Depreciation and Recessions in East Asia

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The author thanks Mary Daly, Mark Spiegel, and participants at a Federal Reserve Bank of San Francisco seminar for helpful comments, and Guillermo F. Pinczuk for research assistance.

One of the striking characteristics of the recent currency crises in East Asia is the sharp reductions in output that followed depreciations. This paper draws on an earlier literature on contractionary depreciations to motivate an empirical model of the relationship between exchange rate and output fluctuations in a panel of six East Asian economies. There is evidence of a negative relationship between economic activity and the real exchange rate in East Asia. Informal examination of output fluctuations around episodes of sharp depreciation over the 1975–1996 period conveys the impression that such episodes are associated with modest expansion and contraction cycles, with output above trend before a sharp depreciation episode and below trend after it. The cyclical pattern is accentuated when the sharp depreciation episode occurs during a banking crisis. The very steep output declines that followed the 1997 sharp depreciation episodes appear to reflect a high concentration of banking crises of unprecedented severity. However, explicitly accounting for sharp depreciation episodes or banking crises does not add to the explanatory power of the benchmark model over the period 1975–1996.

The recent currency and financial crises in East Asia have sparked a new round of theoretical and empirical research on the causes of such crises, leading to significant advances in our understanding of these issues.[1] However, there has been relatively little recent discussion of the aftermath of these crises. In particular, one of the striking characteristics of the recent currency crises in East Asia is the sharp reductions in output that followed depreciations. At first glance, this outcome seems counterintuitive, as depreciations are generally expected to boost output.

Recent explanations for closely timed depreciations and output contractions focus on the interaction between external shocks and financial sector disruptions. In this view, low interest rates in industrial economies and sterilized intervention policies that kept interest rates high in emerging markets contributed to a surge in capital flows to the emerging markets in the first half of the 1990s (Calvo, Leiderman, and Reinhart 1996). These capital flows supported credit growth and a boom in economic activity in East Asia that was associated with growing financial sector vulnerability. Financial liberalization also may have played a role in financial vulnerability (Diaz Alejandro 1985, Kaminsky and Reinhart 1999). According to these explanations, the unprecedented contractions in output observed in East Asia following the currency depreciations of 1997 were the result of financial crises. These in turn were caused either by panics in illiquid financial systems (Chang and Velasco 1998, Radelet and Sachs 1998) or by moral hazard that made financial systems vulnerable to shocks because of excessively risky lending or unhedged foreign currency borrowing (McKinnon and Pill 1998, Krugman 1998, Corsetti, Pesenti, and Roubini, 1998).

While the relationship between financial crises and currency crises in East Asia in 1997 is very evident and is broadly consistent with the experience in other emerging markets (Kaminsky and Reinhart 1999), the characteristics of past depreciations in East Asia—and their implications

1. For a recent overview of this literature of stylized facts around currency crises episodes, see IMF (1998). Glick and Moreno (1998) and Moreno (1999) discuss the predictive ability of alternative macroeconomic indicators on the eve of currency crises in East Asia. For discussions of the causes of these crises see also Corsetti, Pesenti, and Roubini (1998), Radelet and Sachs (1998), and Chang and Velasco (1998).

for output behavior—have not been so closely studied. In particular, it is of interest to inquire whether depreciations have been associated with output contraction in East Asia in the past, and whether currency and banking crises have played a significant role in explaining output fluctuations.

To address these questions, we draw on an earlier literature on contractionary depreciations[2] to motivate an empirical model of the relationship between exchange rate and output fluctuations in a panel of six East Asian economies.

This paper is organized as follows. Section I discusses alternative ways in which a reduced-form relationship between the real exchange rate and output may be derived and interpreted and conditions under which contractionary depreciation may occur. Section II estimates regression models of the relationship between exchange rate behavior and output fluctuations. Section III highlights the behavior of exchange rates and output around periods of sharp depreciation and banking crises and extends the model to control for episodes of currency crises and banking crises. Section IV offers some conclusions.

I. Models of Contractionary Depreciation

To motivate the analysis of contractionary depreciations, consider the following reduced-form model of the relationship between the real exchange rate and output:

$$(1) \qquad y - \bar{y} = \tau_1(e - \bar{e}) + \tau_2(m - \bar{m}) + \tau_3(g - \bar{g}) + \tau_4(y^* - \bar{y}^*) + \tau_5(r^* - \bar{r}^*) + \xi,$$

where bar superscripts refer to expected or trend values and

y = output
e = real exchange rate, measured so that an increase is a depreciation
m = money
g = government spending
y^* = foreign output
r^* = world interest rate, and
ξ = reduced-form residual.

Equation (1) is broadly consistent with empirical models of contractionary depreciation that have been estimated in the literature, and it provides a reasonably complete description of possible influences to economic activity, as it accounts for domestic monetary and fiscal conditions, as well as external shocks. Researchers have been particularly interested in the coefficient τ_1, which measures the direct relationship between the real exchange rate and output. If the coefficient is negative, depreciations are contractionary. Using panel data from developing countries Edwards (1989) and Agenor (1991) estimate equations similar to equation (1) and find evidence suggesting that depreciations are contractionary. As we shall see, τ_2 and τ_3 also may be affected by contractionary depreciation effects.

As much of the discussion that follows will focus on the derivation and interpretation of the first three coefficients of equation (1), it is worth discussing the external shocks briefly. The coefficient τ_4 reflects the impact of foreign economic activity on domestic output, and its sign is expected to be positive.

The coefficient τ_5 reflects the impact on domestic output of global interest rate shocks, which may occur through international capital flows and which is likely to be negative. A rise in world interest rates reduces capital inflows and may adversely affect investment demand and output. Research by Calvo, Leiderman, and Reinhart (1993, 1996) suggests that global interest rate shocks are important contributors to capital flows in developing countries. Agenor and Hoffmaister (1998) confirm that these results carry through in the East Asian context. Using VAR models, they find that world interest rates have a significant impact on capital flows and the real exchange rate in Korea, the Philippines, and Thailand. Agenor (1998) develops an intertemporal optimizing model that spells out the conditions that determine the impact of global interest rate shocks on capital flows.

Before estimating equation (1), two questions are worth addressing. First, what explanations may be offered for contractionary depreciation effects? Second, what type of macroeconomic framework is consistent with the reduced-form specification used in equation (1), and what do these models say about the signs of the various coefficients? In particular, to what extent can equation (1) be reconciled with equilibrium optimizing behavior by rational agents?

In the discussion that follows, we will review how the literature has addressed these questions by focusing on two models. One model, by Agenor (1991) shows how contractionary depreciation effects may reduce aggregate supply because of the use of imported inputs in production. Another model, by Gavin (1992) shows how depreciation may have a contractionary influence on demand if there is investment spending on imported capital goods. Thus, the two models provide complementary interpretations of equation (1). Agenor's model will be discussed in some detail to provide a benchmark for alternative interpretations and to highlight the contributions and limitations of the literature on contractionary depreciation. We also will briefly discuss alternative explanations of contractionary depreciation effects, the difficulties associated with incorporating

2. The traditional literature refers to contractionary *devaluations* rather than depreciations, because the focus was on episodes in which single-currency pegged exchange rates were abandoned. In this sense, the reference to depreciations is more general, referring to economies where exchange rates may be flexible to varying degrees.

contractionary depreciation effects in fully specified intertemporal optimizing models, and the possible implications of sharp depreciation episodes and banking crises.

Depreciation Effects with Imported Inputs

Following Agenor (1991),[3] consider a small open economy with a fixed exchange rate and a perfectly elastic supply schedule for imports. Two composite goods which are imperfect substitutes are traded in the economy, one produced domestically and the other produced abroad. The foreign good is both consumed and used as an intermediate input in production. Its foreign currency price is determined in world markets.

The analysis of the effects of depreciations on output proceeds in three stages. First, the behavior of producers is described in order to derive the demand for imported inputs and labor. Second, labor market equilibrium is derived, which permits a description of how shocks to prices, the real exchange rate, and productivity affect the supply of output. Finally, a simple ad hoc model of aggregate demand is introduced, which, when equated to aggregate supply, yields the relationship between the real exchange rate and output when markets clear.

Producers

Domestic output is produced using imported inputs (N), and value added by a CES production function. Value added (V) in turn is produced using labor (L) and capital (K) with Cobb-Douglas technology. The capital stock is fixed in the short run. That is,

$$(2) \qquad Q = B[\alpha N^{-\rho} + (1-\alpha)(L^{1-v}K^{v})^{-\rho}]^{-1/\rho}\exp(\varepsilon^s), \quad 0<\rho<1;\ 0<v<1,$$

where Q is the gross output of domestic final good in levels, B is a multiplicative constant, ε^s is a white noise productivity shock, and v is the share of capital in the production of value added.

Risk-neutral producers maximize expected profits by choosing short-run inputs N and labor L. Using a log-linear approximation of equation (2) and taking the first-order conditions yields the derived demand for labor that depends on the real wage (deflated by the price level of the producer), the real exchange rate, and the productivity shock:[4]

$$(3) \qquad l^d = -(1/v)(w-p_d) - (c_1/vc_2)e + (\varepsilon^s/vc_2),$$

where w is the log nominal wage, p_d is the log producer price for the domestic good, $c_1 = \alpha(\bar{Q}/\bar{N})^{\rho}$ is the share of imported materials ($0 < c_1 < 1$), $c_2 = (1-\alpha)(\bar{Q}/\bar{V})^{\rho}$ is the share of domestic value added ($0 < c_2 < 1$, $c_1 + c_2 = 1$), $e = (s + p_n - p_d)$ is the log of the real exchange rate, and s is the log nominal exchange rate.

The derived demand for imported raw materials depends on the same three variables:

$$(4) \qquad n^d = -\left[\frac{(1-v)}{v}\right](w-p_d) - \left(\frac{1}{c_2}\right)\left[\sigma + c_1\frac{(1-v)}{v}\right]e + \left(\frac{1}{c_2}\right)\left[\sigma + \frac{(1-v)}{v}\right]\varepsilon^s,$$

where $\sigma = 1/(1+\rho) > 0$ is the elasticity of substitution between imported inputs and value added.

In equations (3) and (4), a real depreciation reduces the demand for labor and imported inputs, illustrating how contractionary depreciation effects arise in this model. In addition, the demand for imported intermediate goods are more sensitive to real exchange rate changes the greater the weight of imported raw materials in the production function.

Labor Markets

In order to guarantee that demand affects output, labor supply is assumed to depend on the expected (rather than the actual) real wage:

$$(5) \qquad l^s = \beta(w - \bar{p}),\ \beta > 0,$$

where $\bar{p}$ is the log of the price level expected in the current period.

Equating labor supply (5) to labor demand (3)[5] and using the first-order conditions for profit maximization yields expressions for labor demand and labor supply that depend on price surprises, the real exchange rate, and the productivity shock. These in turn can be used to obtain net output supply in terms of final goods:[6]

$$(6) \qquad y^s = \gamma_1(p-\bar{p}) + \gamma_2 e + \gamma_3\varepsilon^s,$$

where it can be shown from the profit maximization and the labor supply conditions that $\gamma_1 > 0$, $\gamma_2 < 0$, and $\gamma_3 > 0$.

3. See also Krugman and Taylor (1978), Hanson (1998), Marston and Turnovsky (1985), Hardouvelis (1987), and Edwards (1989).

4. More detailed derivations can be found in Agenor (1991).

5. It is worth noting that while firms react to the price of their own output (p_d) in maximizing profits, workers react to the expected overall price level, $\bar{p}$, since consumption depends on the price of the basket of consumption goods. The overall price level in logs is $p = \delta p_d + (1-\delta)(s + p_n)$.

6. This involves substituting the labor and input demands into the log-linear version of the production function and then subtracting inputs from aggregate supply.

The supply side of the model has the property that price "surprises" have a positive impact on output, a "Phillips curve" relationship that is consistent with rational equilibrium behavior if agents cannot easily distinguish between aggregate and relative price shocks (Lucas 1972). This feature of the model allows shocks to aggregate demand to influence output, in the manner described below.

A real exchange rate depreciation has two main effects on the supply side. First, by increasing the relative price of the imported input expressed in domestic currency, it leads to a fall in the real wage, tending to increase output. Second, producers reduce the demand for labor and imported inputs, producing a fall in output.

To obtain a specification more in line with our estimation strategy (based on taking deviations from expected values or trend of all variables), we depart from Agenor (1991) to define the expected component of output supply in equation (6) as the value of output when the right-hand side variables are at their expected levels. In this case, we have

$$\bar{y} = \gamma_2 \bar{e}. \tag{7}$$

Subtracting the expected output (7) from (6), we obtain the equation for deviations of output supply from its expected level:[7]

$$y^s - \bar{y} = \gamma_1(p - \bar{p}) + \gamma_2(e - \bar{e}) + \gamma_3 \varepsilon^s. \tag{8}$$

Aggregate Demand

Aggregate demand depends on domestic and foreign conditions, according to the following reduced form equation:

$$y^d = b_1 e + b_2(m - p) + b_3(g - p) + b_4 y^* + b_5 r^* + \varepsilon^d, \tag{9}$$

where e is the real exchange rate, $m - p$ is real balances, $g - p$ is real government spending, y^* is foreign real output, r^* is the foreign real interest rate, and ε^d is white noise. Equation (9) is Agenor's (1991) aggregate demand specification expanded to take into account the world interest rate. The signs on the coefficients b_1 to b_4 in equation (9) are assumed to be positive. The sign of b_5 is ambiguous, but is likely to be negative. The plausibility of these assumed signs is discussed further below.

Equating aggregate demand (9) to aggregate supply (6), and manipulating the equation yields a reduced form expression for the determinants of deviations from expected output that corresponds to equation (1).[8] The model implies that τ_2, τ_3, $\tau_4 > 0$, and $\tau_5 < 0$, as the signs of these coefficients are determined by the aggregate demand coefficients in equation (9).

As for τ_1, it has an ambiguous sign because it combines the contractionary effects of the real exchange rate on supply with the effects on demand, which are assumed to be expansionary.

Depreciation Effects on Investment Demand

Agenor (1991) extends an earlier literature that highlights how contractionary depreciation effects may arise on the supply side, by introducing aggregate demand effects in an economy where workers react to price surprises. However, the aggregate demand specification he uses describes neither the underlying consumer and investor behavior nor the transmission mechanism by which policy shocks influence output through the exchange rate. Such effects may imply that the signs of the coefficients on the money and government spending variables in equation (1) are not those suggested by Agenor's model.

Gavin (1992) sheds light on a number of these questions by developing an open economy macroeconomic model in which investment decisions by rational agents are explicitly described. He also illustrates another channel by which contractionary depreciation effects may arise. In Gavin's model, firms can convert domestically produced goods or imported goods into an investment good. The static optimization decision of firms implies that a share of investment expenditure falls on imported goods. This share is negatively related to the terms of trade, which is the ratio of the price of domestically produced goods to that of imported goods. As the terms of trade are the same as the real exchange rate in this model, the discussion that follows will refer to real exchange rate depreciation (a terms-of-trade deterioration).

7. Note that equation (7) is a simplified description of the expected level of output. In a more general specification, expected output would depend on other factors, notably an upward trending productivity component. We do not add this component as it would complicate the algebra without adding insights to our analysis of contractionary depreciation. In any case, the issue is addressed in our empirical analysis by taking deviations from a Hodrick Prescott trend.

8. Equating aggregate demand (9) to aggregate supply in equation (6), yields an expression for the price level. This expression can be used to take expectations and solve for $\bar{p}$. Subtracting the resulting expectations from the actual price level yields the unanticipated movements in domestic prices. Substituting these into (8) yields (1). The estimating equation (1) differs from Agenor's (1991) equation. Agenor focuses on the actual level of output rather than on deviations from the expected level and estimates versions of the following equation:

$$y = \tau_1(e - \bar{e}) + \tau_2(m - \bar{m}) + \tau_3(g - \bar{g}) + \tau_4(y^* - \bar{y}^*) + \tau_5(r^* - \bar{r}^*) + \tau_6 e + \xi.$$

We estimate equation (1) instead because it allows us to transform all the variables in a similar manner to achieve stationarity.

Firms also maximize the present value of anticipated future cash flow. This forward-looking optimizing behavior allows the analysis of the short-run and long-run effects of permanent and temporary depreciations. The first-order conditions imply that net investment is an increasing function of Tobin's q, the ratio of the firm's shadow value of installed capital (typically represented by the market value of capital) and the replacement cost of capital. The precise effects of depreciation on investment are influenced by the fact that the numerator of Tobin's q depends on the *anticipated* real exchange rate, while the denominator depends on the *current* real exchange rate.

If there is some import content to investment, a permanent depreciation in the real exchange rate causes a reduction in the stock market valuation of domestic capital, because the value of the goods which the capital is used to produce has fallen in world markets. The result of depreciation is then a fall in Tobin's q and *a decline in investment.*

In the case of a temporary real depreciation that is sufficiently short, Tobin's q may rise and investment will increase because investors know that the price of output will recover and they will want to buy investment goods while the price is still cheap. However, the precise effect depends on the import content of investment. If all capital goods are imported, investment will be adversely affected by a real depreciation, no matter how short-lived. On the other hand, if no capital goods are imported, investment either responds favorably to an exchange rate depreciation or is unaffected (if the shock is permanent).

Gavin embeds his investment model in an open economy Keynesian framework[9] and derives the effects of permanent and temporary monetary and fiscal policy shocks. Assuming sticky prices, a monetary expansion causes the real exchange rate to depreciate. Investment will tend to drop if the share of investment spending that falls on imported goods is large enough, and the duration of the monetary shock is sufficiently long. Thus, if some investment spending falls on imported capital goods, *a monetary expansion, by causing a depreciation, may be contractionary.*

In contrast, a fiscal expansion will tend to cause the real exchange rate to appreciate, which may cause investment to *rise.* Gavin shows that this requires that the share of spending that falls on imported goods be large enough and the duration of the fiscal shock be sufficiently long. *Thus, fiscal stimulus tends to "crowd in" domestic investment by this channel, reinforcing the direct expansionary effect of a fiscal spending shock on output.*[10]

Gavin's model illustrates one way in which monetary and fiscal shocks may embed contractionary depreciation effects. Under plausible conditions in which such contractionary effects are present, $\tau_2 < 0$, $\tau_3 > 0$ in equation (1). In addition, it is clear that the coefficient τ_1 must reflect fluctuations in the real exchange rate that are distinct from those caused by contemporaneous monetary and fiscal shocks, such as global or regional terms of trade shocks.

Taken together, the Agenor (1991) and Gavin (1992) models illustrate how depreciations may have contractionary effects on aggregate supply and demand because of spending on imports. The literature surveyed by Agenor and Montiel (1996) suggests other ways in which depreciations can reduce aggregate output, at least in the short run. These include reducing real income, and therefore consumer demand;[11] reducing wealth and raising real interest rates, which may adversely affect both consumption and investment demand; redistributing income away from groups with a high propensity to spend, so that consumption or investment demand fall; and raising the cost of working capital financing, which would tend to reduce supply.

Although earlier research has advanced our understanding of how contractionary depreciation effects may arise, it is worth bearing in mind that the studies we have reviewed are not based on fully specified dynamic equilibrium models. One obstacle to using such models is that these traditionally have assumed flexible prices. Monetary shocks —which are considered to be an important source of exchange rate fluctuations—have no effect on output unless prices are rigid or there is imperfect information.[12] Recent research (Obstfeld and Rogoff 1996, Chapter 10) clarifies the impact of monetary and fiscal policies in open-economy dynamic equilibrium models with sticky prices or wages. However, further research is needed to explain contractionary depreciation effects using such models.

9. The model includes the following elements: (1) saving is modeled as an increasing function of the difference between current disposable income and long-run (steady state) disposable income, (2) money demand depends on the domestic nominal interest rate and the level of output, and (3) inflation is a decreasing function of the gap between the domestic price level and its long-run steady state level (sticky prices).

10. Sevren (1995) confirms the crowding-in impact of fiscal policy in a model with an investment sector very similar to that described by Gavin but in which agents optimize consumption over their lifetimes.

11. This effect is implicit in the Agenor (1991) model.

12. Calvo and Vegh (1999) describe equilibrium models in which an anticipated increase in the *rate* of devaluation can generate cyclical fluctuations in output. However, these fluctuations do not reflect contractionary devaluation effects of the kind discussed in the text.

Sharp Depreciation Episodes and Output Contraction

Our discussion so far has not focused on the implications for economic activity of sharp depreciation episodes or currency crises, which is one of the original motivations of the literature on contractionary depreciation. However, neither "first generation" (Krugman 1979) nor "second generation" (Obstfeld 1995) currency crisis models suggest any direct contractionary effects of currency crises. "Third generation" models, developed in the wake of currency crises and steep output contractions in Mexico in 1994 and in East Asia in 1997–1998, do suggest that sharp depreciation episodes may lead to output contraction by disrupting the operation of the financial sector.

There is disagreement on the reasons for the financial sector disruption. Some authors (Chang and Velasco 1998, Radelet and Sachs 1998) argue that economies that become open to foreign borrowing may become increasingly illiquid, even in a socially efficient equilibrium, making them vulnerable to sudden loss of confidence or panic. Others (Burnside, Eichenbaum, and Rebelo 1999, Corsetti, Pesenti, and Roubini 1998, Krugman 1998, McKinnon and Pill 1998) argue that government guarantees encourage risky behavior (moral hazard), and make the financial system vulnerable to shocks. In particular, moral hazard may encourage unhedged foreign currency borrowing that accentuates contractionary depreciation effects.

As sharp depreciation episodes and financial crises are relatively rare, it is not clear that output fluctuations around such episodes can be fully predicted by equation (1). We address this issue in more detail in our empirical analysis.

II. Empirical Analysis

To test for the presence of contractionary depreciation effects in East Asia, we estimate the following version of equation (1):

$$(10)\quad (z-\bar{z})_{it} = \tau_1(e-\bar{e})_{it} + \tau_2(m-\bar{m})_{it} + \tau_3(g-\bar{g})_{it} + \tau_4(y^*-\bar{y}^*)_{it} + \tau_5(r^*-\bar{r}^*)_{it} + \xi, \quad i = 1,\ldots,n;\ t = 1,\ldots,T;$$

where

z = log of real GDP, consumption, or gross investment from the national income accounts

e = log of real trade-weighted exchange rate against the dollar, the yen and the deutschemark, adjusted by CPIs

m = log of nominal M2

g = log of ratio of government spending over CPI

y^* = trade-weighted industrial production of U.S., Japan, and Germany (see Data Appendix), and

r^* = real U.S. federal funds rate.

The coefficients of interest are τ_1 and τ_2, which may be negative if contractionary depreciation effects are present. Equation (10) was estimated using panel data for a sample of six East Asian economies over the period 1975–1996. Further details on the data are provided in a Data Appendix.

In equation (10) the variables are expressed as deviations from some anticipated value. We estimate Hodrick Prescott trends (with the penalty parameter set at 100, reflecting our use of annual data) to proxy for the anticipated values of output and the remaining variables in equation (10). This trend specification, which is widely used in the analysis of business cycles, has a number of advantages. First, since it is a measure of trend behavior, it is a plausible proxy for the expected value of a series. In this case, the trend is stochastic and is assumed to vary (gradually) over time. Second, the Hodrick Prescott trend does not require too much knowledge of theory, which is an advantage given that we are using a reduced form and that the literature has not advanced to the point of deriving contractionary depreciation effects from fully specified dynamic equilibrium models. Third, country-specific fixed effects are eliminated because we are taking deviations from the trends of each country series. (As expected, an F test does not reject the null hypothesis that country-specific dummies are zero and equal to each other.)[13]

Estimation of equation (10) raises questions about the direction of causality. An increase in output can cause the real exchange rate to appreciate, which would imply simultaneous equation bias. Nominal M2 and real government spending also may respond contemporaneously to output behavior. To control for this, we estimate the model by instrumental variables. The trade-weighted real exchange rate, M2, and real government spending are treated as endogenous. The instruments used in the first-stage regression are a constant, the contemporaneous yen-dollar exchange rate, one lag of the monetary and government spending variables, and the contemporaneous values of foreign trade-weighted industrial production and the U.S. real federal funds rate. These variables are admissible as instruments on the assumption that the foreign variables are exogenous and the lagged domestic variables are predetermined.

Table 1, Panel A reports the results of estimation for the whole sample. In the case where output is the dependent variable (columns 1 and 2), we first report the OLS and then

13. Some features of the Hodrick Prescott filter have been criticized. See Cogley and Nason (1995).

TABLE 1

RELATIONSHIP OF REAL EXCHANGE RATE TO OUTPUT AND ITS COMPONENTS

	PANEL A: 1975–1996				PANEL B: 1975–1990		
	GDP		Consumption	Investment	GDP	Consumption	Investment
	1	2	3	4	5	6	7
Real Exchange Rate	–0.14***	–0.07	–0.17	–0.60**	–0.18**	–0.25**	–0.81***
	(0.00)	(0.39)	(0.12)	(0.03)	(0.04)	(0.02)	(0.01)
Nominal M2	0.07	0.01	–0.02	0.19	–0.11	–0.05	–0.12
	(0.23)	(0.91)	(0.91)	(0.65)	(0.49)	(0.81)	(0.84)
Real Government Expenditure	0.12***	0.20***	0.28***	0.83***	0.23***	0.28***	0.95***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Foreign Output	0.24***	0.19**	0.39***	0.85***	0.30***	0.46***	0.92***
	(0.00)	(0.02)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
Real Fed Funds Rate	-2.6×10^{-3}*	-1.1×10^{-3}	-4.7×10^{-3}**	-4.6×10^{-3}	-2.2×10^{-3}	-6.5×10^{-3}***	-6.7×10^{-3}
	(0.09)	(0.54)	(0.02)	(0.36)	(0.20)	(0.00)	(0.24)
$\bar{R}^2$	0.32	—	—	—	—	—	—
NOBS	132	132	132	132	96	96	96

NOTES: The models were estimated with a constant which was not significant and is not reported. P-values in parentheses. All results are based on instrumental variable regressions except for column 1, which is based on OLS.

* Significant at 10 percent.

** Significant at 5 percent.

*** Significant at 1 percent.

the instrumental variable regression results. The OLS regressions suggest that shocks to real government spending and foreign output have an expansionary cyclical effect on output, while the real federal funds rate has a negative effect. In addition, *real depreciations are contractionary,* as the coefficient on the trade-weighted real exchange rate has a negative sign, significant at 1 percent. Monetary disturbances have no significant effect on output. One interpretation, suggested by our discussion of Gavin's model, is that contractionary depreciation effects offset any expansionary effects of monetary shocks. The null hypothesis that the coefficients are zero is rejected at 1 percent for government expenditures and foreign output, and at 10 percent for the real fed funds rate.

The instrumental variable regression in column 2 gives similar qualitative results to the OLS regression; however, the null hypothesis that the coefficient on the real exchange rate is zero can now no longer be rejected, and the estimated coefficient value falls. The real fed funds rate is no longer significant either.

The impact of the explanatory variables on GDP reflects their effects on consumption and investment, which are reported in columns 3 and 4. Inspection of these results suggests that contractionary depreciation effects largely reflect the impact on investment (significant at 5 percent). As for the remaining explanatory variables, shocks to real government spending and foreign output have a significant impact on both consumption and investment. The coefficient on the real fed funds rate is significant at 5 percent in the case of consumption but not significant in the case of investment.

In Table 1, the yen-dollar exchange rate is one of the instruments used in the first-stage regression. To see whether the results are sensitive to the use of this instrument, we replace it by the lagged trade-weighted real exchange rate. The results (not reported in the table) are qualitatively similar. However, the negative coefficient on the real exchange rate is significant at the 7 percent level in the output equation but is not significant in the remaining equations.

The Effects of Greater Capital Market Integration

One question of interest is how the growing capital market integration apparent in the 1990s affects the results. In their survey of the sources of contractionary depreciation effects, Agenor and Montiel (1996) observe that in the absence of capital mobility a depreciation may raise interest rates by reducing wealth, which may in turn reduce investment demand. This additional contractionary effect is absent when capital is mobile, as domestic interest rates are then anchored by world interest rates. The anchoring occurs because the exchange rate depreciation induces capital flows that may stimulate domestic investment spending. Goldberg and Klein (1998) provide evidence that this effect is important in East Asia. They show that after controlling for exchange rate movements of Southeast Asian currencies against the dollar, a real depreciation of Southeast Asian currencies against the Japanese yen is associated with an increase in Japanese direct investment into these economies.

An implication is that greater capital mobility may *reduce* contractionary depreciation effects. That is, if capital flows were indeed more important in the 1990s, the negative coefficient on the real exchange rate would tend to be larger and more significant before 1990 than over the full sample.

Columns 5–7 of Table 1, Panel B report regression results for the subperiod 1975–1990. The results are qualitatively similar to those reported for the full sample. One striking difference, however, is that the coefficients on the real exchange rate are indeed larger, and, for the real GDP equation, the coefficients now are significant at the 5 percent level. These findings are consistent with the hypothesis that greater capital mobility after 1990 tended to dampen contractionary depreciation effects. One caveat to this interpretation is that the coefficient on the real fed funds rate (columns 2 and 5) provides no additional information as it is insignificant for GDP over both the full sample and the subsample.

Overall, the results reported in Table 1 suggest that the real exchange rate has a significant effect on cyclical fluctuations in economic activity in East Asia. The effects are reflected most consistently on consumption and investment behavior, while the evidence of a significant impact on aggregate output is mixed, being sensitive to the sample period or the instrument used.

III. Sharp Depreciation Episodes, Banking Crises, and Output

As noted earlier, the traditional literature on contractionary depreciation was at least partly motivated by a desire to understand the implications of sharp depreciation episodes in developing countries, rather than the broad relationship between output and real exchange fluctuations that has been examined thus far. Our earlier discussion suggests at least three questions of interest.

First, are sharp depreciation episodes "different," in the sense of being associated with an unusually sharp output contraction that is not entirely explained by the model estimated so far?

Second, what role have banking or financial crises played in influencing business cycle fluctuations in the region in the past?

Third, how do the 1997–1998 sharp depreciation episodes in East Asia differ from past experience and why?

To address these questions, we first identify episodes of sharp depreciation and banking crises and attempt to assess the relationship between these variables and the cyclical behavior of output.

The criteria for identifying sharp depreciation episodes are based on Frankel and Rose (1996), with some modifications. Using annualized monthly nominal exchange rate data, a sharp depreciation episode is identified whenever an East Asian currency depreciates against the U.S. dollar by more than 25 percent and by more than 10 percentage points than it did over the prior twelve months. To prevent double counting the continuation of the same episode, the data in the year after a crisis are excluded in identifying subsequent crises. In addition, to exclude depreciations that simply reflect the volatility of exchange rates (in which a currency may appreciate and then depreciate very sharply within a short period) we only count as crises those years in which the depreciation from year-end to year-end exceeds 5 percent.[14] Fifteen sharp depreciation episodes are identified in this manner over the period 1975–1996, an average of about 0.7 per year. This compares to 6 episodes in 1997 alone (outside the estimation period).

To identify banking crises, we draw on a series used by Glick and Hutchison (1999), who rely on criteria developed by Caprio and Klingenbiel (1996) and Demirgüç-Kunt and Detragiache (1998). As a lack of data complicates the identification of banking crises, most studies combine a number of criteria to date their occurrence. These include institutional events such as forced closures, mergers, government intervention in the operations of financial institutions or large-scale assistance to these institutions, bank runs, and balance sheet indicators (nonperforming or problem loans, etc.). According to the Glick-Hutchison data set, there are 18 observations in which banking crises occur

14. Frankel and Rose (1996) use a similar cutoff rule without the year-end condition. Their approach differs from ours because they identify crises using annual average data and a 3-year exclusion window.

in East Asia in the period 1975–1996, an average of nearly 1 per year. This compares to 5 banking crises in 1997 alone.

Figure 1 shows averages of the actual and predicted values for output, consumption, and investment around sharp depreciation episodes for the period 1975–1996. On the horizontal axis the figures show a 6-year window around depreciation episodes, where 0 is the date of the sharp depreciation. On the vertical axis log deviations from trend are reported. The fitted values are for the models reported in Table 1. The actual values are average deviations from trend during currency crises alone and during years in which a currency crisis coincides with a banking crisis.

Figure 1A reveals a cycle of expansion and contraction around sharp depreciation episodes. Periods of sharp depreciation are typically preceded by a cyclical expansion, with actual real GDP above trend. Real GDP falls below trend at the time of the episode and is still below trend in the third year after the episode. The fluctuations span approximately 3.5 percentage points from peak to trough. This may be compared to average growth rates of 7 percent a year over the sample period, ranging from a low of 3.6 percent for the Philippines to a high of 8.4 percent for Korea. The fitted value closely follows the actual before the episode. However, the predicted decline in output at the time of the episode is more moderate and the recovery quicker. Figures 1B and 1C reveal that real consumption and real investment also follow expansion and contraction cycles around episodes of sharp depreciation, but investment tends to swing much more sharply.

Figure 1 also illustrates fluctuations in economic activity when the sharp depreciation episode coincides with a banking crisis as defined by Glick and Hutchison (1999). The expansion and contraction cycles tend to be more pronounced during such periods, suggesting a significant contractionary impact from banking crises.

To see how the most recent depreciation episodes compare to past episodes, Figure 2 shows actual and fitted values for output around the 1997 depreciation episodes (the coefficient values still correspond to the 1975–1996 period). On the figure's horizontal axis, 0 corresponds to 1997. There is no fitted value for 1998 because data are incomplete. Figures for real consumption and real investment are not included because of missing data.

As is apparent in Figure 2, the boom in economic activity prior to the 1997 depreciation episodes was much larger than in the past. On average, real GDP peaks at 4 percent above trend before the 1997 episodes, compared to about 1 percent for the full set of prior episodes. The model tracks some of the boom in economic activity prior to 1997, but less successfully than it did in prior depreciation episodes. The contraction that followed the depreciation episodes is

FIGURE 1

ECONOMIC ACTIVITY AROUND SHARP DEPRECIATIONS IN EAST ASIA, 1975–1996
(LOG DEVIATION FROM TREND)

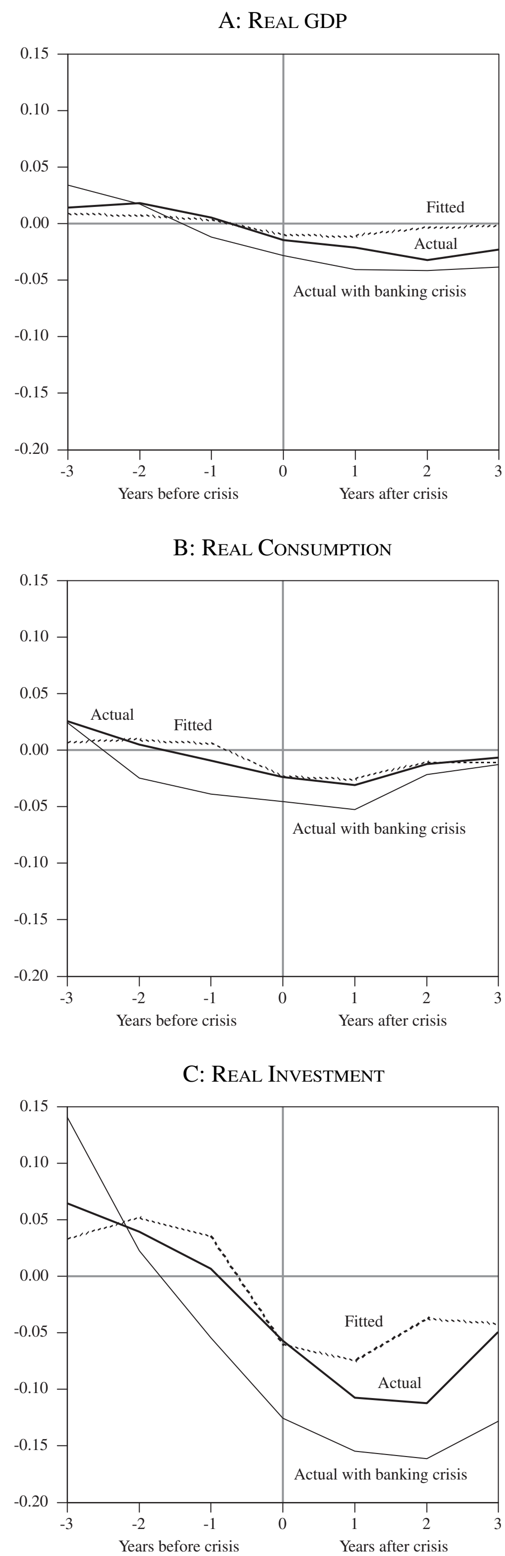
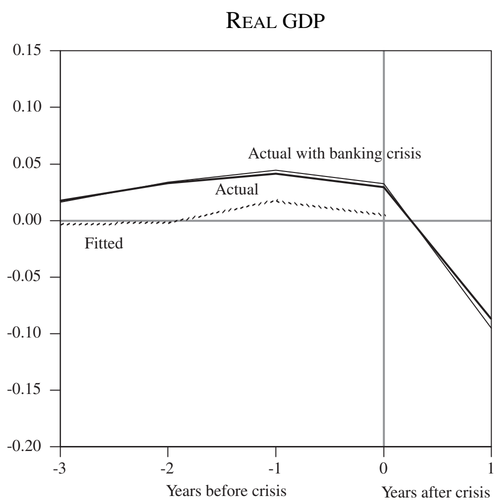


FIGURE 2

Real GDP around Sharp Depreciations in East Asia, 1997–1998 (Log Deviation from Trend)



similarly unprecedented. Real GDP on average falls over 8 percent below trend in the year after the episodes. This compares to a peak decline of around 3 percent in the aftermath of the full set of sharp depreciation episodes up to 1996, and around 4.5 percent in the aftermath of sharp depreciation episodes accompanied by banking crises.

The figure suggests that one reason why the output contraction in the most recent episode is so large is that it is associated with a large number of banking crises in a short period of time. The 1997 currency collapses were associated with banking crises in five out of six countries affected (83 percent). Prior to that, sharp depreciation episodes and banking crises coincided less frequently, an average of 40 percent of the total of sharp depreciation episodes.

Another reason is that the costs of the most recent banking crises also appear to be much larger than in the past. For example, during the 1980s, according to Caprio and Klingenbiel (1996), only two systemic banking crises were identified. One crisis was in the Philippines in 1981–1987, with central bank assistance peaking at about 3 percent of GDP. The other crisis was in Thailand in 1983–1987, at a cumulative cost of about 3.5 percent of GDP over the 5-year period. In contrast, in January 1999, government-issued bonds to finance the restructuring of the financial sector were expected to amount to 38 percent of GDP in Thailand, 25 percent of GDP in Indonesia, and 18 percent of GDP in South Korea (Lane, et al. 1999, Appendix 7.3). As the restructuring of the financial sectors in these economies is not complete, these costs may well be higher.

The figures create a distinct impression that combined episodes of sharp depreciation and banking crisis episodes have a more severe impact on output contractions than is the case for the average of sharp depreciation episodes. However, it remains to be seen whether the effects of these combined episodes on output fluctuations are statistically significant.

Statistical Analysis

To analyze the impact of sharp depreciation episodes and banking crises on output fluctuations more systematically, we create the variable *DEPREC*, which consists of intercept dummies for years in which a sharp currency depreciation episode occurred and the year after. We also create the variable *BKCRISIS*, which is taken from a data set of a much larger number of countries used by Glick and Hutchison (1999). The data set contains ones in the years in which a banking crisis is reported and zeros elsewhere. Thus, this variable refers to the entire span of banking crisis episodes rather than the period in which such crises coincide with periods of sharp depreciation, as in the figures.

Table 2 reports the results of regressing output and its components first on *DEPREC* and *BKCRISIS* alone, and then on an expanded equation (10) that includes these variables on the right-hand side. For purposes of the present analysis, we treat these episodes as exogenous, determined by factors outside the model. With this caveat in mind, the results in Table 2 suggest the following:

First, taking them in isolation, episodes of sharp depreciation and their aftermath, as well as banking crises, tend to be associated with below-trend real GDP, consumption, and investment.

Second, when both sharp depreciation and banking crises are on the right-hand side of the equation, sharp depreciation episodes continue to be associated with below-trend output, consumption, and investment. Banking crises are associated with below-trend consumption, and, more weakly, investment and overall output (columns 3, 6, and 9, respectively).

To see whether the sharp depreciation episodes and banking crises provide additional information to that provided by equation (10), we expand that equation to include *DEPREC* and *BKCRISIS* on the right-hand side of the equation (these two variables are treated as exogenous in the first-stage regression). The results, reported in Table 3, suggest that once we take into account the behavior of the explanatory variables in equation (10), banking crises have no additional effect on real GDP, while episodes of sharp depreciation

TABLE 2

EFFECTS OF SHARP DEPRECIATION EPISODES AND BANKING CRISES ON ECONOMIC ACTIVITY (OLS)

	GDP			CONSUMPTION			INVESTMENT		
	1	2	3	4	5	6	7	8	9
Constant	0.01*** (0.00)	8.0×10^{-3}*** (0.00)	0.01*** (0.00)	8.7×10^{-3}** (0.03)	7.2×10^{-3}* (0.06)	0.01*** (0.01)	0.03*** (0.01)	0.02** (0.04)	0.04*** (0.00)
DEPREC	–0.03*** (0.00)		–0.02*** (0.00)	–0.03*** (0.00)		–0.02** (0.02)	–0.11*** (0.00)		–0.09*** (0.00)
BKCRISIS		–0.03** (0.01)	–0.02* (0.07)		–0.05*** (0.00)	–0.04*** (0.00)		–0.12** (0.02)	–0.08* (0.08)

* Significant at 10 percent.
** Significant at 5 percent.
*** Significant at 1 percent.

TABLE 3

SHARP DEPRECIATION EPISODES AND BANKING CRISES IN AN EXPANDED MODEL OF ECONOMIC ACTIVITY (INSTRUMENTAL VARIABLES)

	GDP			CONSUMPTION			INVESTMENT		
	1	2	3	4	5	6	7	8	9
Constant	5.6×10^{-3} (0.14)	5.2×10^{-3} (0.12)	7.1×10^{-3}* (0.08)	-1.5×10^{-4} (0.97)	1.5×10^{-3} (0.72)	1.9×10^{-3} (0.69)	2.8×10^{-3} (0.82)	4.0×10^{-3} (0.72)	7.3×10^{-3} (0.60)
Real Exchange Rate	–0.08 (0.26)	–0.06 (0.49)	–0.07 (0.34)	–0.17* (0.09)	–0.15 (0.14)	–0.16 (0.11)	–0.63** (0.02)	–0.57** (0.05)	–0.59** (0.02)
Nominal M2	–0.01 (0.92)	0.03 (0.80)	5.7×10^{-3} (0.96)	–0.03 (0.85)	1.3×10^{-3} (0.99)	-3.7×10^{-3} (0.98)	0.14 (0.72)	0.23 (0.58)	0.19 (0.63)
Real Government Expenditure	0.18*** (0.01)	0.18** (0.01)	0.17** (0.02)	0.27*** (0.00)	0.25*** (0.00)	0.25*** (0.00)	0.79*** (0.00)	0.77*** (0.00)	0.75*** (0.00)
Foreign Output	0.18** (0.02)	0.17** (0.04)	0.17** (0.03)	0.39*** (0.00)	0.37*** (0.00)	0.37*** (0.00)	0.84*** (0.01)	0.79*** (0.01)	0.79*** (0.01)
Real Fed Funds Rate	-6.5×10^{-4} (0.70)	-1.9×10^{-4} (0.92)	-6.3×10^{-5} (0.97)	-4.6×10^{-3}** (0.02)	-3.8×10^{-3}* (0.06)	-3.8×10^{-3}* (0.06)	-3.9×10^{-3} (0.46)	-2.3×10^{-3} (0.68)	-2.1×10^{-3} (0.71)
DEPREC	–0.01 (0.14)		–0.01 (0.17)	-5.2×10^{-3} (0.63)		-2.3×10^{-3} (0.82)	–0.03 (0.43)		–0.02 (0.51)
BKCRISIS		–0.02 (0.19)	–0.01 (0.28)		–0.02 (0.17)	–0.02 (0.16)		–0.05 (0.28)	–0.04 (0.30)

* Significant at 10 percent.
** Significant at 5 percent.
*** Significant at 1 percent.

tend to have a negative effect, at a marginal significance level of 10 percent. Neither *DEPREC* nor *BKCRISIS* have additional effects on consumption or investment.[15]

We may now suggest answers to the questions posed at the beginning of this section.

First, a visual inspection of output fluctuations around episodes of sharp depreciation over the 1975–1996 period suggest that such episodes are followed by negative deviations of output from trend. However, there is little if any additional explanatory power obtained from adding a sharp depreciation dummy variable to equation (1).

Second, there appears to be an even steeper drop in output below trend when sharp depreciation episodes coincide with banking crises. However, a banking crisis dummy variable has no significant effects on output fluctuations over the 1975–1996 period that are not already captured in our benchmark model.

Third, the 1997 sharp depreciation episodes were associated with output contractions that are orders of magnitude larger than those experienced in East Asia in the past. This appears to reflect a large concentration of banking crises whose magnitude is also larger than in past episodes of sharp depreciation.

IV. Conclusions

In this paper, we have discussed alternative ways in which a reduced-form relationship between the real exchange rate and output may be derived and interpreted, and conditions under which contractionary depreciation may occur. We have focused on how spending on imported inputs or imported investment goods may affect aggregate supply and aggregate demand, and also discussed the potential importance of capital flows and financial crises in explaining episodes of particularly severe output contraction. We also have noted that further research is needed to motivate contractionary depreciation effects using dynamic equilibrium models.

Our exploration of the relationship between the exchange rate and output in East Asia allows us to address the two questions posed in the introduction.

First, there is evidence of a negative relationship between economic activity and the real exchange rate in East Asia; that is, depreciations were contractionary in the region even before the most recent crisis. This relationship is more evident in the period before 1990, as greater capital market integration appears to have attenuated contractionary depreciation effects.

Second, informal examination (using figures) of output fluctuations around episodes of sharp depreciation over the 1975–1996 period convey the impression that such episodes are associated with modest expansion and contraction cycles, with output above trend before a sharp depreciation episode and below trend after it. The cyclical pattern is accentuated when the sharp depreciation episode occurs during a banking crisis. The very steep output declines that followed the 1997 sharp depreciation episodes appear to reflect a high concentration of banking crises of unprecedented severity. Statistical analysis suggests that prior to 1997, sharp depreciation episodes and banking crises, when taken in isolation, were associated with below-trend economic activity. However, these variables do not add to the explanatory power of our benchmark model in our 1975–1996 sample.

15. One question that may be raised about these results is the assumption that *DEPREC* and *BKCRISIS* are exogenous, determined by factors outside the model (they are included in our instrument set in the regressions reported in Table 3). To see whether the results are sensitive to this, we replace these two variables in our instrument set by (1) export growth in U.S. dollars lagged one period, and (2) the deviations of the trade-weighted real exchange rate from trend lagged one period (in addition to the contemporaneous value of the yen-dollar exchange rate). These variables appear to affect the likelihood of currency crises and, through their effects on output, may also affect banking crises. However, this change in specification had no qualitative effect on the results reported in Table 3.

Data Appendix

The countries included in the analysis are Indonesia, Korea, Malaysia, the Philippines, Singapore, and Thailand. The data span is 1975 to 1998. Unless otherwise indicated, the frequency is annual. Data are from the International Financial Statistics (IFS) of the International Monetary Fund, unless otherwise indicated. IFS codes for each data series are indicated in parentheses below.

Consumer prices: IFS 64.

Exchange rates: End-of-period nominal exchange rates (AE) were used in defining currency crisis episodes and in constructing real exchange rates. The trade-weighted real exchange rate was created by taking the trade-weighted sum of logs of the bilateral real exchange rates (defined in terms of CPI indices) against the U.S. dollar, the deutschemark, and the yen. The trade weights are based on the average bilateral trade with the U.S., Europe, and Japan in 1980 and 1990. An increase in this index is a real depreciation of the domestic currency.

Money: M2 (IFS 34 + 35).

National accounts data: Real GDP (99b.p). Forecasts for 1999 and 2000 were obtained from the Asia Pacific Consensus Forecasts (5/10/99) for use in the figures (not the regressions). Private Consumption (96f). Gross Fixed Capital Formation (93e). For Indonesia, we used Gross Capital Formation (93). 1998 GDP data were obtained from JP Morgan, World Financial Markets (7/30/99). Real consumption and investment variables were obtained by scaling by the CPI (62) (including consumption and investment, but not real GDP).

Real federal funds rate: The funds rate was taken from IFS line 60b for the United States, deflated by U.S. CPI inflation.

Trade-weighted industrial production: This series was created by taking the trade-weighted sum of logs of the industrial production indices for the U.S., Germany, and Japan. For the U.S. and Germany, the data are from the IFS (66.c). For Japan the data were taken from DRI's International Economics Database (JQI90@JP). The trade weights were the same as those used in constructing the trade-weighted real exchange rates.

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