

International Monetary Transmission, a Factor-Augmented Vector Autoregressive (FAVAR) Approach: The Cases of Mexico and Brazil

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Abstract

This paper studies whether and how U.S. monetary shocks are transmitted to emerging economies utilizing as samples Mexico and Brazil. A Factor-Augmented Vector Autoregressive (FAVAR) methodology is employed to take advantage of the wide array of variables that can be included in this model to provide a more accurate picture of the transmission process. The results suggest that differences exist in the transmission of foreign monetary shocks. This implies that no generalizations can be made even for countries of equal economic size and in the same geographic region. When international transmission does exist, as it is in the case of Mexico, it induces large responses in several macroeconomic variables. Interest rate is the main channel of transmission, with some impact on the trade channel. Although little transmission exists in the case of Brazil, it appears that this country slightly benefits from U.S. contractional monetary shocks. In the Brazilian case, the channel of transmission appears to be interest rates.

Keywords: Monetary policy shocks; international transmission; FAVAR models; Latin American economies; international economics.

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1. Introduction

The extent to which one country's actions affect other economies is a topic of current interest, especially with the increasing globalization process that makes countries more vulnerable to external shocks. A particular interesting type of external shocks is foreign monetary shocks. What makes monetary transmission a complex and interesting topic is the fact that there are not one but many channels through which monetary policy operates. The existence of such transmission, if that impact can be generalized to different economies (both developed and developing), and if monetary authorities are reacting to other countries' policy changes are still open questions in the existing literature.

This paper examines the impact of U.S. monetary policy shocks on Mexico and Brazil. These countries are selected for several reasons. First, they are economies of similar size and in the same geographical region. This facilitates the comparison of their reaction to foreign shocks. Second, they have different trading ties with the United States. Third, these countries provide a spectrum of monetary arrangements that includes periods of fixed, flexible and managed exchange rates, and a late adoption of inflation targeting so it allows to measure the transmission process. Lastly, they provide a reasonable data set on a wide range of variables, which is an important consideration for this type of time series analysis.

This paper aims to study what Canova [1] defines as 'normal times'. That is, the goal is to investigate monetary transmission in general. This paper does not address questions with respect to sources of hyperinflation or currency crises that have affected not only the countries under study but also many other Latin American economies in the last 25 years. Studying monetary transmission and other propagation of shocks in 'normal times' is important because it contributes to the understanding of how countries are regularly impacted aside from particular crisis episodes. This, in turn, may help in understanding how external shocks can become sources of explosive behavior if the reaction in 'normal times' appears unstable. Moreover, understanding how the transmission mechanisms of monetary policy work at an international level "is important not only in their own right, but also because they have important lessons for monetary policy" [2, 1996, p.1]. One of the most important lessons is that if a transmission process exists, "Monetary policy can be highly effective in reviving a weak economy even if short-term interest rates are already near zero" [2, 1996, p. 22].

This paper asks whether foreign monetary shocks have a systemic impact on emerging economies by comparing the cases of Mexico and Brazil. It is also interested in analyzing whether transmission occurs through the same channels in each country and whether it is similar to the transmission documented in developed countries. Few studies analyze international transmission to emerging economies; of those few studies, most use a vector autoregressive (VAR) methodology, which has been criticized

because it centers on a small amount of information to preserve degrees of freedom. This leads to standard VARs that rarely employ more than six to eight variables. Studying the transmission of shocks with such a small number of variables poses the risk of overlooking the real extent of the impact of shocks to an economy. To account for the limitations of a VAR, this paper uses a new methodology developed by Bernanke et al. [3]; a Factor-Augmented Vector Autoregressive (FAVAR). This new methodology takes advantage of large sets of information to properly identify the monetary transmission mechanism, providing a comprehensive view of the effect of monetary shocks. This methodology has just started to be used in studies of international transmission¹.

The contribution of this paper to the literature is twofold. First, it analyzes the impact of international monetary shocks on emerging economies contrasting the responses of two economies of similar size and in the same geographical region. Second, a new methodology is employed, a FAVAR model that includes a wide array of variables that can provide a more accurate picture of the transmission process of foreign monetary shocks.

Several interesting facts emerge from the analysis. First, different responses exist in the transmission process of foreign monetary shocks. This implies that no generalizations can be made even for countries of equal economic size and in the same geographic region (Latin America). Second, in the case of Mexico, where international transmission to US monetary shocks does exist, it induces large responses in several macroeconomic variables and a decline in output. Interest rates seem to be the main channel of transmission, with some effects of the trade channel. In the case of Brazil, where the channel of transmission appears to be only interest rates, the effects on output show that it slightly benefits from a contractional shock. Lastly, exploring of the reaction to a U.S. output shock confirms that different responses to foreign shocks exist among emerging economies.

The paper is organized as follows: Section 2 presents a brief description of literature related to the topic analyzed. Section 3 explains the methodology and data utilized, while Section 4 presents estimation results. Finally, Section 5 presents the conclusions of this study.

2. Related Literature

The term “monetary transmission mechanism” involves different definitions. Some explanations focus mostly on the credit channel aspects [6], others emphasize the importance of price stickiness and multiple assets [7], while other authors analyze the impact of the exchange rate policy [8].

Mishkin [2] provides a brief overview of a transmission mechanism that includes interest rates, prices, and credit channels. Some authors concentrate on nominal aspects of monetary shocks, while others analyze effects on real variables.² Most of the existing literature on monetary transmission has focused on transmission effects at domestic levels. That is, the impact of domestic monetary policy on the domestic economy. Explanations about the transmission mechanism differ in this literature with the empirical evidence providing a wide range of results.³

In order to explore the international monetary transmission, it is necessary to analyze open economies. The support for the existence of a transmission mechanism at an international level comes from the international economic literature. For the most part, the basic framework used in this type of studies is the Mundell–Flemming–Dornbusch (MFD) model.⁴ Under perfect capital mobility and a floating exchange-rate system, the basic MFD model predicts that an expansionary monetary policy will lead to expansion of domestic output and a fall in the output in the foreign country. This is the case referred as a “beggar-thy-neighbor” policy because it results in an expansion of domestic output at the expense of foreign output. Under a fixed exchange-rate regime, on the other hand, domestic monetary expansion results in a monetary expansion in the foreign country as well. With imperfect capital mobility and flexible exchange rates, home country expansions of monetary policy will stimulate its output and price level, but “because the exchange rates move to ensure the current account is always balanced, there will be no output implications for the foreign country (although the foreign consumer price level will fall due to the exchange rate change)” [13, pp.102].

In the monetary economic literature, studies on international transmission for small open economies are useful to analyze the impacts of policy actions in cases where, as in the case of the countries under study, one country's actions have little or no

¹ See Senbet [4], Mumtaz and Surico [5].

² See, for example, Sims [9], Christiano et al. [10], and Bernanke and Blinder [11].

³ See, for example, Christiano et al. [10] and Kim [12].

⁴ See Hallwood and MacDonald [13] for detailed explanation of this model.

impact on other economies. Works in the area include Walsh [14], Obstfeld and Rogoff [8] and those following their developments such as the open-economy models with optimizing agents and nominal rigidities. For small open economies, full transmission of foreign monetary shocks are expected for fixed exchange rate regimes; no transmission for pure flexible exchange regimes as the exchange rate fluctuates to accommodate the shocks; and, "semi" transmission are expected for mixed or managed exchange rate regimes.

At empirical level, few studies analyze monetary transmission at an international level. Kim [15] found that U.S. expansionary monetary shocks lead to booms in the non-U.S. G-6 countries. For the European case, the reaction to U.S. shocks seems to be similar to the response reported for domestic U.S. variables [16]. Differences in the transmission mechanism can generate asymmetric behavior among countries experiencing identical shocks, which creates differences in the size of the responses of some variables as in the case of New Zealand and Australia [17]. Eickmeier [18] investigates the transmission of US macroeconomic shocks to Germany and finds that the main reactions are in the trade and monetary areas, although financial markets have become more relevant. Sousa and Zaghini [19] found that in the Euro area a positive monetary shock leads to a permanent increase in the price level, a temporary rise in real output, and a temporary appreciation of the real effective exchange rate of the euro.

Exploration of monetary transmission in emerging economies is an understudied area. Ibrahim [20] found that shocks in U.S. real activity and monetary policy are transmitted to Malaysian real activity; while Desroches [21] argues that world output and real interest rate shocks are transmitted to emerging economies. The latter study uses aggregated measures and not country specific data, which prevent the distinction of differences in the responses. For the case of Latin American economies, Canova [1] suggests that a U.S. monetary policy shock affects quickly and strongly interest rates in Latin America. Using structural VARs, Canova [1] also asserts that external shocks are an important source of macroeconomic fluctuations in Latin America and that U.S. monetary policy shocks are particularly important relative to two other U.S. shocks. Similarly, Mackowiak [22], also using structural VARs, concludes that U.S. monetary shocks quickly and strongly affect interest rates and exchange rates, while the price level and real output in a typical emerging market have a greater reaction than the same variables in the U.S. itself. Meanwhile, Miniane and Rogers [23] found no evidence that countries with less open capital accounts react less to foreign monetary shocks, an indication that capital controls do not play a role in the transmission mechanism.

This study expands the research on international transmission with the analysis of the relation between a large economy and a small country. Specifically, the objective of this paper is to analyze how U.S. monetary policy affects emerging countries with the cases of Mexico and Brazil utilizing a FAVAR, which allows for a more detailed analysis.

3. Empirical Framework

3.1 Methodology

The two most commonly used empirical approaches in studies of monetary transmission are vector autoregressive (VAR) models and structural macromodels. The advantages of VAR models over structural models have been well detailed in the econometric literature. Sims (1980) is well known for his criticism of traditional large macro structural models because of their implausible identification restrictions. Identification in this method can be achieved by Choleski decomposition of the reduced-form residuals. Some authors, such as Christiano et al. [10] and Kim [15] in their studies of monetary transmission, make use of the Choleski decomposition, which assumes that the contemporaneous system is recursive and hence allows identification.

Although the VAR approach has been extensively employed in monetary policy analysis, recent criticisms have been directed at the sparse information content of VAR models. Since a typical VAR model for monetary policy does not usually include more than eight variables because of the degrees of freedom restriction, the main criticism is that it could not accurately reflect the information central banks have when interpreting the state of the economy prior to making policy decisions. Similarly, in analyzing the process of monetary transmission, a VAR model may exclude variables that may be relevant in that transmission process.

To overcome the shortcomings of VAR models, a new methodology has been proposed by Bernanke et al. [3], a FAVAR model. This methodology consists of two basic equations in a two-step procedure similar to that of Stock and Watson [24].⁵

⁵ In what follows, a basic explanation about this methodology is provided following Bernanke et al. [3]. For a detailed description, the reader should refer to the original article.

Let Y_t be a $m \times 1$ vector that contains the policy instrument and other variables relevant for policy purposes. It is possible that additional economic information may exist and that such information may not be fully captured by Y_t . This additional information can be summarized in a $w \times 1$ vector of unobserved factors F_t . These unobservable factors represent economic or financial indicators that cannot be fully captured by a few variables in a model, which is the limitation of a VAR⁶. The dynamics of the model are given by:

$$(1) \quad \Phi(L) \begin{bmatrix} F_t \\ Y_t \end{bmatrix} = u_t$$

where $\Phi(L)$ is a lag polynomial of finite order p , which can contain structural a priori restrictions. The error vector u_t is assumed to have mean zero with covariance matrix V . A Choleski decomposition of the reduced form covariance matrix V can be used to orthogonalize the reduced form innovations and to identify the structural model.

Equation (1) cannot be directly estimated because the factors are unobserved. However, it is assumed that F_t represents information that potentially affects many economic variables. In such case, those factors could be inferred from observations from a variety of economic variables contained in a $n \times 1$ vector X_t , an "informational" vector of variables assumed to be known to central banks in their monetary policy decision making process, which is to say X_t contains additional information monitored by central banks. Thus, the following relationship can be inferred:

$$(2) \quad X_t = K^F F_t + K^Y Y_t + \varepsilon_t$$

where K^F , K^Y are the $n \times w$, $n \times m$ matrix of factor loadings respectively, and the $n \times 1$ vector of error terms ε_t is mean zero and assumed to be either weakly correlated or uncorrelated. The policy instrument Y_t is assumed to be controlled by the policy maker.

Given that the purpose of this paper is to analyze the impact of a foreign monetary shock on a small open economy, which has no influence in the large economy where the shock is produced, Y_t comprises a single variable, the U.S. federal funds rate.⁷ Bernanke and Blinder [11] have shown that this variable is the most appropriate variable to reflect U.S. monetary policy actions. Thus, including only this variable for U.S. monetary policy makes sense for the purpose of this paper, which is to analyze how U.S. monetary policy shocks affect emerging economies. We are not interested in looking at how the United States designs monetary policy and the macroeconomic conditions that affect such decision, but rather in investigating how the designed monetary policy affects other economies. Although a point could be raised on the possibility economic conditions existent in other countries may affect the design of U.S. monetary policy, such concern may apply if the case under study were that of developed economies. It would be difficult to argue that the Federal Reserve considers the macroeconomic aspects of emerging economics for its policy decisions. In fact, Canova [1] shows that no statistically significant feedback exist from Latin American main macro variables to the United States.

The problem in our specification is how to recover the unknown factors.⁸ Following Bernanke et al. [3], a two-step principal component approach is used⁹. The first step is to uncover the common space spanned by the factors of X_t , represented by $C(F_t, Y_t)$. Given that Y_t is not assumed to be observable in this first step, the first k principal components are assumed to uncover the space spanned by the estimated factors $\hat{C}(F_t, Y_t)$ of the dataset X_t . To correct for the dependence of $\hat{C}(F_t, Y_t)$ on the policy instrument, the initial data set is divided in slow- and fast-moving variables. Slow-moving variables, such as employment, industrial production, housing, are assumed not to contemporaneously respond to monetary policy shocks. On the other side, fast-moving variables contemporaneously respond to monetary shocks¹⁰.

The second step is to estimate (1) by a standard VAR model with F_t replaced by \hat{F}_t under the following specification:

⁶ Bernanke et al. [3] cites for instance "price pressures" or "economic activity" as information that cannot be fully capture in just one variable.

⁷ That single variable will become U.S. industrial production in section 4.2 when a shock from that foreign variable is under analysis.

⁸ With respect to the number of factors needed to properly capture the effects of monetary policy, Bernanke et al. [3] explored the sensitivity of results to an alternative number of factors and concluded that, when the number of factors is five, no qualitative changes occur with respect the results of using one factor and that, further increases in the number of factors (after five) did not change the results. Considering that analysis, this paper uses five factors.

⁹ This approach provides a nonparametric way of estimating the factors, and, as shown by Bernanke et al. [3], it is more accurate than a single-step Bayesian approach.

¹⁰ The classification of variables into the two categories is provided in the Appendix.

$$(3) \quad \hat{\Phi}(L) \begin{bmatrix} \hat{F}_t \\ Y_t \end{bmatrix} = v_t$$

where $\hat{\Phi}(L)$ is a polynomial of order p in the lag operator L , and the variance of v_t is a semiparametric, positive definite matrix. The linear equations of Y_t within the system of equations in the identified FAVAR equation (3) show the monetary policy reaction function, and the monetary policy shocks are the innovations in their equations. From this identification, impulse response functions can be obtained, which is the goal in using this methodology since impulse responses allow observe the reaction of variables to a particular shock. The interpretation of impulse responses is the same as those obtained from a traditional VAR model. That is, the impulse response functions (IRF) measure the response of the j th component of X_t to an unanticipated disturbance in the Y_t component.

3.2 Data

The FAVAR approach is based on an information rich dataset. Two datasets are employed, one for Mexico and another for Brazil. In the case of Mexico, 88 variables were included while in the case of Brazil, 86 variables are in the dataset. Variables for each country include macroeconomic indicators commonly used in previous studies such as industrial production, consumer price index, exchange rate, and interest rates, but also other variables that can provide a better understanding of the transmission process such as measures of industrial production per sector, and measures of prices by commodity or type of goods. All variables were standardized. A detailed description of variables appears in the Appendix.

The period of study for Mexico starts at October 1982; while for Brazil it starts in January 1991. The selected period of analysis depends purely on data availability. The data are monthly measures and series are transformed to induce stationariness.¹¹ The data sources are Datastream and the Bank of Mexico for some interest rates. In addition to the economic indicators included in the dataset, dummy variables for financial crises and exchange rate regimes were incorporated. For financial crisis, a dummy for the 1994 Mexican crisis is used, while one for 1999 is employed for Brazil. The exchange rate regime dummies are based on the work by Levy-Yeyati and Sturzenegger [25] who constructed a *de facto* classification of exchange rates based on changes in the nominal exchange rate, the volatility of these changes, and the volatility of international reserves.

In this research, the interest rate is the policy instrument; more specifically, the U.S. federal funds rate.¹² The use of interest rate as the policy instrument more closely reflects the way in which central banks implement their policy. Taylor rule models have been used to describe the policy behavior of central banks, which typically react to domestic inflation and to output gaps. However, in an open economy the variables toward which monetary policy can react are larger.¹³

4. Empirical Results

4.1 Response to U.S. Monetary Shocks

To illustrate the situation of Mexico and Brazil, Table 1 presents some macroeconomic indicators of these economies at two specific points in time. The first row shows the size of each economy, as measured by GDP. Both countries have a similar output, in dollar terms, with Brazil maintaining its position as a slightly larger economy than Mexico. These countries also display a strikingly similar economic rate of growth: about 9% in 1980 and 2% in 2005. In spite of a similar economic performance, GDP per capita is lower in Brazil because of its larger population, which is almost twice the Mexican population.

An area of divergence is the inflation pattern. Brazil had dramatic hyperinflation episodes¹⁴ in the 1980s, while Mexico held a level of inflation of two digits. In both countries, inflation has been reduced in the 1990s. When considering labor force participation, each country has slightly increased that percentage; however, Brazil maintained a larger participation than Mexico of about 12 percentage points.

¹¹ Estimations were also run for variables in levels and since they do not significantly differ from the main results, they are not presented but are available upon request.

¹² Bernanke and Blinder [11] argue that the federal funds rate is the most appropriate variable to reflect U.S. monetary policy actions.

¹³ See McCallum and Nelson [26], and Svensson [27].

¹⁴ Since data for Brazil starts in 1991, the hyperinflation crisis period is largely outside the period of analysis of this paper.

When considering international trade, Mexico is a much more open economy than Brazil. Indeed, Mexico is twice as open as Brazil based on the commonly used openness measure of $[(\text{exports plus imports})/\text{GDP}]$. The participation of manufactured goods among merchandise exports, a measure of the level of development of the economy, shows an impressive growth in the case of Mexico, growing from 11.91% of participation in 1980 to 77.1% in 2005. Although Brazil also exhibited growth in exports of manufactured goods, its case was not as large as in Mexico. Finally, when analyzing the commercial ties with the United States, Mexico exhibits a longer share in both exports and imports. Moreover, the United States is the main commercial partner for Mexico, receiving over 50% of Mexican exports and being the source of more than 70% of its imports. From the United States point of view, Mexico is the second largest commercial partner.

Based on these macroeconomic indicators, some points are noted. First, Brazil and Mexico are economies of comparable economic size. Second, Brazil exhibits more variability in the behavior of macro variables than Mexico. Third, Mexico is more open to trade than Brazil. Lastly, Mexico has much stronger commercial ties with the United States than Brazil. In principle, one may expect to find a stronger reaction to U.S. shocks in Mexico than in Brazil. For analyzing such reactions to U.S. monetary shocks, a FAVAR model is employed.

The use of a FAVAR approach makes it possible to construct impulse response functions of any element of X_t to monetary policy shock. The impulse responses that appear below show responses of a selection of key macroeconomic variables to a U.S. monetary policy tightening shock for the FAVAR model up to 48 months. The solid line indicates the estimated response. The upper and lower dashed lines plotted in each graph represent 90 percent bootstrap confidence intervals based on 1,000 bootstrap samples. To facilitate comparisons and for sake of brevity, results for a group of 20 selected macroeconomic variables are displayed in the figures.¹⁵ We use twelve lags, but employing six and three lags led to very similar results. We standardize the monetary shock to correspond to a 1 standard deviation innovation in the federal funds rate. It should be noted that the figures report impulse responses in standard deviation units.

Figure 1 presents impulse response functions (IRFs) of Mexico to a U.S. monetary shock. Even though the general industrial production index (IP) does not show a significant response, the manufacturing industrial production does present a significant and immediate decline. This last reaction indicates that international transmission of monetary shocks exists in the case of Mexico. The FAVAR methodology uncovers such response which may have been ignored by a VAR methodology because of the limited number of variables, which usually means including only a general measure of production. The decline in industrial production is also consistent with raising domestic interest rates. Equally consistent with higher interest rates is the decline in money as measured by M1. Hence, interest rates are a channel of transmission of foreign monetary shocks.

In the second row of Figure 1, a slight increase in exports (X) is observable, while imports (M) do not significantly react, suggesting some role exists for the trade channel. No significant response exist by the exchange rate, which may be explained by the significant response offered by international reserves (Reserves). In an effort to keep the exchange rate stable, monetary authorities sell foreign currency in the foreign exchange rate market, a reaction that leads to a decline in international reserves.

Meanwhile, no significant impact is found in the stock market (Stock and Stock Commerce), which signals that this particular asset price channel plays a negligible role in the transmission process. Also, no price puzzle is found, except for an increase in the price of corn. Finally, consistently with the decline in output, average earnings (Avg Earnings) decline.

It was explained above that the interest in this paper is to explore the response in emerging economies to U.S. monetary actions; however, some concern may exist in the fact that only a variable representing such measure was included in the model. Figure 2 presents the response of Mexican variables to U.S. monetary shocks when two additional U.S. variables are included, U.S. prices and U.S. output as it is standard in some studies that use VAR methodology [15]. The figure shows that including those other U.S. variables does not alter the response of Mexican variables to U.S. monetary shocks. Since that was a general pattern in all estimations, in the remaining figures, we only include results for those were U.S. federal funds rate was the variable of monetary shocks and no other foreign variables were considered¹⁶.

Figure 3 shows the response of Brazilian variables to a U.S. monetary shock. In contrast with the case of Mexico, fewer variables display a significant response in Brazil, an indication of limited international monetary transmission; and, the channel of transmission differs. Different to the Mexican reaction, after an increase in U.S. federal funds rates, Brazilian output shows as slightly improvement, an indication that this country may benefit from downturns of the U.S. economy. Also, interest rates do

¹⁵ Responses from other variables are available upon request.

¹⁶ Estimations including U.S. output and U.S. prices were run for each model. For sake of brevity, they are not presented here but are available upon request.

have a significant reaction; they (Domestic FFR, Money market rate) slightly decrease after a U.S. monetary shock signaling intervention of monetary authorities to control external shocks. The only two other variables that display a significant response are the stock market index (Stock) and retail sales, with a brief increase that follows a U.S. monetary shock. Thus, in the case of Brazil, interest rates seem to be a channel of transmission of foreign shocks.

Several important features are worth discussing from contrasting the responses of each country to a foreign monetary shock. First, U.S. monetary shocks appear to have more economic impact on Mexico than in Brazil. From what was previously discussed about the characteristics of these economies, such patterns of responses were expected. However, these responses (or lack of them) substantially differ from the understanding of monetary transmission to emerging economies in the existing literature, where a common pattern of response is attributed. The figures show that no countries of similar economic size or those of the same geographical region exhibit a similar response to foreign monetary shocks. Second, the main channel of transmission appears to be interest rates, with no significant role of exchange rates. Third, when transmission occurs, it is immediate after the shocks.

Fourth, the effects of transmission differ, while Mexican output decline after a contractional U.S. monetary shock, Brazilian output shows a slightly improvement. This evidence contrasts with findings for developed countries [15] where in general, a decline in economic conditions follows contractional U.S. monetary shocks. Also, the reaction of monetary authorities to contractional policy shock seems to differ, while in Mexico an effort seems to exist for control fluctuations of exchange rates, in the case of Brazil, the focus seems to be on interest rates.

Table 1: Main economic indicators.

V a r i a b l e	1 9 8 0	2 0 0 5
G D P (c o n s t a n t 2 0 0 0 U S \$, m i l l i o n s)		
B r a z i l	39 5 , 9 8 1	67 0 , 4 5 0
M e x i c o	34 5 , 5 6 3	63 6 , 2 6 8
G D P g r o w t h (a n n u a l %)		
B r a z i l	9 . 1 1	2 . 3 0
M e x i c o	9 . 2 3	2 . 9 6
G D P p e r c a p i t a (c o n s t a n t 2 0 0 0 U S \$)		
B r a z i l	3 , 2 5 6	3 , 5 9 7
M e x i c o	5 , 1 1 4	6 , 1 7 2
I n f l a t i o n , c o n s u m e r p r i c e s (a n n u a l %)		
B r a z i l	1 0 1 . 7 2	6 . 8 7
M e x i c o	2 6 . 3 6	3 . 9 9
L a b o r f o r c e p a r t i c i p a t i o n r a t e , t o t a l (% o f t o t a l p o p u l a t i o n a g e s 1 5 - 6 4)		
B r a z i l	6 4 . 5 3	7 2 . 1 2
M e x i c o	5 7 . 2 3	6 2 . 1 0
P o p u l a t i o n , t o t a l (m i l l i o n s)		
B r a z i l	1 2 1 . 6 2	1 8 6 . 4 0
M e x i c o	6 7 . 5 7	1 0 3 . 0 9
T r a d e (% o f G D P)		
B r a z i l	2 0 . 3 6	2 9 . 1 6
M e x i c o	2 3 . 6 8	6 1 . 4 3
M a n u f a c t u r e s e x p o r t s (% o f m e r c h a n d i s e e x p o r t s)		
B r a z i l	3 7 . 2 1	5 3 . 8 8
M e x i c o	1 1 . 9 1	7 7 . 1 5
E x p o r t s t o t h e U n i t e d S t a t e s (% o f t o t a l e x p o r t s)		
B r a z i l	1 3 . 2 8	1 1 . 5 1
M e x i c o	6 0 . 7 4	5 2 . 3 6
I m p o r t s f r o m t h e U n i t e d S t a t e s (% o f t o t a l i m p o r t s)		
B r a z i l	4 4 . 1 7	2 4 . 7 7
M e x i c o	5 6 . 3 5	7 0 . 2 3

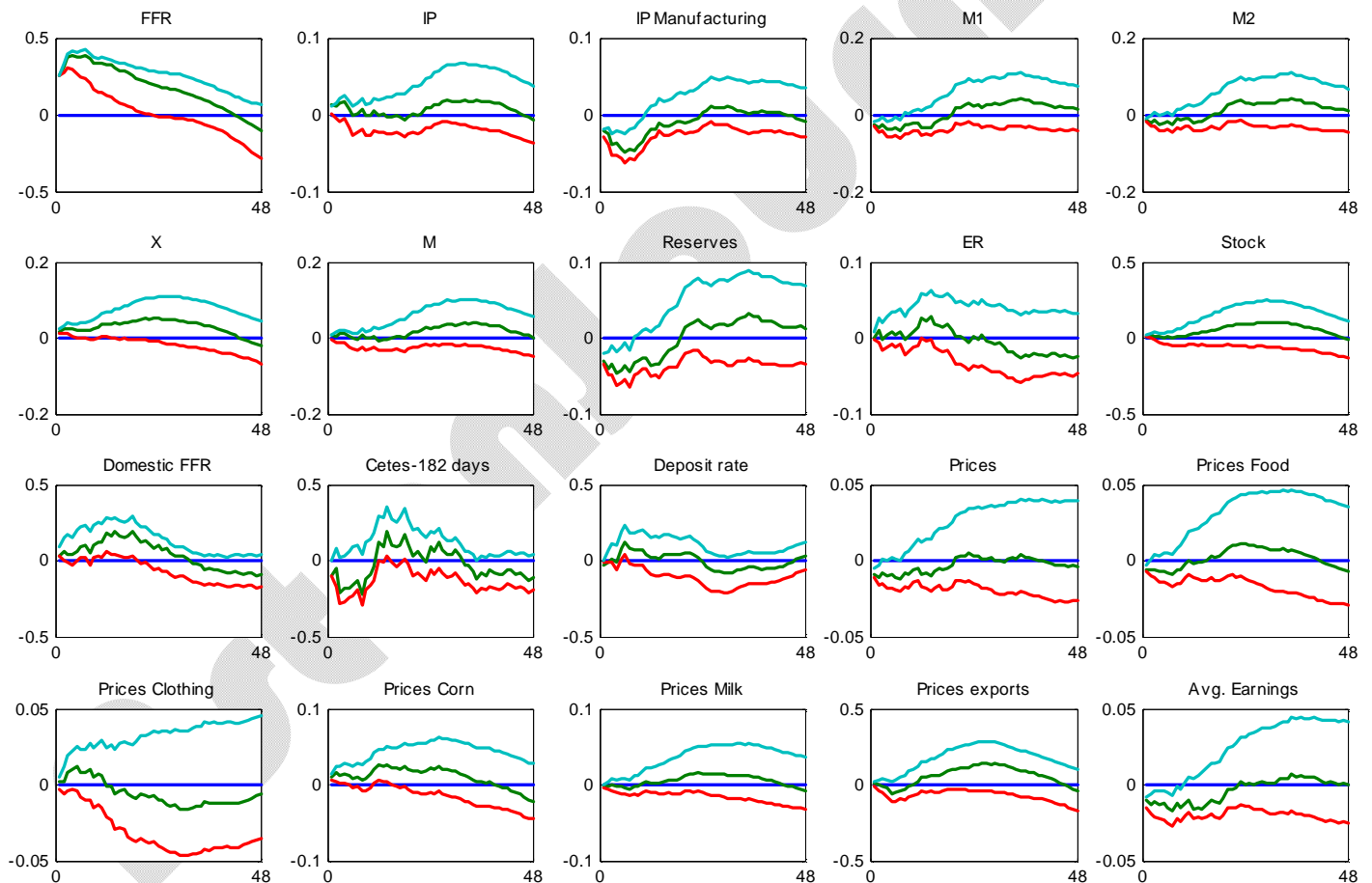
Source: World Development Indicators and Foreign Trade Division, U.S. Census Bureau.

Lastly, differences based on exchange rate regimes do not seem to hold in the transmission process. It is expected that countries with floating regimes would be less exposed to a transmission process than countries with a fixed or managed regime. However, the exchange rate regime classification for Mexico and Brazil that appear in Table 2¹⁷ shows that Brazil had slightly more periods of managed intervention in the foreign exchange market, while Mexico has tended more towards a floating regime. Based on this classification, Brazil should exhibit more evidence of monetary transmission than Mexico, but the opposite results are evident. It is possible that the presence of a mix of regimes, the poor quality of the data or the small differences between the two regimes could also be part of the explanation.

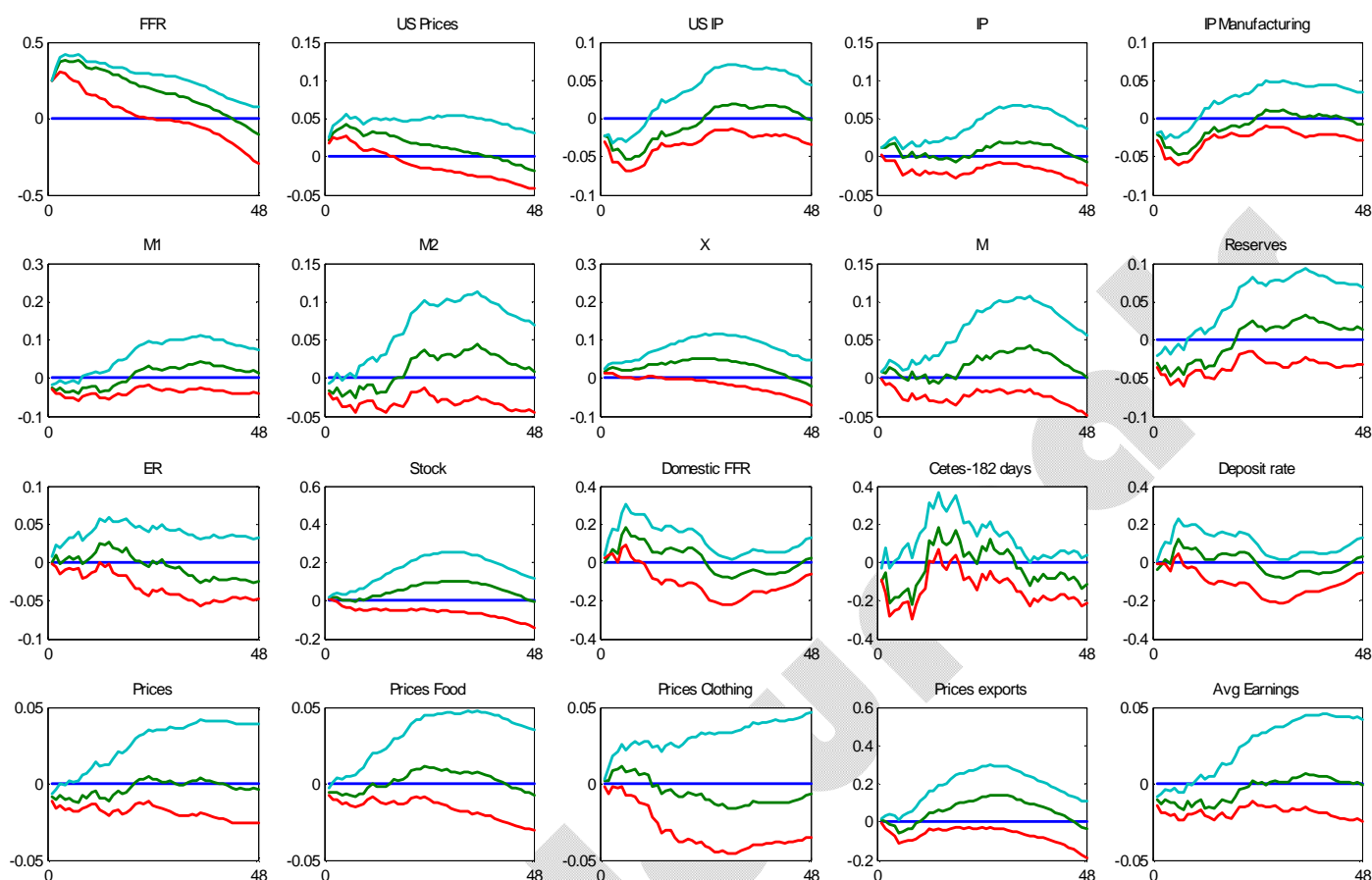
4.2 Response to Other Foreign Shocks

The reported diversity in the response to U.S. monetary shocks questions the belief of a common response of emerging economies to foreign shocks. Taking advantage of the FAVAR methodology, a specific foreign shock is considered, a foreign income shock. This exploration may add some insights about whether the divergence in responses is specific to monetary shocks or the reaction to foreign shock in general.

Figure 1: Mexican impulse response functions to U.S. monetary shock.



¹⁷ Alternative exchange rate classifications exist, see for instance Calvo and Reinhart [28]; although the classification used in this paper is extensively used in the literature. With respect to Mexico and Brazil in particular, Canova [1] classifies Mexico and Brazil as “floaters,” which again would induce similar responses to foreign shocks in principle.

Figure 2: Mexican impulse response functions to U.S. monetary shocks – more U.S. variables.

It is frequently claimed among policymakers in emerging countries that a source of variability on these economies are fluctuations in U.S. economic activity. Figures 4 and 5 present the impulse response functions to a U.S. output shock in Mexico and Brazil respectively.¹⁸ From the figures, a difference in the transmission of a foreign output shock is evident between Mexico and Brazil. Mexico, as in the case of a U.S. monetary policy shock, exhibits more response to a U.S. shock than Brazil.

Following a positive shock in U.S. output, Mexican output (IP) increases, an indication that the Mexican economy benefits from U.S. economic growth and hurts in the presence of a U.S. recession. The Mexican stock market reacts positively, a reaction that increases income and may explain a higher demand for money as income rises, which in turn may also explain why interest rates are higher. In the presence of an aggregate demand shock from an external source, prices also increase. Overall, international transmission occurs in the Mexican economy after a U.S. shock.

In contrast with the Mexican response, little reaction follows a U.S. output shock in Brazil. Only a slight improvement appears in output, retail sales, stocks, average earnings and the price of exports, but such improvements are temporary and die down. That slight imports increase may explain the brief increase in retail sales, national prices and average earnings. Overall, little evidence of an international transmission process exists in Brazil. Once again, contrasting the evidence in the responses to a U.S. shock indicates that different reactions exist in emerging economies even for countries that belong to the same geographical region or that are of comparable economic size. This evidence suggests that considering the reaction of emerging economies to foreign shocks as a block might lead to wrong conclusions and might confuse policy makers in their decision making process.

¹⁸ U.S. industrial production is used as a measure of U.S. output.

5. Conclusion

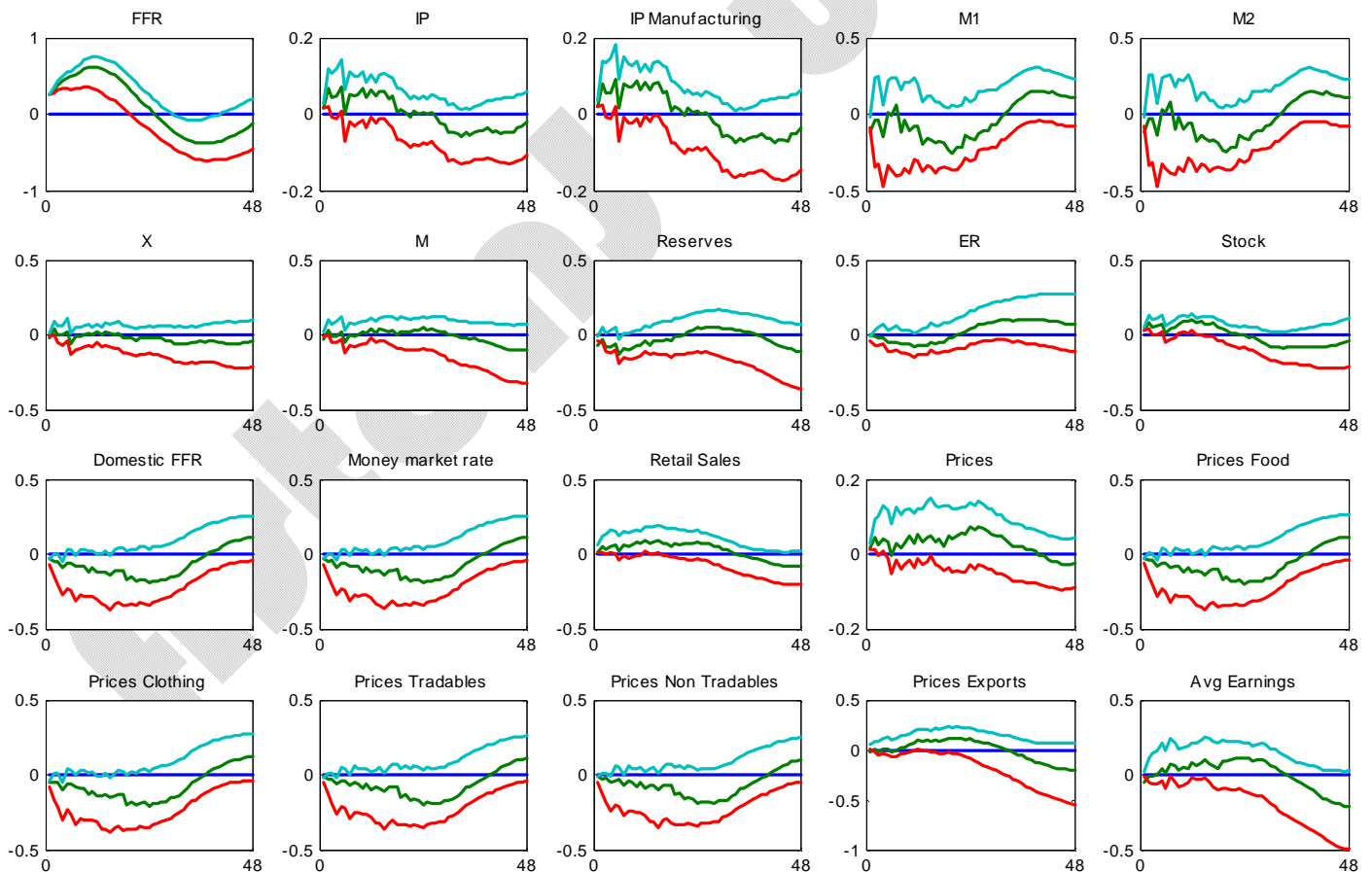
This paper examines the international transmission of U.S. monetary policy to emerging economies with the use of a FAVAR approach. This methodology offers the advantage over traditional VAR models of considering a wide array of variables, which provides a more accurate description of the transmission process. The paper explores international transmission of U.S. monetary shocks with the comparison of two economies of similar size and in the same geographic region, an approach that facilitates comparisons of responses.

This paper suggests that no common pattern of response to U.S. monetary shocks exists among emerging economies. While Mexico offers evidence of a strong international transmission process, Brazil shows less response to foreign monetary shocks. Furthermore, the paper suggests that expected responses from exchange rate regimes in the transmission process are inconsistent with the empirical evidence. As regards policy, the paper finds support for the view that a central question for policy in emerging markets is how to stabilize the economy in response to external shocks provided that those shocks impact an emerging economy. For the case of Mexico and Brazil, which operate under an inflation-targeting goal, the evidence of international transmission discussed in this paper offers different implications.

Competing Interests

The author declares that she has no competing interests.

Figure 3: Brazilian impulse response functions to U.S. monetary shocks.



References

- [1] Canova F, 2005. The transmission of US shocks to Latin America. *Journal of Applied Econometrics*, 20: 229–251.
- [2] Mishkin F, 1996. The channels of monetary transmission: lessons for monetary policy. NBER Working Papers, No. 5464.
- [3] Bernanke B, Boivin J, Elias P, 2005. Measuring the effects of monetary policy: a factor-augmented vector autoregressive. *The Quarterly Journal of Economics*, 120(1): 387-422.
- [4] Senbet D, 2008. Measuring the impact and international transmission of monetary policy: a factor-augmented vector autoregressive (FAVAR) approach. *European Journal of Economics, Finance and Administrative Sciences*, 13: 121-143.
- [5] Mumtaz H, Surico P, 2009. The transmission of international shocks: a factor-augmented VAR approach. *Journal of Money, Credit and Banking*, 41(S1): 71-100.
- [6] Bernanke B, Gertler M, 1995. Inside the black box: the credit channel of monetary policy transmission. *Journal of Economic Perspectives*, 9: 27–48.
- [7] Meltzer A, 1995. Monetary, credit (and other) transmission processes: a monetarist perspective. *Journal of Economic Perspectives*, 9: 49–72.
- [8] Obstfeld M, Rogoff K, 1995. The mirage of fixed exchange rates. *Journal of Economic Perspectives*, 9: 73–96.
- [9] Sims C, 1992. Interpreting the macroeconomic time series facts: the effects of monetary policy. *European Economic Review*, 36: 975–1000.
- [10] Christiano L, Eichenbaum M, Evans C, 1999. Monetary Policy Shocks: What Have We Learned and to What End? *Handbook of Macroeconomics*, ed. by J. B. Taylor and M. Woodford. Amsterdam: Elsevier Science, 65–148.
- [11] Bernanke B, Blinder A, 1992. The federal funds rate and the channels of monetary transmission. *American Economic Review*, 82(2): 901–921.
- [12] Kim H, 1999. Was the credit channel a key monetary transmission mechanism following the recent financial crisis in the Republic of Korea? *The World Bank, Policy Research Working Paper Series No. 2103*.
- [13] Hallwood P, MacDonald R, 2000. *International Money and Finance*. 3rd edition, Blackwell Publishers, Oxford, Great Britain.
- [14] Walsh C, 2003. *Monetary Theory and Policy*. The MIT Press, Cambridge, Massachusetts, 2nd edition.
- [15] Kim S, 2001. International transmission of U.S. monetary policy shocks: evidence from VARs. *Journal of Monetary Economics*, 48 (2): 339–372.
- [16] Angeloni I, Kashyap A, Mojon B, Terlizzese D, 2003. Monetary transmission in the euro area: does the interest rate channel explain all? NBER Working Paper 9984.
- [17] Haug A, Karagedikli O, Ranchhold S, 2005. Monetary policy transmission mechanisms and currency unions. A vector error correction approach to a trans-Taman currency union. *Journal of Policy Modeling*, 27(1): 55–74.
- [18] Eickmeier S, 2007. Business cycle transmission from the US to Germany - a structural factor approach. *European Economic Review*, 51(3): 521-551.
- [19] Sousa J, Zaghini A, 2008. Monetary policy shocks in the euro area and global liquidity spillovers. *International Journal of Finance & Economics*, 13(3): 205-218.
- [20] Ibrahim M, 2003. International disturbances and domestic macroeconomic fluctuations in Malaysia. *ASEAN Economic Bulletin*, 20(1): 11–27.

- [21] Desroches B, 2004. Explaining the transmission of world shocks to emerging market countries: an empirical analysis. Bank of Canada Working Paper.
- [22] Mackowiak B, 2007. External shocks, U.S. monetary policy and macroeconomic fluctuations in emerging markets. *Journal of Monetary Economics*, 54(8): 2512-2520.
- [23] Miniane J, Rogers J, 2007. Capital controls and the international transmission of U.S. money shocks. *Journal of Money, Credit and Banking*, 39(5): 1003-1035.
- [24] Stock J, Watson M, 2002. Macroeconomic forecasting using diffusion indexes. *Journal of Business Economics and Statistics*, 20(2): 147-162.
- [25] Levy-Yeyati E, Sturzenegger F, 2005. Classifying exchange rate regimes: deeds vs. words. *European Economic Review*, 49: 1603-1635.
- [26] McCallum B, Nelson E, 1999. Nominal income targeting in an open-economy optimizing model. *Journal of Monetary Economics*, 43: 553-578.
- [27] Svensson L, 2000. Open economy inflation targeting. *Journal of International Economics*, 50: 155-183.
- [28] Calvo G, Reinhart C, 2002. Fear of floating. *The Quarterly Journal of Economics*, 117(2): 379-408.

Table 2: De facto exchange rate regime classification by Levy-Yeyati and Sturzenegger (2005).

Year	Mexico	Brazil
1980	Managed	Float
1981	Managed	Managed
1982	Managed	Managed
1983	Managed	Managed
1984	Float	Managed
1985	Managed	Fix
1986	Managed	Fix
1987	Managed	Managed
1988	Fix	Managed
1989	Managed	Managed
1990	Managed	Managed
1991	Fix	Managed
1992	Fix	Managed
1993	Fix	Managed
1994	Fix	Managed
1995	Managed	Float
1996	Managed	Managed
1997	Float	Managed
1998	Float	Fix
1999	Float	Managed
2000	Float	Fix

Notes: Original data contain several managed regimes, but all those regimes appear here listed under Managed regime. Original sample ends at 2000, author's calculations were used for 2001-2008.

Figure 4: Mexican impulse response functions to U.S. output shocks.

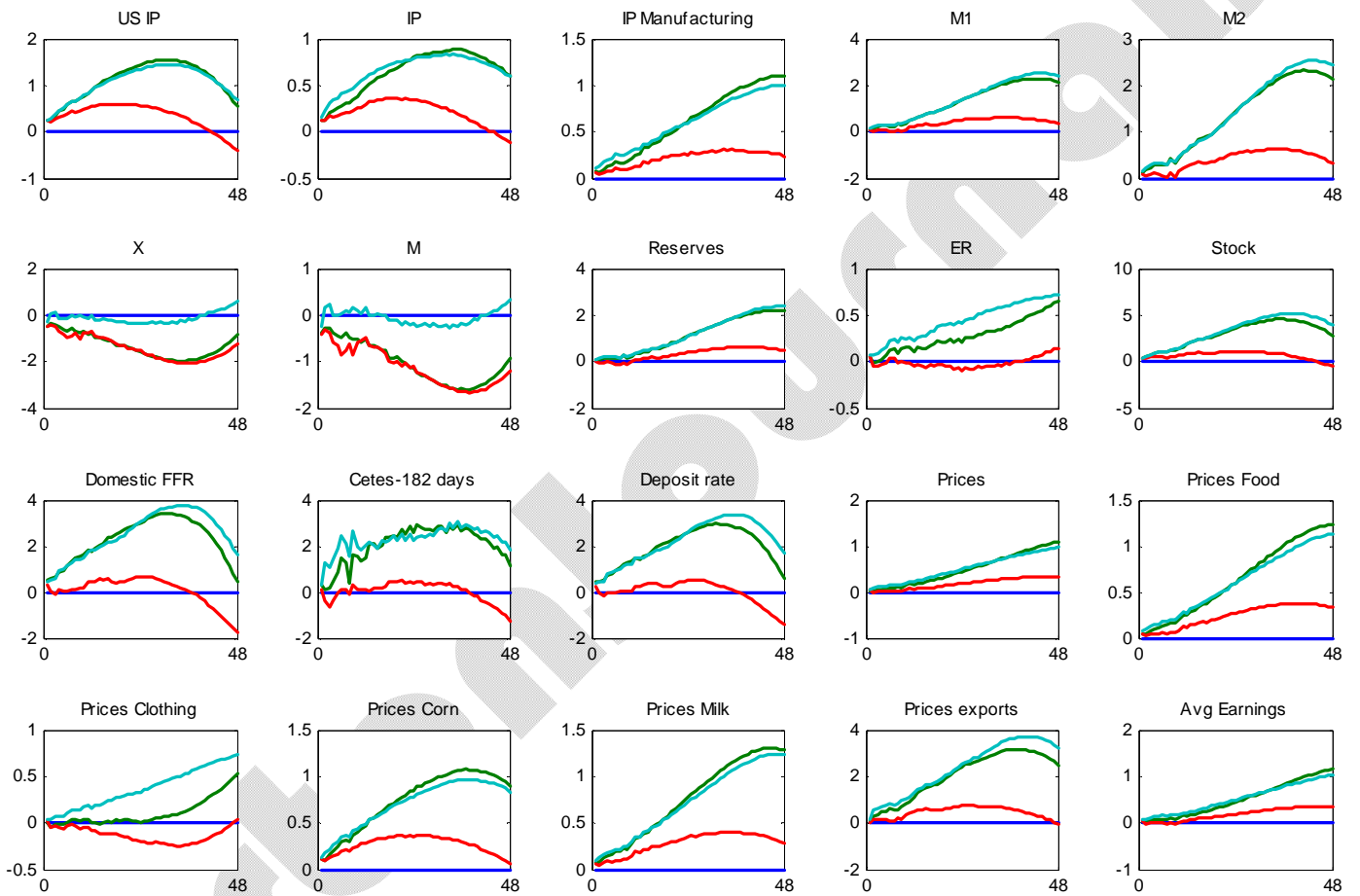
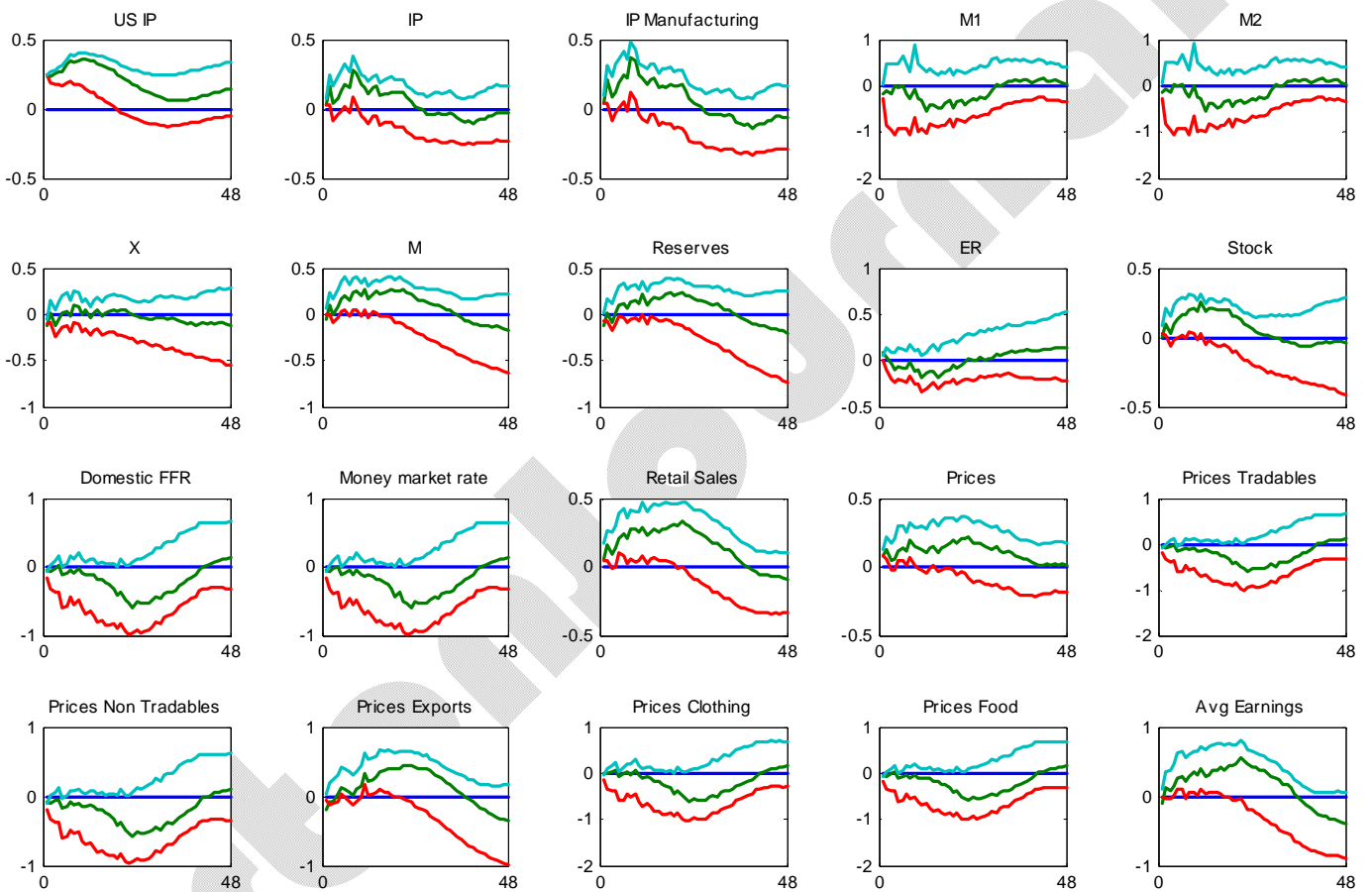


Figure 5: Brazilian impulse response functions to U.S. output shocks.



Data Appendix

Almost all series are from Datastream. Few series come from Banco de Mexico and have a plus sign (+) preceding the name of the variable. Data are from January 1982 to October 2008 for Mexico; and, January 1991 to October 2008 for Brazil. An asterisk * before the name of the variable denotes a variable assumed to be slow moving in the estimations. Data for U.S. Federal Funds rate and U.S. Industrial Production Index is taken from the website of the Federal Reserve Bank of St. Louis.

Brazil – Variables

- 
- | | |
|--|--|
| 1 *Industrial Production | 44 *New Car Sales - Foreign |
| 2 *Industrial Production - Manufacturing | 45 Exports - Manufactured Goods |
| 3 *Productivity - Manufacturing Sector | 46 Imports - Capital Goods |
| 4 *Capacity Utilization | 47 Exports (Fob): Primary Products |
| 5 *Industrial Production | 48 Exports (Bop Basis) |
| 6 *Industrial Production - Manufacturing | 49 Imports (Bop Basis) |
| 7 *Industrial Production - Consumer Goods | 50 International Reserves |
| 8 *Industrial Production - Capital Goods | 51 Money Supply - M0 |
| 9 *Industrial Production - Intermediate Goods | 52 Money Supply - M2 |
| 10 *Industrial Production - Food | 53 Brazilian Reals To Us Dollar |
| 11 *Industrial Production - Basic Metallurgy | 54 Bovespa Share Price Index |
| 12 *Industrial Production - Machineries And Equipment | 55 Money Market Rate Or Cdi (% Per Month) |
| 13 *Industrial Prod- Electronic And Communication Equip. | 56 Unit Labor Cost |
| 14 *Industrial Production - Automotive Vehicles | 57 National CPI Or Inpc |
| 15 *Industrial Production - Food | 58 Export Price Index |
| 16 *Industrial Production - Beverage | 59 Import Price Index |
| 17 *Industrial Production - Cigarette | 60 Terms Of Trade |
| 18 *Industrial Production - Textile | 61 Broad CPI Or Ipca |
| 19 *Industrial Production - Accessories And Clothing | 62 Cpi - General |
| 20 *Industrial Production - Leather Goods And Footwear | 63 National CPI - Housing |
| 21 *Industrial Production - Wood | 64 National CPI- Domestic Goods |
| 22 *Industrial Production - Paper And Paper Products | 65 National CPI - Clothing |
| 23 *Industrial Production - Petroleum Refinery And Alcohol | 66 National CPI - Health And Personal Care |
| 24 *Industrial Production - Pharmaceuticals | 67 National CPI - Personal Expenditures |
| 25 *Industrial Prod. - Personal Care And Cleaning Agents | 68 CPI Or Inpc |
| 26 *Industrial Production - Automotive Vehicles | 69 CPI - Food |
| 27 *Production - Four Wheel Tractor | 70 Broad National Consumer Price Index Or Ipca |
| 28 *Production - Track Driven Tractor | 71 Broad National CPI - Tradables |
| 29 *Production - Combined Harvesters | 72 Broad National CPI - Non Tradables |
| 30 *Production - Mechanical Diggers | 73 Broad National CPI: Supervised Prices - Total |
| 31 *Production - Other Agricultural Machinery | 74 Broad National CPI: Supervised Prices - Gasoline |
| 32 *Production - Agricultural Machinery - Total | 75 WPI - Construction Materials |
| 33 *Production Of Motor Vehicles (Cars, Trucks, Buses) | 76 WPI - Machineries, Vehicles And Equipment |
| 34 *Production - New Cars | 77 Export Price Index - Durable Consumer Goods |
| 35 *Petroleum Derivatives Production | 78 Export Price Index - Non Durable Consumer Goods |
| 36 *Petroleum Derivatives Production - Natural Gas | 79 Export Price Index - Intermediate Goods |
| 37 *Petroleum Derivatives Production - Liquefied Natural Gas | 80 Export Price Index - Capital Goods |
| 38 *Production - Crude Steel | 81 Import Price Index - Durable Consumer Goods |
| 39 *Production - Pig Iron | 82 Import Price Index - Non Durable Consumer Goods |
| 40 *Production - Laminated Steel | 83 Import Price Index - Intermediate Goods |
| 41 *Retail Sales - Sao Paulo | 84 Import Price Index - Capital Goods |
| 42 *Sales - Motor Vehicles - Total | 85 Import Price Index - Fuel |
| 43 *New Car Sales - Domestic | 86 Overnight Federal Funds Rate Or Selic (% Per Month) |

Mexico – Variables

1	*+ Index of Volumen of Industrial Activiy	45	CPI : Food - O m ellettes & Corn
2	*+ Index of Volume of Mining Industry	46	CPI : Food - Bread
3	*+ Index of Volume of Construction	47	CPI : Food - Meat
4	*+ Average Productivity per Worker	48	CPI : Food - Bird Meat
5	*+ Average Earnings per Worker	49	CPI : Food - Hog Meat
6	*+ Unit Cost per Worker	50	CPI: Food - Beef Meat
7	* Daily Minimum Wage	51	CPI : Food - Fish & Shellfish
8	*Net Public Debt	52	CPI : Food - Milk, By-Products O f Milk & Egg
9	Money Supply -M 1	53	CPI : Food - Pasteurized & Fresh Milk
10	Money Supply -M 2	54	CPI : Food - Milk By Prds, Butter
11	Exports with Maquila	55	CPI : Food - Egg
12	Imports with Maquila	56	CPI : Food - Oils & Edible Greases
13	Exports without Maquila	57	CPI : Food - Oils & Edible Vegetable Greases
14	Imports without Maquila	58	CPI : Food - Fruits & Vegetables
15	International Reserves	59	CPI : Food - Fresh Fruits
16	Index of leading Indicators	60	CPI : Food - Fresh Vegetables
17	Nominal Exchange Rate	61	CPI : Food - Dry Vegetables, Beans
18	Effective Exchange Rate	62	CPI : Food - Dry Vegetables, Dry Chili
19	Share Price Index	63	CPI : Food - Processed Fruits & Vegetables
20	General Index of Prices	64	CPI : Food- Sugar, Coffee & Bottled Refreshments
21	Index of Prices - Extractive Industry	65	CPI : Food - Sugar
22	Index of Prices - Industry of Transformation	66	CPI : Food - Coffee
23	Index of Prices -Construction Industry	67	CPI : Food-Chocolates & Delic,Sweets,Candies
24	Index of Prices -Commerce	68	CPI : Alcoholic Beverages & Tobacco
25	Index of Prices - Transport and Communications	69	CPI : Alcoholic Bevg & Tobacco-Alcoholic Beverages
26	Index of Prices - Services	70	CPI : Alcoholic Bevg & Tobacco - Beer
27	Index of Prices - Other sectors	71	CPI : Alcoholic Bevg & Tobac-Wines & Liquors,Tequila
28	Cetes 91 days -average	72	*CPI : Apparel, Footwear & Clothing
29	Cetes 91 days -weighted average	73	*CPI : Clothes
30	Cetes 182 days -weighted average	74	*CPI : Clothes - Clothes For Men
31	2-month Deposit rate -gross rate	75	*CPI : Clothes - Clothes For Women
32	3-month Deposit rate -gross rate	76	*CPI : Clothes - Clothes For Children & Infants
33	6-month Deposit rate -gross rate	77	Export Price Index (U.S.\$)
34	2-month Deposit rate -net rate	78	Import Price Index (U.S.\$)
35	3-month Deposit rate -net rate	79	Trade Balance
36	6-month Deposit rate -net rate	80	Exports-Petroleum
37	CPI -general	81	Exports - Non Petroleum
38	CPI -Underlying Core	82	Exports - Non Petroleum - Agriculture & Livestock
39	CPI by Expenditure`	83	Exports - Non Petroleum - Extractive
40	CPI : Food, Beverages & Tobacco	84	Exports - Non Petroleum - Manufactures
41	CPI : Food	85	Imports - Consumer goods
42	CPI: Food - Bread, O m ellettes & Cereals	86	Imports - Intermediate goods
43	CPI: Food - O m ellettes & Corn By-Prds.	87	Imports - Capital goods
44	CPI : Food- O m ellettes & Corn By-Prds, Cornflour	88	Federal Treasury Certificate (Cete) Rate - 28 Day