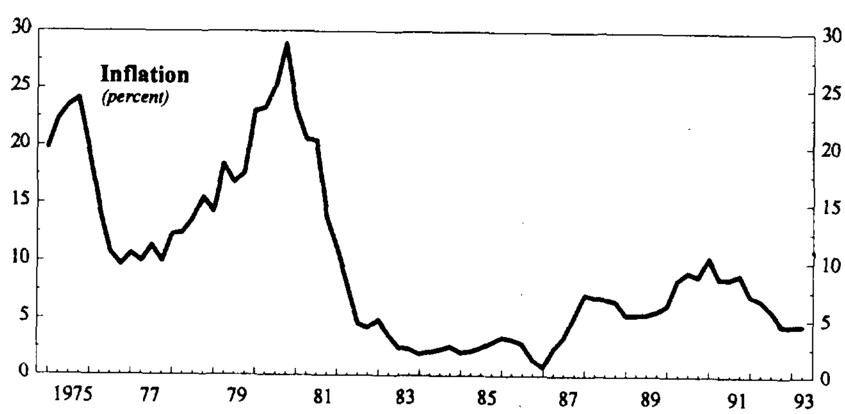


Source: IMF, *International Financial Statistics.*

Chart A2. Korea, 1975:Q1-93:Q2

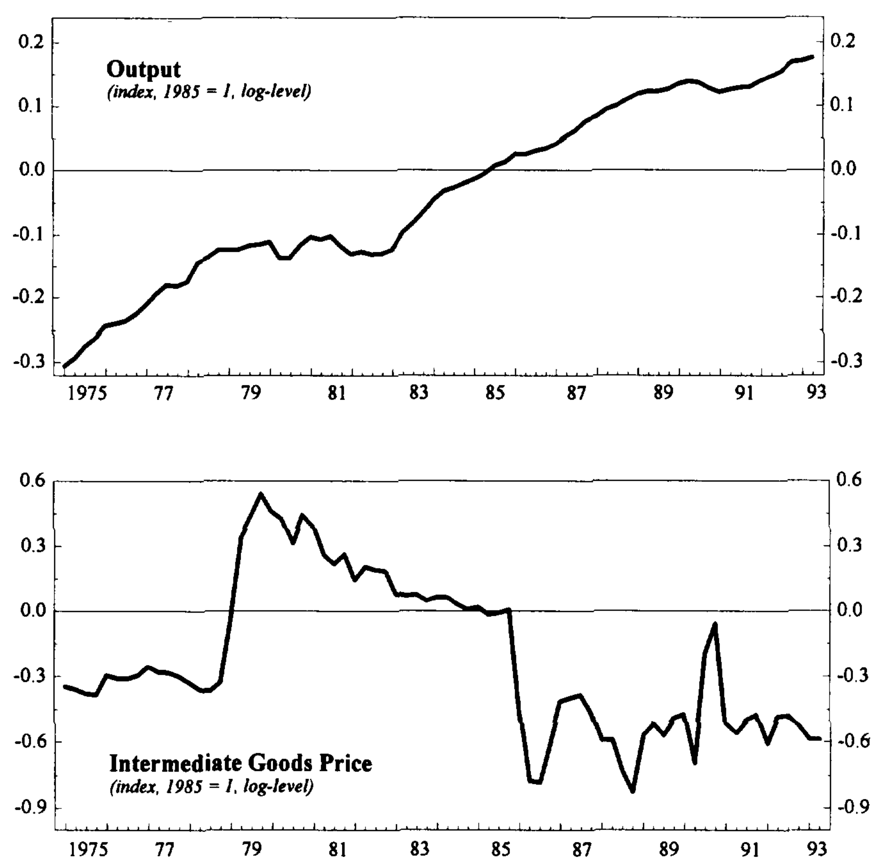






Source: IMF, *International Financial Statistics.*

Chart A3. World, 1975:Q1-93:Q2



Source: IMF, *International Financial Statistics.*

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