

# Shock Persistence and the Choice of Foreign Exchange Regime

## An Empirical Note from Mexico

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Empirical econometric evidence shows that Mexico's simulated output recovery after a negative external shock was faster (a third as long) when the country's policymakers let the nominal foreign exchange rate float than when they fixed it, and much faster than in other developing countries that kept nominal foreign exchange rates constant, especially those that resorted to currency board arrangements to support that constancy.



## Summary findings

The academic and policy debate about optimal foreign exchange rate regimes for emerging economies has focused more on the theoretical costs and benefits of possible regimes than on their actual performance.

Giugale and Korobow report on what can be called *exchange-rate-regime-dependent differential shock persistence*—that is, the time output takes to return to its trend after a negative shock—in a sample of countries representing various points on the spectrum of nominal foreign exchange flexibility.

They find strong evidence that Mexico's simulated output recovery after a negative external shock was faster (a third as long) when the country's policymakers

let the nominal foreign exchange rate float than when they fixed it, and much faster than in other developing countries that kept nominal foreign exchange rates constant, especially those that resorted to currency board arrangements to support that constancy.

These results are insufficient to guide the choice of regime (they lack general equilibrium value and are based on a limited sample of countries), but they highlight an important practical consideration in making that choice: How long it takes for output to adjust after negative shocks is sensitive to the level of rigidity of the foreign exchange regime. This factor may be critical when the social costs of those adjustments are not negligible.

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This paper—a product of the Mexico Country Department, Latin America and the Caribbean Region—is part of a larger effort in the region to understand policy options open to developing countries for handling macroeconomic volatility in a globalized economy. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Michael Geller, room I4-142, telephone 202-458-5155, fax 202-522-2093, email address [mgeller@worldbank.org](mailto:mgeller@worldbank.org). Policy Research Working Papers are also posted on the Web at [www.worldbank.org/research/workingpapers](http://www.worldbank.org/research/workingpapers). The authors may be contacted at [mgiugale@worldbank.org](mailto:mgiugale@worldbank.org) or [akorobow@worldbank.org](mailto:akorobow@worldbank.org). July 2000. (15 pages)

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**Shock Persistence and the Choice of Foreign Exchange Regime:**

**An Empirical Note from Mexico**

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## **Shock Persistence and the Choice of Foreign Exchange Regime: An Empirical Note from Mexico**

### **I. Introduction and Rationale**

Recent global financial crises (East Asia, 1997; Russia, 1998; Brazil, 1999) have refocused the attention of economists and policy makers on the search for an exchange rate regime that could minimize, and optimally isolate a country from the impact of external financial shocks on the domestic economy, especially on domestic output and employment. That search, and its ensuing policy debate, has been particularly relevant for emerging economies that embraced international financial integration (i.e., open capital accounts) in the late 1980s and early 1990s to underpin broader efforts at structural reform.

At one end of the spectrum, proponents of various forms of rigid foreign exchange systems (traditional fixed, currency boards, unilateral dollarization, monetary associations, monetary unions) cite lower inflation and domestic interest rates, reduced cost of external borrowing through lower country risk premia, and confidence-driven increases in long-term foreign direct investment among the key benefits that the elimination of nominal volatility in the exchange rate brings about.<sup>1</sup> If they indeed accrue, these benefits may not be costless. As those in favor of flexible foreign exchange regimes point out, emerging market economies which choose to fix their exchange rate (or to give up their own currency completely) may suffer greater real output volatility, for two main reasons: they effectively forego monetary policy as a tool to smooth short-term real-side fluctuations, and the likelihood of abandoning the fixed foreign exchange regime is not zero (see, for example,

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<sup>1</sup> For a good listing of the generally purported benefits of dollarization, see *Costs and Benefits of Dollarization in Latin America*; Testimony Before the U.S. Senate, Manuel Hinds, January 1999. For a good roundtable-type discussion on the cost and benefits of currency boards, see; *Currency Boards and External Shocks: How Much Pain, How Much Gain?*, edited by Guillermo Perry.

Osakwe and Schembri [1999], Flood and Hodrick [1986], Flood and Marion [1982], Dornbusch [1976]).

However, while real output *volatility* has been addressed by the literature as a factor in the choice of optimal foreign exchange regimes, scant attention has been given to the time necessary for real output to return to its trend after an adverse external financial shock takes place, that is, *persistence*. This appears particularly relevant for emerging markets, where seamless neo-classical adjustments in labor markets are all but absent. In recent empirical research, Caporale, Kalyvitis, and Pittis (1994) find evidence of greater persistence in a number of real variables, including industrial production, in 18 OECD countries after the collapse of the Bretton Woods fixed exchange rate system. Their work, which covers no emerging economies, is based on the modified re-scaled range statistic discussed by Lo (1991), which is employed to test for long term persistence. They reject the null hypothesis of “no long-run memory” for industrial production in both fixed and floating regimes within the three month period following a shock. For a test of nine month persistence, however, they find that they cannot reject the null hypothesis of “no long run memory” for industrial production in the fixed rate period, while it can be rejected in the floating period. Though this is an important contribution to the empirical issue of persistence under alternate exchange regimes, it does not examine any emerging market economies. Additionally, the method of empirical testing can yield neither an overall picture relating to the depth of a shock nor a rough estimate of the length for which the shocks effect approaches zero, i.e., it is only able to conclude that, for example, there is evidence of persistence after 9 months, but not whether that persistence diminishes in the tenth month or when the series returns to its long run path.

This note contributes to the debate over optimal foreign exchange regimes by reporting on empirically observed persistence under alternative foreign exchange arrangements. To control for

country specific characteristics, it initially focuses on a single, globally integrated, emerging economy (Mexico's) that has, during the period of observation, experienced both fixed and flexible foreign exchange regimes, and that has seen adverse external financial shocks under both.

Mexico's flexible regime period is then compared with an array of emerging countries that maintained fixed exchange rates with various levels of rigidity. In all cases, persistence is estimated by using the impulse response functions obtained from estimating a vector autoregressive system for a set of variables traditionally used to describe a macroeconomic system.

## II. Empirical Results

This section is based on a four-variable VAR specification whereby current real output is ultimately determined by past output and the past values of the other three endogenous variables. That specification is shown in Equation (1) and consists of *Industrial Production (Y)*, our measure of real output, a domestic *Interest Rate (r)*, *Money (m)*, and *Inflation (Π)*, where the subscript  $i$  reflects the time period for the lagged variable and its respective coefficient estimate, and  $l$  represents the number of lags.<sup>2</sup>

$$Y_t = \beta_0 + \sum_{i=t-1}^{t-l} \beta_{r,i} r_i + \sum_{i=t-1}^{t-l} \beta_{m,i} m_i + \sum_{i=t-1}^{t-l} \beta_{\pi,i} \pi_i + \sum_{i=t-1}^{t-l} \beta_{Y,i} Y_i + \mu_t \quad (1)$$

Table 1 shows the countries and their associated forms of foreign exchange regimes for which Equation 1 is estimated. Additionally, the number of lags for each country's VAR, and the order of exogeneity used in the impulse response functions are also shown in Table 1, as well as

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<sup>2</sup> *Money* refers to *Broad Money*, as defined in the IMF's International Financial Statistics, except for Estonia where M2 is employed. Additionally, we use an indexed measure of real total industrial sales for Estonia.

the length of the data, i.e., the time periods and corresponding number of observations used for each country.

**Table 1**

Country and Type of Regime		VAR-Model /Ordering: <i>Rate Money CPI IndProd</i>	
<i>Country</i>	<i>Exchange Rate Regime</i>	<i>Lags</i>	<i>Series Length*</i>
Mexico Pre "Tequila"	Crawling Peg	2	04 1987—11 1994 (92)
Mexico Post "Tequila"	Float	2	01 1995—02-2000 (62)
Brazil Pre-Devaluation	Fixed	2	09 1994—12 1998 (52)
Thailand (Pre-Devaluation)	Fixed	2	01 1990—06 1997 (88)
Latvia	Fixed	2	09 1993—02 2000 (77)
Estonia	Currency Board	2	01 1994—02 2000 (74)
Hong Kong	Currency Board	1	03 1982—04 1998 (66)**
Argentina	Currency Board	2	06 1994—03 2000 (69)

*\*number of observations in parentheses, \*\*quarterly data*

Since there may likely exist a long run equilibrium relationship among the four variables, cointegration tests among the data series were carried out using the likelihood ratio test developed by Johansen (1988) rather than immediately detrending the data, working with the series in differences, and thus, likely mis-specifying the model. If the null hypothesis that, there does not exist a cointegrating vector for the system is rejected, then an unrestricted VAR for each country in the sample is estimated in levels (which implicitly fits the cointegrating relation among the variables, thereby accounting for the long-run equilibrium relationship among variables in the system).<sup>3</sup> Naka and Tufte (1997) note several advantages for estimating VAR's in levels when a cointegrating

<sup>3</sup> The justification for estimating an unrestricted VAR in levels when the variables are cointegrated is attributed to the research results established by Engle and Granger (1987).



relation exists rather than employing an error correction model.<sup>4</sup> Consequently, the impulse response functions generated in this paper are the result of dynamic multipliers estimated from unrestricted VAR models in levels when the null hypothesis of cointegration is not rejected. Furthermore, the specification of the VAR for each country with respect to the number of lags is based upon the minimization of the Schwarz criterion.<sup>5</sup> This criterion, compared to an alternate criterion such as Akaike's for example, imposes a harsher penalty on added regressors which do not augment the explanatory power of the model, thus encouraging a more parsimonious selection of lags in the model.

The impulse response function ordering was based on standard neoclassical macroeconomic theory which reveals the variables that are endogenously determined in a system. More specifically, we choose output as the *most* endogenous variable —determined by the *more* exogenous domestic rate of interest which is a function of external shocks (in the open capital account economies covered by the country sample) and the global rate of interest.<sup>6</sup> We use nominal interest rates in our empirical model and separately account for inflation by incorporating a variable which reflects changes in the price level. Thus, the VAR system implicitly incorporates the variables necessary to capture the real interest rate output-determining investment decisions made by rational agents.

Figure 1 displays the reaction of output to a one standard deviation shock in interest rates as well as the corresponding standard error bounds for the group of countries used in the analysis.

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<sup>4</sup> Naka and Tufte (1997) point out that there is little evidence that imposing a cointegrating vector via a vector error correction model leads to better performance at all horizons. Additionally, they note that other researchers such as Engle and Yoo (1987), Clements and Hendry (1995), and Hoffman and Rasche (1996) show that when the cointegrating restriction is true, unrestricted VAR's may be more efficient than a restricted error correction model at short horizons.

<sup>5</sup> See Greene (1993) for a complete discussion and comparison of the 2 criteria.

<sup>6</sup> The variable-ordering sensitive nature of the impulse response functions has been highlighted in the literature, especially the somewhat arbitrary nature of the Choleski decomposition involved in constructing the impulse responses. In this paper, theory guides the ordering of the variables in the response function so that the behavioral relationships variables, such as interest rates and output for example, are properly gleaned from the empirical

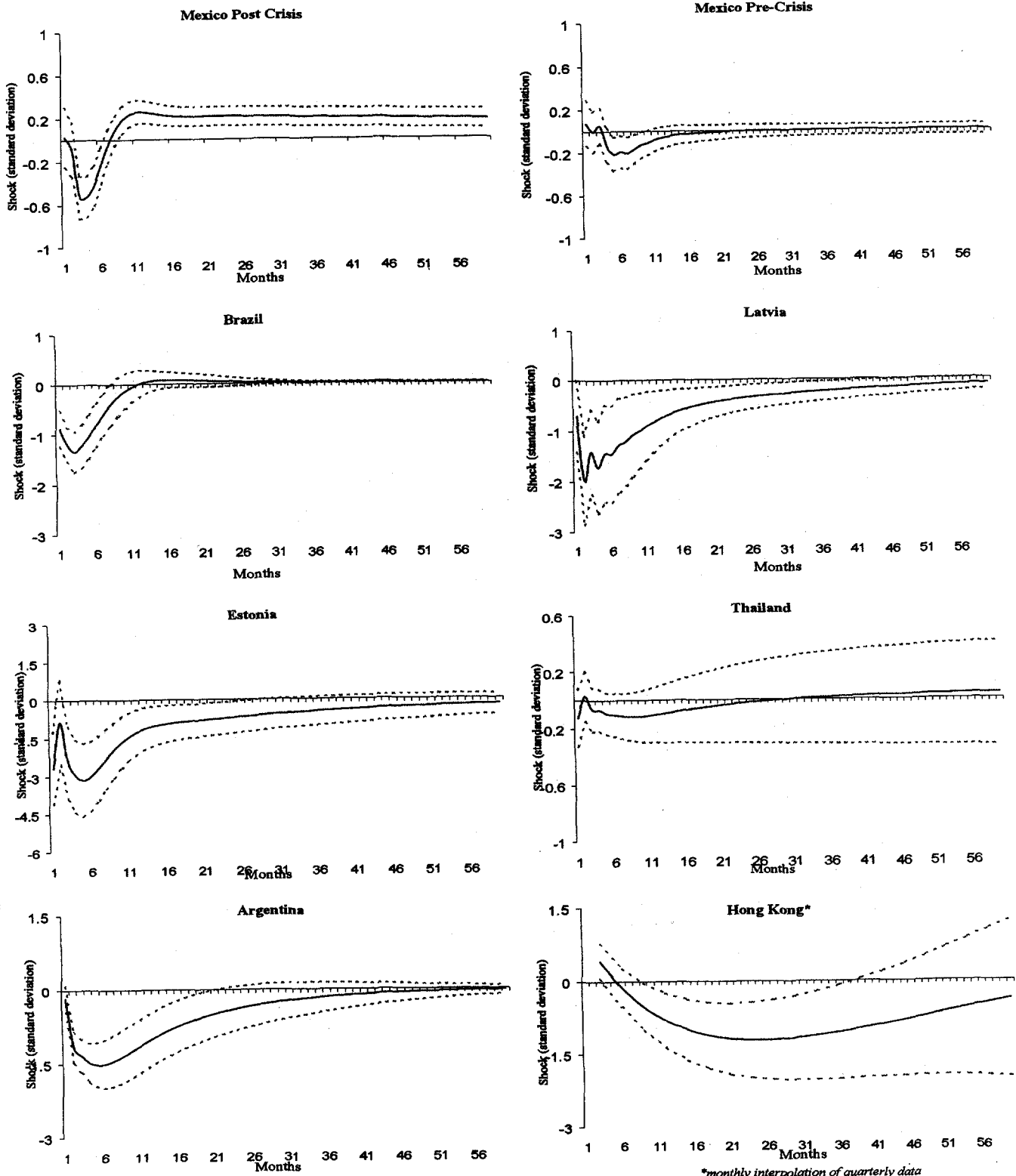
Before interpreting the result, however, it is worth noting, as Rosensweig and Tallman (1993) point out, that there is no general consensus or specific testing criteria for evaluating significance in VAR analysis. Here, a method similar to that of Sims (1987) is followed, i.e., the significance in VAR analysis is determined by whether or not the response to innovations are bounded away from zero. Thus, error bands (plus and minus one standard deviation) are computed and displayed around the response function in order to yield some rough indication of the statistical significance of the output generated values over the forecast horizon. Returning attention to Figure 1, we see that the countries with the more rigid exchange rate regime seem to exhibit longer periods of adjustment to simulated shocks, i.e., the simulated shocks show more marked persistence in those countries.

Figure 2 examines the differential length of output adjustment to an economic shock in Mexico before and after that switch in exchange rate regime (the switch did not affect the degree of capital account openness). As a reference point, we use the so-called Tequila Crisis of December 1994 in which Mexico allowed its nominal exchange rate to float six years after introducing the *Pacto* of 1988, which called for a freezing of the nominal exchange rate to the dollar. The shock is represented by a one standard deviation change in the domestic nominal interest rate. The simulated interest rate shock has an immediate negative impact upon output, as expected. More importantly, the time of adjustment of output is notably longer for Mexico under the Pre-Tequila managed exchange rate regime than for the Post-Tequila exchange rate float.

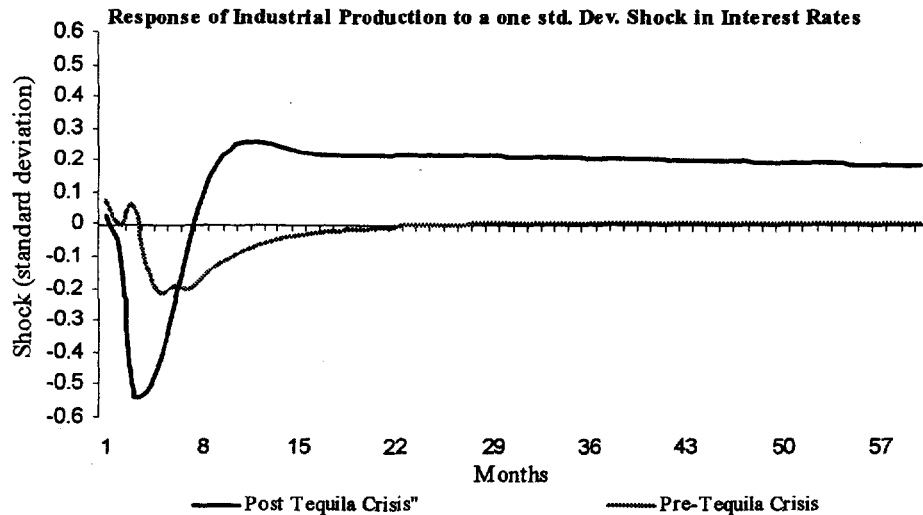
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estimation.

**Figure 1**  
**One Standard Deviation Shock to Industrial Production for Selected Countries**  
*Time Period in Months, (+/- One standard deviation bound included)*



**Figure 2**  
**Mexico:**

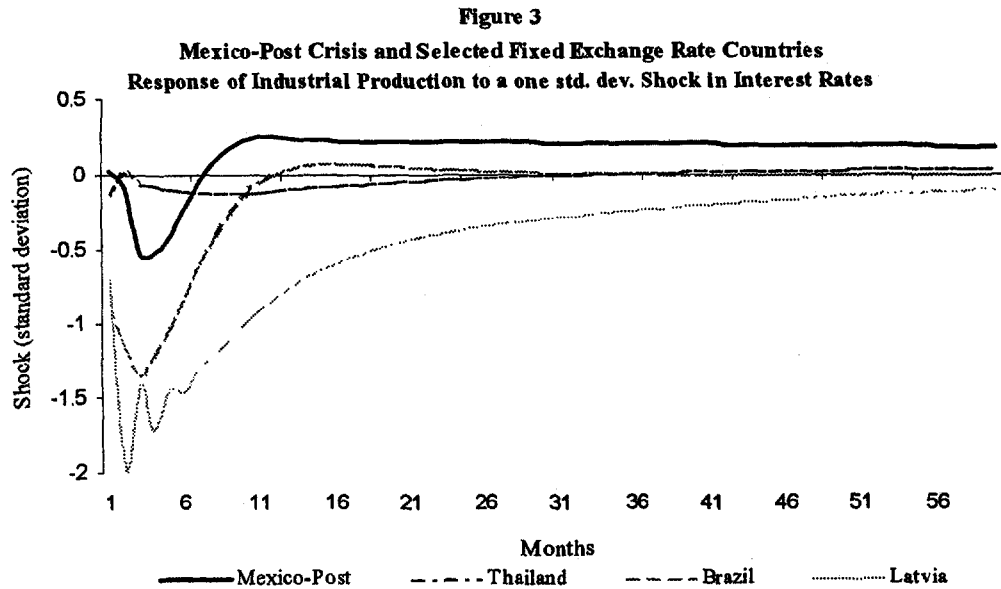


That is, the one standard deviation increase in the domestic interest rate leads to longer persistence in output under the fixed regime than the floating regime. The negative impact of the shock under the floating regime for Mexico lasts for about 6-9 months, while Pre-Tequila Mexico exhibits a response that is roughly between 14-18 months, or about two times longer.

A similar exercise is then performed with data from countries which, over the period of observation, employed either a currency board or a fixed exchange rate regime.<sup>7</sup> Figure 3 shows Post Crisis Mexico's response to a simulated shock in interest rates compared to three other countries which have fixed exchange rate regimes. The responses for Brazil and Thailand are estimated excluding post-devaluation data. That is, the responses for these two countries are estimated using data which were generated under their respective fixed exchange rate regime periods (up to January 1999 and June 1997, respectively). From the response function, it is clear

<sup>7</sup> The countries are chosen based upon readily available data and are not proposed as a complete sample of exchange regimes.

that while Mexico recovers from the shock after about 6-9 periods, the responses of the other, fixed exchange rate countries is noticeably longer. Though the magnitude of the simulated shock to Thailand's interest rate does not appear as large as that of the other countries, there is still a noticeably longer period of adjustment until the effect of the shock no longer persists. Care should be exercised in interpreting the response function for Thailand since its upper standard error bound includes zero over most of the forecast horizon.



Brazil and Latvia on the other hand show a longer period of adjustment than Mexico to their respective shocks in interest rates. Brazil's shock seems to persist for about one year, while for Latvia the shock persists for about at least 2 years.<sup>8</sup> Again, as in the case for Thailand, the upper error band for Latvia encompasses zero over most of the forecast horizon.

Next, Post-Tequila Mexico's response to shocks is compared with three currency board countries. Figure 4 illustrates the output responses of Hong-Kong, Argentina, and Estonia to

<sup>8</sup> We focus here on the relative behavior of the impulse response functions with respect to one another over the forecast horizon. In other words, from our simulations we are not concerned with trying to predict precisely how

simulated shocks in interest rates. The magnitude of the shock for the currency board countries is apparently deeper.

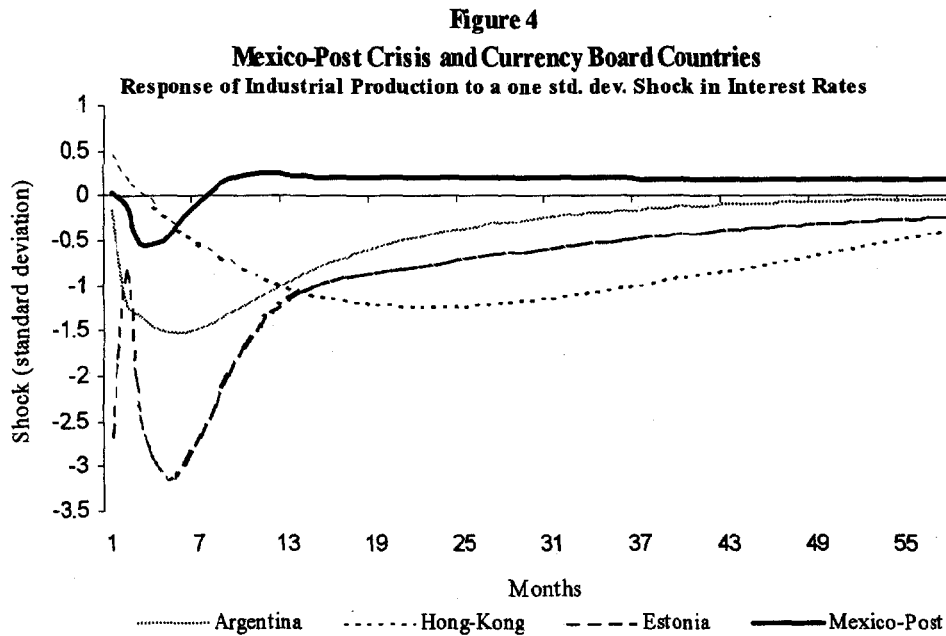
Though Estonian output exhibits a first period positive response to a one standard deviation shock in its domestic interest rate, it is immediately followed by the expected negative output response. This may be partially explained by a lagged reaction of output to a current change in the domestic interest rate. From Figure 4, we see that the Estonian adjustment process is more prolonged than that of the Mexican output response following the shock to interest rates. The most striking result in this chart is, however, the response functions of Hong-Kong and Argentina which show much more marked shock persistence relative to Mexico.<sup>9</sup> Moreover, the standard error bounds for Argentina and Hong Kong, do not approach zero for at least 24 months and 36 months respectively out in the forecast horizon, thus yielding a reasonable indication that the flatter slopes of the response functions are reflective of a relatively prolonged output adjustment to a shock in interest rates. Table 3 *roughly* summarizes those empirical results by listing the countries in the sample and displaying the *approximate* response time of output to a shock in interest rates, all else constant.<sup>10</sup>

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many periods it takes for a shock to completely dissipate, but rather, how the response functions compare with one another across countries.

<sup>9</sup> The quarterly data for Hong-Kong is interpolated monthly in order to plot the response function on the same axes as the other countries. That is, one quarter for Hong-Kong is correspondingly plotted once every three months, and the interim monthly span is interpolated.

<sup>10</sup> For standard error bands for the impulse response functions, see Figure 1.



**Table 3**  
**Approximate Recovery Time for Output from a Shock to Interest Rates\***

<i>Country</i>	<i>Response time in Months</i>
Mexico (Pre Devaluation)	12-18
Mexico (Post Devaluation)	6-12
Brazil (Pre-Devaluation)	12-18
Thailand (Pre-Devaluation)	18-24
Latvia	>24
Estonia	>18
Hong Kong	>48
Argentina	>48

\*Measured by the time period at which the standard error bound crosses the horizontal axis

### **Section III: Conclusions and Policy Considerations**

The academic and policy debate over optimal foreign exchange rate regimes for emerging economies has focused extensively on the theoretical costs and benefits of various possible regimes, and to a lesser extent on their actual performance. This paper contributes to that debate by reporting on what can be called *exchange rate regime dependent differential shock persistence*, that is, the time that output takes to return to its trend after a negative shock takes place, in a sample of countries that encompass a spectrum of nominal foreign exchange flexibility. It finds strong evidence that Mexico's output recovery was a) faster (a third as long) when the country's policy-makers let the nominal exchange rate float than when they fixed it; and b) much faster than in other developing countries that kept nominal exchange rates constant, especially those which resorted to currency board arrangements to support that constancy.

While much research has focused on volatility in output, this note draws attention to the need for possible future theoretical research to focus on models which link the persistence of real variables and the choice of a foreign exchange regime in a dynamic context. Future empirical work could also expand on this note in a number of areas, namely by expanding the scope of countries and number of real variables covered here or modeling the persistence of shocks using a panel data approach, which would include countries representing alternate foreign exchange regimes.

Though the results of this note are of course insufficient to guide an optimal choice of regime (they lack general equilibrium value, and are based on a limited sample of countries), they may highlight an important practical consideration in making that choice—the length of output adjustment periods after negative shocks take place is in practice sensitive to the level of rigidity in the foreign exchange regime. This may prove a particularly critical element when the social costs of those adjustments are not negligible.



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