

Mexico: Selected Issues

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MEXICO

Selected Issues

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I. EXTERNAL SHOCKS AND BUSINESS CYCLE FLUCTUATIONS IN MEXICO: HOW IMPORTANT ARE U.S. FACTORS?¹

A. Introduction

1. **In the last two decades, Mexico has undergone a process of trade and financial liberalization and integration, including by entering NAFTA in 1994.** While such increased integration with the global economy is likely to allow faster trend growth in Mexico, integration may also make the economy more sensitive to certain kinds of external shocks, making external spillovers more relevant in explaining output fluctuations. At the same time, with the implementation of sound macroeconomic and financial policies in the period since the 1994–95 crisis, Mexico has been able to leave behind its past pattern of crises, avoiding the severe fluctuations and losses of output associated with such episodes. In this way, Mexico has achieved its own “Great Moderation” of the business cycle.
2. **In this light, the effect on output of shocks related to external trade is likely to have grown over time, at least in relative terms.** The share of primary commodities in Mexico’s exports has declined over the past 30 years—potentially reducing the relative importance of terms of trade shocks. However, the importance of U.S. cycles in driving output fluctuations in Mexico may have increased with the dramatic expansion of trade between the two countries since the inception of NAFTA. Total trade—exports plus imports—between the two countries increased from about US\$90 billion in 1993 to approximately US\$350 billion in 2006. The U.S. is by far Mexico’s largest trading partner: about 85 percent of Mexico’s exports are destined to the U.S., and about half of its imports are from the U.S.
3. **Several interesting questions emerge here.** How significant are external shocks as sources of Mexican business cycle fluctuations? Do shocks stemming from the U.S. indeed play a key—or even a predominant—role in driving domestic output fluctuations? What is the dynamic response of Mexican GDP to a shock affecting the country that buys most of Mexico’s exports? What are the main transmission mechanisms through which these shocks are propagated to Mexico? The purpose of this paper is to address these questions.
4. **In light of current concerns about the health of the U.S. economy, a careful examination of the macroeconomic linkages between the U.S. and Mexican economies is helpful in assessing the impact of the recent slowdown of the U.S. economic activity on Mexico, and the likely effects of a potential U.S. “hard landing” scenario (involving an abrupt narrowing of the U.S. trade deficit).** An identification and assessment of the sources and propagation mechanisms of foreign disturbances is useful not only to characterize the Mexican business cycle but also to potentially inform the design and conduct

¹ Prepared by Sebastian Sosa. Thanks to staff of the Bank of Mexico for helpful comments.

of macroeconomic policy. Moreover, empirical evidence on the sources and transmission channels of external shocks could bring additional perspectives to the issue of regional trade integration and its economic effects.

5. **The empirical strategy used to study the sources of macroeconomic fluctuations and to identify the responses of the Mexican economy to external disturbances is a VAR model with block exogeneity restrictions.** The model contains two blocks—one block of foreign variables and one of domestic variables. This specification assumes that foreign variables are completely exogenous to the Mexican domestic economy.² The paper focuses on the linkages between the U.S. and Mexican economies, seeking to shed light on potential spillovers and the channels of transmission underlying them.

6. **The main results and conclusions are as follows:**

- Shocks to U.S. demand for Mexico’s exports—as proxied by U.S. industrial production—represent a major factor driving macroeconomic fluctuations in Mexico (in fact constituting the largest source of foreign disturbances) in the post-NAFTA period, accounting for about 40 percent of output fluctuations. This basic result is robust to the use of alternative measures of U.S. demand for Mexico’s exports (such as U.S. GDP, and U.S. total imports).
- A positive innovation to U.S. industrial production increases Mexican output on impact, with effects continuing over six quarters; and the largest response occurs only one quarter after the shock. The size of the apparent effect of U.S. real variables on Mexican GDP is rather large. As a “rule of thumb,” an innovation of 1 percentage point in U.S. industrial production growth typically has been accompanied by a change of some 0.9 percentage point in Mexican GDP growth one quarter after the shock.³
- The key role played by U.S. demand shocks is seen mainly in the post-NAFTA period. If instead a longer period starting at 1980 is considered, the relative importance of U.S. influences is substantially smaller. These differing results can be explained mainly by the greater importance of idiosyncratic shocks in the pre-NAFTA period, in particular the

² The block exogeneity approach in VAR models has been previously used in the literature to analyze the importance of, and the response to, external shocks in a number of other economies. For instance, Cushman and Zha (1997), Dungey and Pagan (2000), Hoffmaister and Roldos (2001), Buckle et al (2002), Franken, Le Fort and Parrado (2005), and Sosa (2007a) applied this approach to Canada, Australia, Brazil and Korea, New Zealand, Chile, and the ECCU. Raddatz (2006) quantified the impact of different external shocks and determined their contributions to output volatility in low-income countries. Finally, Osterholm and Zettelmeyer (2007) developed a Bayesian VAR with block exogeneity to investigate the sensitivity of GDP growth—for an aggregated group of the largest Latin American economies—to external developments.

³ Throughout this paper, the “rule of thumb” elasticities derived from impulse response functions are computed considering the effects at the peak quarter, and not the cumulative—and typically larger—effects over longer periods, such as 8 or 12 quarters.

economic and financial crisis episodes in Mexico, and probably also reflect the lesser degree of trade integration with the U.S. before NAFTA.

- U.S. output variables—industrial production and GDP—appear to be more important for Mexican output than U.S. domestic demand indicators. This fact probably reflects the extent to which Mexico’s exports consist of intermediate goods used as inputs in U.S. production, rather than final goods.
- For perspective, Mexico’s exports to the U.S. are now roughly one-fourth of Mexican GDP (value-added from such exports must be significantly smaller, taking into account the high import content of many exports). Evidently, the effect of U.S. output fluctuations goes far beyond its immediate and direct influence on Mexico’s exports. Indeed, changes in U.S. economic activity are also important in driving—directly or indirectly— output fluctuations in the services sector, which accounts for more than 65 percent of Mexican GDP. Given the presumably small direct exposure—through trade channels—of the service sector to the U.S. economy, these results suggest that there are important spillovers or multiplier effects transmitting shocks from the export sector to the rest of the Mexican economy.

7. **Business cycles in Mexico have been studied extensively in the literature using different approaches, usually with a focus on the U.S. economy (or NAFTA) as the key external influence.** For instance, Oliveira Santos (2002) uses a regime-switching model to characterize business cycles in Mexico. Herrera (2003) tests and measures the existence of common cycles between the economies of Mexico and the United States, finding that both economies share a common trend and a common cycle. Cuevas, Messmacher and Werner (2003) analyze changes in the degree of macroeconomic synchronization between Mexico and its NAFTA partners, and find that synchronization increased after the inception of NAFTA.⁴ They also show that this has occurred in a large number of economic sectors and regions, reinforcing traditional links between these countries. Torres and Vela (2003) examine the relationship between business cycles in Mexico and the U.S., and find that, as the manufacturing sectors of the two economies have become more integrated through trade linkages, business cycles across the border have become more synchronized.⁵

8. **Chiquiar and Ramos-Francia (2004) study the changes in the degree and the nature of synchronization between Mexico and the U.S. manufacturing output levels.**⁶ They provide evidence that production-side links between Mexico and U.S. manufacturing sectors became stronger after NAFTA was enacted and, as a consequence, business cycles in

⁴ Their empirical approach is based on correlation and regression analyses, as well as on factor analysis.

⁵ Their study is mostly based on co-movement and regression analyses.

⁶ In particular, they apply spectral analysis and cointegration tests to assess the correlation of the business cycle and low frequency components of the manufacturing output series of the two countries.

these countries became more synchronized. Jean Louis and Simons (2005) use Markov-switching regimes in a multivariate framework to investigate the business cycle linkages between Canada, Mexico, and the United States, and find that Mexico and Canada individually share a common cycle with the U.S., but not with each other.⁷ Kose, Meredith, and Towe (2004) provide an overall assessment of the impact of NAFTA on growth and business cycles in Mexico. More recently, Bergin, Feenstra, and Hanson (2006) develop two theoretical models of outsourcing that can explain how domestic demand shocks in the U.S. are transmitted in an amplified manner to Mexican outsourcing industries.⁸

9. **This paper builds on this literature in several ways:**

- First, while most of the work in this area has examined the synchronization between Mexico and its NAFTA partners, we are not aware of any studies that seek to measure the relative importance of different types of external shocks—and their importance vis-à-vis idiosyncratic shocks—in explaining Mexican output fluctuations in a unified framework, and to determine the dynamic responses of the Mexican economy to each of them. Whereas most previous studies have focused on individual external factors (for example U.S. growth, oil price movements, etc.), the use of a VAR model with block exogeneity allows us to assess the simultaneous effect of each of the foreign variables included in the external block of the model.
- Second, we put emphasis on the *magnitude* of the responses of Mexican GDP to individual shocks. For example, “rule of thumb” elasticities are derived from the impulse response functions, which can help inform conditional forecasts, of Mexican growth.
- Finally, we are able to add several years’ more data to the analysis of the post-NAFTA era. By including the most recent period—through mid-2007—the analysis can provide some clues on the causes of the recent slowdown of Mexican growth, and on whether the relationships found in the earlier literature continue to hold.

10. **The rest of the paper is organized as follows.** The next section examines the relative importance of U.S. demand shocks—and other foreign disturbances—in explaining Mexican output fluctuations, and identifies the dynamic response of Mexico’s output to those shocks. Section C investigates which U.S. variables are most relevant to explaining business

⁷ They investigate other issues including the role of the common cycle in explaining each country’s economic fluctuations and the responses of each country to a common shock.

⁸ Their study focuses on the second moment properties of outsourcing, and they document a new stylized fact: the maquiladora outsourcing industries in Mexico experience fluctuations in value added that are roughly *twice* those of the corresponding industries in the U.S. Their models are able to replicate this stylized fact.

cycles in Mexico. Section D analyses potential spillovers and channels of transmission underlying the linkages between the U.S. and Mexican economies. Finally, section E presents some concluding remarks, including identifying some outstanding questions and areas for further research.

B. The Role of U.S. Demand and Other External Shocks in Mexican Output Fluctuations

11. **To determine the relative importance of external shocks as sources of business cycle fluctuations in Mexico, and to identify the dynamic responses of domestic output to U.S. shocks, a VAR model with block exogeneity is estimated for the Mexican economy in the post-NAFTA period.** Critical external factors for Mexico are likely to include terms of trade, global financial conditions, and external demand. Hence, the external block of the model includes oil prices,⁹ world real interest rates,¹⁰ and U.S. demand as proxies for these factors. The domestic block, in turn, includes real output—the variable of main interest, as well as the real exchange rate—which may play a key role in macroeconomic adjustment to external shocks—and capital inflows—a variable which has been mentioned in the literature¹¹ as highly correlated with the business cycle in emerging market countries, and an important driver of their output fluctuations.¹² A key feature of this specification is that foreign variables are assumed to be completely exogenous to the Mexican domestic economy. A description of the empirical approach, including specification and identification issues as well as the estimation strategy, is presented in the Appendix.¹³

⁹ Mexico is among the world's top ten oil exporters, in absolute terms, although the value of its oil exports as a percent of GDP is much less than in some other countries. Oil revenue accounts for almost 40 percent of budget revenue.

¹⁰ Changes in the international real interest rate constitute an important factor driving portfolio capital inflows to Latin America, thus influencing business cycles across this region (Calvo, Leiderman, and Reinhart, 1993, and Calvo, Fernandez Arias, Reinhart, and Talvi, 2001). This link between the U.S. interest rate and capital flows to Latin America (and to emerging markets in general) may be a consequence of a number of reasons. Low interest rates in mature markets may lead investors in those markets to seek higher returns in other markets, increasing the demand for emerging market assets. Not only does external financing become more abundant for emerging markets, but also the cost of borrowing declines as a consequence of the lower interest rates in the U.S. In fact, Fernandez Arias (1996) shows that country-risk premia in emerging markets is indeed affected by international interest rates, amplifying the interest rate cycles in mature markets.

¹¹ Calvo, Fernandez Arias, Reinhart, and Talvi (2001), and Kaminski, Reinhart, and Vegh (2004).

¹² Oil prices are measured as the average of three crude oil spot prices (Dated Brent, WTI, and Dubai Fateh), in U.S. dollars per barrel. The world real interest rate is computed using the 6-month LIBOR and the CPI inflation rate of industrial countries. U.S. demand is proxied by the U.S. industrial production index (s.a., 2002=100). "Capital inflows" are the net flow of money from abroad (net transfers received plus capital inflows minus accumulation of international reserves minus net payments of interest, dividends, profit remittances, etc.). Finally, the real exchange rate and real output are measured using the real effective exchange rate index and Mexican GDP (saar, million of 1993 new pesos).

¹³ For a more detailed description of the empirical modeling approach see Sosa (2007b).

12. **The main objectives of the paper are achieved through two standard tools of VAR analysis: impulse response functions and variance decomposition.** Variance decomposition provides a quantification of the relative importance of each of the shocks as sources of output fluctuations. Impulse responses constitute a practical way to identify the dynamic responses of the domestic economy to external shocks, illustrating how growth in Mexico has tended to react to U.S. and other external shocks—taking into account not only the direct effects of disturbances, but also the indirect effect through reactions of other endogenous variables.

13. **Shocks to U.S. demand for Mexican exports—proxied by U.S. industrial production, toward which many Mexican exports are destined—represent a major factor driving output fluctuations in Mexico in the post-NAFTA period, accounting for about 40 percent of GDP fluctuations** (Table 1). Moreover, U.S. demand shocks constitute the largest source of foreign disturbances, with oil price and world real interest rate shocks explaining 7 and 15 percent respectively.¹⁴ The *relative* importance of U.S. demand shocks appears to be much larger in Mexico than in the rest of Latin America, according to two recent studies conducted at the IMF: Osterholm and Zettelmeyer (2007), and IMF (2007) show that U.S. demand shocks (proxied by U.S. GDP) accounted for 16 percent of the variance of Latin American GDP growth in the period from 1994 through 2006.¹⁵ However, considering all types of external shocks together, their importance in Mexico seems to be similar to that in the rest of the region. While, as shown in Table 1, external shocks account for about 60 percent of output fluctuations in Mexico, these other studies find that external factors explain 57 percent in the case of Latin America.¹⁶

14. **Shocks to U.S. activity appear to have quite large, and rapid, effects on Mexican GDP.** Figure 1 shows the dynamic response of Mexico’s GDP growth to a one standard deviation positive shock to U.S. industrial production growth: output increases on impact, with a lasting effect of six quarters, and the largest response occurs only one quarter after the shock.¹⁷ A “rule of thumb” elasticity can be derived from the impulse response, which indicates that a 1 percentage point increase in U.S. industrial production growth leads to an

¹⁴ For a horizon of eight quarters, which is when the percentages stabilize.

¹⁵ Latin American growth is measured using a weighted index for Argentina, Brazil, Chile, Colombia, Mexico and Peru, which together represent about 90 percent of Latin American output.

¹⁶ Other studies have quantified the fraction of output fluctuations explained by external factors in different countries and regions. External shocks explain 11 percent of real output fluctuations in low-income countries, 27 percent in Brazil and 29 percent in Korea, 43 percent in Chile, 54 percent in the ECCU, and 72 percent in Canada, according to Raddatz (2006), Hoffmaister and Roldos (2001), Franken, Le Fort and Parrado (2005), Sosa (2007a), and Cushman and Zha (1997), respectively. This comparison should be considered only as suggestive or illustrative, since the econometric strategies and identification procedures used, the variables included, and time periods analyzed differ across studies.

¹⁷ A one-standard deviation shock to U.S. industrial production growth is equal to 0.51 percentage points.

increase in Mexican GDP growth of 0.9 percent after one quarter. The output response to shocks to the other variables in the model is shown in Table 2.¹⁸

15. **To check the robustness of the results, the VAR model is alternatively estimated using U.S. GDP and U.S. total imports as proxies for U.S. demand for Mexican exports, instead of U.S. industrial production.**¹⁹ The results do not change substantially, with U.S. GDP and imports accounting for 36 percent and 32 percent of business cycle fluctuations respectively (Tables 3 and 4). A positive (one standard deviation) shock to U.S. GDP (U.S. total imports) is also expansionary, with the largest effect occurring two (one) quarters after the shock (Figures 2 and 3).²⁰ The derived “rule of thumb” elasticities suggest that a one percentage point increase in U.S. GDP growth leads to an increase in Mexican GDP growth of 0.9 percentage points after two quarters, which implies that a positive innovation in U.S. growth is passed on to Mexico almost one-for-one.²¹ A one percentage point increase in U.S. imports growth, in turn, increases Mexico’s growth by 0.3 percentage points.

16. **The VAR model is also estimated using other variables to capture international financial conditions: the U.S. real interest rate, the VIX volatility index, and U.S. junk bond yields (as a proxy for global risk appetite).**²² The role played by external factors in explaining Mexican output fluctuations does not change dramatically, with a somewhat higher fraction explained by U.S. growth and smaller fractions by each of the alternative financial variables, compared with the specification using world real interest rates (Tables 5, 6, and 7). The dynamic response of Mexican output to a (one standard deviation) U.S. growth shock is fairly similar under these alternative specifications, with the “rule of thumb” elasticities ranging from 0.75 to 0.9.

17. **The key role played by U.S. demand shocks is a phenomenon observed mainly in the post-NAFTA period.** In fact, if we consider a longer period, starting at 1980 instead of 1995, changes in U.S. industrial production account for less than 5 percent of output

¹⁸ It may be argued that other domestic factors—especially public expenditure—might also play a role in driving output fluctuations in Mexico. Hence, in an alternative version of the model, the VAR is estimated including government consumption in the domestic block. The results do not change substantially. In particular, the percentage of Mexican output fluctuations explained by U.S. real shocks, as well as the dynamic response of Mexican GDP to a shock to U.S. industrial production do not vary significantly. Moreover, the relative importance of government consumption in explaining business cycle fluctuations is very small in Mexico, and the dynamic response of Mexican output to a shock to public expenditure is not statistically significant.

¹⁹ The data used are U.S. real GDP (saar, in billions of chained 2000 dollars), and U.S. real imports of goods and services (from National Accounts, saar, in billions of chained 2000 dollars).

²⁰ A one-standard deviation shock amounts to 0.4 percentage points in the case of U.S. GDP growth and to 1.3 percentage points in the case of U.S. imports.

²¹ Osterholm and Zettelmeyer (2007), and IMF (2007) find that the average reaction of Latin American growth to a shock in U.S. growth is also about one-for-one.

²² The data used are the 3-months T-bill rate deflated by the U.S. CPI, the S&P 500 based VIX index, and the junk bonds yields from S&P.

fluctuations in Mexico, and the impact of a (one standard deviation) shock to U.S. demand is also smaller (Table 8 and Figure 4).²³ These differing results can be explained mainly by the greater importance of idiosyncratic shocks in the pre-NAFTA period, in particular in the economic and financial crisis episodes in Mexico, and probably also reflect the lesser degree of trade integration with the U.S. before NAFTA. In fact, over the last decade, Mexico's output fluctuations have been of the "normal business cycle" variety, and closely synchronized with that of the U.S.²⁴

C. Capturing U.S. Demand Linkages to Mexico: Which U.S. Variables Help Explain Fluctuations in Mexican Economic Activity?

18. **Two exercises are performed to address this question, focusing on the post-NAFTA period.** First, variance decomposition analysis from a number of simple bivariate VARs is conducted, to determine what fraction of the fluctuations in Mexican activity is explained by changes in the corresponding U.S. variable.²⁵ Second, the synchronization between the Mexican and U.S. economic variables is examined. Both exercises are conducted with the aim of explaining not only GDP but also export fluctuations in Mexico in the post-NAFTA period.²⁶

Bivariate VARs: variance decomposition analysis

19. **As in the case of the multivariate VARs examined in the previous section, U.S. industrial production, GDP and total imports each can explain a large share of output fluctuations in Mexico, accounting for 47, 48, and 34 percent respectively** (Table 10). In regard to components of U.S. industrial production, durable manufacturing appears to play a larger role than non-durable manufacturing. In terms of U.S. domestic demand, private investment can explain a larger fraction than private consumption. Auto sales in the U.S., in turn, can explain about 25 percent of output fluctuations in Mexico (Table 10).

20. **The analogous exercise was also used to explain fluctuations in Mexican exports: it turns out that U.S. industrial production—in particular durable goods manufacturing—as well as U.S. GDP and total imports can also explain a large fraction**

²³ A one-standard deviation shock to U.S. industrial production is equal to 0.65 percentage points.

²⁴ The output response to shocks to the other variables for the longer period is shown in Table 9. The size of the shocks—in particular idiosyncratic shocks—appears to be larger in the pre-NAFTA period. Moreover, the Mexican economy in general seems to be more resilient to shocks in the post-NAFTA period (except in the case of U.S. demand shocks).

²⁵ The bivariate VAR models allow for 4 lags, and are estimated in first differences using quarterly data. Standard Choleski decomposition is used, and the ordering is such that the U.S. variable precedes the Mexican variable.

²⁶ The exports time series used is the U.S. real exports of goods and services (from National Accounts, saar, in billions of chained 2000 dollars).

of fluctuations in Mexican exports (Table 11). Other U.S. variables with important explanatory power are private investment and auto sales.

Synchronization between the U.S. and Mexican economies

21. **The important role played by U.S. factors in determining output (and export) fluctuations in Mexico after NAFTA is consistent with the higher synchronization between the U.S. and Mexican business cycles during that period, a phenomenon that has been documented in the previous literature.**²⁷ Here, we use simple time-series charts and cross-correlograms to illustrate this synchronization, and to confirm that it continues in the most recent years (using data through mid-2007).

22. **Figure 5 illustrates the striking co-movement between Mexican output and a number of U.S. variables during the period 1996Q1–2007Q2.** Even in a sample span of less than 12 years, there are enough fluctuations in the data to make readily apparent a tight relationship. Of particular interest is the close alignment of turning points. This alignment is observed not only during the sample's dominant event (the 2001–02 recession-recovery) but also during the several fluctuations during 2004 to mid-2007. The high positive correlation between these variables can also be observed in the cross-correlograms in Table 12. The correlation coefficient with Mexican GDP is higher than 0.8 for U.S. industrial production (and the sub-component durable manufacturing), GDP, and imports. For all these variables the highest coefficient corresponds to the contemporaneous correlation (except in the case of GDP, with U.S. output leading Mexican output by one quarter).

23. **Figure 6 and Table 13 show the high synchronization between Mexican exports and the different U.S. variables.** The co-movement—as in the case of Mexican GDP—is striking, and turning points also appear to be closely aligned. The cross-correlogram, in turn, shows that the highest correlation coefficients are those corresponding to U.S. imports, industrial production—especially the category durable manufacturing—and GDP, and in all these cases the contemporaneous coefficients appear to be the highest (except in the case of U.S. GDP, which appears to lead Mexican output by one quarter).

24. **As noted earlier, U.S. output variables—industrial production and GDP—appear more important for Mexican output than indicators of U.S. demand.** This fact probably reflects the extent to which Mexico's exports consist of intermediate goods used as inputs in U.S. production, rather than final goods.

²⁷ See, for instance, Torres and Vela (2003), Cuevas, Messmacher and Werner (2003), and Chiquiar and Ramos-Francia (2004).

D. U.S. Shocks and Business Cycle Fluctuations in Mexico: Potential Spillovers and Channels of Transmission

25. **The apparently strong influence of fluctuations in U.S. real variables on Mexico's output fluctuations is particularly interesting given the still relatively low share of exports in Mexico's output.** Certainly, external trade is important to Mexico: total exports have grown to roughly 30 percent of GDP, of which about 25 percent of GDP goes to the U.S. However, value added from the export sector must be significantly less than these numbers, in light of the very high import content of many exports, particularly those of the maquila sector.

26. **In this context, the structure of production and specialization patterns induced by trade integration may help explain how trade shocks could be amplified.**²⁸ As emphasized above, U.S. output variables—industrial production and GDP—appear to be more relevant for Mexican output than U.S. demand indicators, probably reflecting the extent to which Mexico's exports consist of intermediate goods used as inputs in U.S. production, rather than final goods. Indeed, the importance of intra-industry trade in transmitting U.S. shocks to Mexico has been highlighted in the literature. Chiquiar and Ramos-Francia (2004) argue that the increased synchronization of Mexico and U.S. business cycles is driven not only by the transmission of demand shocks, but also by supply-side links derived from production-sharing schemes induced by NAFTA. Bergin, Feenstra, and Hanson (2006) emphasize a key stylized fact: maquiladora “outsourcing” industries in Mexico experience fluctuations in value added that are roughly *twice* those of the corresponding industries in the U.S. Those authors then develop two theoretical models of outsourcing to explain how domestic demand shocks in the U.S. are transmitted in such an amplified manner to Mexican outsourcing industries.

27. **Interestingly, production of the services sector—accounting for about 65 percent of GDP in Mexico, and in principle not strongly dependent on external markets—is also highly correlated with U.S. economic activity.** Figure 7 and the cross-correlogram in Table 14 illustrate the high degree of co-movement between output in the services sector in Mexico and U.S. GDP, industrial production, and total imports.

²⁸ In theory, an increase in bilateral trade flows could lead to either higher or smaller business cycle synchronization between the trading partners. Most obviously, trade integration would strengthen the propagation of shocks in case demand shocks are dominant, especially through the effects on import demand. This effect could be either amplified or weakened depending on the production structure and specialization patterns induced by trade integration. On the one hand, if specialization leads to more inter-industry trade and shocks are mainly sector-specific, the net effect of increased trade on output co-movement could become even negative. If, on the other hand, trade is mostly intra-industry, we should expect a higher synchronization of output, induced by the “back and forth” trade. See Frankel and Rose (1998), and Kose and Yi (2001).

Explaining Services Sector GDP, with Unrestricted VAR Models

28. **In order to shed light on the existence of potential spillovers from the export sector to the rest of the Mexican economy, an unrestricted VAR model is estimated, which includes U.S. industrial production, as well as Mexican exports and the services sector component of Mexican GDP.**²⁹ Variance decomposition analysis shows that 27 percent of output fluctuations in the services sector is explained by innovations in U.S. industrial production (Table 15). Taken together, U.S. industrial production and Mexican exports account for about 40 percent of the variation in services output.

29. **Effects on the services sector seem to happen fairly quickly.** Figure 8 shows the dynamic response of services output to a (one standard deviation) shock in U.S. industrial production. Growth in the services sector expands on impact, with a lasting effect of two years, with the peak occurring only one quarter after the shock.³⁰ Given the small direct exposure—through trade channels—of the services sector to the U.S. economy, these results suggest the existence of important spillovers or amplifier effects stemming from the export sector to the rest of the economy in Mexico.³¹

30. **This unrestricted VAR model is also estimated using U.S. GDP and U.S. imports instead of U.S. industrial production.** Variance decomposition analysis shows that 33 percent of output fluctuations in the services sector is explained by innovations to U.S. GDP (Table 16). Taken together, U.S. GDP and Mexican exports account for about 40 percent. The corresponding numbers in the specification using U.S. imports are 37 and 50 percent respectively (Table 17). The dynamic response of services output to a (one standard deviation) shock in U.S. GDP and in U.S. imports is illustrated in Figures 9 and 10.

Channels other than external trade?

31. **Of course, shocks originated in the U.S. economy can be transmitted to Mexico through other channels, in addition to the trade channels on which our discussion has**

²⁹ The unrestricted VAR model is estimated including 4 lags, in first differences, and using quarterly data. Standard Choleski decomposition is used, and the ordering is as follows: U.S. industrial production, Mexican total exports, and Mexican GDP in the services sector.

³⁰ The unrestricted VAR is also estimated including government expenditures in the model. Once again, the main results from the variance decomposition and impulse response functions do not change dramatically.

³¹ In order to provide some clues on which subcomponents of the services sector are driving these results, the correlation analysis as well as the unrestricted VAR were also undertaken using each of the four subcomponents of services GDP, instead of total GDP in services. The results suggest that the two categories most influenced by U.S. developments are “Trade, restaurants, and hotels”; and “Transport, storage and communication”. On the other hand, the category that appears to be least affected by U.S. growth shocks is “Finance, insurance, real estate, and business services”. Finally, the category “Community, social, and personal services” constitutes an intermediate case.

focused. Here, we note briefly three particular channels that might also be relevant (although empirical analysis of these potential channels is not part of this paper).

32. **One potential channel through which the Mexican economy can be affected by U.S. economic conditions is the large flow of remittances from the U.S. to Mexico.** It is thought that more than 10 million Mexican immigrants reside in the U.S., who sent about \$23 billion in 2006, an amount equivalent to 2.7 percent of GDP. The recent slowdown in remittances growth—remittances increased by only 1.6 percent in the first seven months of 2007 compared to the same period of 2006, down from an annual rate of 15 percent in 2006³²—is likely due in part to the recent U.S. economic deceleration, particularly in sectors such as construction that employ a large number of immigrants. However, the Mexican economy is far less vulnerable to a slowdown in remittances flows than other economies in the region (particularly in some countries in Central America and the Caribbean where remittances-to-GDP ratios are above 15 percent). In fact, if we assume that remittances remain flat in the last five months of 2007 compared to the flows in the same period of 2006, the magnitude of the slowdown for 2007—vis-à-vis a scenario where remittances increase at the same rate as in 2006—would equal US\$3.2 billion, about 0.35% of GDP. If this amount were to translate entirely into reduced domestic demand (i.e., making an extreme assumption that all remittances are spent fairly soon after they are received), the short-run effect on GDP would not be dramatic, but it could be non-negligible.

33. **Another potential propagation mechanism is the large flows of FDI flows coming into Mexico from its big neighbor.** In fact, FDI flows from the U.S. accounted for about 60 percent of FDI in Mexico since the inception of NAFTA. As noted by Calvo, Fernandez Arias, Reinhart, and Talvi (2001), FDI flows from the U.S. to Latin America are highly procyclical, contracting during downturns in the U.S. economy and increasing during expansions, leading to higher synchronization of business cycles in the region.

34. **Finally, an additional potential link between the U.S. and Mexican economies is given by the large presence of U.S. and other international banks in the Mexican banking system.** Foreign banks represent about 80 percent of the Mexican banking system, in principle creating a channel through which changes in financial conditions in the U.S. or other mature markets could influence financial and real developments in Mexico.

E. Concluding Remarks

35. **The recent slowdown of the U.S. economy has strengthened interest in a key question: how do changes in U.S. economic conditions tend to affect the business cycle in Mexico?** The main results of this paper confirm that shocks to U.S. real variables—such as U.S. industrial production—can explain a large share of fluctuations in Mexico’s output

³² According to data from Bank of Mexico.

and exports, constituting the largest foreign source of macroeconomic fluctuations in Mexico. The relative importance of U.S. influences has been higher in the post-NAFTA period, partly reflecting greater trade integration—but also Mexico’s own “Great Moderation,” as the country escaped its former pattern of macro-financial crises. In the last decade, Mexico’s output fluctuations have been of the “normal business cycle” variety, and moreover closely synchronized with that of the U.S.

36. **It is significant that the most important U.S. variables for Mexico relate to U.S. output rather than to U.S. domestic demand.** This finding likely reflects the extent to which Mexico’s exports are inputs to U.S. production, rather than satisfying final demand—a trade pattern that would work to Mexico’s advantage if the large U.S. current account deficit were to contract abruptly (i.e., with U.S. domestic demand being affected much more than U.S. output).

37. **Since Mexico’s export/GDP ratio is not particularly high, the apparently large effect of U.S. factors on Mexican output evidently goes much beyond a direct effect on exports.** Even services—a sector not so directly dependent on foreign markets—seem to have been strongly influenced by developments in the U.S. economy, suggesting the existence of important spillovers or amplifier effects from the export sector to the rest of the economy. A deeper understanding of these spillover effects, as well as a quantitative assessment of other potential channels of transmission of shocks stemming from the U.S.—some of which were discussed in this paper—would be useful. Finally, the effects of U.S. shocks may themselves be subject to structural change; for example, as the composition of Mexico’s exports evolves. It is also possible that the multiplier effects that occurred in the past may become less relevant as the Mexican economy develops—in particular, with today’s greater confidence in the macroeconomic policy framework, and consumers now gaining access to credit, domestic demand may be more resilient than in the past.

Appendix: Econometric Approach

Specification and identification strategy

The empirical approach to examine the sources of business cycle fluctuations in Mexico is a standard **VAR model with block exogeneity restrictions**. The structural model can be expressed –omitting the constant terms for simplicity– as:

$$A(L)y_t = \gamma_t$$

where y_t is an n vector of variables, $A(L)$ denotes a lag polynomial matrix, and γ_t is an n vector of structural disturbances or shocks. A_0 , which represents the contemporaneous relationships between the variables of the model, is a non-singular matrix normalized to have ones on the diagonal.

The reduced form corresponding to this structural model can be written as:

$$B(L)y_t = u_t$$

where $B(L)$ is a lag polynomial matrix such that $B(L) = (A_0)^{-1}A(L)$ and $B_0 = I$, and u_t is an n vector of mean zero reduced form disturbances with covariance matrix Γ , such that $u_t = (A_0)^{-1}\gamma_t$.

In order to identify the structural parameters, a set of restrictions must be specified. Following Sims (1980), the reduced form errors are orthogonalized by Choleski decomposition. The selected Choleski ordering is characterized by the idea that the external variables of the model precede the Mexican domestic economic variables. This ordering implies that foreign variables do not instantly respond to Mexican domestic variables, but the domestic variables may be affected by contemporaneous changes in external conditions.

It is worth noting, however, that the restrictions implied by such ordering refer only to the contemporaneous relationships between the variables of the model. To assume complete exogeneity of the foreign variables, lagged values of the domestic variables should not affect them either. This is achieved by imposing block exogeneity restrictions. Hence, the model is separated in two blocks of equations: one external block and one domestic economy block. The domestic economic variables are completely absent from equations in the external block, meaning that shocks to domestic variables cannot affect, neither contemporaneously nor with any lags, the external variables.

The block exogeneity approach implies that some of the VAR equations have regressors not included in others. This type of model is known as “near-VAR” in the literature. The block exogeneity procedure reduces the number of parameters to be estimated, which helps to limit the erosion of degrees of freedom and to improve the efficiency of the estimation.

Block structure, variables, and data

The model contains six variables and equations arranged into two blocks—one external and one domestic block. Critical external factors for Mexico include terms of trade, global financial conditions, and external demand. Hence, the external block of the model includes oil prices, world real interest rates, and indicators of U.S. demand for Mexican exports as proxies for these factors³³. The domestic block, in turn, includes real output—the variable of main interest, as well as the real exchange rate—which plays a key role in macroeconomic adjustment to external shocks, and capital inflows—a variable highly correlated with the business cycle in some emerging market economies, and which the literature has mentioned as an important driver of output fluctuations in those countries.

The model is estimated using quarterly data from 1995 (or 1980 when analyzing a longer period) through 2007Q2. All the variables—except the world real interest rate and capital flows—are expressed in log levels, and the model is estimated in first differences³⁴. The data sources are International Financial Statistics (IMF), Bank of Mexico, and Haver Analytics.

Estimation issues

Standard VAR models may be estimated by Ordinary Least Squares (OLS). However, as noted before, the model developed in this paper is a near-VAR: given the block exogeneity restrictions, not all the equations include the same regressors. When some of the equations in a VAR present regressors not included in others, Seemingly Unrelated Regressions (SUR) provide more efficient estimates of the coefficients than OLS. The efficiency gains are larger the higher the correlation of the residuals across equations. Therefore, the system is estimated using SUR rather than OLS.

The specification of the estimated equations follows from the block exogeneity restrictions mentioned earlier. The model is estimated with four lags—the lag length being selected according to the Akaike Information Criterion (AIC).

³³ Industrial production, as well as GDP and total imports, are used as measures of demand from the U.S. Alternative specifications in section II use the U.S. real interest rate, the VIX volatility index, and U.S. junk bond yields (as a proxy for global risk appetite) to capture international financial conditions. All data used is described in section II.

³⁴ Standard unit root tests (augmented Dickey-Fuller) show that all the variables are stationary in first differences. In addition, cointegration tests (with some exceptions) suggest that the variables in the model are not cointegrated (i.e., the null hypothesis of no cointegration cannot be rejected). Hence, it is adequate to estimate the model in first differences. It is worth noting that previous studies (for instance, Chiquiar and Ramos-Francia, 2004) have found a cointegration relationship between Mexican and U.S. manufacturing output in the post-NAFTA period.

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Table 1. Variance Decomposition of Mexican Real Output: post-NAFTA period
(in percent)

Horizon	Standard Error	Oil price	World real interest rate	US industrial production	Capital inflows	REER	Real GDP 1/	External shocks	Idiosyncratic shocks
1	0.0045	4.35	0.00	5.01	6.79	3.33	80.53	9.36	90.65
4	0.0080	5.91	13.58	35.98	8.25	6.16	30.12	55.47	44.53
8	0.0087	7.05	14.51	37.52	7.22	6.44	27.27	59.07	40.93
12	0.0089	7.42	17.05	36.22	6.98	6.25	26.08	60.69	39.31

1/ This column indicates the proportion of fluctuations in real GDP explained by its "own" shocks.

Table 2. Size of the Shocks and Output Response in Mexico: Post NAFTA
(one standard deviation shock)

type of shock	size of shock	peak quarter (after the shock)	GDP response (at peak)
Oil price	0.104	3	0.0017
World real interest rate	0.386	8	-0.0012
U.S. industrial production	0.005	1	0.0046
Capital inflows	192.4	1	0.0012
REER	0.035	1	-0.0017

Table 3. Variance Decomposition of Mexican Real Output: post-NAFTA period
(in percent, using U.S. GDP as a proxy for U.S. demand)

Horizon	Standard Error	Oil price	World real interest rate	U.S. GDP	Capital inflows	REER	Real GDP 1/	External shocks	Idiosyncratic shocks
1	0.0046	10.13	9.02	22.00	13.08	0.12	45.66	41.14	58.86
4	0.0076	5.28	21.13	26.41	17.71	5.26	24.22	52.82	47.18
8	0.0084	4.79	18.97	36.05	14.86	4.54	20.79	59.81	40.19
12	0.0087	6.14	20.54	34.77	14.33	4.47	19.74	61.45	38.55

1/ This column indicates the proportion of fluctuations in real GDP explained by its "own" shocks.

Table 4. Variance Decomposition of Mexican Real Output: post-NAFTA period
(in percent, using U.S. total imports as a proxy for U.S. demand)

Horizon	Standard Error	Oil price	World real interest rate	U.S. total imports	Capital inflows	REER	Real GDP 1/	External shocks	Idiosyncratic shocks
1	0.0054	0.02	9.87	25.88	9.33	0.10	54.81	35.77	64.23
4	0.0086	5.92	18.16	34.73	11.01	6.33	23.84	58.82	41.18
8	0.0093	6.37	19.37	32.35	12.65	5.92	23.35	58.08	41.92
12	0.0095	7.93	18.87	32.34	12.41	5.76	22.69	59.14	40.86

1/ This column indicates the proportion of fluctuations in real GDP explained by its "own" shocks.

Table 5. Variance Decomposition of Mexican Real Output: post-NAFTA period
(in percent, using U.S. real interest rate as a proxy for international financial conditions)

Horizon	Standard Error	Oil price	U.S. real interest rate	U.S. GDP	Capital inflows	REER	Real GDP 1/	External shocks	Idiosyncratic shocks
1	0.0045	3.23	16.30	20.46	9.79	0.01	50.22	39.98	60.02
4	0.0076	3.07	13.36	38.62	12.67	5.63	26.66	55.05	44.95
8	0.0082	4.03	11.63	42.58	12.01	4.84	24.93	58.23	41.77
12	0.0085	6.16	12.20	40.82	11.70	5.17	23.95	59.18	40.82

1/ This column indicates the proportion of fluctuations in real GDP explained by its "own" shocks.

Table 6. Variance Decomposition of Mexican Real Output: post-NAFTA period
(in percent, using VIX volatility index as a proxy for international financial conditions)

Horizon	Standard Error	Oil price	U.S. GDP	VIX volatility index	Capital inflows	REER	Real GDP 1/	External shocks	Idiosyncratic shocks
1	0.0046	13.46	20.17	1.55	14.42	1.17	49.23	35.18	64.82
4	0.0076	7.61	42.16	4.08	16.34	5.95	23.85	53.85	46.15
8	0.0083	7.96	44.22	7.46	14.09	5.21	21.07	59.64	40.36
12	0.0084	9.61	42.78	7.80	14.07	5.32	20.43	60.19	39.81

1/ This column indicates the proportion of fluctuations in real GDP explained by its "own" shocks.

Table 7. Variance Decomposition of Mexican Real Output: post-NAFTA period
(in percent, using junk bond yields as a proxy for international financial conditions)

Horizon	Standard Error	Oil price	U.S. GDP	Junk bond yields	Capital inflows	REER	Real GDP 1/	External shocks	Idiosyncratic shocks
1	0.0037	0.06	25.17	3.69	0.94	1.74	68.40	28.92	71.08
4	0.0070	4.30	44.01	8.72	9.84	3.43	29.71	57.03	42.97
8	0.0080	6.19	44.44	9.99	11.77	3.54	24.09	60.61	39.39
12	0.0088	11.44	39.74	12.47	12.47	3.23	20.66	63.64	36.36

1/ This column indicates the proportion of fluctuations in real GDP explained by its "own" shocks.

Table 8. Variance Decomposition of Mexican Real Output: 1980Q1-2007Q2
(in percent)

Horizon	Standard Error	Oil price	World real interest rate	US industrial production	Capital inflows	REER	Real GDP 1/	External shocks	Idiosyncratic shocks
1	0.0096	6.88	0.33	0.57	1.30	1.66	89.26	7.78	92.22
4	0.0131	11.09	3.57	0.75	19.74	11.40	53.46	15.41	84.60
8	0.0138	11.87	5.87	2.57	19.95	11.01	48.74	20.30	79.70
12	0.0138	11.99	5.95	2.64	19.93	11.04	48.45	20.58	79.42

1/ This column indicates the proportion of fluctuations in real GDP explained by its "own" shocks.

Table 9. Size of the Shocks and Output Response in Mexico: 1980:1-2007:2
(one standard deviation shock)

type of shock	size of shock	peak quarter (after the shock)	GDP response (at peak)
Oil price	0.122	1	0.0026
World real interest rate	0.654	3	-0.0022
U.S. industrial production	0.006	4	0.0016
Capital inflows	445.7	1	0.0048
REER	0.055	1	-0.0041

Table 10. Mexican GDP and U.S. Variables: Bivariate VARs
(post-NAFTA period)

VAR's variables	Variance decomposition of Mexican output % explained by US variable
MEX GDP - US ind. prod.	
4 quarters	45.097
8 quarters	46.552
MEX GDP - US GDP	
4 quarters	46.865
8 quarters	48.335
MEX GDP - US IP durable manufacturing	
4 quarters	43.702
8 quarters	46.215
MEX GDP - US Imports	
4 quarters	33.965
8 quarters	34.277
MEX GDP - US IP non-durable manufacturing	
4 quarters	28.604
8 quarters	28.621
MEX GDP - US auto sales	
4 quarters	22.583
8 quarters	24.110
MEX GDP - US private investment	
4 quarters	21.602
8 quarters	33.763
MEX GDP - US imports, auto	
4 quarters	21.118
8 quarters	21.364
MEX GDP - US IP motor, vehicles and parts	
4 quarters	15.588
8 quarters	17.186
MEX GDP - US imports, ind. supplies and materials	
4 quarters	11.117
8 quarters	13.613
MEX GDP - US private consumption	
4 quarters	7.012
8 quarters	8.760

Table 11. Mexican Exports and U.S. Variables: Bivariate VARs
(post-NAFTA period)

VAR's variables	Variance decomposition of <u>Mexican exports</u> % explained by US variable
MEX exports - US IP durable manufacturing	
4 quarters	49.192
8 quarters	48.991
MEX exports - US GDP	
4 quarters	47.931
8 quarters	47.030
MEX exports - US Imports	
4 quarters	44.170
8 quarters	44.389
MEX exports - US ind. prod.	
4 quarters	41.677
8 quarters	42.235
MEX exports - US private investment	
4 quarters	36.348
8 quarters	36.053
MEX exports - US auto sales	
4 quarters	27.718
8 quarters	28.567
MEX exports - US IP motor, vehicles and parts	
4 quarters	23.894
8 quarters	27.096
MEX exports - US imports, auto	
4 quarters	22.164
8 quarters	23.398
MEX exports - US imports, ind. supplies and materials	
4 quarters	10.023
8 quarters	10.893
MEX exports - US IP non-durable manufacturing	
4 quarters	6.279
8 quarters	7.419
MEX exports - US non oil imports	
4 quarters	0.887
8 quarters	0.950
MEX exports - US private consumption	
4 quarters	0.474
8 quarters	2.000

**Table 12. Cross Correlations of Mexican GDP and U.S. Variables
(yoy percent change, post-Nafta period) 1/**

U.S variable	Cross correlations of Mexican real <i>GDP</i> in period <i>t</i> and U.S. variable in period								
	<i>t-4</i>	<i>t-3</i>	<i>t-2</i>	<i>t-1</i>	<i>t</i>	<i>t+1</i>	<i>t+2</i>	<i>t+3</i>	<i>t+4</i>
Industrial production	0.36	0.50	0.66	0.80	0.86	0.78	0.58	0.36	0.15
I.P: durable manuf.	0.41	0.53	0.69	0.81	0.85	0.76	0.58	0.40	0.22
GDP	0.45	0.61	0.75	0.81	0.80	0.63	0.45	0.27	0.15
Total imports	0.19	0.35	0.55	0.73	0.84	0.78	0.56	0.30	0.06
Private investment	0.47	0.55	0.64	0.71	0.71	0.66	0.58	0.46	0.31
I.P.: non-durable manuf.	0.20	0.32	0.46	0.57	0.63	0.51	0.26	0.00	-0.22
US imports: ind. supplies	-0.09	0.05	0.22	0.35	0.42	0.34	0.11	-0.17	-0.40
US imports: auto	0.35	0.45	0.49	0.46	0.41	0.21	-0.01	-0.11	-0.13
I.P.: motor, vehicles and parts	0.38	0.45	0.43	0.32	0.20	-0.05	-0.23	-0.30	-0.31
Private consumption	-0.12	-0.05	0.05	0.09	0.12	0.07	-0.04	-0.13	-0.22
Auto and light truck sales	0.32	0.39	0.34	0.29	0.10	-0.06	-0.02	-0.02	0.04

1/ Numbers in bold correspond to the peak quarter.

**Table 13. Cross Correlations of Mexican Exports and U.S. Variables
(yoy percent change, post-NAFTA period) 1/**

U.S variable	Cross correlations of Mexican real exports in period t and U.S. variable in period								
	$t-4$	$t-3$	$t-2$	$t-1$	t	$t+1$	$t+2$	$t+3$	$t+4$
Total imports	0.14	0.25	0.45	0.69	0.82	0.74	0.54	0.29	0.07
I.P.: durable manuf.	0.35	0.45	0.62	0.76	0.81	0.73	0.55	0.36	0.22
Industrial production	0.34	0.43	0.60	0.72	0.78	0.72	0.53	0.33	0.18
GDP	0.36	0.52	0.70	0.78	0.77	0.62	0.44	0.33	0.21
Private investment	0.36	0.47	0.58	0.66	0.74	0.65	0.56	0.48	0.32
US imports: ind. supplies	-0.08	0.02	0.15	0.33	0.47	0.45	0.31	0.04	-0.25
US imports: auto	0.29	0.34	0.46	0.48	0.46	0.28	0.09	-0.02	-0.12
I.P.: non-durable manuf.	0.29	0.30	0.40	0.44	0.41	0.39	0.20	0.02	-0.07
Auto and light truck sales	0.24	0.38	0.43	0.31	0.27	0.08	-0.01	0.01	0.07
I.P.: motor, vehicles and parts	0.40	0.39	0.45	0.36	0.15	-0.07	-0.29	-0.34	-0.27
Private consumption	-0.16	-0.09	-0.04	0.06	0.14	0.21	0.21	0.09	-0.05

1/ Numbers in bold correspond to the peak quarter.

**Table 14. Cross Correlations of Mexican GDP (Services) and U.S. Variables
(yoy percent change, post-NAFTA period) 1/**

<u>U.S variable</u>	<u>Cross correlations of Mexican real GDP (Services) in period t and U.S. variable in period</u>									
	$t-4$	$t-3$	$t-2$	$t-1$	t	$t+1$	$t+2$	$t+3$	$t+4$	
Industrial production	0.30	0.44	0.60	0.73	0.75	0.60	0.37	0.10	-0.14	
GDP	0.44	0.59	0.71	0.72	0.67	0.43	0.21	0.03	-0.08	
Total imports	0.18	0.35	0.55	0.71	0.77	0.62	0.33	0.04	-0.19	

1/ Numbers in bold correspond to the peak quarter.

Table 15. Variance Decomposition of Mexico's Real Output in Services
(in percent, Post-NAFTA Period)

Horizon	Standard Error	U.S. industrial production	Mexican exports	Mexican GDP services 1/
1	0.0069	5.49	1.29	93.21
4	0.0086	25.78	13.90	60.32
8	0.0088	27.53	14.07	58.40

1/ This column indicates the proportion of fluctuations in real GDP (services) explained by its "own" shocks.

Table 16. Variance Decomposition of Mexico's Real Output in Services
(in percent, using U.S. GDP as a proxy for U.S. demand, Post-NAFTA Period)

Horizon	Standard Error	U.S. GDP	Mexican exports	Mexican GDP services 1/
1	0.0068	1.65	1.27	97.08
4	0.0086	29.50	8.60	61.90
8	0.0088	33.02	8.25	58.74

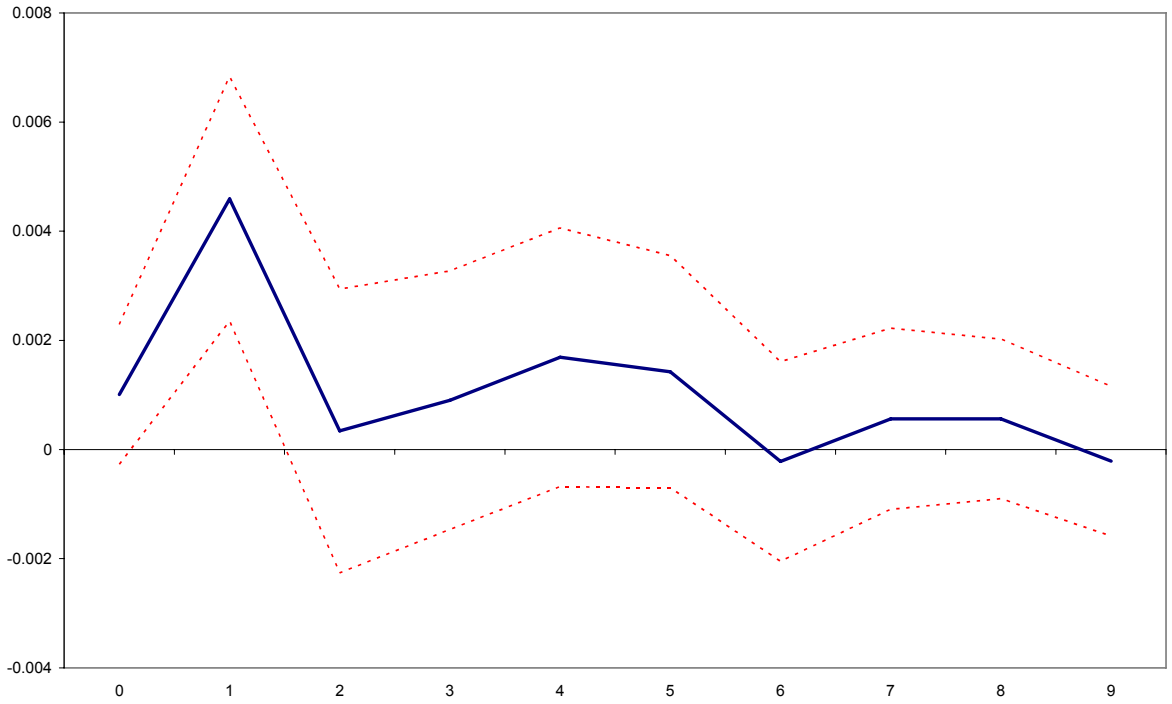
1/ This column indicates the proportion of fluctuations in real GDP (services) explained by its "own" shocks.

Table 17. Variance Decomposition of Mexico's Real Output in Services
(in percent, using U.S. imports as a proxy for U.S. demand, Post-NAFTA Period)

Horizon	Standard Error	U.S. imports	Mexican exports	Mexican GDP services 1/
1	0.0074	30.84	0.01	69.15
4	0.0087	37.23	11.14	51.63
8	0.0088	37.20	12.46	50.34

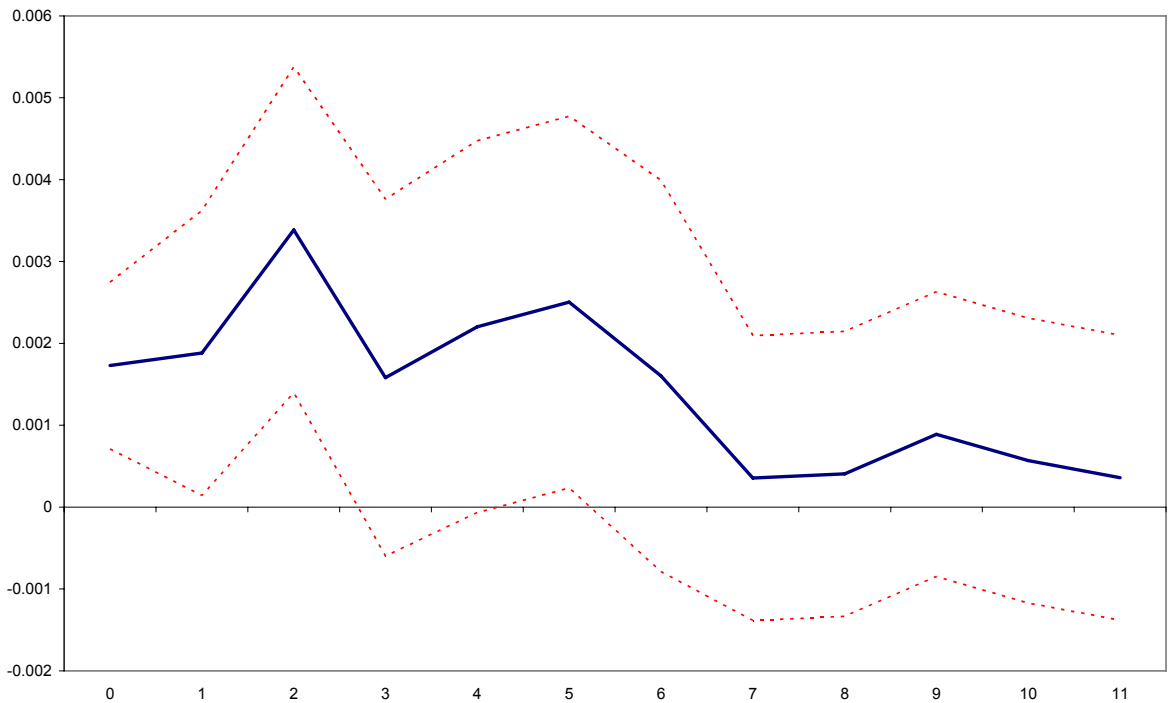
1/ This column indicates the proportion of fluctuations in real GDP (services) explained by its "own" shocks.

Figure 1. Response of Real Output to a U.S. Industrial Production Shock 1/



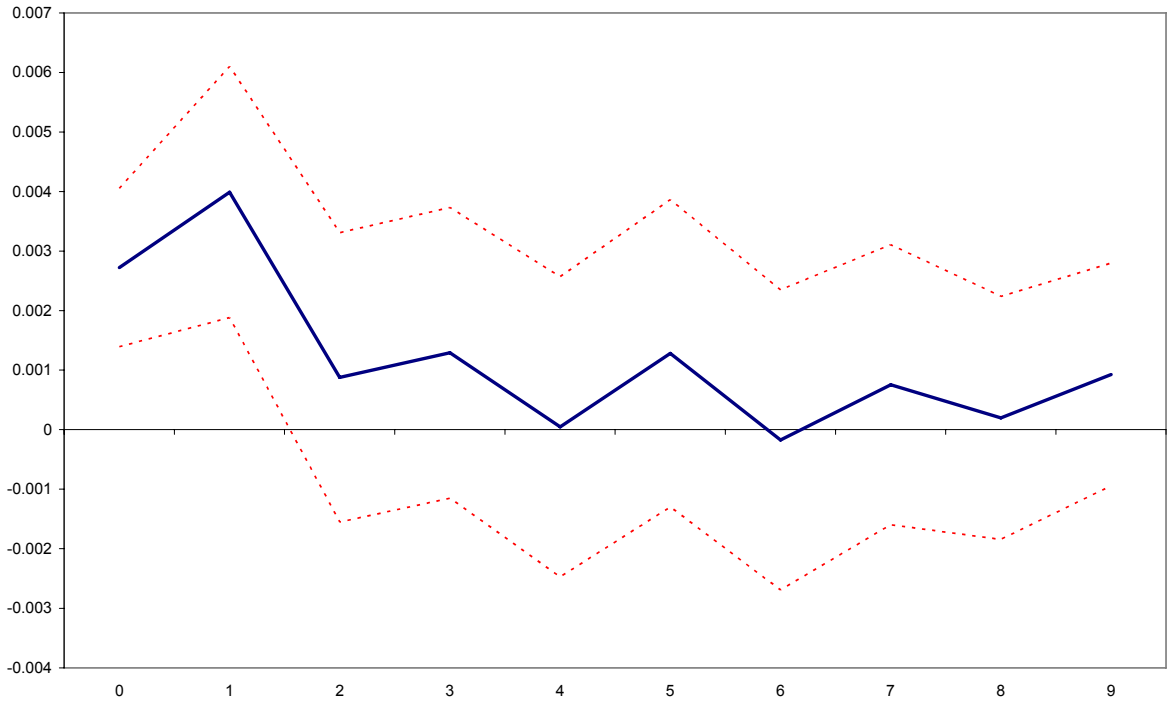
1/ Response to one standard deviation shock to U.S. industrial production growth rate (0.51 percentage points) \pm 2 s.e.

Figure 2. Response of Real Output to a U.S. GDP Shock 1/



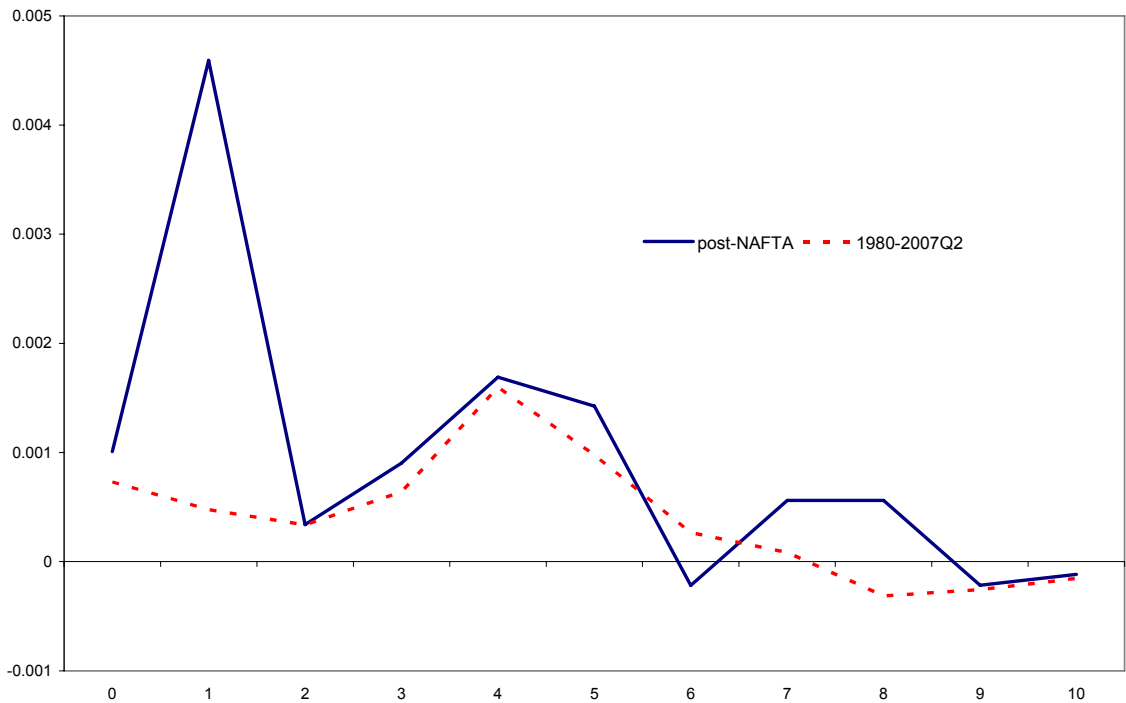
1/ Response to one standard deviation shock to U.S. GDP growth rate (0.4 percentage points) \pm 2 s.e.

Figure 3. Response of Real Output to a U.S. Imports Shock 1/



1/ Response to one standard deviation shock to U.S. imports growth rate (1.3 percentage points) + - 2 s.e.

Figure 4. Response of Real Output to a U.S. Demand Shock 1/



1/ One standard deviation shocks to U.S. industrial production growth rate (post-NAFTA: 0.51 percentage points; 1980-2007Q2=0.65 percentage

Figure 5. Synchronization Between Mexican GDP and U.S. Variables
(yoy % changes)

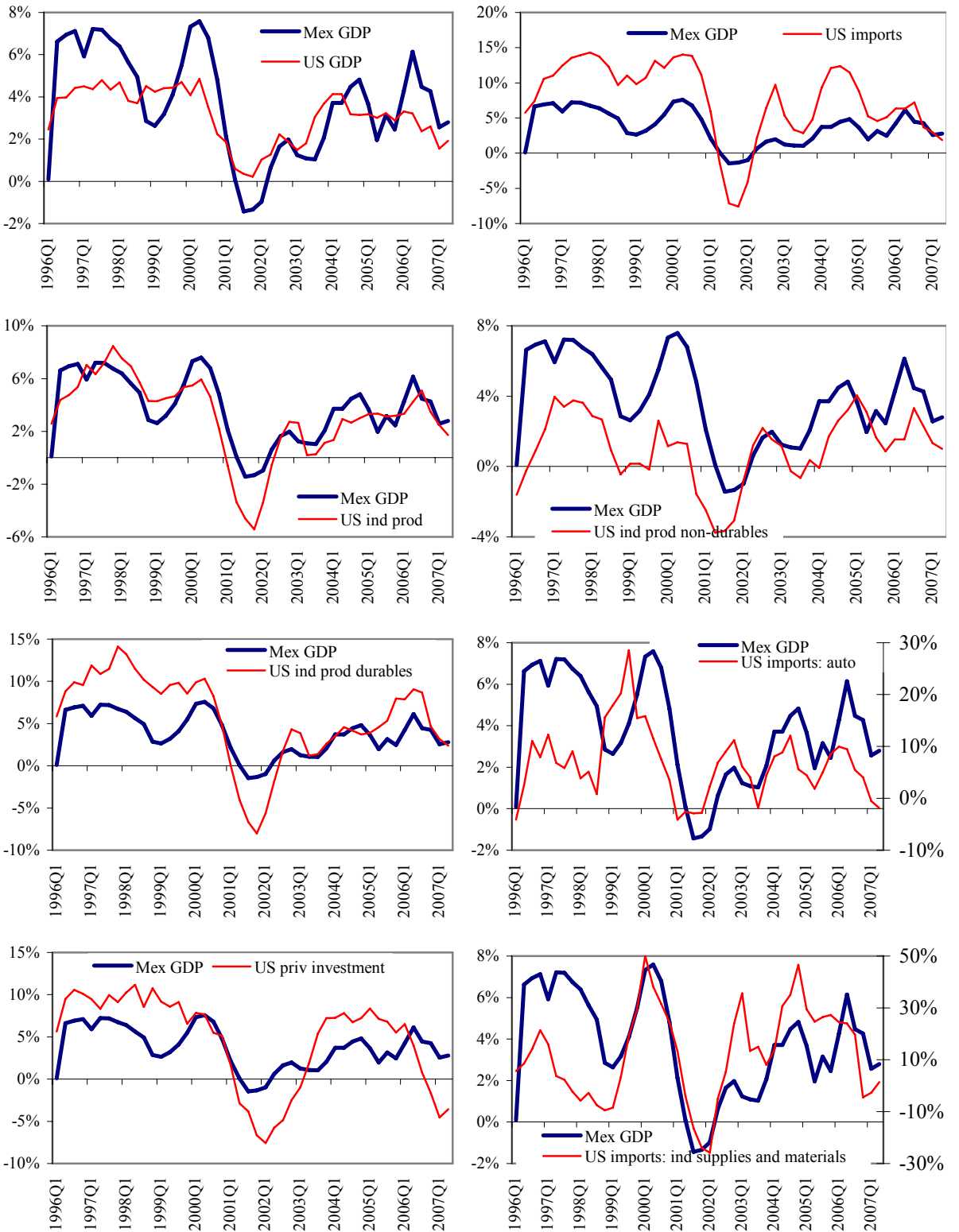


Figure 6. Synchronization Between Mexican Exports and U.S. Variables
(yoy % changes)

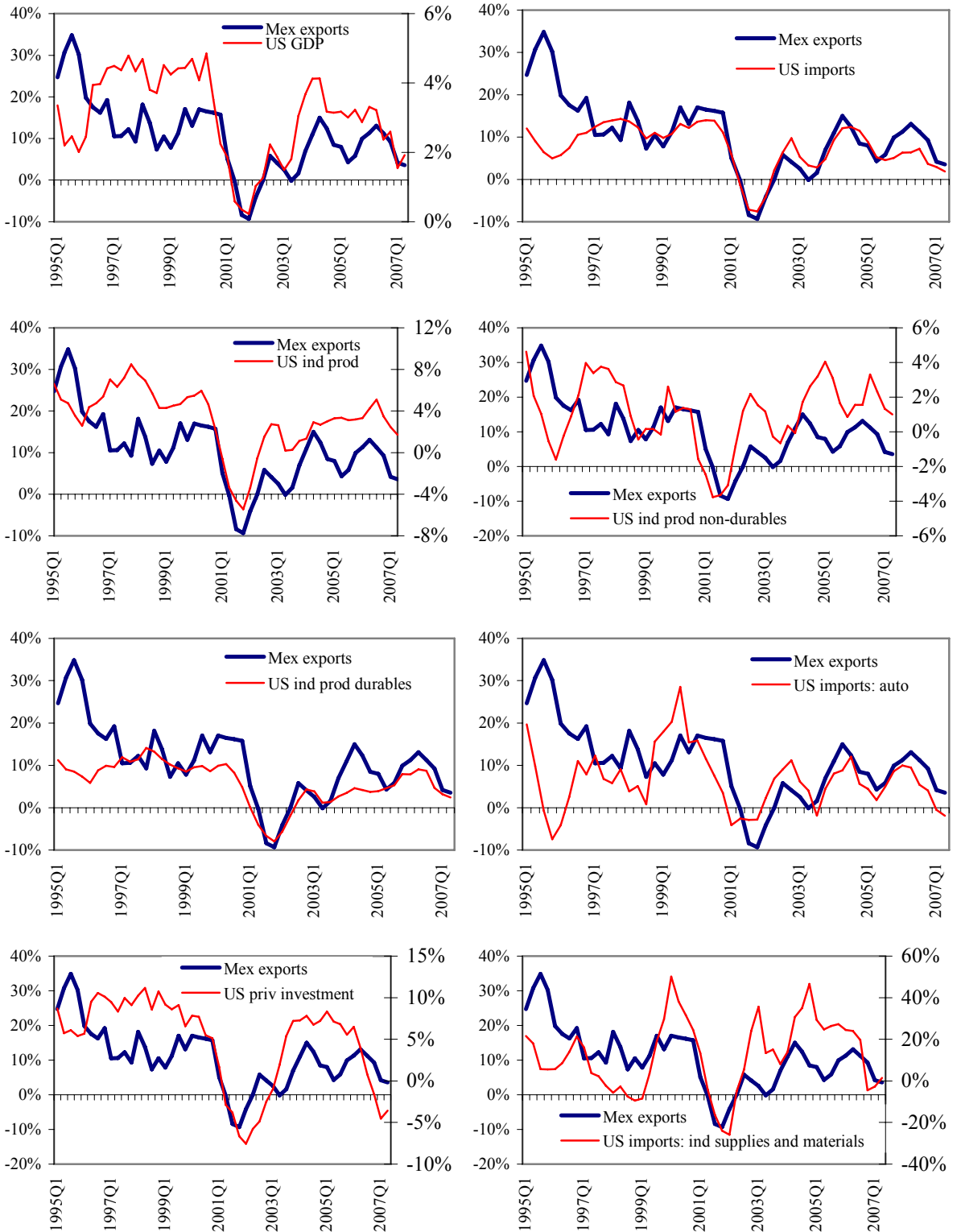


Figure 7. Synchronization Between Mexican GDP (Services) and U.S. Variables
(yoy % changes)

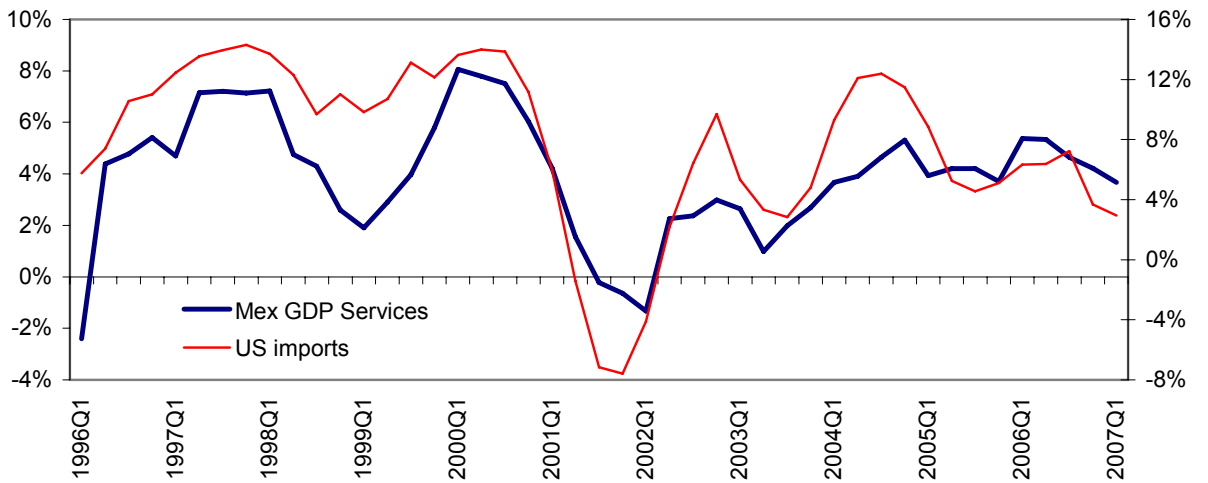
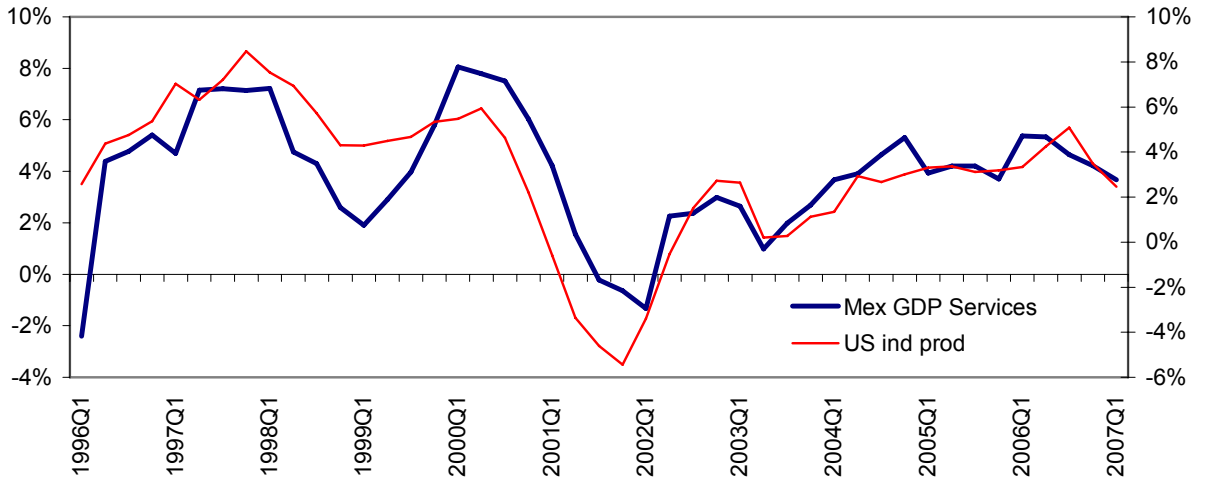
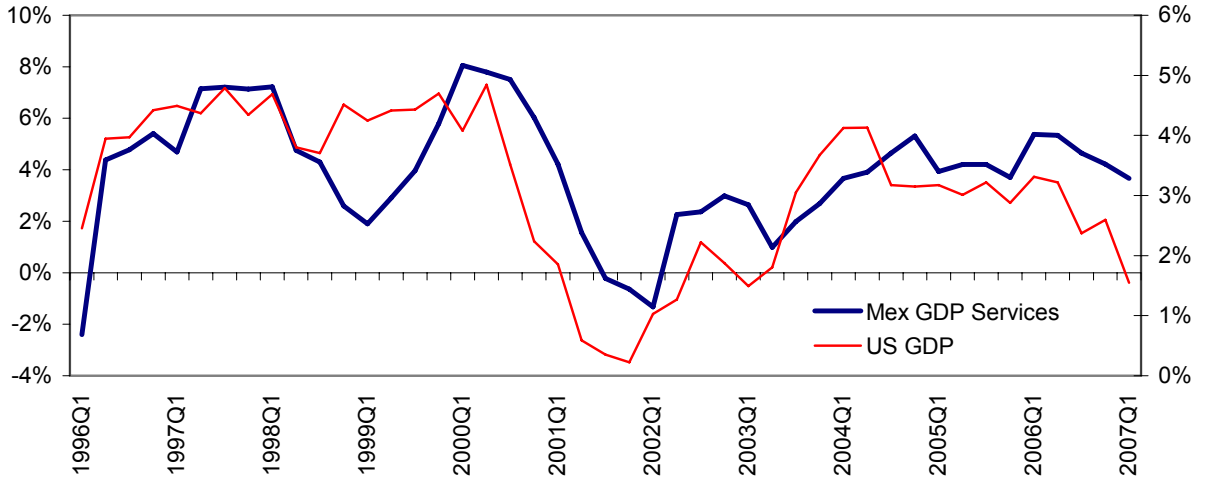
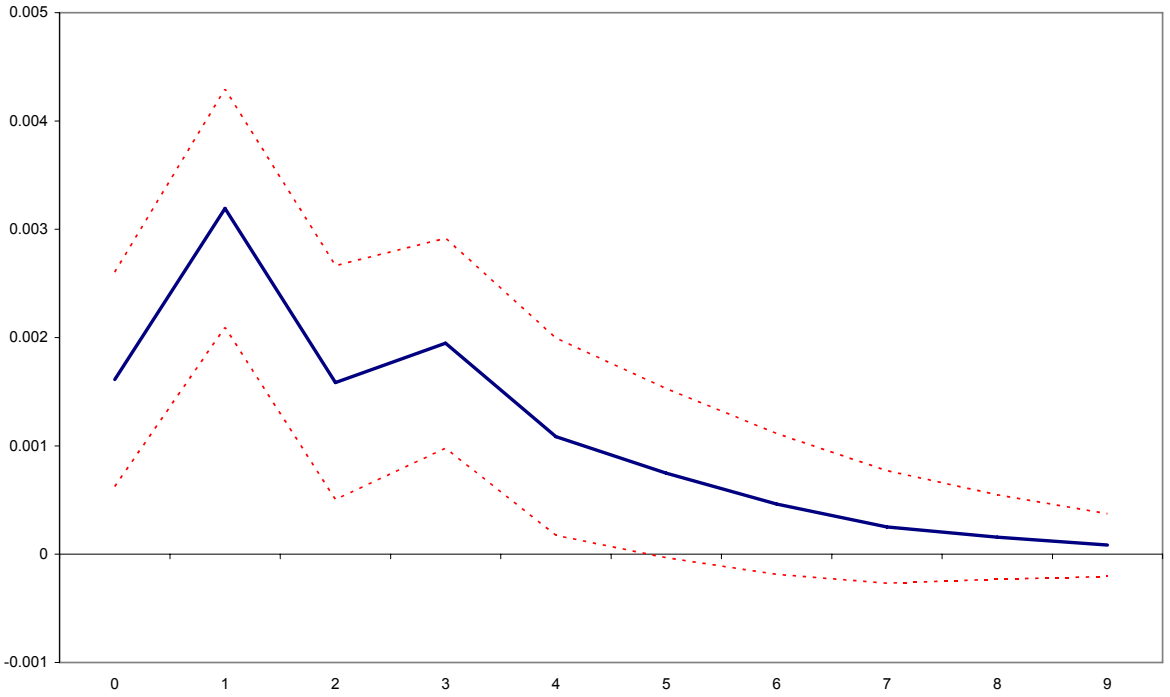
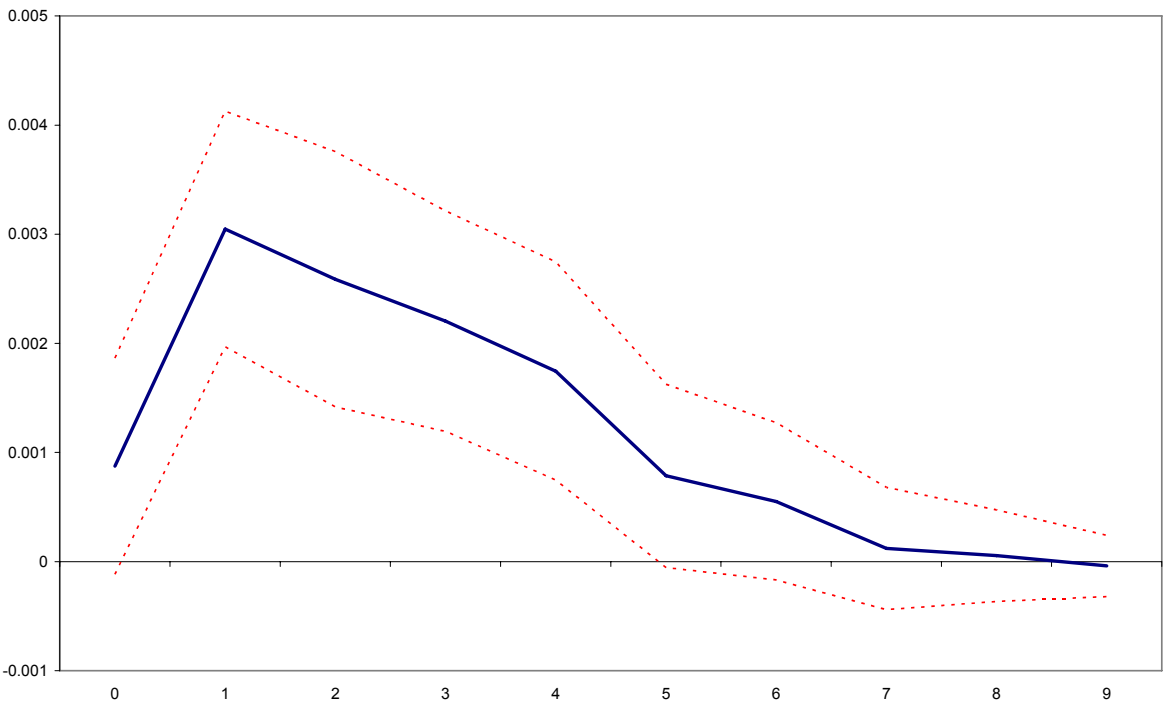


Figure 8. Response of Real Output in Services to a U.S. Industrial Production Shock 1/



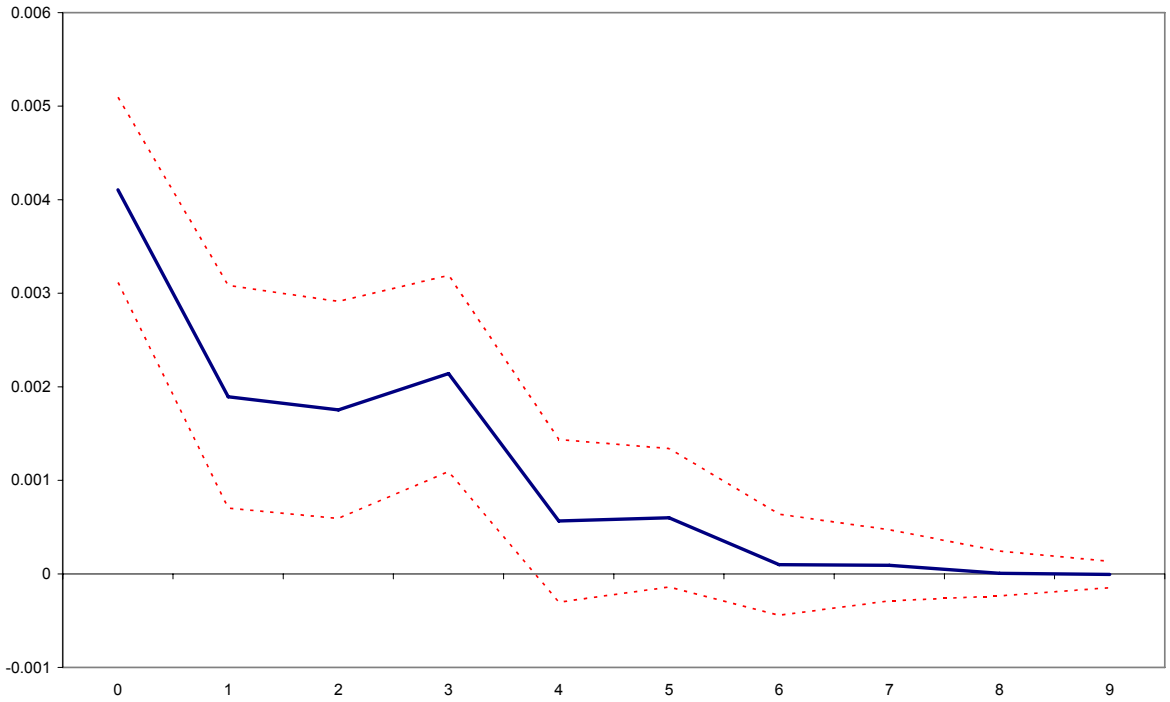
1/ Response to one standard deviation shock to U.S. industrial production growth rate (0.69 percentage points) \pm 2 s.e.

Figure 9. Response of Real Output in Services to a U.S. GDP Shock 1/



1/ Response to one standard deviation shock to U.S. GDP growth rate (0.46 percentage points) \pm 2 s.e.

Figure 10. Response of Real Output in Services to a U.S. Imports Shock 1/



1/ Response to one standard deviation shock to U.S. imports growth rate (1.6 percentage points) \pm 2 s.e.

II. THE MORTGAGE-BACKED SECURITIES MARKET IN MEXICO ¹

A. Introduction

1. **Widespread household access to home finance has long been a goal of governments in Mexico.** For generations, the Mexican approach focused primarily on redistributive schemes, implemented through state-sponsored housing funds, which were notorious for their inefficiency and poor governance. During the first part of the 1990s, the privatization of the banking sector led to very rapid growth in mortgage loans, but the sharp increase in interest rates following the 1994 Tequila crisis contributed to record defaults and the near-collapse of the banking sector, followed by a long period of retrenchment of lending. Since 2001, the Mexican authorities have focused on developing the framework and infrastructure to support primary and secondary mortgage markets; in contrast to previous initiatives, the new approach places emphasis on market mechanisms, such as partial guarantees to private non bank intermediaries, improvements in housing repossession procedures, and improvements in property registries. Both the primary and secondary mortgage markets have been developing in recent years, but remain work in progress as the government continues to adapt best international experiences to Mexican circumstances.

2. **This paper focuses on one aspect of the development of the Mexican private mortgage market, the market for mortgage-backed securities.** In general, mortgage securitization is a technique which allows mortgage banks to fund new loans while transferring market and credit risk from their balance sheets. In many instances securitization helps to reduce any term-mismatch between assets and liabilities. In a securitization operation, a mortgage originator sells its loans to an independent special purpose company or vehicle (SPE or SPV) which issues mortgage-backed bonds (MBSs) and uses the proceeds to pay the mortgage originator for the loans. The cash flow generated from the interest and principal re-payment of the loans is then used to service the bonds, while the mortgage collateral secures the bonds. (Box 1: Key Features of Securitization).

B. A Brief Overview of Housing Finance in Mexico

3. **The evolution of housing finance in Mexico can be broadly classified into three stages:**

- **Before the 1990s: focused on redistributive schemes and directed lending to support home ownership by low to moderate income households.** Initially, these schemes were administered by development banks; since the early 1970s, two

¹ Prepared by Luisa Zanforlin and Marco Espinosa. The authors thank David Robinson and Steve Phillips for useful comments and suggestions, and Claudia Pescetto for her able research assistance. Special thanks to Alan Elizondo and Oscar Grajales Herce in SHF for very informative and candid communications, and to staff of the Bank of Mexico and Hacienda for helpful comments and suggestions.

government sponsored housing funds, INFONAVIT (funded with a mandatory contribution of 5 percent of private sector employees' gross wages) and FOVISSTE (funded with mandatory contributions from government employees' gross wages) have played the leading role. Commercial bank lending for housing was limited, in part because banks had to comply with a requirement that 6 percent of their credit be directed to housing finance at fixed, capped nominal interest rates.

- 1990–2000: featuring a boom and bust of private mortgage lending followed by a prolonged period of retrenchment.** In the early 1990s, the re-privatization of the banking system, the launching of inflation-indexed mortgages, and a benign and liquid global financial environment facilitated a generalized boom in bank lending, including for real estate. Between 1989 and 1994, total bank credit to the private sector increased from close to 13 percent of GDP to more than 50 percent of GDP, while bank mortgage lending jumped from 1.3 percent of GDP to 2.4 percent of GDP (some 4.7 percent of total bank credit, compared with 10 percent in 1989). However, poor risk-management practices in the banking sector, combined with the sharp interest rate spike in the aftermath of the Tequila crisis—which caused rates on the widespread adjustable mortgages to rise to over 100 percent—triggered a wave of bank mortgage defaults and the near collapse of the banking system. Following the 1994 NAFTA negotiations, the government granted the first non-bank license to so-called Sofoles, non-deposit taking institutions which operated mainly with funds of FOVI—a public fund with the central bank—directed at providing housing financing for lower income families. While commercial banks were working-out bad loans and debt, they withdrew from mortgage lending, leaving INFONAVIT and the Sofoles as the main mortgage originators.
- 2000–2007: characterized by a gradual recovery of private mortgage lending.** A series of legal reforms were implemented, including improvements in housing repossession procedures and in property registries, coupled with the creation of Sociedad Hipotecaria Federal (SHF), a housing development bank set up to foster the development of private primary and secondary mortgage markets for low to middle income households. The SHF supported standardization of mortgage origination and underwriting criteria, while providing mortgage insurance and partial financial guarantees. Initially, SHF's mortgage lending was channeled through the Sofoles, and a primary mortgage market soon took off, displaying Mexico-specific characteristics such as the quoting of repayment in terms of minimum wages (VSMs²) and inflation-

² Veces Salario Mínimo or times minimum wage: effectively an index for wage levels which is adjusted once a year following contractual negotiations. For example, workers would be earning 1, 2 5 times the VSM and thus each increase in the VSM would translate in an equivalent wage increase. This wage structure applies predominantly to lower income wage earners.

indexed repayment (in terms of UDIs³). Soon after, commercial banks re-entered this market. Although inflation has been relatively low and stable in recent years, Sofoles continue to extend most of their lending in the inflation-indexed UDIs, but their peso lending is on the rise. Notably, in order to leave space for private sector involvement in the development of a secondary mortgage market, SHF's Organic Law established that direct financing to Sofoles would cease by 2009. Supported by SHF's guarantees, Sofoles gradually began to access capital market financing through direct debt placements and through the securitization of their portfolios, thus providing the impetus for the development of a secondary mortgage market.

Box 1. Key Features of Securitization

Mortgage securitization is a technique which allows mortgage issuers to gain fresh funding and to transfer market and credit risk imbedded in their existing loans. In a securitization operation, a mortgage originator sells its loan portfolio to an independent special purpose company or vehicle (SPE or SPV). The SPV's funding comes from its issues of securities to capital market investors. The cash flow generated from the interest and principal re-payment of the loans is used to service the securities backed by assets (ABS) or mortgages (MBSs).

There are a number of legal steps and infrastructure requirements for an efficient securitization of mortgages (see Lea et al 2004). First, the loans in the pool to be the securitized should have uniform characteristics, including terms of the loan, documentation, credit quality and performance history. Second, mortgage foreclosure procedures, which ensure protection of creditor rights, must be relatively speedy and of low cost to ensure high creditworthiness of the securities. In addition, mortgages must be fully transferable, as the SPV needs to acquire full rights over the receivables from the loans, and its claim on the collateral must be senior to any other claim. This is necessary to insure that the creditors of the originators banks will be voided from any claim on the collateral of the securitized loans in the event the originators enter into default. Also, the tax system must be designed so as to allow for the transfer of assets to be securitized without generating costs in the mere swap of funds entailed from the loan originator to the SPV issuer.

³ The UDI (Unidad de Inversion) is a unit of account, the value of which is updated daily and reflects the changes in the consumer price index. On the 10 and the 26 of each month the Bank of Mexico publishes the UDI's value for the next fifteen days. On the 10 and the 26th day of the month the change in UDI value will be equal to the change in the consumer price index in the previous 15 days of the month, the value for the days between the 10 and 26th will be computed by distributing the total increase in the CPI across the number of days in the period. The UDI had a value of 1 on April 4, 1995 (as of April 2007 approximately 3.85).

Box 1. Key Features of Securitization (continued)

The SPV must be an entity of “high credit quality”, and often times in the U.S. it is capitalized to ensure creditworthiness to the securitized issues and to be legally able to issue securities. The SPV in the U.S. would also perform high quality mortgage service, which in the U.S. is paid between 0.25 and 0.5 percent of the loan balance.

The pricing of MBS will have to reflect the historical patterns of re-payments and defaults in the areas where the mortgage loans were originated. Originator banks should therefore maintain data on default rates and—if pre-payment occurs at no fee—pre-payment behavior, which will be crucial to an accurate pricing of the MBSs. Not only the collection of such data but also an agreement that financial institutions will share credit information will be necessary for an MBS market to develop.

Main Benefits

There are benefits in securitizing loans and developing mortgage markets under many different perspectives, both for the mortgage originators for the borrowers and for the investors alike.

Mortgage originators, by securitizing the mortgage loans, will be able to book the proceeds from the sale of the mortgages immediately as cash, thus, the operation generating funding for new lending activities. By transforming the loans into securities that can be held in investors’ portfolios, mortgage originators are also able to access a broader pool of private sector savings. By removing the loans from the balance sheets, mortgage originators will achieve a diversification of credit and market risk. In effect, together with the loans, any term mismatch between assets and liabilities and any credit risk will be removed and dispersed across market investors. As a result, the regulatory capital requirements of the mortgage originators are typically reduced as the loans are taken off balance sheet.

In addition, the securitized bonds backed by mortgage loans (MBSs) can be structured in different ways to either achieve a certain diversification of risk or to cater to the investor base. The most commonly found securities which are backed by mortgage loans are so-called pass-through securities or so-called tranching issues.

Pass-through securities will present exactly the same characteristics as those of the underlying loans in terms of coupon, term, duration and market risk. In particular they will also have the same pre-payment risk as the underlying loans, and all market and credit risk will be passed on to the investors.

Tranching issues will have separated the loan pool in such a way that the higher tranches of the securities are those to which all pre-payments will be imputed and thus have shorter duration but lowest risk, whereas the lower tranche will be redeemed only after the higher tranches have been redeemed in full. This allows investors some choice on the expected duration or risk of the security they acquire. It is typical that MBSs will aim for an investment grade rating so as to be marketed to institutional investors. Since mortgage originators may not have very high credit ratings, mortgage securitization transactions typically require some form of credit enhancement in order to achieve an investment grade rating or, a rating higher than that of the originator bank. Such enhancements can either be included in the structure of the securities, so that, for example, the principal of the underlying pool of loans is greater than the principal value of the securities issued (over-collateralization) or provided by a partial guarantee from a third party.

4. **The emergence of primary and secondary private mortgage markets in Mexico has been facilitated by a series of financial sector reforms. These included:**

- **Measures to standardize private mortgages, thereby allowing mortgage loans to be easily pooled.** In 2003, new legislation ⁴ provided specific guidelines for the standardization of mortgage contracts. Standardization was encouraged by the SHF, which set specific loan criteria for providing mortgage insurance and other financial guarantees (see below), among these, that early repayment options for borrowers should be free of penalties or and fees.⁵
- **Creation of the legal basis for Special Purpose Vehicles (SPVs) which could issue mortgage-backed securities.** The new Securities Law of 2000 and amendments to the “Ley General de Títulos y Operaciones de Crédito” modified the legal framework of trusts (fideicomisos), to enable them to act as SPVs in securitization operations. Foreclosure procedures were simplified for these trusts by authorizing, in the case of borrower default, financial institutions to act both as trustees and beneficiaries of the trust, and by granting their trustees the right to sell loan collateral in a public auction without a judicial foreclosure process in uncontested cases (Box 2).^{6 7 8}
- **Development of securitization instruments.** The new Securities Law introduced the so-called “certificados bursátiles” or ceburs, a flexible type of security that could be also used for securitized issuances.
- **Improvements in contract enforcement and creditor rights, which previously were significantly constrained.**⁹ In 2000, the reform of bankruptcy procedures clarified and streamlined the real estate repossession process, strengthening contract enforcement procedures and creditors’ rights.

⁴ Ley de Transparencia y de Fomento a la Competencia del Crédito Garantizado.

⁵ See Section B of Appendix C in Ley de Transparencia y de Fomento a la Competencia del Crédito Garantizado.

⁶ Only in the cases whereby the foreclosure process is not contested, in all other cases the foreclosure has to be ordered by a court.

⁷ Only in the cases whereby the foreclosure process is not controversial, in all other cases the foreclosure has to be ordered by a court.

⁸ Under Mexican law, the transfer of real estate titles must be registered with a central registry office—a lengthy and costly process—and the law pertaining to real estate foreclosures established other creditors as senior to mortgage lenders during foreclosure procedures. The use of trusts allows mortgages loan rights to be transferred without registration and the application of trusts foreclosure procedures rather than real-estate procedures.

⁹ Historically, foreclosures in Mexico could take up to 5 years and home owners were protected against negative equity. Under Mexican law, the transfer of real estate titles must be registered with a central registry office, a lengthy and costly process. And, the law establishes other creditors as senior to mortgage lenders during foreclosure procedures, dis-incentivating investor participation in securitization issuances.

- **Development of credit reporting.** The lack of comprehensive credit histories had made it difficult to distinguish creditworthy households, and thus to estimate default and pre-payment probabilities. The only credit information sharing mechanism until the early 1990's was the public credit registry (SENICREB) operated by the central bank, but its use in supporting credit decisions was limited. Reforms included the enactment of a banking secrecy reform, which enabled banking institutions to share information on customer credit operations and led to the creation of a dominant credit bureau (Buró de Crédito). This boosted the credit reporting industry, facilitated the sharing of credit information, and improved the analysis of credit risk.

5. **These financial reforms were supported by the creation of the SHF—with the explicit mandate to promote a secondary mortgage market—in 2002.**¹⁰ Originally the SHF was seen as playing a role similar to that of the Federal Housing Agencies (FHA) in the U.S., such as Fannie Mae and Ginnie Mae, providing partial mortgage credit guarantees and

Box 2: The Reform Of The Mexican Legal Framework for Trusts

In Mexican law,^{1/} the trust (fideicomisso) is a contract by which a person designs a property for a special purpose, transfers the title of the property to a fiduciary institution to fulfill that purpose, and appoints a beneficiary of the trust to receive the benefits. Any trust has to be filed in the public registry.

The trustor does not deliver the physical possession of the property, instead he could agree that in the case of his delinquency in the payment of the loan the trustee is allowed to sell the real estate in an auction in order to pay off the credit to the lender. The creditor secured by a guaranty trust (fideicomisos) will receive principal and proceedings from this credit with no exclusion. The law also allows for the trustee and the beneficiary of the trust to be the same.

The procedure which guarantees the trust is stipulated in a federal law and therefore uniform in every court across Mexico. The enforcement allows for extra-judicial execution in the case when there is no controversy among the parties. The trustee takes possession of the collateral in the guaranty trust, after its value and price have been determined, and the collateral shall be sold in a public auction. When the sale of the collateral amounts to the same as the credit, the trustee will be able to gain title to the property of the collateral and to dispose of it freely. If there is a legal controversy, there will have to be a judicial execution of the possession of the collateral and payment of the credit.

¹⁰ The SHF took over most of the responsibilities of the FOVI, which since 1963 had directed government resources, and World Bank loans, to fund housing mortgage and construction loans for low to moderate income households.

acting as a second-tier bank for Sofoles.¹¹ However, the SHF was designed to gradually reduce its direct second-tier bank role, shifting toward supporting financial institutions in issuing mortgage-backed securities directly in the capital markets. In this supporting role, the SHF began selling financial guarantees and mortgage insurance to Sofoles in 2004 (Box 3). The partial financial guarantees (Garantía de Pago Oportuno or GPO), relieve investors from a portion of the liquidity risk associated with shortfalls in interest and principal payments of securitized portfolios. In addition, SHF provides mortgage insurance (Garantía de Incumplimiento or GPI), to protect lenders (and thus investors) against default risk up to a certain percentage of the outstanding principal and interest of the loan.¹² Such arrangements or “enhancements” are designed to increase the credit quality of securitized loan portfolios, which can exceed the credit quality of the originating institution. The criteria set by SHF for the sale of its programs (GPI or GPO) also have, as noted, the important effect of inducing standardization in mortgage products.¹³

¹¹ Direct SHF financing of Sofoles is to be discontinued in 2009 and, by 2013, SHF is to be a self-sufficient agency. The latest data available show that, as of the end of 2005, the agency held close to US\$ 15 billion in direct home loans, from US\$ 13 billion in 2002.

¹² This is called a “first loss” position.

¹³ In particular, to qualify for GPI mortgages have to meet certain debt specific income ratios, loan to value ratios, property type and values, and reporting requirements for the financial intermediaries.

Box 3. SHF's Guarantees Program

Different kinds of guarantee programs are directed both to mortgage borrowers and to lenders seeking to securitized mortgage portfolios. In general, SHF sets specific criteria to qualify for such guarantees.

Guarantees for mortgage borrowers

- A swap of UDI for minimum salary payments (VSM). This swap allows borrowers in UDI-denominated loans to reduce the risk of mortgage debt by transforming payments in multiples of minimum salaries. The structure of the mortgage for the borrower is similar to that of a loan in UDIs. However, the risk that increase in UDIs is higher than the increase in minimum wages is taken over by SHF upon payment of a fee.

Guarantees for lenders

- A default payment guarantee (GPI) or mortgage insurance¹ will pay to the relevant financial intermediary or the trust up to 35 percent¹ of the outstanding balance of the mortgage loan, plus interest thereon, and for unpaid service and insurance fees, after a mortgage loan is delinquent for six consecutive months and foreclosure takes place. The fee for the GPI is paid for by the borrower, through the financial intermediary.
- A mortgage insurance scheme (GI) which insures the lender for up to 70 percent of the outstanding balance of the mortgage loan, plus interest thereon, and for unpaid service and insurance fees for certain loans, including those that contain an up-front subsidy from the government.

Financial Guarantees for RMBS issuers

- A timely payment partial guarantee program (Garantia de Pago Oportuno or GPO) is designed to provide assurance of timely payment of principal and interest up to 85 percent of the outstanding balance of principal and interest for those loan portfolios that comply with certain requirements. (However, the maximum protection acquired by any institution so far has been 25 percent.) Timely payment guarantee is a credit enhancement at the deal level of the structure, and is similar to a credit line. If the trust does not have sufficient cash to make a given payment, the line of credit can be drawn to pay both interest and principal. Once the line of credit is repaid, it can be drawn down again, if the need arises. The fee to the provider of the GPO is part of the expenses of the trust.

To qualify for SHF's support, mortgages have to be originated and underwritten following specific requirements—among others, debt-to-income ratios, loan-to-value ratios, property type and values, and reporting requirements for the financial intermediaries. Should a loan not comply with the eligibility criteria, the trust would have to reimburse SHF for any payment made under the guarantee for that specific loan.

C. The Mexican RMBS Market

Structured Finance in Mexico

6. The issuance of structured finance securities in Mexico has experienced very rapid growth since their introduction.

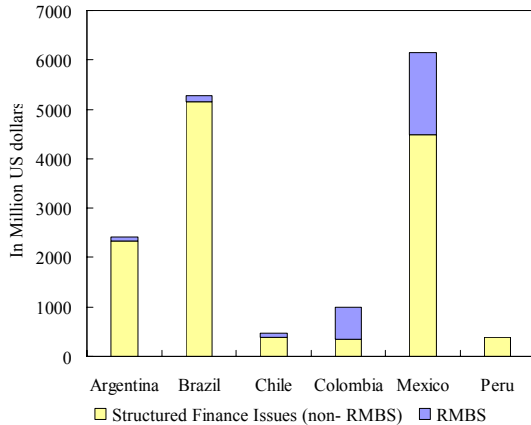
Total issuance of structured securities reached over US\$6 billion in 2006—tripling in volume since 2004¹⁴—the largest annual issuance volume in Latin America, surpassing Brazil. In other emerging market countries in Eastern Europe and Africa, securitized issuance is about 1/3 of Mexico’s volume. However, the volume in Mexico is still very small when compared with the market for domestic government securities

(US\$255 billion) or with structured finance markets in industrial countries (ranging from US\$50 billion in Japan to US\$125 billion in the U.K. and US\$1.4 trillion in the United States).¹⁵

7. The structured finance market in Mexico has grown also in terms of asset types and debt structures.

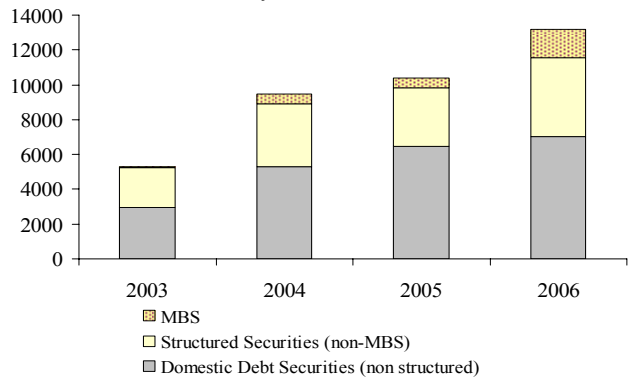
Early structured issues comprised primarily bridge loans for construction to developers; federal tax participation revenues (transfers from the federal government to states and municipalities); toll road receivables and consumer credit flows. Mortgage backed securities (MBS)

Figure 1. Latin America Local Issuance of Securitized Assets 2006



Source: Fitch.

Figure 2. Mexico: Domestic Market Private Debt Issues by Structure



¹⁴ Data according to Fitch. There were two operations in 2004 and 2005 identical in nature for US\$ 4.5 billion and US\$ 2.4 billion by Banamex and Banorte respectively. However, the two operations, which concerned the securitization of a loan by IPAB (the deposit insurance agency), were only possible because of a legal loophole in the terms of the original loans which is not present in other loans by IPAB. Therefore, similar operations cannot be repeated and are considered of one-off nature, therefore excluded from the total for comparison purposes.

¹⁵ All data by Fitch.

based on residential mortgage loans (RMBS) made their first appearance in late 2003 and by 2006 they had become the largest structured asset class, representing over 25 percent of total local structured issues.¹⁶ As of October 2007, there were over US\$6.4 billion RMBS issues outstanding in the Mexican bond market, issued by seven different Sofoles, two commercial banks, and INFONAVIT.

8. **From the outset, Sofoles have been the most active issuers of the new securitization instruments.** SHF's scheduled withdrawal from direct financing of Sofoles at a time of growing demand for mortgage credit has given Sofoles strong incentives to search for alternative funding sources.

9. **Favorable global liquidity conditions and a growing local institutional investor base have supported the new structured issues.** Securitized structures are particularly attractive to pension fund managers because they typically carry a high credit rating and long duration which matches their natural liability structure and prudential regulatory restrictions well. In particular:

- by enhancing the credit profiles through tranching, over-collateralization, and the use of financial guarantees, structured issues achieve an investment grade credit rating that the issuer would otherwise not achieve. In addition, they carry slightly higher yields than comparable government securities.
- in most cases, the terms of the underlying loans, together with those of the securing collateral, allow structured issues to have a relatively long duration with respect to other instruments in the local market, which tend to be concentrated on the short-end of the yield curve.

Demand by local and foreign pension fund managers for longer duration paper has also spurred sophistication in the structured finance market—the first Mexican collateralized debt obligation (CDO), pooling local RMBSs, was launched in March 2007.

RMBS in Mexico

10. **The strong growth in the RMBS in particular has been supported also by SHF, the housing development bank.** Unlike Fannie-Mae and Freddie Mac in the U.S., SHF has not bought mortgages to issue RMBSs or underwritten RMBSs. Instead, mortgage loan originators have been issuing directly so-called “pass-through securities” in the market. These RMBS securities have the same characteristics of the underlying loans, in terms of coupon type and term. The RMBSs that satisfy the loan origination criteria making them eligible for SHF's support, through credit enhancements (mortgage insurance and partial

¹⁶ Data by Fitch.

financial guarantees), are commonly referred to as BORHIS¹⁷ in the local market; however there are also other types of mortgage-backed securities outstanding. In the case of Borhis, SHF also offers support to the liquidity of the issues by acting as a “market-maker” and thus committing to buy Borhis both in the primary and secondary markets. Under normal conditions, SHF buys at a price based on its own cash-flow projections for the securitized loans and computed according to a methodology based on certain prepayment and default assumptions.

11. **More recently, Mexico has adopted the Danish technological platform, enabling mortgage originators to start issuing RMBs closer to the Danish ones.** The important difference between the RMBS issued previously and the new “Borhis fungibles” is that an existing series of “Borhis fungibles” can be augmented by re-opening them during the first year, up to a pre-established maximum, thereby increasing the size of each issue in the market and allowing it to achieve higher liquidity.¹⁸ A loan’s monthly payments will cause some bonds to be withdrawn from the pool, in the amount that the loan pays down. These pass-through securities will be issued through a centralized agency, HiTo, that provides issuer and data services directly into the mortgage market. The first re-openable RMBSs, so-called “Borhis fungibles,” appeared in late 2006.

Issuers and Investors

12. **Sofoles were the first and by far the most active users of the new financial instruments, but INFONAVIT quickly followed.** As of October 2007, SOFOLES accounted for 60 percent of total outstanding stock of RMBS, while commercial banks represented around 5 percent of issues. As discussed earlier, the structural decline in Sofoles’ other funding sources, together with the rising demand for housing credit, gave strong incentives to securitize their portfolios. Following the success of the initial RMBS structures, INFONAVIT rapidly became one of the largest issuers in the market, and in October 2007 accounted for around 27 percent of the outstanding stock of RMBS in the market.

13. **Local institutional investors dominate the market for structured issues.** To date, the bulk of RMBS issues are held by domestic pension funds and insurance companies. Beyond the reasons noted above, this strong demand reflects the fact that Mexican RMBSs are typically denominated in UDIs—see below—and generate inflation-linked returns. More recently, high liquidity in international markets generated some foreign investor interest for RMBS as securities with a relatively higher yield and a low risk profile.

¹⁷ Bonos Respaldados por Hipotecas.

¹⁸ Every fungible Borhi structure has reopening periods ranging from one to three years.

Main Characteristics of Mexican RMBS issues

14. **As the RMBS market in Mexico has developed as a “pass-through” securities market, the characteristics of the outstanding RMBS issues reflect the terms of the underlying pools of mortgages of the different issuers.**

- **RMBS issues by Sofoles.** These are inflation-linked, typically denominated in UDIs, reflecting the underlying mortgages that Sofoles offer. The underlying loans are typically standardized, and carry enhancements purchased through SHF or other insurers (see below).
- **RMBS issues originated by INFONAVIT.**¹⁹The underlying loans tend to be more diverse, although reportedly sharing the same duration of the structured paper that has been issued. INFONAVIT’s loans typically are denominated in VSMs and depend on the borrower’s income level and on the value of the house to be purchased.²⁰ These issues carry no direct financial guarantees but have included over-collateralization as a form of credit enhancement. Because INFONAVIT is a government-sponsored institution, there appears to be a perception, on the part of investors, that these products have an implicit government guarantee.²¹
- **RMBS issues by commercial banks.** Such issuance has picked up strongly recently, so that 2007 seen some of the largest RMBSs issues in the market. These issues are mostly structured to reflect the fixed-rate, peso-denominated characteristics of the mortgages extended by banks. Interestingly, not all of these RMBs carry mortgage insurance and guarantees offered by SHF. Instead, the enhancements in a number of commercial bank issues consist of extended liquidity facilities (or total financial guarantees—see below) by large international insurance institutions and tranching structures to support the credit ratings.

¹⁹ Infonavit is a housing fund, funded with private sector worker contributions. It provides housing credit for low-income workers. Infonavit is currently the largest housing fund with total credit of about 30 percent of GDP. In the case of an increase in inflation (UDI) not matched by increases in VSM, INFONAVIT remains responsible for the servicing of the RMBSs in UDIs.

²⁰ Payments due to Infonavit for mortgage credit are automatically deducted from payroll wages and thus offer a certain degree of payment assurance. However, when the workers are unemployed, Infonavit typically allows for extensive grace periods on its loans.

²¹This is reflected, for example, in the following quote from From *S&P’s Presale report for CEDEVIS5U-2*, of September 2005: “Infonavit’s ratingreflect the institution’s strong importance in the implementation of the housing policy followed by the Mexican government and incorporate a degree of implicit government support.”

Coupon and Term

15. **Interest rates on RMBS issues have averaged between 5 to 6 percent in real terms.** Early issues carried a spread of around 120–140 basis points with respect to inflation-indexed government bonds (UDIbonos), this has declined more recently to around 80-90 basis points. Over time the spreads for Sofoles-issued RMBSs have narrowed thanks to the greater demand and higher liquidity of the market provided by SHF’s activity in the secondary market. However, the compression in spreads also reflected changes in the structure of the RMBS, in particular, the increased use of a mezzanine tranches as the market developed (see below). The most recent issues have benefited from a total financial guarantee (rather than just the partial GPO guarantee) on the senior notes which brought a further decline in spreads to around 40–50 basis points.

16. **The term of RMBS issues has ranged from 10 to 30 years, lately with most around 30 years.** These are the longest maturities available for a private sector security on the market. The typical term for other types of asset-backed issues in Mexico has been five to seven years.

Credit Enhancements

17. **Most issues by Sofoles are structured so as to comply with the requirements to qualify for the SHF’s partial financial guarantee (GPO).** Initially, SHF was the only GPO provider. However, recent regulatory changes cleared the way for the entry of private sector financial guarantee providers such as Ambac, Genworth FMO, IFC and most recently MBIA, to compete with SHF in providing these guarantees. The qualification requirements for GPO consist of the following:

- The holders of the underlying mortgages denominated in UDIs, must hold a UDIs-VSM swap offered by SHF. Such a swap protects the borrower against sudden swings in inflation that are not matched by an increase in general wages, while SHF would continue to service the loan in UDIs.
- The holders of the underlying mortgages must be covered by the mortgage insurance (GPI), which covers the “first loss position” upon default of the borrower for up to 35 percent of the outstanding balance of the mortgage loan.²²

²² Mortgage insurance allows the borrower to increase the maximum allowed loan-to-value ratio. While, in general, loan-to-value ratios have been around 65 percent at mortgage origination, if the borrower qualifies to receive mortgage insurance (GPI) then the loan-to-value ratio is increased to 80 percent for UDI-denominated mortgages and to 90 percent for peso-denominated loans.

18. **Most RMBSs have additional credit enhancements in terms of over-collateralization.** That is, the value of the principal assets backing a certain issue exceeds the value of the security outstanding. The rates of over-collateralization have varied, from 0.8 up to 15 percent. Over-collateralization tends to be lower for RMBS pools that carry SHF's guarantees, around 1.3 percent.²³

19. **As the market has developed, additional types of credit enhancements have appeared.** Most recently, several issues included a total financial guarantee (so-called *full wrap*), which covers 100 percent of shortfalls in principal and interest payments. Such a guarantee is in fact a liquidity guarantee that does not cover against losses due to default but does insure timely payment. However, for those issues carrying such guarantee, there would also be a subordinated tranche (see below) that would be the first to absorb the credit losses.

Structure

20. **Initially, given the absence of a market for securities rated below investment grade, only one tranche was sold in the market and this carried SHF's guarantees.** The originator retained, and fully provisioned for, a small equity position, typically around 4 percent.

21. **More recently, issues have had a senior and a subordinated tranche structure, as is typical in mature debt markets, and a broader variety of credit enhancements.** When issues are tranced, receipts are distributed by tranche seniority, i.e. accruing to the senior tranches first, while losses are distributed inversely.²⁴ Equity positions between 4 and 8 percent have been retained by the originating institutions. Reportedly, junior tranches have had less appeal, but appetite for such tranches appears to have been growing recently. Mutual funds and foreign investors are attracted by the high yield they offer, but some have also been retained by some commercial banks; senior tranches have been eagerly received by local investors.

Valuation and Rating

22. **In Mexico, there is a high degree of uncertainty surrounding the parameters used to model the cash flows from the RMBSs' underlying assets.** In particular, there is a lack of comprehensive historical data on default rates, prepayment rates, and recovery rates and on the length of the foreclosure process. In addition, recent legislative reforms affecting the foreclosure process (as discussed above) may have altered the significance of the

²³ In more recent deals, the initial collateralization has been close to 1.0 percent, with the over-collateralization expected to build to a higher target value as the bond principal amortizes.

²⁴ Senior tranches have represented about 80 percent of the portfolios, while junior or "mezzanine" tranches have ranged from 3 to 12 percent.

available historical information, so that most of the relevant parameters in the valuation process have to be assumed.²⁵

23. **The lack of historical and market data housing prices further complicates assessment of loan-to-value ratios and of the over-collateralization of portfolios.** In principle, house values for mortgages in portfolios guaranteed by SHF must be formally appraised, however, most of the time, house prices for loan purposes have been supplied directly by the constructors. The authorities are also aware of the need to deter fraudulent appraisals as these would compromise the valuation of RMBS, and the integrity of the investors' (e.g. pension funds') portfolios.

24. **The government bonds denominated in UDIs (Udibonos) used as benchmark bonds for the pricing of the securities have been illiquid, complicating the price discovery process for the securities valuation in the RMBS market.** These bonds were the only local UDI-denominated securities with a term structure relevant to RMBSs. However, historically, the Udibono market usually has been very illiquid (it is heavily influenced by pension funds that do not trade Udibonos actively).

25. **Currently, the only source of information for RMBS prices in the secondary market are the local price vendors.**²⁶ The models used by these agencies to price the securities are not fully clear; SHF is working with the price vendors to improve practices. SHF is not required to buy the bonds at the prices announced by the vendors.

26. **The valuation of RMBS relies heavily on rating agencies' review process.** High ratings make securities suitable for pension funds' portfolios. Factors behind the high rating of the early Borhis, beyond SHF's partial financial guarantee, include SHF's incentives to Sofoles to issue loans with conservative loan-to-value ratios, mortgage insurance, and the UDI -VSM swap for all UDI-denominated loans. In more recent issues, since the junior tranches²⁷ effectively provide an additional buffer for the senior tranches, the senior tranches have not needed a financial guarantee to attain a "AAA" rating on the local Mexican scale. Some issues which had a senior tranche with a total financial guarantee were rated "AAA" on the global ratings scale. Because the mortgages in most securitizations are covered by mortgage insurance for up to 35 percent of the losses, even the junior tranches still qualified

²⁵ For example, repayments rates are typically assumed to be constant, imputed either to the loan pool or to each single loan. While in Mexico typically there are no restrictions or penalties on prepayments, the cost of re-financing mortgages is high, thus prepayment rates have tended to be less sensitive to interest rates than in the U.S. Market reports suggest the constant pre-payment rate has been assumed at 5 percent, and indeed according to an SHF White Paper, historical experience with prepayments has been around this level.

²⁶ Price vendors are a figure created in Mexico because of the structural illiquidity of the private issues market. Such institutions are supposed to be independent and to provide price information for market operators.

²⁷ Junior tranches are also referred to as "mezzanines."

for an “A” rating.²⁸ However, for the initial rating of the securities, rating agencies have tended to rely heavily on SHF’s due diligence on the quality of the loan portfolio to be securitized. Furthermore, some have suggested that rating agencies should play a more proactive role in the rating review of RMBS, as there are reports that downgrades to RMBSs have occurred only after irregularities had become readily apparent.

D. Concluding Remarks

27. **The recent rapid growth in housing finance through private mortgages appears grounded on more solid primary and secondary markets than in the past.** Private mortgage lending has been steadily increasing since the beginning of 2003, and all expectations are that the trend will continue. Although such rapid growth could raise concerns about a repeat of the mortgage market collapse during the Tequila crisis, there are a number of important differences this time:

- Most mortgages are inflation-indexed or have fixed-peso rate interest, and the bulk of the origination has taken place through non-deposit taking institutions.
- Financial sector reforms and SHF actions have supported the standardization of mortgage issuance, including SHF’s requirements of strict origination practices in terms of underwriting and eligibility criteria, thus facilitating access by mortgage issuers to capital markets.
- The development of the mortgage bond market with pass-through securities has enabled financial institutions to reduce on-balance sheet credit, market and maturity mismatch risks, while also creating increasingly liquid bond pools in the local capital markets. Most importantly, RMBS have allowed mortgage issuers to tap capital markets funding directly.
- Sofoles have progressively moved away from reliance on direct public funding and have been able to access market funding, with average rates about 100 basis points above similar sovereign issues.

28. **Nevertheless, a number of issues merit close attention to improve the outlook for the future:**

- **The need to improve public property registries.** These registries are still paper based and not systematized, raising the cost of collateral verification.
- **The need to strengthen the role of auditors and credit rating agencies.** In many instances, auditors are reportedly able to check only 5 to 10 percent of titles of a

²⁸ Local scale A is equivalent to BB- on the international scale.

portfolio pool. And, as recommended in the 2006 FSAP Update, issuers and regulators should consider standards for the inclusion of due diligence firms to review the files of the loans that make up collateral pools.²⁹ (To illustrate the concern, the FSAP technical note reported that 30 percent of a pool for which SHF was asked to provide mortgage insurance, suffered from deficiencies in documentation, ranging from missing credit bureau reports to missing or deficient appraisals. Furthermore, the rating agency did not review any loan files, nor did the institutions that were offering credit enhancements.)

- **The need to adapt the securities valuation methodology to the Mexican reality.** Although reliance on highly theoretical models is a common problem with the valuation of structured products in general, for the case of Mexico, the problem compounds due to a lack of mortgage pre-payment and default history. SHF has been cognizant of this problem and has sought to develop centralized prepayment and default databases, but these are not fully operational at this time.
- **Low liquidity in the RMBS may represent a contingent fiscal liability under stress events.** As a market maker, SHF has an explicit commitment to buy Borhis, both in the primary and secondary markets, even under stress events. So far, no limit has been explicitly set as to the total amount of Borhis that SHF could buy. In the event of stressed-induced off-load of RMBS, the SHF would step in to maintain liquidity, leaving the bank vulnerable to market losses.
- **SHF would benefit from stress test analysis to periodically reassess its level of liquidity.** Appropriately, SHF creates provisions in its portfolio on the basis of expected losses, reinsures part of the risk from its mortgage insurance products with international insurance corporations, and fully hedges its VSM-UDI liabilities with FOVI. However, it would be important to assess on a regular basis the institution's liquidity under stress events.
- **The absence of a market for lower-rated securities means that the mezzanine or junior tranches of the securitized portfolios are held by the originating institutions.** This tends to reduce the risk-diversification value of securitization for those institutions, as well as the capital relief they can obtain from securitization.

²⁹ Technical Note on Housing Finance, prepared for the 2006 FSAP Update
(<http://wbln0018.worldbank.org/FPS/fsapcountrydb.nsf/FSAPexternalcountryreports?OpenPage&count=5000>).

- **While there is little risk of providing incentives for overbuilding, incentives for substandard house construction may exist.** The program of guarantees for constructors—which effectively relieve the lender from the market risk associated with construction activity—are directed at increasing further the amount of funding directed to the housing sector without increasing the associated risk to the lenders.
- **Large securitizations by INFONAVIT might complicate RMBS pricing in the market and crowd-out private sector issuers.** INFONAVIT has been able to issue RMBS at very compressed spreads relative to the benchmark government bonds. This is somewhat surprising given that its mortgages are not, generally, standardized and there are significant problems in valuing the housing constituting its collateral. This highlights, as discussed earlier, the importance that markets assign to implicit public guarantees on the securities. Such guarantees, which constitute a contingent liability for the government, may lead to crowding-out other private sector issuers while obscuring the pricing process in the market.

29. **The recent troubles in the U.S. mortgage market have raised questions about the possibility of a similar replay in Mexico—but there are significant differences between two markets.** The fast pick up in private mortgages in Mexico was preceded by several years of stagnation and is from a low level. Furthermore, RMBS remains a very small share of the domestic mortgage market in Mexico, with much lesser systemic implications. Finally, the complex securities currently generating volatility in the U.S. markets, such as CDOs, are practically non-existent in the Mexican financial sector.

30. **Nevertheless, the recent troubles in the U.S. mortgage market may provide lessons—for Mexico and other countries—about vulnerabilities of the securitization model, in particular:**

- The RMBS valuation process is intrinsically complex.
- Rating agencies face a conflict of interest because the issuers of the structured products pay the rating agencies for their opinions. Rating agencies seem to have been slow to adjust the methodology used to evaluate the default probabilities of subprime mortgage-backed securities.
- Financial institutions' sale of loans to independent vehicles seems to have relaxed their origination standards; there appears to be an inherent weakening of the borrower-lender relationship within the securitization vehicle structure.

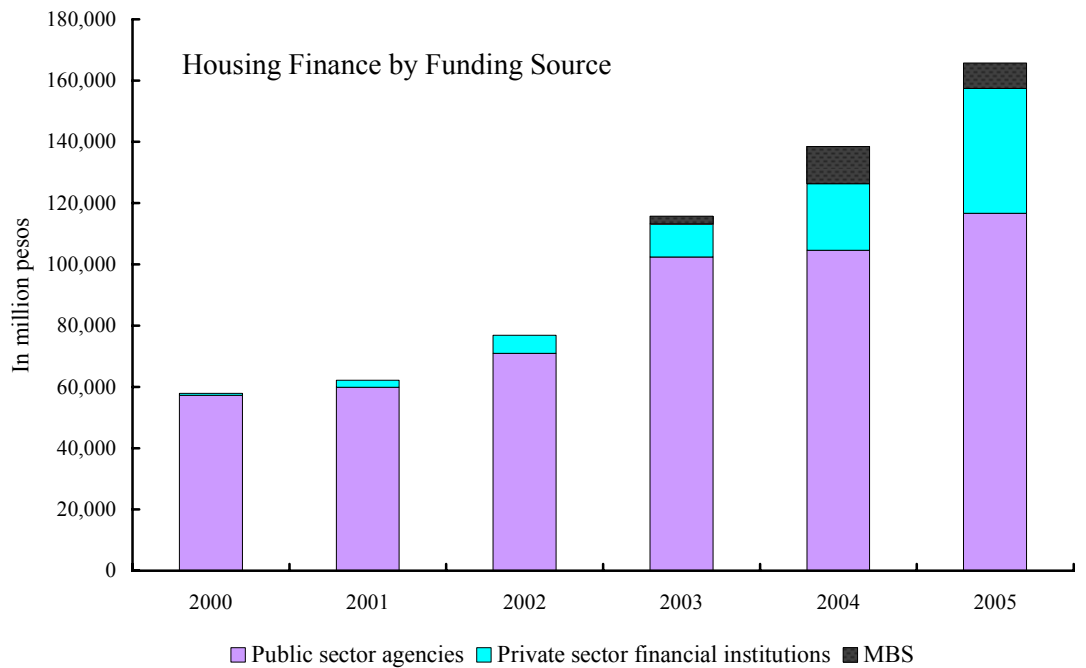
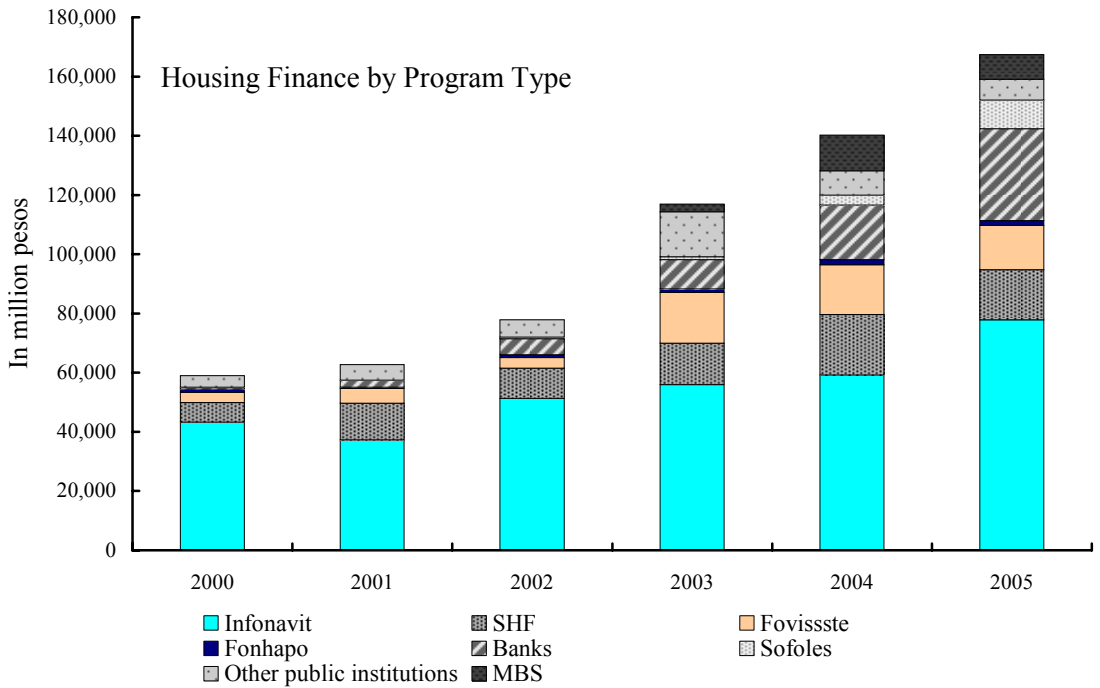
- In the event that securitization vehicles run into liquidity problems, either because of rising defaults or because of inability to place new issues (as is currently the case with asset-backed commercial paper conduits), the sponsoring financial institution may have to step in, either through the extension of credit lines or outright buy backs. That is, even though sales of loans are final in legal terms, financial institutions may be forced to buy back their loans. Fideicommissos in Latin America may be even more vulnerable to this problem than SPV structures in the U.S., because they do not have their own capital.

Figure 3. Mexico: Historical Trends in Credit to Housing



Source: CONAVI, Bank of Mexico, Dealogic and Fund Staff calculations.

Figure 4. Mexico: Structure of Housing Finance, 2000-2005



Source: Conavi, Bank of Mexico, Dealogic and Fund Staff calculations.

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III. MEXICO'S INTEGRATION INTO NAFTA MARKETS: A VIEW FROM SECTORAL REAL EXCHANGE RATES AND TRANSACTION COSTS¹

A. Introduction

1. **Is Mexico reaping the full benefits of its integration within NAFTA markets?**

The analysis of relative price differentials across countries and sectors offers a way to evaluate the degree of market integration. The study of NAFTA members is of particular interest, allowing an assessment of whether regional trade liberalization has resulted in faster price convergence and smaller price differentials across countries, and, greater market integration.

2. **The Law of One Price, or “LOOP,” states that identical goods should sell for the same price across countries when prices are expressed in a common currency.** Evidence has shown, however, that prices of goods fail to fully equalize between countries, indicating that markets are not perfectly integrated—due to some kind of transaction costs that limit price arbitrage. Obstacles to integration include transport costs and (explicit or implicit) trade barriers. Our analysis sheds light on the following questions:

- **Is the degree of Mexico – U.S. integration similar to that of Canada—U.S. integration?** We find that transaction costs are larger for the Mexico – U.S. country pair than for the Canada – U.S. pair.
- **Have markets become more integrated, with reduced transaction costs, after the introduction of NAFTA?** Our results show that NAFTA significantly reduced price differentials between the U.S. and Mexico, as trade liberalization evidently reduced transaction costs, though this was not uniform across sectors.
- **What are some of the determinants of transaction costs?** In addition to trade liberalization, sharing a common border and having lower exchange rate volatility are found to reduce transaction costs. However, it appears that industry or good-specific characteristics must account for a large part of transaction costs.

3. **The empirical methodology analyzes dynamics in relative price adjustment and innovates by taking the perspective of an emerging market—Mexico.**² Due to transaction costs, it may not be profitable to arbitrage away relative price differences across countries.

¹ Prepared by Rodolphe Blavy and Luciana Juvenal. We would like to thank the staff of the Banco de Mexico for their helpful comments, Steven Phillips for his contributions at various stages of this paper, and Roberto Benelli, Roberto Garcia-Saltos, David Robinson, Lucio Sarno, and seminar participants at the IMF and at the LACEA conference. We also thank Modupeh Williams for excellent editorial assistance.

² There is now an established literature on nonlinear behavior of sectoral real exchange rates for developed markets (see Obstfeld and Taylor, 1997; Sarno, Taylor and Chowdhury, 2004; Imbs and others, 2003; and Juvenal and Taylor, 2007),

When the marginal costs of arbitrage exceed the marginal benefit, there is a zone of no-trade and consequently prices in two locations fail to equalize. Outside this zone, arbitrage is profitable and the sectoral real exchange rate (SRRER) can become mean-reverting. The existence of such “threshold band” requires the use of a nonlinear model—more specifically, a threshold autoregressive model (Tong, 1990; and Hansen, 1996, 1997). The estimated price thresholds are a measure of transaction costs, and the absence of relative price convergence is interpreted as a sign of weak market integration.³ We also attempt to identify determinants of transaction costs across country pairs, sectors, and over time.

4. **The remainder of the paper is organized as follows.** Section B reviews theoretical considerations on nonlinear dynamics in sectoral real exchange rates and presents the corresponding econometric methodology. The results are discussed in Section C. The determinants of transaction costs are studied in Section D. The last section summarizes and concludes.

B. Nonlinear Dynamics in Sectoral Real Exchange Rates

Theoretical underpinnings

5. **According to the law of one price (LOOP), there should be no price differentials across countries for similar goods when prices are expressed in a common currency.** At the aggregate level, the LOOP translates into purchasing power parity (PPP). The LOOP is based on the assumption that there are no transaction costs or impediments to trade that would prevent perfect arbitrage and allow sectoral price differentials—it relies on a frictionless goods arbitrage.

6. Deviations x_{jt}^i from the LOOP for a sector j in country i at time t are defined as:

$$x_{jt}^i = s_t^i + p_{jt}^i - p_{jt} \quad (1)$$

where s_t^i is the logarithm of the nominal exchange rate between country i 's currency and the reference country, p_{jt}^i is the logarithm of the price of good j in country i at time t and p_{jt} is the logarithm of the price of good j in the reference country at time t .

7. **Ample empirical evidence (Isard, 1977; Richardson, 1978 and Giovannini, 1988) suggests that relative prices do not converge, or only in a very long-term horizon, and that price differentials are persistent.** These studies also found that relative price differentials are significant and highly correlated with exchange rate movements.

³ An important contribution of our paper is methodological: to use recently developed testing techniques to confirm whether the autoregressive process outside the threshold band is different from the random walk observed inside the band.

8. **The existence of transaction costs, in the form of transport costs or (explicit or implicit) trade barriers, is an explanation for lack of price convergence.**⁴ Several theoretical studies account for the importance of transaction costs in modeling deviations from the LOOP (for example, Dumas, 1992; Sercu and others, 1995; O'Connell, 1998). These studies suggest that frictions to trade imply the presence of significant nonlinearities in sectoral real exchange rate dynamics. That is, transaction costs generate a band in which the marginal costs of arbitrage exceed the marginal benefit. Within this band, there is a zone of no-trade and consequently prices in two locations fail to equalize. Outside this band, arbitrage is profitable and the sectoral real exchange rate can become mean-reverting.

9. **Empirical studies have investigated the presence of nonlinearities in deviations from the LOOP using a TAR model and focusing on developed markets.** Obstfeld and Taylor (1997) find evidence of significant transaction costs in a sample of 32 international locations, using disaggregated data on clothing, food and fuel. Sarno and others (2004) provide support for nonlinear mean reversion, with considerable cross-country and sectoral variations. They use annual price data interpolated into quarterly for nine sectors and quarterly data on five exchange rates vis-à-vis the US dollar. Juvenal and Taylor (2007) study the presence of nonlinearities in deviations from the LOOP for 19 sectors in 10 European countries and find significant evidence of threshold adjustment with transaction costs varying considerable across sectors and countries.

Estimation Methodology and SETAR Model

10. **To analyze patterns in relative price convergence, we model deviations from the LOOP using a self-exciting threshold autoregressive (SETAR) model for each sectoral exchange rate.** More precisely, we investigate the presence of nonlinearities in deviations from the LOOP using a threshold-type model with two regimes. To analyze the characteristics of the threshold dynamics, we proceed in 3 steps:

- First, we explore the validity of the nonlinear threshold model with respect to a null hypothesis of a random walk (unit root process). In other words, we first test for the existence of *some* degree of price convergence (whether partial or complete convergence), as opposed to no price convergence at all.
- Second, for all cases in which some degree of price convergence is found, we assess whether price convergence is indeed partial—up to a threshold that we estimate—or complete. That is, we test whether a nonlinear model fits the data better than a linear one.

⁴ Heckscher (1916) first pointed out at the possibility of nonlinearities in relative prices in the presence of trade frictions. In the case of Mexico, González and Rivadeneyra (2004) investigate the LOOP between Mexican cities and provide empirical evidence that transactions costs (including tariff and non-tariff barriers) explain departures from the LOOP.

- Finally, when we find evidence of nonlinear price convergence both in the pre-NAFTA and post-NAFTA periods, we test if the size of the threshold band is equal in both periods.⁵

11. **The model tests for the existence of a threshold band, within which deviations from the LOOP are smaller than transaction costs and consequently are not arbitrated.** In this case, the SRER would follow a unit root process—the LOOP would not hold. In the outer regime, deviations from the LOOP would be higher than transaction costs, making arbitrage profitable. In this case the process would become mean reverting. We test whether the autoregressive process followed by the real exchange rate switches across regimes.⁶

Under the assumption that adjustments from deviations from the LOOP are symmetric outside the threshold band, a simple three-regime TAR model may be written as:

$$\Delta q_{jt}^i = [(\rho - 1)(q_{jt-1}^i - \kappa_j^i)]1(q_{jt-d}^i > \kappa_j^i) + [(\rho - 1)(q_{jt-1}^i + \kappa_j^i)]1(q_{jt-d}^i < -\kappa_j^i) + \varepsilon_{jt}^i \quad (2)$$

where q_{jt}^i to be the demeaned component of the relative price difference x_{jt}^i , given by $x_{jt}^i = c_j^i + q_{jt}^i$ (q_{jt}^i is estimated as an OLS residual), κ_j^i is the threshold parameter for sector j in country i , q_{jt-d}^i is the threshold variable for sector j and country i . The parameter d accounts for the delay with which economic agents react to real exchange rate deviations.

The key variables, i.e., the threshold and autoregressive parameters, are estimated simultaneously using least squares via a grid search over κ_j^i .

C. Estimation Results

12. **We use disaggregated monthly data on consumer price indices (CPI) for 18 sectors** from January 1980 to December 2006, for Mexico, the United States and Canada.⁷

Testing for nonlinear price convergence

Table 1 reports the results of the estimation of the SETAR model.

⁵ As noted in Hansen (1997), the conventional tests have asymptotic nonstandard distributions, approximated using a bootstrap procedure.

⁶ A forthcoming working paper discusses the econometric methodology in greater detail.

⁷ The data sources for the CPI indices are the Bank of Mexico, the U.S. Bureau of Labor Statistics and Statistics Canada. Monthly nominal exchange rates are period averages taken from the International Financial Statistics (IFS) of the International Monetary Fund (IMF).

13. **The first step consists of testing the null hypothesis of a unit root (Figure 1).** Our interpretation of such a case is that transaction costs are so large that arbitrage is not profitable and the threshold band is wide enough to contain the whole time series of the SRER. A number of observations follow from this first set of results:

- Results provide a first indication that **NAFTA led to greater integration between the United States and Mexico**, with price equalization between locations taken as a sign of higher degree of market integration. Half of the SRERs in the pre-NAFTA period followed a unit root process and only four of them in the post-NAFTA period.
- By contrast, results suggest that **the Canadian and American markets have been more closely integrated**, with a further improvement with NAFTA.

Figure 1. Extent of Price Convergence between Mexico—U.S. and Canada—U.S.

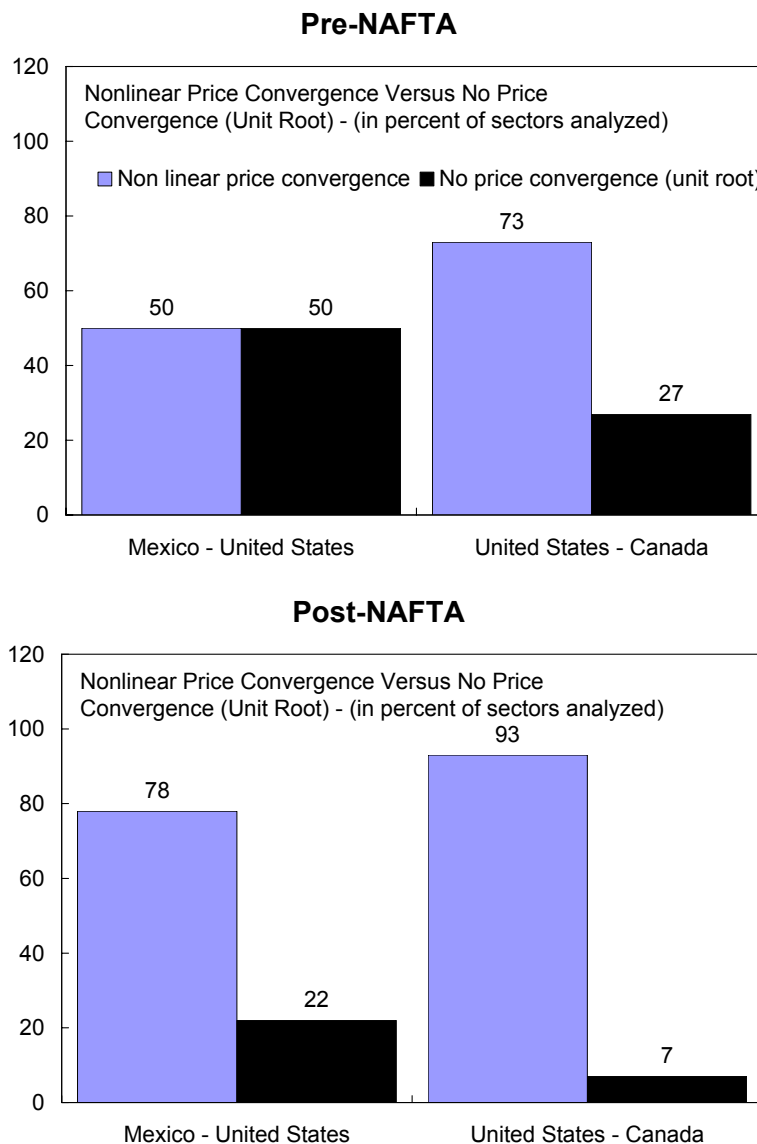


Table 1. SETAR Estimation Results

Mexico - United States									
Sector	Pre-NAFTA				Post-NAFTA				<i>p-value Hc</i>
	Threshold	Mean-reversion	Unit root test	Hansen Test	Threshold	Mean-reversion	Unit root test	Hansen Test	
	k	ρ	<i>p-value Ha</i>	<i>p-value Hb</i>	k	ρ	<i>p-value Ha</i>	<i>p-value Hb</i>	
Bread	--	--	0.52		--	--	0.24		
Meat	0.27	0.92		0.00	0.09	0.96		0.00	0.00
Fish	--	--	0.15		0.02	0.96		0.00	
Dairy	0.28	0.85		0.00	0.10	0.75		0.00	0.00
Fruits	--	--	0.25		0.05	0.84		0.00	
Vegetables	0.09	0.78		0.00	0.15	0.70		0.00	0.05
Nonalcoholic beverages	--	--	0.35		0.15	0.81		0.00	
Alcoholic beverages	0.10	0.92		0.00	--	--	0.11		
Tobacco	0.32	0.73		0.00	0.14	0.86		0.00	0.00
Clothing (women)	0.18	0.86		0.00	0.09	0.83		0.00	0.01
Clothing (men)	--	--	0.13		0.16	0.87		0.00	
Footwear	0.07	0.95		0.02	0.08	0.87		0.00	0.64
Fuel	--	--	0.34		--	--	0.59		
Furniture	--	--	0.28		0.18	0.86		0.00	
Medication	--	--	0.14		0.20	0.85		0.00	
Vehicles	0.14	0.75		0.00	0.12	0.64		0.00	0.39
Gasoline	--	--	0.23		--	--	0.11		
Photo	0.19	0.97		0.03	0.19	0.85		0.00	-

Canada - United States									
Sector	Pre-NAFTA				Post-NAFTA				<i>p-value Hc</i>
	Threshold	Mean-reversion	Unit root test	Hansen Test	Threshold	Mean-reversion	Unit root test	Hansen Test	
	k	ρ	<i>p-value Ha</i>	<i>p-value Hb</i>	k	ρ	<i>p-value Ha</i>	<i>p-value Hb</i>	
Bread	--	--	0.36		0.09	0.93		0.00	
Meat	0.06	0.91		0.00	0.04	0.94		0.00	0.39
Fish	0.08	0.85		0.00	0.04	0.90		0.00	0.08
Dairy	0.07	0.91		0.00	0.07	0.95		0.00	
Fruits	0.16	0.95		0.02	0.09	0.79		0.00	
Vegetables	0.14	0.80		0.00	0.05	0.79		0.00	0.01
Alcoholic beverages	0.15	0.89		0.00	0.14	0.93		0.00	0.47
Tobacco	--	--	0.14		--	--	0.41		
Clothing (women)	0.05	0.94		0.00	0.13	0.81		0.00	0.07
Clothing (men)	--	--	0.23		0.14	0.93		0.00	
Footwear	--	--	0.18		0.08	0.96		0.00	
Fuel	0.08	0.95		0.00	0.04	0.94		0.00	0.07
Furniture	0.16	0.91		0.00	0.10	0.95		0.00	0.02
Vehicles	0.08	0.92		0.00	0.07	0.94		0.00	0.54
Gasoline	0.27	0.79		0.00	0.26	0.72		0.00	0.46

Notes: This table shows the results from the estimation of the SETAR (1, 2, d) model in equation (5). k is the value of the threshold and ρ is the outer root of the TAR process. The estimation of k, ρ and d is done simultaneously via a grid search over k and d as described in section III. *p-value Ha*, *p-value Hb* and *p-value Hc* represent, respectively, the marginal significance levels of the null hypothesis of unit root in the outer regime, null hypothesis of linearity and null hypothesis of equality of thresholds pre- and post- NAFTA.

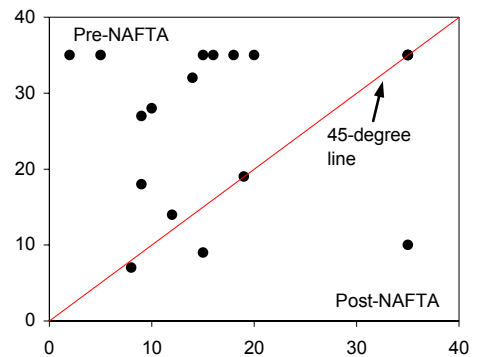
14. **The second step**—conducted only for cases in which SRER does not follow a unit root process—**tests whether the nonlinear threshold model is superior when tested against a linear process in which no threshold exists.** Table 1 reports the p-values indicating the significance level at which the linearity hypothesis can be rejected. In all cases the SETAR model clearly outperforms the linear one, confirming the existence of thresholds and therefore providing an estimate of transaction costs.

Estimated Transaction Costs⁸

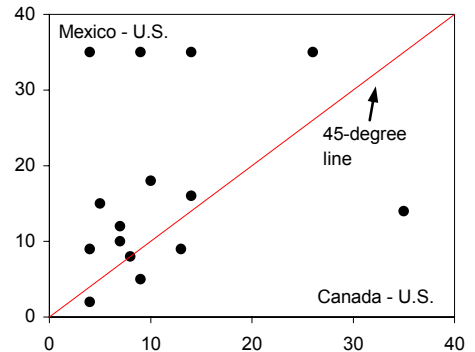
15. **Table 1 also reports the estimated thresholds for each SRER—that we interpret as a measure of overall transaction costs and reflecting market integration:**

- Across sectors, the results generally confirm that **highly homogenous sectors**—for example, fish products and fruits—**show low threshold bands.** This is a standard result in the literature for other country pairs (see Juvenal and Taylor, 2007).
- **For the United States – Mexico SRERs, evidence of a strong NAFTA effect is found.** The range of transaction costs across sectors is smaller, from 7–32 percent in the pre-NAFTA period to 2–20 percent in the post-NAFTA period, also with a number of cases in which transaction costs go from “infinite” (unit root process) to measurable. Transaction costs bands are reduced in a number of sectors, suggesting greater market integration.
- **Overall, average transaction costs among NAFTA members are 34 percent higher between the U.S. and Mexico than between the U.S. and Canada.** This result

Estimated transaction costs (in percent /1): Mexico - U.S.: Pre-NAFTA vs. Post-NAFTA



Canada - U.S. vs. Mexico - U.S. (post-NAFTA)



Source: IMF staff calculations.

1/ In cases of absence of price convergence, transaction costs are too large to be estimated, and reported here as 35 percent.

⁸ To gauge the sensitivity of empirical results to underlying assumptions and variable definitions, we conduct three robustness checks. First, we consider the possibility of long-run trends in the measured price differentials arising from aggregation issues in price indices or from the presence of nontradable components (Harrod-Balassa-Samuelson effect). We also test the sensitivity of the results to (i) allowing for a different mean over the 1994–12 to 1995–12 period (corresponding to the Tequila Crisis), and (ii) restricting the estimation period to 1996–2006. Overall, our baseline findings are robust to these checks.

confirms previous evidence that the United States and Canada are the most integrated among NAFTA members.⁹

16. **In comparison to the work of Juvenal and Taylor (2007), threshold bands among NAFTA members are on average slightly lower than between the United States and European countries.** Interestingly, when considering the United Kingdom as a reference country, their estimated country average transaction costs range from 7 percent to 17 percent. The latter benchmark is probably most relevant to our study for comparison purposes given the process of liberalization among European countries and the distance factor.

Half-Lives

17. **A usual measure of the speed of mean reversion is the half-life, the time it takes for the effect of 50 percent of a shock to die out.** Table 2 reports the estimated half-lives (in terms of months) of price deviations from the LOOP, for the Mexico – U.S. SRER.¹⁰

18. **On average, relative price adjustment is significantly faster in the post-NAFTA period.** For example, for a 10 percent shock, the average half-life pre-NAFTA was 20 months, while the average was reduced to 11 months in the post-NAFTA period. Our results also bring additional observations:

- **In the post-NAFTA period, there is less variation across different shock sizes than in the pre-NAFTA period**—suggesting that relative prices adjust more quickly, independently of the size of the price shock. In the post-NAFTA period, almost 60 percent of the SRERs adjust (by half) to a 10 percent shock within 6 to 9 months. In contrast, most (70 percent) SRERs take more than a year to adjust in the pre-NAFTA period, and 55 percent more than 18 months.

⁹ One possible alternative explanation for finding that thresholds are lower between the U.S. and Canada than between Mexico and the U.S. may be that goods are more homogenous between the first two countries. More generally, the comparability of the sectors may vary across country pairs. First, wealth effects may be at play. The relatively large income differences between Mexico and the U.S. and Canada affects the specific goods sampled in each CPI category. This may complicate the analysis, with the composition between luxury, middle, and ordinary products varying across countries. Second, statistical differences exist in the compilation of price level data, notably in adjustments for quality changes. A solution to this problem is to look at more disaggregated price indices and SRERs. Preliminary work on this is reported in Box 1.

¹⁰ Previous studies computed the half-life of the SETAR model in the outer regime, which depends on the parameter ρ , as in a linear model ($\ln(0.5)/\ln(\rho)$). This has the limitation that it does not consider the regime switching that takes place within and outside the band and provides misleading results. We compute the half-life taking into account the regime-switching nature of the SETAR model. This is important in the context of our model because the half-life takes different values depending on whether the SRER is within or outside the threshold band. The half-life is infinite with the threshold band and depend on ρ (more exactly, equal to $\ln(0.5)/\ln(\rho)$) outside the band. We compute the half-lives for a 10 percent, 20 percent, 30 percent, 40 percent and 50 percent shocks by stochastic simulation using the generalized impulse response functions procedure developed by Koop and others (1996).

- **Half-lives vary substantially across sectors.** Relative prices adjust relatively fast for homogenous goods, such as food products. The relative price of the more high-end products takes longer to adjust, for example furniture, and photographic equipment.

Table 2. Estimation of Half-Lives for Mexico-U.S. Sectoral Real Exchange Rates (in months)

Sector	Shock (%)					Shock (%)				
	10	20	30	40	50	10	20	30	40	50
Bread										
Meat	36	26	20	17	15	29	25	23	22	21
Fish						19	18	18	18	18
Dairy	20	15	11	9	8	7	5	5	5	5
Fruits						6	5	5	5	5
Vegetables	4	4	4	4	4	5	5	5	5	5
Non alcoholic beverages						7	7	6	6	6
Alcoholic beverages	13	12	12	11	11					
Tobacco	18	12	8	7	6	8	7	7	7	7
Women's clothing	10	10	10	9	9	5	5	5	5	5
Men's clothing						10	8	8	7	7
Footwear	18	17	16	16	16	6	6	6	6	6
Fuel										
Furniture						14	10	8	8	8
Medications						10	8	8	8	7
Vehicles	6	5	5	4	3	6	4	4	4	4
Gasoline										
Photo	55	49	44	40	37	24	14	10	9	8
Average	20	17	14	13	12	11	9	8	8	8

Notes: The columns show the half-life of the TAR model as a whole for a given shock estimated conditional on average initial history. The half-lives for a 10%, 20%, 30%, 40% and 50% shocks are computed by stochastic simulation using the generalized impulse response functions procedure developed by Koop and others (1996).

D. Determinants of Thresholds in Real Exchange Rates

19. **In the spirit of the gravity models used to explain trade patterns, we investigate in this section the main determinants of the estimated transaction costs in sectoral real exchange rates.** In their simplest form, gravity equations relate trade to distance between trading partners, as a proxy for transaction costs (see for example the initial work of Linneman (1969)). The models were enriched to account for other determinants of trade. Imbs and others (2007) studied the determinants of relative price dynamics for European countries, using a gravity-type model. They find that distance and exchange rate volatility are strongly correlated with thresholds and the half-life of exchange rate deviations.

The model is defined as:

$$\kappa_j^i = \lambda_j^i + \sum_{k=1}^K \Phi_j^i(k) z_j^i(k) + \varepsilon_j^i \quad (9)$$

where z_j^i is a vector of explanatory variables. We assess in equation (9) whether transaction costs, measured by the threshold κ_j^i , are explained by selected explanatory variables.

Box 1. Evidence on Price Convergence for Specific Goods

Our research also provides preliminary evidence on price convergence at the level of specific goods. Looking at such disaggregated price data has advantages, including greater comparability of goods across countries, and permitting assessment of the role of good-specific characteristics in price convergence.

Here we look especially at a number of goods for which some analysts have suggested that price competition may be relatively weak or even absent—corn, flour, rice, sugar, electricity, telephone services, and cement. We also report results for a comparator sample consisting of nine other specific goods. The main findings are as follows:

- Again we find a significant reduction in relative price thresholds, from an average of 19 percent during the pre-NAFTA period, to 10 percent after the introduction of NAFTA.
- Even after the introduction of NAFTA, relative price thresholds remained relatively high in the sample of interest, in most cases substantially above those in the comparator sample.

Table 3. SETAR Estimation Results for Disaggregated Mexico - U.S. SRERs

	Pre-NAFTA		Post-NAFTA	
	Threshold	Mean-reversion	Threshold	Mean-reversion
	k	ρ	k	ρ
Sample of interest				
corn	0.25	0.91	0.21	0.95
flour	--	--	0.27	0.84
rice	--	--	0.20	0.82
sugar	0.29	0.83	0.06	0.89
electricity	0.06	0.93	0.15	0.87
landline telephone services	n.a.	n.a.	--	--
cement	0.30	0.98	0.17	0.95
concrete	0.33	0.97	0.12	0.92
Comparator sample				
chicken parts	0.28	0.86	0.04	0.89
whole chicken	0.24	0.87	0.02	0.88
ground beef	--	--	--	--
ham	--	--	--	--
canned seafood	0.10	0.93	0.15	0.78
eggs	0.15	0.80	0.02	0.83
apples	--	--	0.05	0.86
oranges	0.13	0.90	0.07	0.85
tomato	0.08	0.75	0.09	0.70
potato	0.05	0.92	0.10	0.91
Full sample average	0.19		0.10	

Notes: See Table 1. "--" signifies no price convergence at all (unit root).

Box 2. Real Exchange Rate Thresholds at the Aggregate CPI Level

Estimation of convergence thresholds can also be conducted at the level of the national CPI index, although the interpretation of the estimated thresholds is much less clear. Still, the results based on aggregate indices may be of some interest, and it turns out that they are broadly similar to the pattern of the sectoral findings. The results are reported in Table 4.

For all three country pairs, we find evidence of non-linear (partial) convergence of aggregate price levels for both the pre- and post-NAFTA periods. The size of the thresholds is significantly smaller in the post-NAFTA period, and is smaller for the U.S.—Canada country pair than for the U.S.—Mexico pair. After NAFTA, the estimated thresholds for the U.S. – Canada and the U.S. – Mexico pairs are reduced, respectively, from 13 percent to 10 percent, and from 18 percent to 14 percent, respectively.

This finding of thresholds at the aggregate level suggests that limitations to price convergence at the sectoral level can also be an issue of macroeconomic significance. This point may be worthy of analysis in empirical studies of (national-level) real exchange rates.

Table 4. SETAR Estimation Results for Aggregate Price Indices

	Real Exchange Rate based on aggregate CPI											
	Pre-NAFTA					Post-NAFTA						
	Threshold	Mean-reversion	Unit root test	Hansen Test		Threshold	Mean-reversion	Unit root test	Hansen Test			
	k	ρ	<i>p-value</i>	<i>Hap-value</i>	<i>Hb</i>	k	ρ	<i>p-value</i>	<i>Hap-value</i>	<i>Hb</i>	<i>p-value</i>	<i>Hc</i>
Mexico - U.S.	0.18	0.95		0.00		0.14	0.83		0.00		0.01	
Canada - U.S.	0.13	0.87		0.00		0.10	0.93		0.00		0.09	
Mexico - Canada	0.20	0.93		0.00		0.18	0.90		0.00		0.41	

	Real Exchange Rate based on aggregate CPI (with dummy for the Tequila crisis period)											
	Pre-NAFTA					Post-NAFTA						
	Threshold	Mean-reversion	Unit root test	Hansen Test		Threshold	Mean-reversion	Unit root test	Hansen Test			
	k	ρ	<i>p-value</i>	<i>Hap-value</i>	<i>Hb</i>	k	ρ	<i>p-value</i>	<i>Hap-value</i>	<i>Hb</i>	<i>p-value</i>	<i>Hc</i>
Mexico - U.S.	0.18	0.95		0.00		0.10	0.91		0.00		0.00	
Canada - U.S.	0.13	0.87		0.00		0.10	0.93		0.00		0.04	
Mexico - Canada	0.20	0.93		0.00		0.15	0.95		0.02		0.03	

Notes: This table shows the results from the estimation of the SETAR (1, 2, d) model in equation (5). k is the value of the threshold and ρ is the outer root of the TAR process. The estimation of k, ρ and d is done simultaneously via a grid search over k and d as described in section III. *p-value* Ha, *p-value* Hb and *p-value* Hc represent, respectively, the marginal significance levels of the null hypothesis of unit root in the outer regime, null hypothesis of linearity and null hypothesis of equality of thresholds pre- and post- NAFTA.

20. **The explanatory variables are intended to capture determinants of transaction costs.** Given the small number of country pairs and their relative closeness, distance appears to be a poor proxy for transaction costs.¹¹ Instead, we include a dummy variable that takes value 1 when countries share a common border. The second variable is the volatility of the nominal exchange rate. Measured as the standard deviation of monthly exchange rate observations, the volatility variable is a proxy for uncertainty of the macroeconomic environment. Third, we include a measure of “tradability,” defined as the sum of imports and exports to the total output in a sector for a given country. Fourth, we use the number of establishments in each sector as a proxy for competition, or concentration, in each sector. Lastly, a dummy for the post-NAFTA period is used.

21. **We examine the determinants of thresholds for the entire sample,** including all three country pairs (we include here the Mexico—Canada pair), including the pre- and post-NAFTA periods. The 94 thresholds computed in the previous section constitute the observations.

Table 5. Threshold Regressions

Determinants of Thresholds		
	(1)	(2)
Distance	-0.041 *	-0.040 *
Dummy post NAFTA	-0.109 **	-0.116 **
Exchange Rate Volatility	4.020 ***	3.991 ***
Firms	-0.001	-
Tradability	-0.042	-
R ²	0.33	0.33
N	94	94

Notes: *** indicates a 1 percent degree of confidence, ** indicates a 5 percent degree of confidence, * indicates a 10 percent degree of confidence.

22. **Three variables appear significant: the post-NAFTA dummy, the border effect, and exchange rate volatility.** For the latter two variables, the results are in line with findings in the rest of the literature. For example, Imbs and others (2007) find that distance, exchange rate volatility, tradability, and industry competition explain the level of thresholds. The dummy post-NAFTA is also strongly significant and negative, confirming our previous results that the introduction of NAFTA reduced transaction costs. However, our attempt to use sectoral variables to explain transaction costs is not successful: neither the number of firms in a sector nor the degree of “tradability” in a sector are found to be statistically significant (column (1) of Table 4). The poor quality of the data and the approximation in proxying intra-industry trade and sectoral competition are a probable explanation for the lack of significance. In column (2), the two variables are excluded, with little change in the results.

¹¹ Note that the three NAFTA countries studied here are all relatively large in terms of land area, so that for example the distance between two cities within a given country could well exceed the distance between two cities in different countries. This situation contrasts with the literature on price convergence within Europe.

23. **Using other types of models, the determinants of relative price differences between the United States and Canada have been extensively studied in the literature.** The results are broadly consistent with our findings. Engle and Rogers (1996) the Canadian and US markets are not perfectly integrated and that distance and border are major determinants of price differentials between cities. Engle, Rogers and Yi Wang (2005) investigate the LOOP between US and Canadian cities using actual prices (instead of price indices). They find that absolute price differences between US and Canadian prices are higher than 7 percent. In addition, their results show that distance and border play a significant role in explaining price differentials between cities.

E. Summary of Results and Conclusion

24. **Using a SETAR model, we find significant differences in transaction costs in different sectors and countries.** Looking at the Mexico—U.S. and Canada—U.S. country pairs, the estimated price thresholds range from 2 percent to 32 percent.

- Across sectors, the results generally confirm that highly homogenous sectors—fish and fruits—show low threshold bands.
- Across country pairs, interpreting the size of the price threshold as a measure of market integration, we find significant differences between the three NAFTA members, with Mexico being relatively less integrated. Overall, average transaction costs among NAFTA members are 34 percent higher between the U.S. and Mexico than between the U.S. and Canada.

We also document the impact of NAFTA on the integration of the three countries and find that NAFTA substantially reduced transaction costs between Mexico and the U.S. while its impact was less marked between Canada and the U.S.

To analyze the adjustment of relative prices to shocks, we also compute the half-lives of the Mexico-U.S. sectoral real exchange rates, a measure of the time it takes for the effect of 50 percent of a price shock to die out. On average, the average half-life was substantially reduced after the introduction of NAFTA, going down from 20 months in the pre-NAFTA period to 11 months post-NAFTA.

25. **The border effect and exchange rate volatility are found to be significant determinants of transaction costs.** The dummy post-NAFTA is also strongly significant and negative, confirming that the introduction of NAFTA reduced transaction costs.

26. **The analysis therefore supports the arguments that (i) emerging markets—in this case, Mexico—still face higher transaction costs than their developed counterparts; and (ii) trade liberalization may help in lowering relative price differentials between countries.** We suspect that lack of competition may be a major determinant of high price thresholds. With limited data, we provide only tentative evidence on this issue.

27. **From the point of view of Mexico, the findings imply that domestic goods' prices today respond more fully, and more quickly, than in the past to either (i) a change in**

the domestic price in the U.S., or (ii) a change in the nominal exchange rate. While greater transmission of sectoral relative price shocks may have consequences for the conduct of monetary policy, it should be distinguished from the question of “exchange rate pass-through” to the overall consumer price index. Such overall pass-through is determined also by other factors, including monetary policy and the business cycle. However, in the last several years, the fluctuation of Mexico’s peso against the U.S. dollar has been fairly modest—with maximum and minimum monthly averages differing by only about 10 percent. Exchange rate movements within such a range are smaller than the transaction cost bands that we find for many sectors, implying that pass-through of such exchange rate changes to domestic prices will often be limited or even non-existent. For Mexico, therefore, it may now be that movements in U.S. prices—rather than nominal exchange rate fluctuations—are the more relevant source of variation in domestic prices of certain traded goods.

28. **The main conclusion of the paper is that Mexico has made progress, but still has considerable room for improvement, in reducing barriers to goods market integration and achieving full benefits of globalization.** It would be important to further analyze the reasons why transactions costs between Mexico-U.S. continue to exceed those for Canada – U.S. for many types of goods, and to determine whether these costs can be reduced through policy actions—for example, by developing logistics, transportation, and internal distribution mechanisms, or by enhancing the state of competition among domestic firms and reducing remaining barriers to external trade.

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