WP/10/63

IMF Working Paper

Financial Liberalization, Structural Change, and Real Exchange Rate Appreciations

Carlos Urrutia and Felipe Meza

INTERNATIONAL MONETARY FUND

 WP/10/63

IMF Working Paper

IMF Institute

Financial Liberalization, Structural Change, and Real Exchange Rate Appreciations

Prepared by Carlos Urrutia and Felipe Meza [1]

Authorized for distribution by Ling Hui Tan

March 2010

Abstract

We account for the appreciation of the real exchange rate in Mexico between 1988 and 2002 using a two sector dynamic general equilibrium model of a small open economy with two driving forces: (i) differential productivity growth across sectors and (ii) a decline in the cost of borrowing in foreign markets. These two mechanisms account for 60 percent of the decline in the relative price of tradable goods and explain a large fraction of the reallocation of labor across sectors. We do not find a significant role for migration remittances, foreign reserves accumulation, government spending, terms of trade, or import tariffs.

JEL Classification Numbers: F41, O40

Keywords: Real Exchange Rate, Appreciation, Financial Liberalization, Structural Change

Author's E-Mail Address: currutiavillalobos@imf.org

[1] This paper has benefited from comments by Rudolf Bems, Daniel Chiquiar, Enrica Detragiache, Behzad Diba, Leslie Lipschitz, Enrique Mendoza and participants in seminars at the International Monetary Fund and Banco de Mexico. We would like to thank especially Sangeeta Pratap for giving us access to her databases. The support of CONACYT through research grant No. 81825 is thankfully acknowledged. Felipe Meza is an assistant professor and research fellow in the Economic Research Center at ITAM, in Mexico City. Carlos Urrutia is a senior economist at the International Monetary Fund, also affiliated to the Economic Research Center at ITAM.

Contents

Page

Figures

Tables

I. Introduction

Between 1988 and 2002 Mexico experienced a substantial appreciation of its real exchange rate (RER). In spite of the 1995 crisis, in which the RER briefly depreciated as a result of a sudden stop of loans from abroad, the trend in the whole period shows a 40 percent appreciation. Similar episodes of RER appreciation have been observed in other Latin American and Central and Eastern European countries. In all these cases, including Mexico, the appreciation coincides with a period of financial liberalization, capital inflows and trade deficits.

In this paper we switch the focus of our analysis from the short run effects of the 1995 crisis to the long run trend observed in Mexico between 1988 and 2002. We use a structural model to analyze the relation between the RER appreciation and different supply and demand shocks affecting the Mexican economy. Building a model allows us to establish causality and decompose the underlying transmission mechanisms. Making this model quantitative, through a careful calibration of the main parameters, allows us to measure its success in generating an appreciation similar to the one observed in the data.

Looking at the Mexican data for the period, we document the following stylized facts: (i) 78 percent of the RER appreciation corresponds to a decline in the domestic relative price of tradable goods, measured as the GDP deflator in the tradable goods sectors divided by the overall GDP deflator; (ii) changes in relative outputs and relative wages across sectors are an important component of the story, but changes in factor income shares are not; (iii) growth accounting for each sector reveals an increase in measured TFP in the tradable sector, while TFP remains stagnant in the non-tradable sector; and (iv) there is a substantial reallocation of resources (capital and labor) from the tradable sector towards the non-tradable sector.

These regularities, in particular fact (iii), are consistent with an explanation of the Mexican appreciation based on the *Balassa-Samuelson hypothesis*: technological progress in the tradable sector reduces the cost of production, making tradable goods cheaper and reducing their relative value with respect to non-tradable goods. One of our objectives is to provide a quantitative assessment of this mechanism in explaining the decline of the relative price of tradable goods in Mexico. For this, our model also needs to be consistent with stylized facts (ii) and (iv), in particular with the observed reallocation of labor.

Differential TFP growth across sectors is only part of our story. Financial liberalization and the opening of the capital account increased the ability of the Mexican economy to borrow in international markets. After being excluded form foreign capital markets following the 1982 default on its sovereign debt, Mexico gradually regained access to international borrowing starting in 1988. This process included not only a successful restructuring of its external debt, but also the dismantling of exchange rate controls and barriers to foreign investment, and the privatization of domestic banks (allowing for the first time foreign participation). The interest rate for loans to Mexico, including the country risk premium, fell from about 15 percent in 1990 to less than 5 percent in 2002, with a short run jump during the 1995 crisis. As the ability to borrow increases, so does the trade deficit and the relative value of non-tradable goods, which cannot be imported. This mechanism is also potentially able to produce a RER appreciation.

The case of Mexico is representative of a more general trend in emerging economies. We document several episodes of RER appreciations in Latin American and European countries following an opening to foreign capital flows. In the case of Latin America we focus on the period post 1988, in which many countries regained access to capital markets after the 1982 debt crisis. In the case of Central and Eastern Europe we focus on the period post 1992, after the changes in regimes in these countries. As in Mexico, we observe in these countries large and sustained RER appreciations accompanied by a massive reallocation of labor towards the non-tradable sector. In some episodes, we can also identify a decline in the cost of foreign borrowing driven by a reduction in the country-specific interest rate premium.

To account for these facts we build a two sector, deterministic, dynamic general equilibrium model of a small open economy that can accommodate both supply shocks (such as sectoral TFP changes) and demand shocks (such as the reduction in the international interest rate). The model is real, abstracting from a monetary side, and constrained-efficient, in the sense that given the adjustment costs to capital accumulation and labor mobility the competitive equilibrium is Pareto-optimal. This distinguishes our analysis from alternative stories based on price rigidities, imperfect competition, and so on.

We calibrate a stationary equilibrium of the model to some aggregate statistics for the Mexican economy. We then feed the model with the exogenous paths for TFP in each sector and the international interest rate for Mexico, and obtain time series for relative prices and other variables of interest. Our model accounts for 60 percent of the change in the domestic relative price of tradable goods observed in the data. The model is also consistent with the size of the reallocation of labor towards the non-tradable sector. The results are robust to the introduction of international goods differentiation and terms of trade shocks. Moreover, adding other demand shocks to the model, such as migration remittances, changes in foreign reserves and government expenditures, and import tariffs reduction following NAFTA, does not change our results nor do these shocks contribute significantly to account for the Mexican appreciation.

Calibrated open economy models have been successfully used to understand the 1995 crisis in Mexico and its effect on real GDP. A few recent examples include Kehoe and Ruhl (2009), Meza (2008) and Pratap and Urrutia (2008). Some of these exercises have implications for the evolution of the RER during the sudden stop. In particular, Kehoe and Ruhl (2009) do obtain an RER appreciation after a jump at the beginning of the crisis. In their model the appreciation is driven mostly by changes in terms of trade rather than changes in the domestic relative price of traded goods. Our empirical analysis shows that for the whole 1988-02 period the latter are more important. Their model also abstracts from sector-specific TFP shocks.

Our analysis also borrows from the *structural transformation* literature, which focuses on the long run reallocation of labor across sectors. Ngai and Pissarides (2007) study how differences in TFP growth rates across sectors lead to structural change in a model with an investment and a consumption sector, while Guerrieri and Acemoglu (2008) study how differences in capital shares across sectors lead to more rapid growth of employment in less capital-intensive sectors. In the context of our model, the tradable sector includes manufacturing, which is an investment good produced in a capital intensive industry, while the non-tradable sector can be mapped into the consumption, labor intensive sector. Differently to these papers, we analyze the process of structural transformation in an open economy model and show that the ability to borrow from abroad is key to understand the size and the speed of labor reallocation across sectors.

Finally, our paper also relates to the empirical literature on the Balassa-Samuelson effect and the long run determinants of the RER (see, for example, Asea and Mendoza (1994), Canzoneri, Cumby and Diba (1999), and Choudhri and Khan (2005)). The results offer mixed support for the Balassa-Samuelson hypothesis. Our approach is different, though, in that we use a structural model to evaluate the impact of sectoral TFP shocks measured from the data.

The paper is organized as follows. In Section II we discuss the evidence from the 1988–2002 Mexican data and show that this experience is similar to other episodes in Latin America and Central and Eastern Europe. Section III introduces the model, while the calibration and the main quantitative exercise are described in Section IV. In Section V, we discuss in more detail the mechanisms driving our results and perform some sensitivity analysis with respect to other demand shocks. Section VI modifies the basic model to allow for international good differentiation and terms of trade shocks. Finally, we conclude.

II. Looking at Mexican Data: 1988–2002

The first step in our investigation is to look carefully at the RER appreciation in Mexico between 1988 and 2002. We show that a fall in the domestic relative price of tradable goods accounts for about 78 percent of the real appreciation. We also provide a decomposition of the changes in the relative price of tradable over non-tradable goods which guides our choice of a model in the next section. We perform sectoral growth accounting exercises for the tradable and non-tradable sectors and identify TFP shocks (Solow residuals) affecting their relative productivity. Finally, we document other experiences in emerging markets sharing the same characteristics as the Mexican case.

A. Real Exchange Rate and Relative Prices

We construct the bilateral, GDP based real exchange rate for Mexico against the US using the standard definition:

$$RER \equiv \frac{eP^*}{P}$$

where e is the nominal exchange rate (pesos per dollar) and P and P^* are the GDP deflators in Mexico and the US. Figure 1 displays the time series for this variable between

1988 and 2002, normalized to take the value 100 in 1988 (as most series in the following graphs). Our measure shows a large 40 percent appreciation in the RER for Mexico between 1988 and 2002 together with a sharp, but short lived, depreciation during the 1995 crisis. We focus in this paper on the long run negative trend, instead of the short run spike of 1995.

Figure 1 also compares our measure of the RER against a multilateral, CPI based measure reported by Banco de Mexico. This is relevant since there are relative advantages and disadvantages of using CPI or GDP deflators as price indices in the RER. Also, it helps us to check if using the US to represent the whole scope of Mexican foreign exchange is a good approximation. These two measures are very similar and capture the same long run trend. If anything, the multilateral CPI based RER features more volatility, with a larger depreciation during the 1995 crisis and a bigger appreciation (45 instead of 40 percent) over the whole period. We choose to continue the analysis with our bilateral GDP based RER since it is easy to map into the NIPA system, allowing for some of the decompositions that follow.

1. Real Exchange Rate and the Domestic Relative Price of Tradables

Measuring prices consistently, the following identity holds:

$$RER \equiv \frac{eP^*}{P} = \underbrace{\left(\frac{eP^*}{P^T}\right)}_{\text{residual}} \left(\frac{P^T}{P}\right). \tag{1}$$

The second term P^T/P is the price of domestic tradable goods relative to the domestic aggregate price level. We will refer to this price in short as the *domestic relative price of tradables*. The first term eP^*/P^T is a *residual* which captures deviations from the price of Mexican tradable goods with respect to the foreign price level.

The decomposition is useful because standard neoclassical models of the small open economy are silent about this residual. If anything, a two-sector version with non-tradable goods can generate deviations between the domestic prices of tradable goods and the aggregate price level: With a weight γ of tradable goods in the aggregate price level, we can approximate the domestic relative price of tradables by:

$$\frac{P^T}{P} \approx \left(\frac{P^T}{P^N}\right)^{1-\gamma}. \tag{2}$$

Hence changes in the relative price of the tradable good over the non-tradable good P^T/P^N could provide a potential explanation of movements in the domestic price of tradables and the RER. However, if the economy is small and markets are competitive, the relation between the price of tradables in the domestic market and the foreign price level is exogenous, so the model has no explanatory power with respect to it.

It is then relevant to assess the quantitative importance of the two channels in explaining the RER appreciation in Mexico. We construct a time series for the domestic relative price of tradables in Mexico dividing the sectoral value added for tradable sectors by the GDP deflator, both obtained from NIPA.[1] Figure 2 compares this price to the GDP based bilateral RER. As shown, the decline in the domestic relative price of tradables is the key component to understand the RER appreciation in Mexico. In a crude decomposition, looking only at endpoints, the decline in the domestic relative price of tradables accounts for 78 percent of the change in the RER. Changes in the residual as defined in equation (1) are much smaller in the long run, although they seem to explain the 1995 jump.

Based on this observation, we use a competitive model of a small open economy to account for the change in the domestic relative price of tradables as our first approximation to understand the long run RER appreciation in Mexico.

2. Terms of Trade and the Residual

The residual in equation (1) could be capturing different things: Terms of trade, transportation costs, price of non-tradables abroad, foreign exporters mark-ups, and so on. Perhaps surprisingly, Figure 3 shows that the long run behavior of the residual for Mexico is captured by the inverse of the terms of trade (i.e., the relative price of imports over exports, computed again using deflators from NIPA). The correlation between these time series is also high (0.79), although the residual shows more volatility in particular during the 1995 crisis.

Product differentiation by country of origin provides an explanation to differences in the prices of exports and imports even in the context of competitive, small open economy models. We will add this feature to a second version of our model to see how robust our results are to exogenous changes in the residual driven by terms of trade shocks.

3. An Alternative Decomposition of the RER

Following Engel (1999), we can also decompose the RER in the following two components:

$$RER \equiv \frac{eP^*}{P} = \underbrace{\left(\frac{eP^{T*}}{P^T}\right)}_{\text{deviations LOP}} \left(\frac{P^T/P}{P^{T*}/P^*}\right) \tag{3}$$

The second term is the domestic relative price of tradables *divided by the foreign relative price of tradables.* The first term captures deviations in the law of one price in tradable goods. Engel (1999) provides a variance decomposition of the RER for the US and shows that deviations in the law of one price in tradable goods are more important than previously thought. Mendoza (2005) confirms this result for Mexico. Using a time frame com-

[1] In our data analysis we follow the convention of including manufacturing, agriculture, mining and fishing activities as part of the traded good sector. All other activities (in particular, services, construction) are treated as part of the non-traded sector. Deflators for each sector are computed dividing value added at current prices by value added at constant (1993) prices.

parable to ours, Kehoe and Ruhl (2009) calculate that deviations in the law of one price in tradable goods account for about 65 percent of the changes in the RER in Mexico.

This result does not contradict our conclusion that most of the action in explaining long run RER movements in Mexico lies in the domestic relative price of tradable goods. Indeed, this price fell in Mexico by 33 percent between 1988 and 2002, a big change with important effects on the allocation of resources inside the Mexican economy. By construction, Engel-style decompositions underestimate the role of the domestic relative price of tradable goods if similar changes in prices are also observed in foreign countries. But for the purpose of our paper, changes in the foreign relative price of tradable goods are irrelevant, as they are exogenous for a small open economy and, contrarily to terms of trade shocks captured by our residual defined in equation (1), they do not affect domestic decisions.

B. More on the Relative Price of Tradable over Non-Tradable Goods

We present now a decomposition of the relative price of tradable over non-tradable goods that will guide our modeling choices. According to equation (2), the domestic relative price of tradable goods can be approximated by a function of the relative price of tradable over non-tradable goods. The following identity provides a useful decomposition:

$$\frac{P^T}{P^N} \equiv \underbrace{\left(\frac{W^T}{W^N}\right)}_{\substack{\text{Relative}\\ \text{Wages}}} \underbrace{\left(\frac{W^N L^N / P^N Y^N}{W^T L^T / P^T Y^T}\right)}_{\substack{\text{Relative Labor}\\ \text{Income Shares}}} \underbrace{\left(\frac{Y^N / L^N}{Y^T / L^T}\right)}_{\substack{\text{Relative Output}\\ \text{per Worker}}} .$$

Note that this formula is indeed an identity and will hold for any economy as long as the data that we feed into it is collected in a consistent way.

Changes in the relative price of tradable over non-tradable goods can be accounted for by: (i) movements in the relative average wage, (ii) changes in the relative labor income shares, and (iii) movements in the relative output per worker. Using Mexican data, Figure 4 plots each of the three components against the relative price.[2] Table 1 summarizes the results of the decomposition, looking only at endpoints.

Notice first that, even though relative labor income shares are far from constant over time, they do not display any significative long run trend. Not surprisingly, their overall impact on relative prices is small. We use this evidence to justify our choice of a Cobb-Douglas production function in the model that follows, instead of a setup in which labor income shares vary over time. By this choice we lose some action, but our decomposition shows

[2] In these series, output for each sector corresponds to sectoral GDP (value added) at constant prices, the number of workers is obtained from employment series by sector, and nominal wages for each sector are computed as the ratio of the wage bill (at current prices) divided by the number of workers.

that we miss less than 10 percent of the change in the variable that we want to explain, in exchange for tractability.

According to our decomposition, everything else equal relative prices and relative wages should be directly related. In the Mexican data, they are. Between 1989 and 1996, wages grew at a faster rate in the non-tradable sector, although from 1997 onwards relative wages are largely flat. Overall, changes in relative wages account for 24 percent of the fall in the relative price of tradable over non-tradable goods. This evidence suggests that deviations from wage equalization across sectors play a role in explaining the RER appreciation. Our model will feature a labor market friction which will be consistent with this property of the data.

The observed decline in relative output per worker of the non-tradable sector against the tradable sector is large and accounts for 66 percent of the fall in the relative price of tradable over non-tradable goods. Adding the contribution of output per worker and relative wages we account for 90 percent of the decline in this relative price. For this, it is key that over the 15-year period analyzed in the data output grew consistently at a faster rate in the tradable sector. We now analyze more deeply what is behind these productivity changes using growth accounting.

C. Sectoral Growth Accounting

Inspired by the previous discussion, we continue our analysis by imposing a Cobb-Douglas production function in each sector:

$$Y_t^i = A_t^i \left(K_t^i\right)^{\alpha_i} \left(L_t^i\right)^{1-\alpha_i}$$

for $i = T, N$. From this equation, we compute the implied total factor productivity (TFP) factors as

$$\widehat{A}_t^i = \frac{Y_t^i}{\left(K_t^i\right)^{\alpha_i} \left(L_t^i\right)^{1-\alpha_i}}$$

using data for sectoral output (VA at constant prices), labor (employment) and capital (also at constant prices). Data for capital stocks is obtained from Banco de Mexico surveys, and is consistent at the sectoral level with the perpetual inventory method. We use the factor shares $\alpha^T = 0.48$ and $\alpha^N = 0.35$, whose values will be discussed in detail in the calibration section.

Table 2 and Figure 5 report the implied TFP factors obtained from the formula above. TFP in the tradable sector grew on average at a 2.2 percent annual rate relative to TFP in the non-tradable sector. This rate does not change significantly over time, and it is mostly driven by the growth in A_T. At the same time capital and labor reallocate from the tradable sector towards the non-tradable sector, as shown in Figure 6.

This evidence characterizes a period of structural transformation of the Mexican economy which is consistent with an explanation of the RER appreciation based on the Balassa-Samuelson hypothesis, this is, based on the differential productivity growth between tradable and non-tradable sectors. We explore how far we can we go with this hypothesis in

Section IV, when we feed a dynamic two-sector general equilibrium model of the economy with the measured sectoral TFPs. A successful model should deliver not only the right change in relative prices between the two sectors, but also the observed factor reallocation.

D. The Mexican Case in Context

Before presenting the model and the quantitative exercise, we provide some evidence situating the Mexican case in a broader context. The Mexican experience shares characteristics with episodes in other emerging economies that have opened to capital flows. We report evidence on the behavior of the real exchange rate in Latin American and Central and Eastern European countries. In the case of Latin America we focus on the period post 1988, in which many countries regained access to capital markets after the 1982 debt crisis. In the case of Central and Eastern Europe we focus on the period post 1992, after the changes in regimes in these countries.

Table 3 reports the percentage change in the RER in selected countries. For some countries in Latin America, such as Brazil and Argentina, the period of appreciation is interrupted by financial crises. Overall, the appreciations are of similar magnitude in our sample of Latin American countries and in Mexico. In Central and Eastern Europe the appreciation of the real exchange rate is larger. Table 3 also reports the size of the reallocation of labor towards the non-tradable sector, as the average percentage change in the ratio of tradable to non-tradable workers. The changes observed in Latin American and in Central and Eastern Europe are of similar magnitude as in Mexico.[3]

The behavior of the interest rates that emerging economies face in the international markets is consistent with our story. Figure 7 reports the country specific interest rate in international markets for selected countries, computed as the real interest rate in the U.S. (3 month T-Bills) plus the JP Morgan's Emerging Markets Bond Index (Global) spread. Unfortunately, indicators for emerging markets country risk are not available for many countries before 1998, so we had to reduce our sample according to the information available. For Mexico, we use a longer series of JP Morgan's Mexican Brady bonds' spread, as described in Meza and Quintin (2007).

Figure 7 shows a consistent decline in the cost of foreign credit in countries experiencing significant RER appreciations. The interest rate for loans to Mexico fell from about 15 percent in 1990 to less than 5 percent in 2002, with a short run jump during the 1995 crisis. Similar declines are observed in Venezuela and Poland, starting in 1995. It is remarkable that the decline in the cost of foreign credit in Bulgaria, the country with the largest RER appreciation, is also the steepest (from 22 percent in 1995 to about 3 percent

[3]Halpern and Wyplosz (2001) analyze in detail the RER appreciation in several Central and Eastern European Countries during the 90s. They report other two facts that are similar to the Mexican experience. First, output per worker grows at a faster rate in manufacturing (tradable sector) than in services (non-tradable sector). Second, the price of non-food manufactures relative to the price of services falls persistently. The authors find evidence in support of the Balassa-Samuelson effect using an econometric analysis.

in 2002). Overall, the evidence supports including changes in the external interest rate in our analysis as a driving force.

Finally, it is also useful to put the period 1988-2002 in context with respect to Mexico's own past experience. A valid concern is whether choosing 1988 as the starting year for our analysis hides previous structural trends in the Mexican economy explaining the subsequent appreciation. Even though we chose the period of analysis mainly due to data availability, we believe that it is indeed a special period marked by a structural break in 1988. Following the 1982 sovereign default, for most of the decade Mexico was indeed excluded from international capital markets. In 1988 a new Mexican government started the negotiations that led to the Brady Plan. Through this negotiation, Mexico finally regained access to international credit markets, although initially facing a very high interest rate. As seen in Figure 7 the country risk premium in international markets gradually felt over the next five years.

Figure 8 extends our series for the domestic relative price of tradable goods and the ratio of employment in tradable sector to non-tradable sector in Mexico back to 1980. As observed, the years before 1988 were characterized by a mild increase in the price of tradable goods (almost entirely accounted for a jump after 1982, the year of the government default) and almost no labor reallocation across sectors. The sustained appreciation of the real exchange rate in Mexico and its driving forces in our analysis (differential sectoral productivity growth and the decline in the cost of foreign borrowing) do seem to have started only by 1988.

III. A Two-Sector Model of a Small Open Economy

We build a simple two sector dynamic general equilibrium model of a small open economy. This model provides a natural laboratory to analyze the impact of sectoral TFP and demand shocks on the relative price of tradable and non-tradable goods and on the allocation of capital and labor across sectors.

A. Production

The economy produces two intermediate goods, one of which is tradable while the other cannot be traded with the rest of the world. Each intermediate good is produced combining capital and labor through a Cobb-Douglas technology:

$$Y_t^i = A_t^i \left(K_t^i\right)^{\alpha_i} \left(L_t^i\right)^{1-\alpha_i} \qquad i = T, N.$$

Capital and labor are rented from consumers. A final good is produced using tradable and non-tradable goods as inputs, using the CES aggregator

$$Y_t = \left[\gamma \left(Q_t^T\right)^{\rho} + (1-\gamma)\left(Q_t^N\right)^{\rho}\right]^{\frac{1}{\rho}}$$

where Y_t is the output of the final good (it will also be equal to domestic absorption in our model), Q_t^T and Q_t^N are quantities of each intermediate good and ρ determines the elasticity of substitution, which is $1/(1-\rho)$.

There is one representative firm in each sector which takes prices as given. The profit-maximization problem for the intermediate producer of good $i = T, N$ is

$$\max_{Y_t^i, L_t^i, K_t^i} \left\{ p_t^i Y_t^i - w_t^i L_t^i - r_t K_t^i \right\}$$

$$\text{s.to} \qquad Y_t^i = A_t^i \left(K_t^i\right)^{\alpha_i} \left(L_t^i\right)^{1-\alpha_i}$$

for all t, where the price of tradable and non-tradable goods (p_t^T and p_t^N), the sector specific wage rates (w_t^T and w_t^N) and the common rental rate of capital r_t are all expressed in units of the final good. As we will see, capital is freely mobile across sectors, but there are frictions to labor reallocation that prevent wages to equate across sectors.

Similarly, the producer of the final good solves each period the static problem:

$$\max_{Y_t^T, Q_t^T, Q_t^N} \left\{ Y_t - p_t^T Q_t^T - p_t^N Q_t^N \right\}$$

$$\text{s.to} \qquad Y_t = \left[\gamma \left(Q_t^T\right)^{\rho} + (1-\gamma) \left(Q_t^N\right)^{\rho}\right]^{\frac{1}{\rho}}.$$

Note that the final good producer does not add any value added to the economy. GDP at current prices will be given by the sum of value added by the tradable and non-tradable intermediate good sectors:

$$GDP_t = p_t^T Y_t^T + p_t^N Y_t^N$$

while real GDP (at constant prices) is constructed using a base year's prices:

$$RGDP_t = p_0^T Y_t^T + p_0^N Y_t^N.$$

B. Consumption and Savings

A representative consumer is endowed with K_0 units of initial capital, B_0 units of foreign bonds, and a sequence $\left\{\overline{L}_t\right\}_{t=0}^{\infty}$ of labor endowments supplied inelastically to the market. Consumers' intertemporal preferences are summarized by the CRRA lifetime utility function:

$$\sum_{t=0}^{\infty} \beta^t \left[\frac{\left(C_t/\overline{L}_t\right)^{1-\sigma} - 1}{1-\sigma}\right]$$

where C_t represents consumption of the final good and $\beta \in (0,1)$ is the discount factor. Income is obtained from renting labor to each sector, at wage rates in units of the final good w_t^T and w_t^N, and renting capital at a common rental rate r_t. The representative consumer decides how much to consume, how much to invest in new capital and new foreign bonds, and the fraction of his/her labor endowment θ_t supplied to the tradable sector.

The budget constraint for each period is:

$$C_t + K_{t+1} + p_t^T B_{t+1} = w_t^T \theta_t \overline{L}_t + w_t^N (1-\theta_t) \overline{L}_t + [r_t + (1-\delta)] K_t$$
$$+ (1+r_t^*) p_t^T B_t - \frac{\psi}{2}\left(\frac{K_{t+1}-K_t}{K_t}\right)^2 - \frac{\phi}{2}(\theta_t - \theta_{t-1})^2$$

where $\{r_t^*\}_{t=0}^{\infty}$ is an exogenous sequence of world interest rates, $\delta \in (0,1)$ is the depreciation rate and the parameters $\psi, \phi > 0$ indicate the magnitude of the quadratic adjustment costs to change the stock of capital and to move labor across sectors, respectively. Our intuition for the latter is that changing sectors implies for workers some loss of sector-specific human capital, whose cost is paid by the representative consumer according to this ad-hoc function.[4] The initial allocation of labor across sectors inherited from the past (θ_{-1}) is exogenously given.

The representative consumer maximizes lifetime utility subject to the budget constraint above. Notice that consumption and investment imply purchases of the same final good (or, alternatively, tradable and non-tradable goods are combined in the same way to produce consumption and investment goods). We choose this specification for simplicity, even though it abstracts from changes in the relative price of investment over consumption goods. Note also that the foreign bond and its exogenous return are also denominated in (real) units of the tradable good.

C. Equilibrium

The model is closed by imposing the following market clearing conditions: (i) for the final good

$$C_t + K_{t+1} - (1-\delta) K_t + \frac{\psi}{2}\left(\frac{K_{t+1}-K_t}{K_t}\right)^2 + \frac{\phi}{2}(\theta_t - \theta_{t-1})^2 = Y_t$$

(ii) for each intermediate good

$$Q_t^T + NX_t^T = Y_t^T \qquad Q_t^N = Y_t^N$$

where NX_t^T represents net exports of the tradable good, and

(iii) for production factors

$$K_t^T + K_t^N = K_t \qquad L_t^T = \theta_t \overline{L}_t \qquad L_t^N = (1-\theta_t)\overline{L}_t.$$

[4]In a recent paper, Pratap and Quintin (2009) argue that labor reallocation can be costly. Using household level data for Mexico, they report that workers who changed occupations during the 1995 crisis experienced sizable losses in earnings. They get this result after controling for individual characteristics, including age and education. Unfortunately for the purpose of our paper, they do not analyze earnings losses of workers who changed sectors (tradable vs. non-tradable), but we believe these losses would be even larger.

In this setup, the current account can be constructed as the value of net exports plus interest payments or as the change in the foreign asset position:

$$CA_t \equiv NX_t^T + r_t^* B_t = B_{t+1} - B_t.$$

Notice that GDP (at current prices) can be constructed according to NIPA methodology as:

$$\begin{aligned} GDP &\equiv p_t^T Y_t^T + p_t^N Y_t^N \\ &= w_t^T \theta_t \overline{L}_t + w_t^N (1-\theta_t) \overline{L}_t + r_t K_t \\ &= Y_t + p_t^T NX_t^T. \end{aligned}$$

IV. Accounting for the Mexican Appreciation

This section describes the main exercise in our paper. We compute the transitional path for the small open economy described in the previous section, starting from an initial stationary equilibrium and given exogenous sequences for sectoral TFP $\left\{A_t^T, A_t^N\right\}$, for international interest rates $\{r_t^*\}$ and total employment $\left\{\overline{L}_t\right\}$ taken from the data. We then analyze the resulting sequences for the domestic relative price of tradables in order to assess the ability of the model to generate an appreciation of the RER as the one observed in Mexico. We also compare model predictions to data on labor reallocation across sectors and discuss its limitations in reproducing the behavior of the current account.

A. Calibrating the Model

The model is calibrated to Mexican data. A few parameters have a direct empirical counterpart. Others are determined simultaneously matching a set of calibration targets. Notice that, although our model is forced to be consistent with some observations for the Mexican economy, no data on the real exchange rate nor on the relative price of tradable goods is used to calibrate the parameters.

We use the 1980 Mexican input-output matrix to calibrate income shares in the production functions. Unfortunately, such matrices are not computed regularly. However, most of our calibration results are consistent with the calibration in Kehoe and Ruhl (2009), using an unpublished 1988 matrix. We measure payments to labor relative to GDP at factor prices for each sector. We adjust the labor income shares by taking into account the income of the self-employed, following Gollin (2002) and Garcia-Verdú (2005). Since self-employment income is not available by sector, we compute an aggregate adjusted labor income share and scale sectoral shares by the same factor. We obtain a capital income share in the tradable sector of 0.48, and 0.35 in the non-tradable sector. As expected, the tradable sector is capital intensive.

For the final goods aggregator, we choose the value of ρ to have an elasticity of substitution of $\frac{1}{2}$ between tradable and non-tradable goods, similar to Stockman and Tesar (1995).

We then calibrate the weight of tradable goods in the production of final goods, γ, using information on final domestic demand for tradable and non-tradable sectors in Mexico from the 1980 input-output matrix. Given the value of ρ, we use the first order conditions of the final goods producer, yielding the relative price of tradable goods as a function of the ratio of Q^T to Q^N. Choosing units to normalize the 1980 relative price of tradable over non-tradable goods to one, the weight of tradable goods is $\gamma = 0.23$.

On the consumption side, we choose a standard risk aversion coefficient implying an intertemporal elasticity of substitution of $\frac{1}{2}$. The exogenous sequence of international interest rates $\{r_t^*\}$ was computed as the real interest rate in the US plus a Mexican specific spread, as discussed in Section II and reported in Figure 7. Since the first observation available is from the end of 1990, we extrapolate the 1988-89 values using information on domestic Mexican interest rates in dollars, giving us an initial interest rate close to 20 percent for 1988. For the purpose of the exercise, from 2003 onwards we assume a constant long run rate of 4.5 percent, that we use to calibrate the discount factor β. The depreciation rate δ is 5 percent.

Given these parameters, we jointly calibrate the initial relative TFP between the two sectors A_0^T/A_0^N and the initial stock of wealth of the economy (B_0) to obtain in the initial stationary equilibrium of the model: (i) a fraction of labor allocated to the tradable sector of 40 percent, and (ii) a fraction of net exports in GDP of 2.3 percent. These numbers are consistent with data for 1988. The sequences for $\left\{A_t^T, A_t^N\right\}$ are constructed given the initial ratio A_0^T/A_0^N and using the rates of growth of TFP for each sector computed from the data (see Figure 5 again). From 2003 onwards we assume constant TFP factors equal to their 2002 level.

This leaves us with two parameters (ψ and ϕ), associated to the adjustment costs for capital and labor. Since the adjustment cost for capital controls the speed of capital accumulation, GDP growth seems a natural target. Similarly, the adjustment cost for labor can be pinned down by deviations from wage equalization across sectors, which are due to labor market frictions in our model. Therefore, we jointly choose the values of these two parameters to minimize the distance between the time series generated by the model along the equilibrium transition path described in the next section and the Mexican 1988-02 data for: (i) the real total GDP per worker, and (ii) the relative wage between tradable and non-tradable sectors. The calibration is summarized in Table 4.

B. Equilibrium Path and the Relative Price of Tradable Goods

We compute the transitional equilibrium path of the model as follows. First, we obtain the initial conditions for capital (K_0), bonds (B_0), and labor allocation (θ_{-1}) from the stationary equilibrium of the model given the values for A_0^T, A_0^N, r_0^*, and $\overline{L}_0$. In particular, we compute this initial steady state assuming a world interest rate $r_0^* = 20\%$ and adjusting the discount factor accordingly. All other parameters are the same as in Table 4.

We then feed the model with the exogenous sequences for sectoral TFP $\left\{A_t^T, A_t^N\right\}$, international interest rates $\{r_t^*\}$ and total employment $\left\{\overline{L}_t\right\}$ constructed from the data.[5] We assume that in $n = 100$ periods (years) the economy reaches the new steady state, given the final values for A_n^T, A_n^N, r_n^*, and $\overline{L}_n$. These values are assumed to be equal to their 2002 counterpart in the data, i.e., from 2003 onwards we assume they remain constant. Solving the system of first order conditions for each of the n periods we obtain the equilibrium transition path for the endogenous variables of the model.[6]

Figure 10 reports the time series obtained from the first fifteen observations generated by the transitional equilibrium path of our model and compares them to the actual 1988-02 Mexican data. By construction, the model reproduces very well the trends for GDP per worker and relative wages across sectors, as the adjustments costs for capital and labor were calibrated to that effect. A better measure of the success of the model is how well it captures the structural shift of labor from the tradable to the non-tradable sector, as well as the downward trend in relative output per worker of the non-tradable sector. The model does this successfully. Moreover, as seen in panel (e) of Figure 10, the model generates a large decline in the domestic relative price of tradable goods, defined as p_t^T in the model. Looking only at endpoints, the model accounts for 60 percent of the change in this relative price which, as discussed in Section II, is responsible for most of the RER appreciation in Mexico.

C. The 1994-95 Crisis and the Current Account

One limitation of the exercise is that it does not capture the observed behavior of the current account. Panel (f) of Figure 10 displays the evolution of net exports (as a fraction of GDP), both in the model and in the Mexican data. Facing an horizon of increasing productivity and declining interest rates, agents in the model borrow *too much* from abroad, compared to the data. Also, instead of a current account reversal in 1995 (the year of the Mexican crisis), the benchmark economy displays an even larger trade deficit. The model has some trouble matching the data around 1995 for other variables as well.

Most of these limitations of the benchmark model are related to our simplified treatment of the 1995 crisis. First, we are assuming that the 1995 interest rate and productivity shocks were perfectly anticipated, so agents start reacting to it in previous periods. Second, we model the crisis itself as a negative TFP shock coupled with an increase in the

[5] Feeding the model with the observed time series for total employment allows us to take into account the effect of population growth and changes in participation rates. By construction, our experiment is consistent with the observed change in the *size* of the labor force in the Mexican economy from 1988 to 2002. What we do not take into account are changes in the *composition* of the labor force, both in terms of age and skill, which could be potentially important in explaining the structural change. A serious analysis of this channel is beyond the scope of our paper.

[6] The design of our experiment is subject to some obvious criticisms: Was the Mexican economy before 1988 in a steady state? Do agents perceive a stationary environment after 2002? Probably not. Nevertheless, our procedure ties our hands in terms of choosing initial and final conditions for the model. In this sense, among other equally arbitrary choices, we believe ours provides the most discipline to the experiment.

international interest rate for Mexico, not as a *sudden stop* of loans from abroad due to foreign credit rationing. The assumptions we use produce a deterioration of the current account due to the temporary negative income shock. On the other hand, modeling the crisis as a sudden stop is consistent with the current account reversal by assumption.[7]

Our focus in this paper is the long run trend of the RER, not the short run depreciation of 1995. Still, we test a simple and alternative way of modeling a sudden stop as a large increase of the international interest rate for Mexico in 1995 and 1996, reaching a value of 40 percent, which would mimic a two-year long quantitative restriction on foreign borrowing. We report in the first panel of Figure 11 the ratio of net exports over GDP when such a large shock is perfectly foreseen (since 1988) or when it comes in 1995 as a complete surprise. If the sudden stop is anticipated, the average level of borrowing of the economy is smaller before the crisis, even less than the one implied by the observed trade deficit. As in the benchmark model, the trade balance worsens during the crisis due to the negative income effect of temporary TFP shocks. When the sudden stop is unforeseen, the economy borrows too much before the crisis but there is a strong reversal of the trade balance in 1995 due to the fall of consumption resulting from the unexpected fall in permanent income caused by the interest rate shock. None of the two versions of the model captures on its own the behavior of the current account in Mexico, but the results suggest that a hybrid model in which the crisis is expected with some probability might help to account for the evolution of net exports.

The implications of these different modeling strategies for the real exchange rate appreciation are important for our exercise. The second panel of Figure 11 displays the evolution of the domestic relative price of tradables. When the sudden stop is anticipated, we account for almost all of the decline in this price, compared to 60 percent in the benchmark model. In the case when the shock is unforeseen, we account for more than 50 percent of the decline in the relative price of tradable goods over the whole period, even though it overshoots during the crisis.

To summarize, our benchmark model generates a large fraction of the decline in the domestic relative price of tradable goods observed in the data and a structural change in the allocation of labor with two main ingredients: (i) the differential TFP growth between tradable and non-tradable sectors, i.e., the Balassa-Samuelson effect, and (ii) a decline in the real interest rate faced by Mexico in the international markets. In the next section we discuss in more detail each channel and provide an assessment of their relative importance.

V. Sources of the Mexican Appreciation

This section accomplishes three things. First, we decompose the decline in the domestic relative price of tradable goods generated by the model distinguishing between its two main sources, sectoral TFP shocks and the decline in the international interest rate. Sec-

[7] Kehoe and Ruhl (2009) model the Mexican Crisis as an exogenous sudden stop of capital inflows. The economy is temporarily unable to borrow from the rest of the world.

ond, we analyze the role of the adjustment cost of labor for our results. Finally, we analyze the effect of three demand shocks: migration remittances, government expenditures and international reserves accumulation, which have received some attention as potential determinants of the real exchange rate in Mexico.

A. Sectoral TFP Shocks vs. Interest Rate Shocks

Our model economy faces two types of shocks: (i) a *supply* shock, the differential TFP growth in tradable and non-tradable sectors, and (ii) a *demand* shock, driven by the change in the international interest rate for Mexico.

Let us start with the sectoral TFP shocks. As discussed in Section II, TFP growth has been unequal across sectors. Between 1988 and 2002, TFP grew at a 1.8 percent yearly rate in the tradable sector, while TFP in the non-tradable sector remained stagnant (in fact, it *declined* by 0.4 percent). In our model, technological progress in the tradable sector reduces the cost of production in this sector, making tradable goods cheaper and appreciating the RER. This is the well known Balassa-Samuelson effect.

The impact of differential productivity growth across sectors on labor reallocation is more ambiguous. The direct effect of TFP changes is to switch resources, including workers, towards the most productive sector. In this case, this is the tradable sector. But there is a second, *income* effect. As productivity growth makes the economy richer, agents demand more of the two goods. The tradable good can be imported, but the non-tradable good has to be domestically produced so resources move towards this sector. Depending on how substitutable tradable and non-tradable goods are in consumption, either effect could dominate.

Figure 12 shows the time series generated by the model shutting down this channel, this is, without sectoral TFP shocks. In this exercise, we still obtain a decline in the relative price of tradable goods, but of about 13 percent instead of 19 percent as in the benchmark model, as shown in Table 5. Moreover, in this version of the model there is also less labor reallocation to the non-tradable sector compared to what is obtained in the benchmark model and observed in the data. We conclude that, roughly speaking, sectoral TFP shocks are responsible for about one third of the Mexican appreciation and structural transformation.

The remaining two thirds is then accounted for the decline in the interest rate faced by Mexico in international credit markets. In the context of the model, a reduction in the world interest rate provides incentives for agents to borrow more abroad, increasing the current account deficit. Hence, tradable goods become less scarce, their relative price falls and resources shift away towards the non-tradable sector. This is a purely *demand* effect, which is consistent with the RER appreciation and the structural change in the Mexican economy and proves to be quantitatively very important.

B. The Role of Adjustment Costs for Labor

To analyze the importance of adjustment costs to labor mobility for our results, we ran a version of the model in which these costs are turned off ($\phi = 0$). The results are reported in Figure 13 and Table 5. Without adjustment costs for labor, the model explains about half of the observed decline in the relative price of tradable goods, about 10 percent less than in the benchmark experiment. Moreover, the model greatly overpredicts the size of labor reallocation towards the non-tradable sector.

Both issues are related. Facing the exogenous sequences of productivity and interest rates, agents want to switch resources from the tradable sector to the non-tradable sector. With adjustment costs, this is done at a slower rate, keeping over time an inefficiently high fraction of labor in the tradable sector and bidding down the wage rate in that sector. Producing tradable goods becomes cheaper, and this is reflected in a decline of its relative price with respect to non-tradable goods, amplifying the RER appreciation.

Adjustment costs for labor are indeed important in our story. We choose the size of adjustment costs that better matches the evolution of relative wages in the data, abstracting from changes in the composition of the labor force in the two sectors. In the absence of direct microeconomic evidence, our calibration provides a degree of discipline to the exercise. Moreover, although $\phi \approx 145$ seems like a large number, the amount of resources wasted by reallocating labor represents only between 0.5 and 0.7 percent of GDP in the model.

C. Other Demand Shocks

We finish this section by quantifying the role of other demand shocks in explaining the decline in the relative price of tradables. These shocks are: (i) migration remittances; (ii) foreign reserves accumulation; and (iii) government spending. Although in theory the three shocks have potentially an effect on the size of the Mexican appreciation, we show that their quantitative impact is minor.

1. Migration Remittances

The importance of immigration for Mexico is difficult to understate. It is estimated that about 9 percent of the Mexican labor force lives in the US. Not surprisingly, migration remittances constitute a significant flow of income for many families. According to one measure, reported in Figure 9, migration remittances have also increased over time between 1988 and 2002, from an average of 1 percent of GDP in the late eighties to about 1.5 percent of GDP in the late nineties.

The impact of migration remittances on the macroeconomy has been widely debated. In particular, the increase in remittances is one of the usual suspects for the RER appreciation in developing countries (see, for example, Amuedo-Dorantes and Pozo (2004) and recent papers by Durdu and Sayan (2008) and Acosta, Lartey, and Mandelman (2007)). In the context of our model, a transfer from abroad finances an increase in the trade deficit, reducing the relative value of tradable goods. How big is that effect?

To answer this question, we feed our model with an additional shock, migration remittances, modeled as an exogenous transfer of tradable goods from abroad of size determined by the data in Figure 9. The results are hard to distinguish from the benchmark economy. Results are also shown in Table 5. Changes in remittances of the size observed in the data have no significant impact on the domestic relative price of tradable goods.

2. Foreign Reserves Accumulation

We also explore the role of international reserves accumulation in the Mexican appreciation. Figure 9 shows that changes in reserves are on average of the same magnitude as migration remittances, although much more volatile. After the 1995 crisis, the Mexican Central Bank accumulated a large stock of foreign reserves as an insurance against sudden stops. As in other countries following similar policies (see Rodrik (2006) for a discussion), reserves accumulation could achieve two related objectives: (i) to reduce the cost of external financing, and (ii) to mitigate the appreciation of the RER caused by the improved access to credit. Both are relevant for our analysis.

We add international reserves as a non-interest bearing asset whose accumulation is exogenous. An increase in international reserves acts in the opposite direction as a transfer from abroad, reducing the current account deficit and making tradable goods more valuable. Again, the question is whether this mechanism is quantitatively important for the appreciation in Mexico. Not surprisingly, given our previous result for remittances, it is not. Feeding the model with the exogenous sequence of changes in reserves from Figure 9 does not change significantly any of the time series generated by the model. It does decrease the fall in the relative price of tradable goods, but by less than one percentage point.

In other words, according to our quantitative model, had the Central Bank not accumulated reserves, the RER in Mexico would have appreciated by a barely noticeable 0.5 percent more.[8] This seems small compared to other policy alternatives. Consider for example the effect of policies increasing the flexibility of the labor market. According to the previous subsection, eliminating the adjustment cost for labor would have reduced by 2.5 percent points the RER appreciation.

[8]This ignores the indirect impact that foreign reserves accumulation might have on the interest rate faced by Mexico in international credit markets, which is exogenous in our setup. Since the external cost of financing was indeed declining during this period, adding this channel could potentially increase the role of foreign reserves accumulation in explaining the Mexican appreciation. But in order to quantify this indirect channel we would need to endogenize the Mexican risk premium, which is outside the scope of the paper.

3. Government Expenditures

Government consumption of non-tradable goods is an important component of total government consumption in Mexico. Using the 1980 input-output table, we find that 94 percent of government consumption is in non-tradable goods. Time series data for 1988-2002 shows that on average 78 percent of total government consumption is allocated to wages of public employees. Changes in the size of government spending can therefore affect the relative demand for non-tradable goods and their relative price. This mechanism has been empirically studied in De Gregorio and Wolf (1994), Balvers and Bergstrand (2002) and recently by Ricci, Milesi-Ferretti and Lee (2008), which find it to be significant in a panel of countries.

As observed in Figure 9, between 1988 and 2002 government consumption as a fraction of Mexican GDP fell steadily from 12 to 9.8 percent. Although this is not a large drop, it still implies a decrease in the demand for non-tradables, which in theory could increase the relative price of tradable over non-tradable goods and partially offset the RER appreciation. In our model it does, but not by much. Assuming that all government consumption is in non-tradables and adding the sequence of observed government expenditure shocks, the model generates a smaller decline in the domestic relative price of tradables. Still, the difference is again less than one percent point.

VI. Terms of Trade, Tariffs and the Mexican Appreciation

In this final section, we modify the basic model by adding international differentiation in tradable goods. This version of the model features an importable good which is an imperfect substitute of the domestically produced tradable good. The relative price between the two defines the terms of trade for this economy which, keeping the assumption of a small open economy, are exogenous. This setup allows us to check the robustness of our previous results with respect to deviations of the price of Mexican tradable goods with respect to the foreign price level (the *residual* discussed in Section II), generated by terms of trade shocks.

A. A Model with International Differentiation of Goods

The basic structure of the model is similar to the one described in Section III. The main difference is that the final good is now produced aggregating non-tradables and a composite tradable good, itself the result of aggregating domestically produced tradable goods and imports (M_t)

$$Y_t = \left[\gamma\left(\left[\mu\left(Q_t^T\right)^{\zeta} + (1-\mu)\, M_t^{\zeta}\right]^{\frac{1}{\zeta}}\right)^{\rho} + (1-\gamma)\left(Q_t^N\right)^{\rho}\right]^{\frac{1}{\rho}}$$

with the (Armington) elasticity of substitution $1/(1-\zeta)$. The assumption is that, because of product differentiation, domestically produced tradable goods and imports are not perfect substitutes.

The producer of the final good solves now each period the static problem:

$$\max_{Y_t^T, Q_t^T, Q_t^N} \left\{ Y_t - p_t^T \left[Q_t^T - (1+\tau_t) \frac{M_t}{(p_t^T/p_t^M)^*} \right] - p_t^N Q_t^N \right\}$$

$$\text{s.to} \qquad Y_t = \left[\gamma \left(\left[\mu \left(Q_t^T\right)^\zeta + (1-\mu) M_t^\zeta \right]^{\frac{1}{\zeta}} \right)^\rho + (1-\gamma) \left(Q_t^N\right)^\rho \right]^{\frac{1}{\rho}}$$

where $\left(p_t^T/p_t^M\right)^*$ are the exogenously given terms of trade for this economy and τ_t represents an import tariff, rebated to the representative consumer as a lump sum transfer.

In equilibrium, markets clear for each domestically produced good,

$$Q_t^T + X_t^T = Y_t^T \qquad Q_t^N = Y_t^N$$

where X_t^T represents exports of the tradable good. Tariff collection is rebated to the consumer as lump sum transfer T_t:

$$T_t = p_t^T \tau_t \frac{M_t}{(p_t^T/p_t^M)^*}.$$

Finally, the current account can be constructed as the value of net exports plus interest payments or as the change in the foreign asset position:

$$CA_t \equiv \left(X_t^T - \frac{M_t}{(p_t^T/p_t^M)^*} \right) + r_t^* B_t = B_{t+1} - B_t.$$

We will focus on the predictions of the model regarding the domestic relative price of tradables p_t. However, this version of the model allows us to construct a real exchange rate which includes the residual exogenously explained by terms of trade shocks, as

$$RER_t = \frac{p_t^T}{(p_t^T/p_t^M)^*}.$$

B. Revisiting our Quantitative Results

In order to compute the new version of the model we need first to calibrate two new parameters in the Armington aggregator, ζ and μ, and recalibrate the parameters γ, A_0^T/A_0^N,B_0, ψ and ϕ to be consistent with the *same* calibration targets as before. We choose initial terms of trade $\left(p_0^T/p_0^M\right)^* = 1$ and set the initial import tariff to the level of $\tau_0 = 10$ percent. We also set $\zeta = 0.5$ in order to have an elasticity of substitution of 2 between imports and tradable goods and jointly calibrate μ and γ using the 1980 input-ouput table.[9]

[9] The range of values for this elasticity varies widely in the literature, from less than 0.5 to more than 10 (see Ruhl, 2008). It turns that our results are very robust to the choice of this parameter. A sensitivity analysis on the value of ζ is available upon request. An appendix providing more detail on the calibration of parameters in this model and in the benchmark model is available upon request.

Finally, we follow the same strategy as with the basic model in order to calibrate A_0^T/A_0^N and B_0 to match the initial labor allocation and net exports, and ψ and ϕ to minimize the distance between the model's GDP and relative wage and the corresponding series in the data. All the remaining parameters have the same values reported in Table 4.

1. The Role of Terms of Trade

As before, we compute the transitional equilibrium path of the new model as follows. First, we obtain the initial conditions for capital, bonds, and labor allocation from the stationary equilibrium of the model. Then, we feed the model with the exogenous sequences for sectoral TFP, international interest rates, total employment *and* terms of trade $\left\{\left(p_t^T/p_t^M\right)^*\right\}$ observed in the data. The sequence for the terms of trade corresponds to the (inverse of the) one reported in Figure 3, while for now we keep tariffs constant during the whole period.

Figure 14 reports the first fifteen observations generated by our model and compares them to the 1988-02 Mexican data. The results are similar to the ones in Figure 10. Once recalibrated to match the trends for GDP per worker and relative wages across sectors, the model with terms of trade shocks also captures the structural shift of labor from the tradable to the non-tradable sector and the change in the composition of output. As reported in Table 7, looking only at endpoints the model with terms of trade shocks accounts for 54 percent of the change in the domestic relative price of tradables, compared to 60 percent in the benchmark model. The model also accounts for 69 percent of the RER appreciation, although it should be noticed that this number includes the contribution of exogenous terms of trade.

Previous studies (see, for example, De Gregorio and Wolf (1994) and Cashin, Cespedes and Sahay (2004)) have found and important role for terms of trade as determinants of real exchange rate movements, especially in commodity exporting countries. Our results are consistent with these findings. The small improvement in terms of trade observed in Mexico between 1988 and 2002 in fact had a direct impact in the RER appreciation by increasing the price of Mexican tradable goods with respect to the foreign price level. However, the improvement in terms of trade slightly reduces the decline in the domestic relative price of tradable goods generated by our model.[10]

2. The Role of Import Tariffs Reduction

In our last experiment we analyze the role of the import tariffs reduction following the free trade agreements negotiated by Mexico at the beginning of the 1990's, in particular NAFTA. Following Kehoe and Ruhl (2009), we model the tariff reduction in a simplified

[10] See Edwards and Van Wijnbergen (1987) for a detailed discussion on the theoretical effects of changes in terms of trade and tariffs on relative prices and on the RER, in particular on the income and substitution effects involved.

way: Starting from a 10 percent import tariff in 1988, we assume a reduction to 5 percent in 1994, followed by a 0.5 percentage point per year decline from 1994 onwards. We compute again the equilibrium path for the model adding this new exogenous shock, and report the main results in Table 7. As observed, the effects of this tariff cut on the labor allocation across sectors and the domestic relative price of tradables are negligible, probably because import tariffs were already low at the beginning of the period studied.

To summarize this section's findings, the results obtained with the benchmark model are robust to deviations from the price of Mexican tradable goods with respect to the foreign price level generated by exogenous terms of trade shocks and to NAFTA's tariff reductions. None of these two shocks on their own played an important role in explaining the decline in the domestic relative price of tradable goods.

VII. Conclusions

We identify two main sources of RER appreciation in emerging markets using a two sector neoclassical growth model of a small open economy: (i) differential TFP growth across tradable and non-tradable sectors, and (ii) a decline in the real interest rate faced in international markets, associated to a process of financial liberalization. These two channels explain approximately 60 percent of the change in the domestic relative price of tradables in Mexico. The results are robust to the inclusion of terms of trade into the model. Contrary to conventional wisdom, we find no important role for migration remittances, government spending, foreign reserves accumulation, or import tariffs reduction.

One important question which remains open is: Are the two identified channels exogenous and independent of each other? One could think of a story in which productivity growth causes an endogenous reduction in the country risk premium by reducing the probability of default, as in Mendoza and Yue (2008). Or even assuming that the country specific interest rate is exogenous, changes in the cost of credit might affect the productivity of firms in a model of financial frictions. Moreover, as shown in Pratap and Urrutia (2008), these changes in the cost of credit affect differently measured TFP in the tradable and non-tradable sectors, providing a potential explanation to differential productivity growth. A quantitative assessment of these transmission mechanisms is an interesting topic for future research.

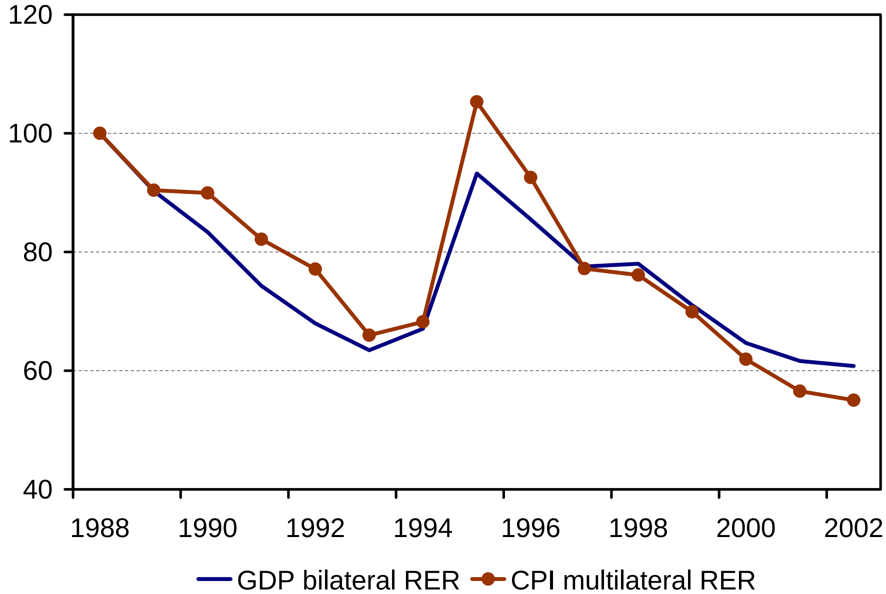

Figure 1. Evolution of the Real Exchange Rate in Mexico, 1988-2002

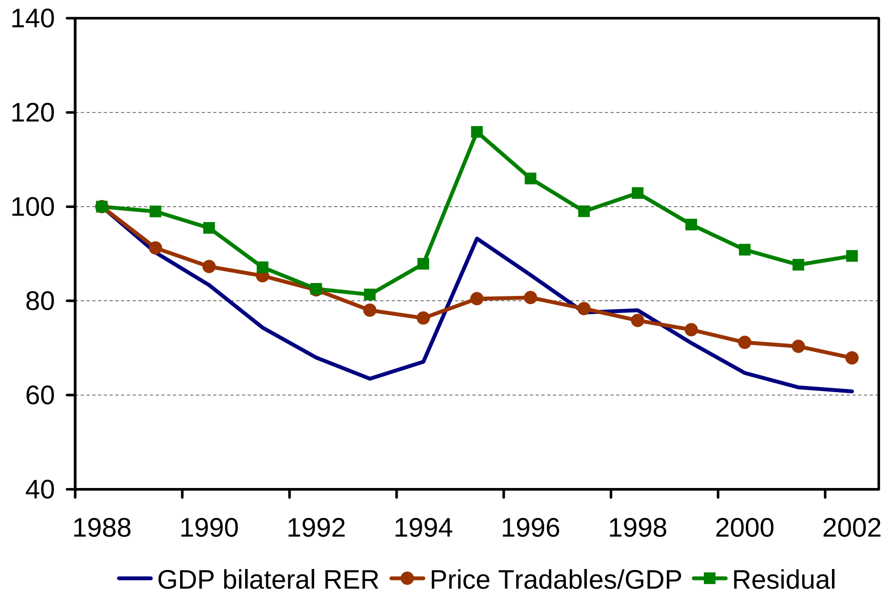

Figure 2. Real Exchange Rate and the Domestic Relative Price of Tradable Goods

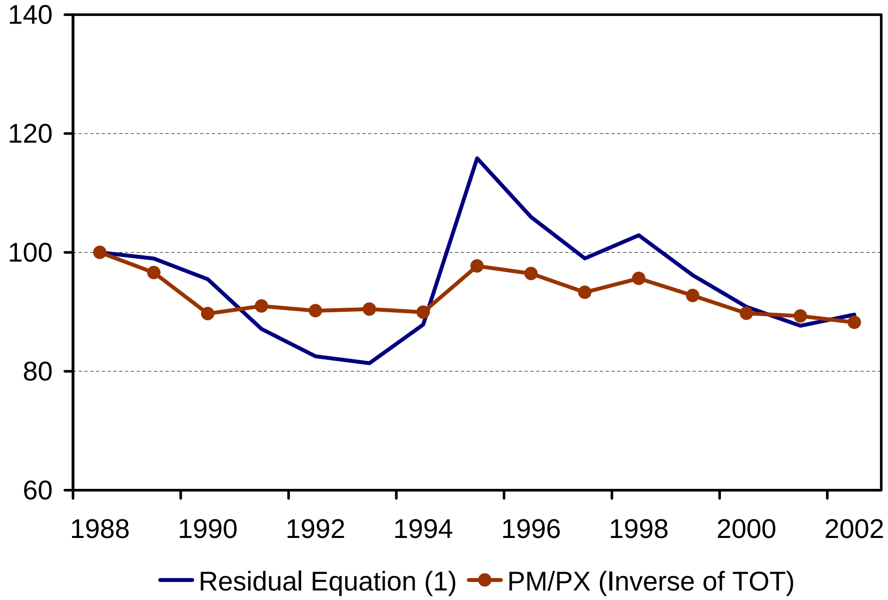

Figure 3. Terms of Trade and the Residual

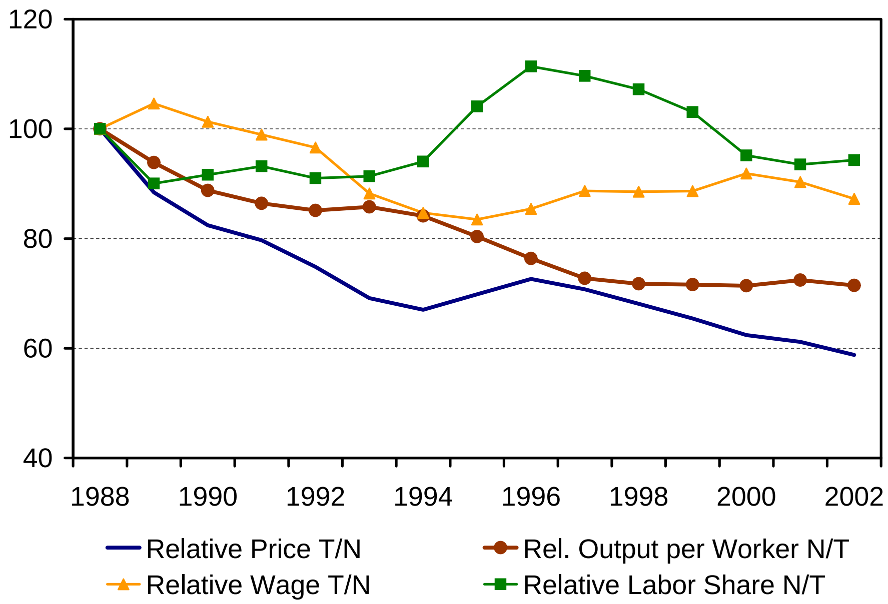

Figure 4. Decomposing the Evolution of the Relative Price of Tradable over Non-Tradable Goods

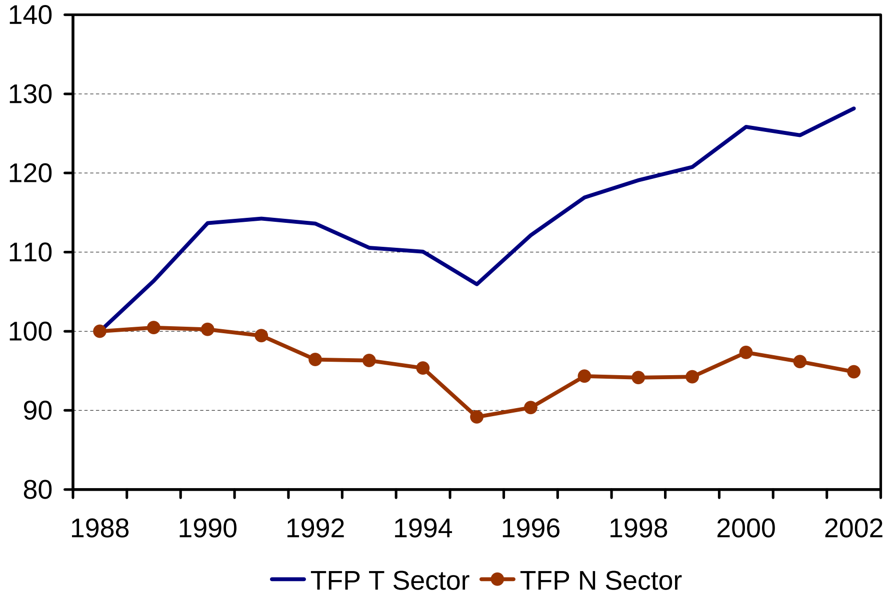

Figure 5. Evolution of Total Factor Productivity in Tradable and Non-Tradable Sectors

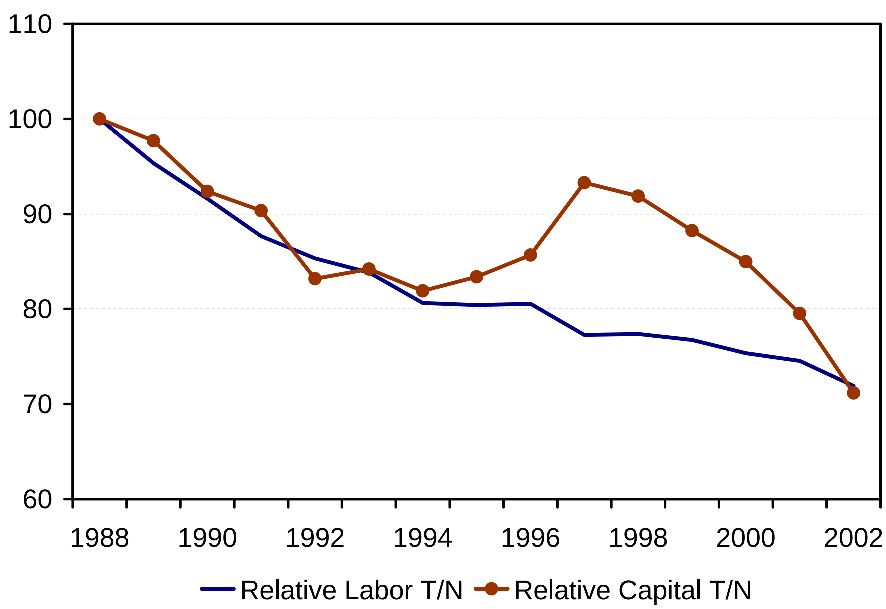

Figure 6. Reallocation of Labor and Capital Between Tradable and Non-Tradable Sectors

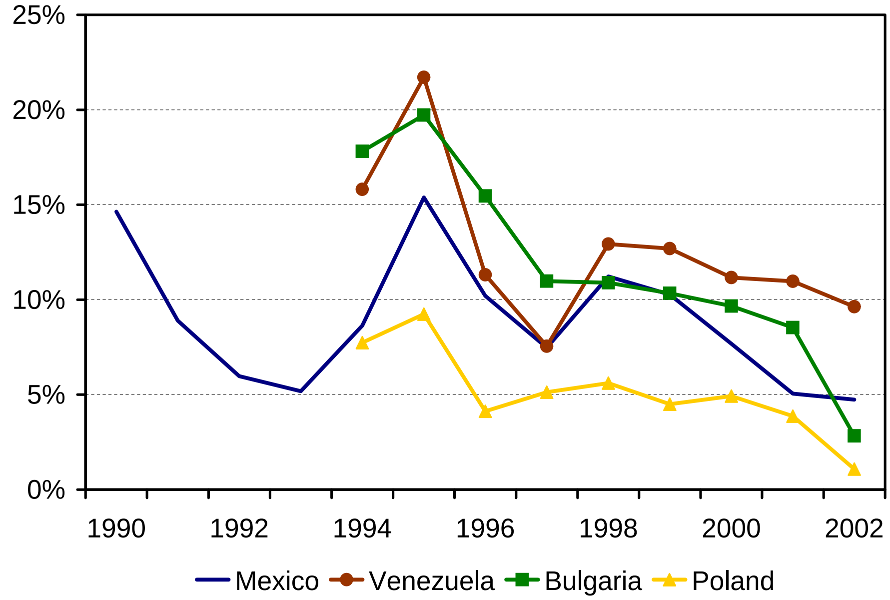

Figure 7. Interest Rate for Foreign Debt in Selected Countries (Including Country Premium)

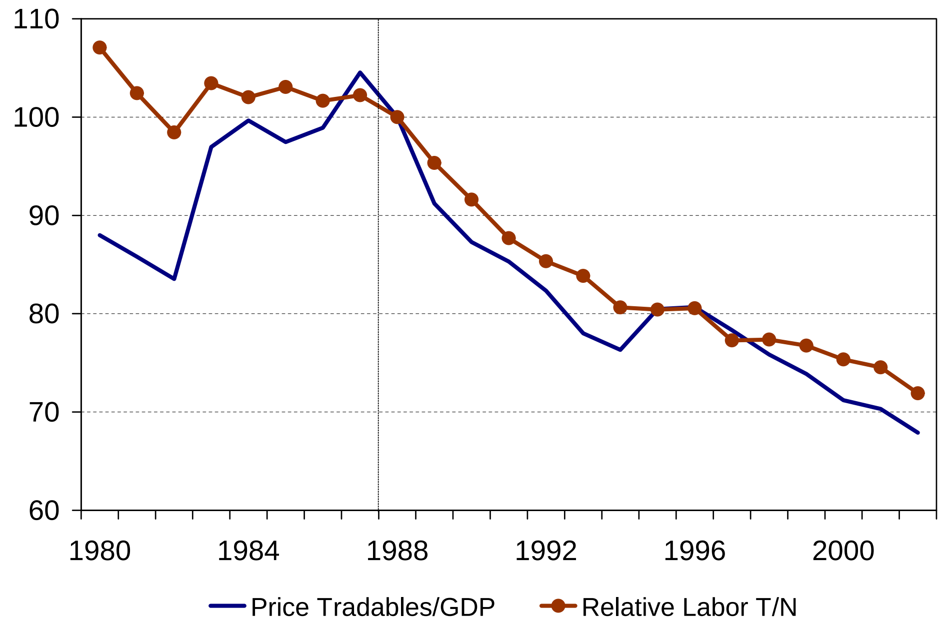

Figure 8. Relative Price of Tradables and Labor Reallocation in Mexico, 1980-2002

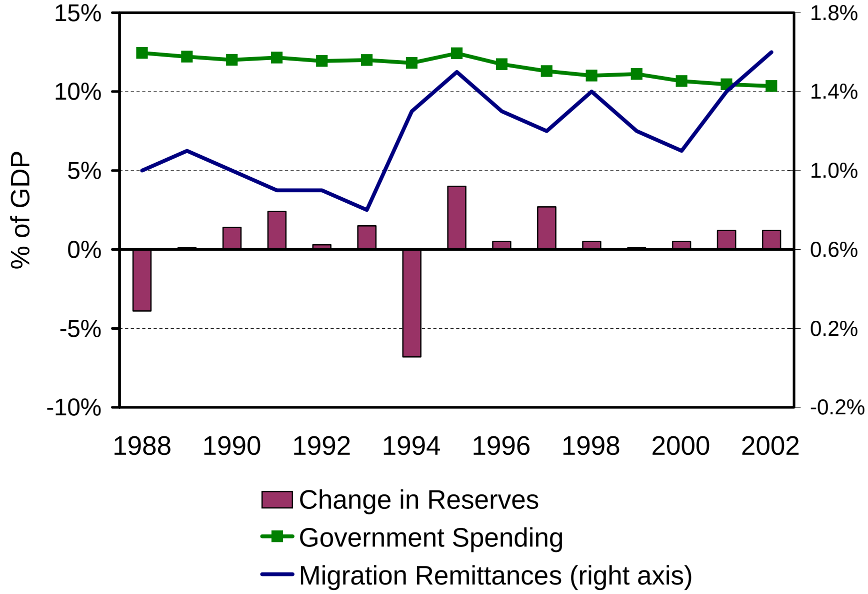

Figure 9. Other Demand Shocks for the Mexican Economy

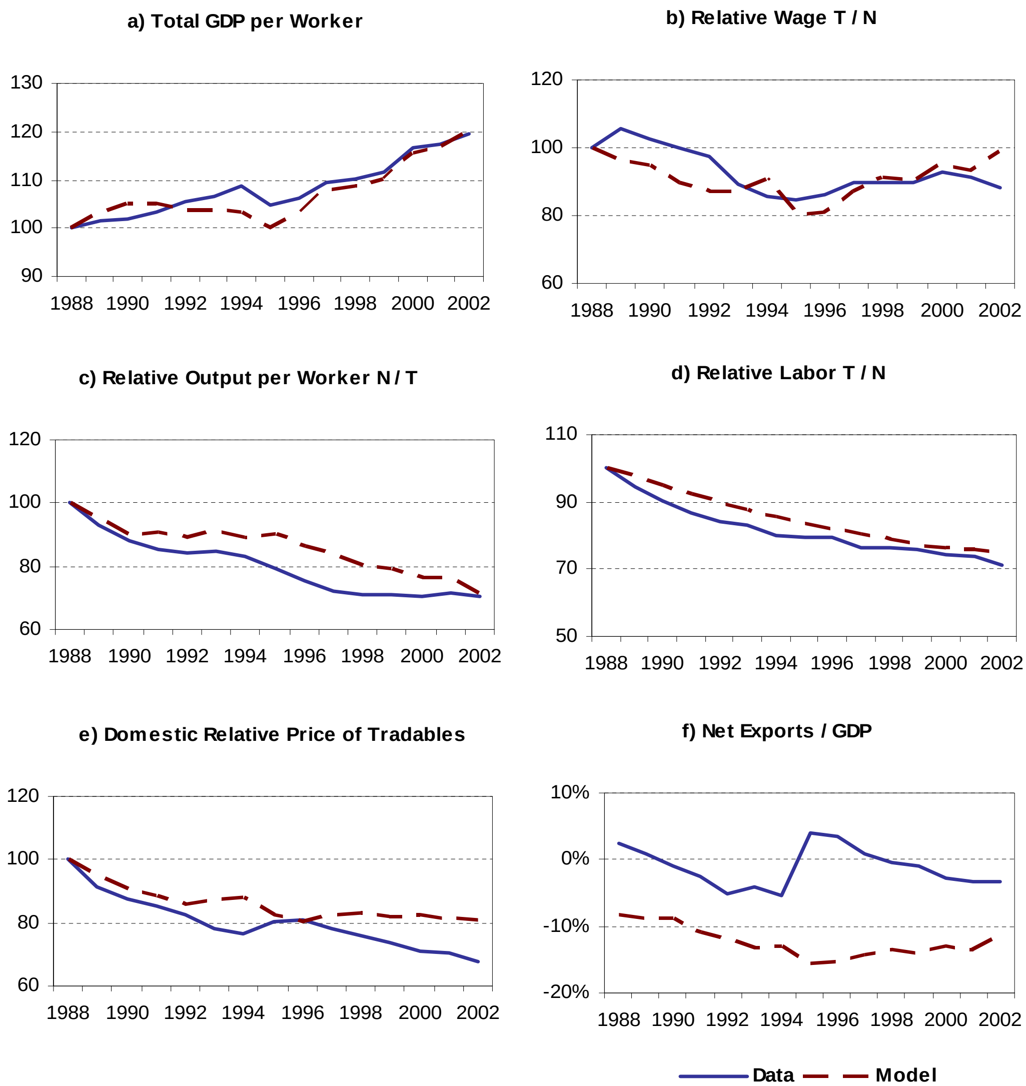

Figure 10. Equilibrium Transition for the Benchmark Economy

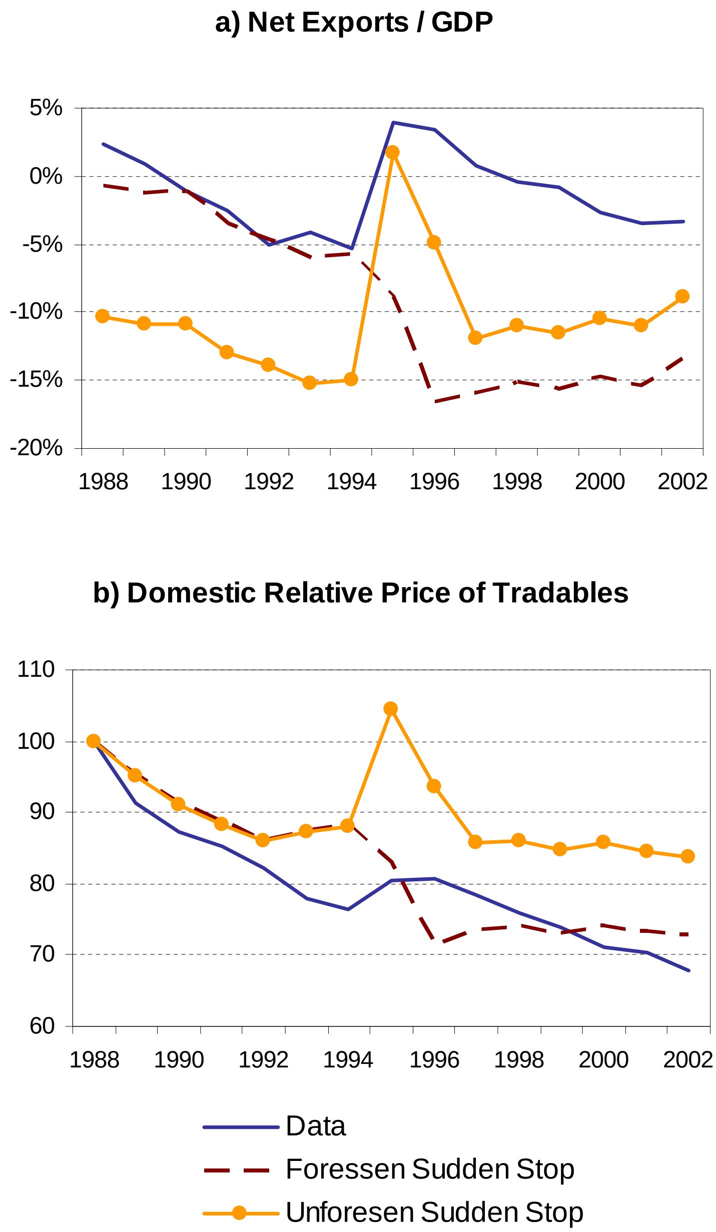

Figure 11. Net Exports with Foreseen and Unforeseen Sudden Stops in 1995

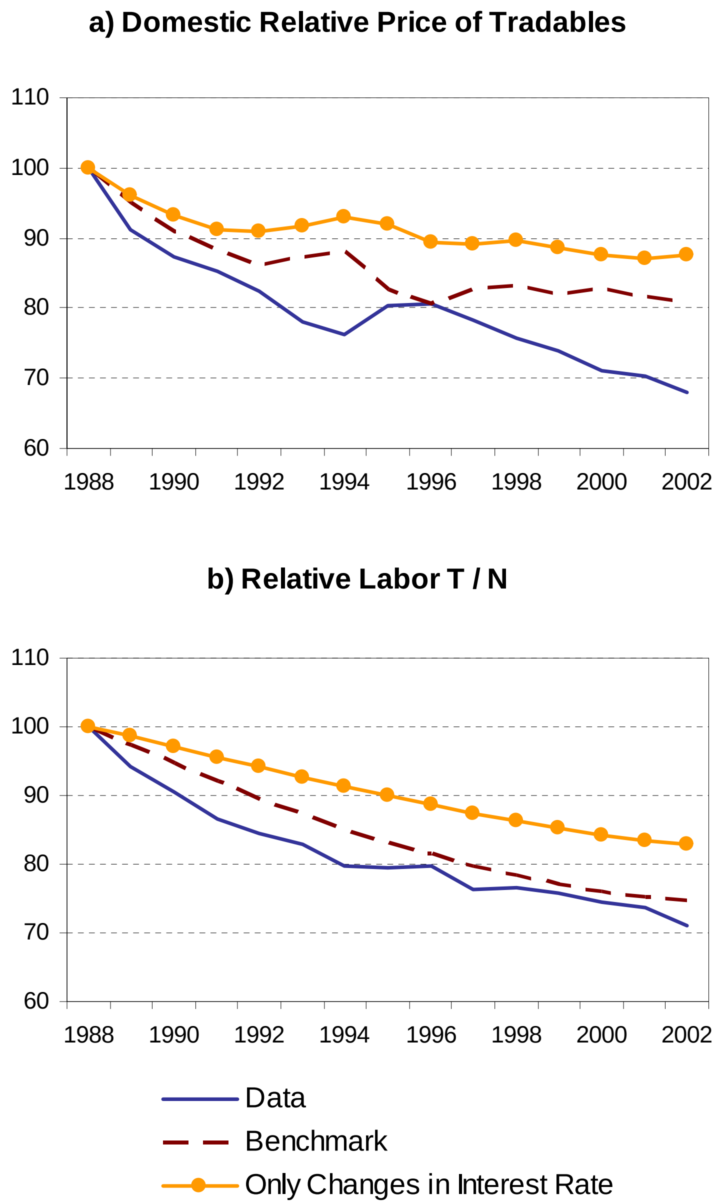

Figure 12. Transition without Sectoral Productivity Shocks

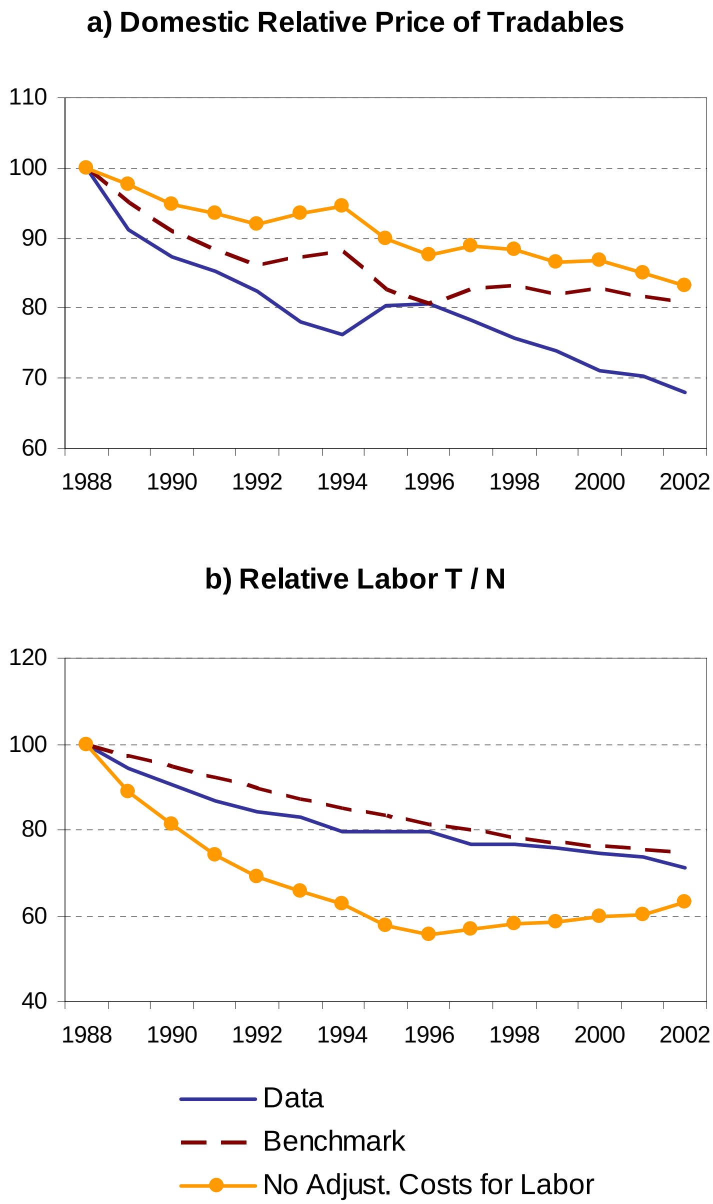

Figure 13. Transition without Adjustment Costs for Labor

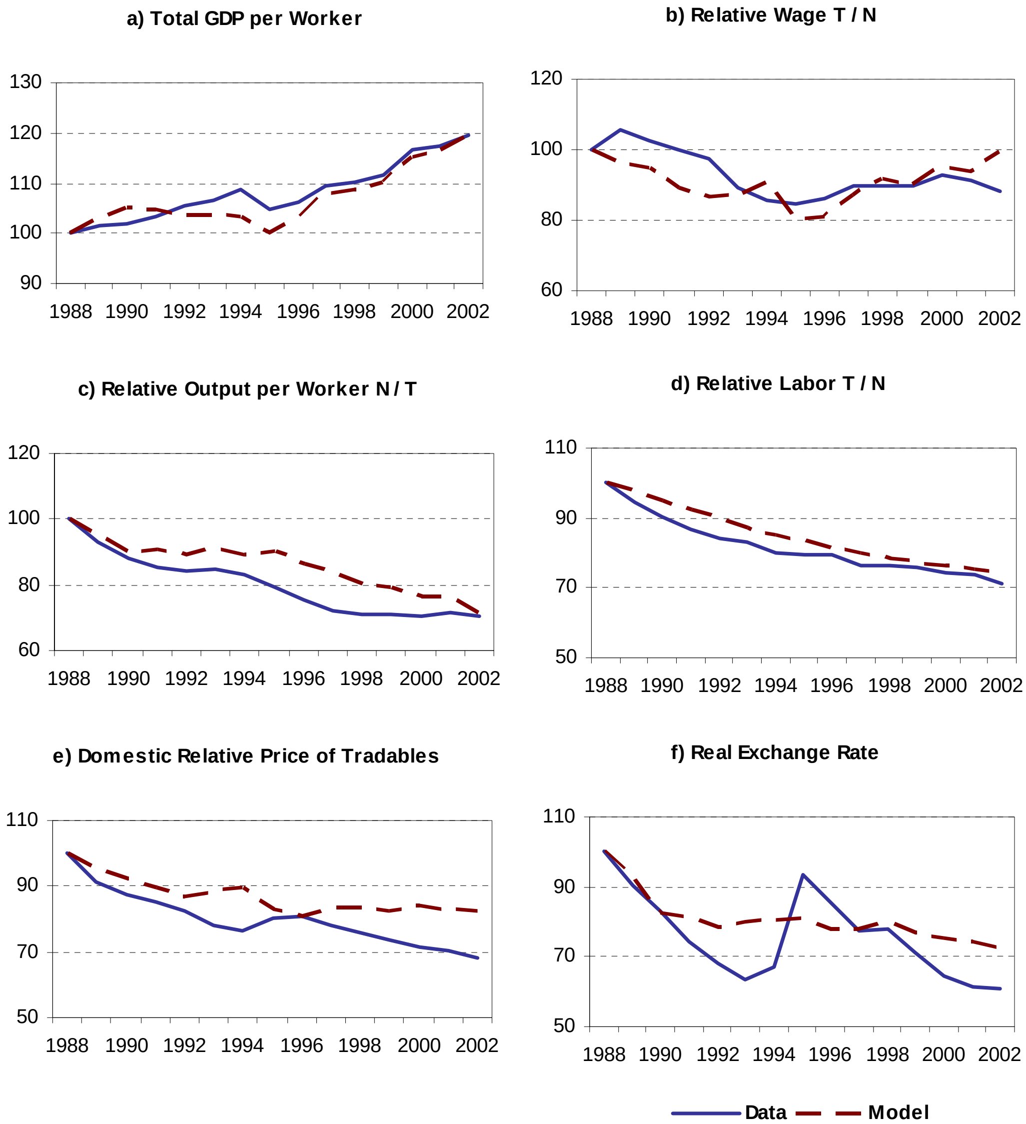

Figure 14. Equilibrium Transition for the Model with Terms of Trade Shocks

Contribution (%)	**Relative Price (T/N)**
(1) Relative Wages (T/N)	24%
(2) Relative Labor Income Shares (N/T)	10%
(3) Relative Output per Worker (N/T)	66%
(1)+(3)	90%
(1)+(2)+(3)	100%

Table 1. Decomposition of the Relative Price of Tradable over Non-Tradable Goods

Annualized Growth Rate (%)	**Output**	**Capital**	**Labor**	**Implied A**
	Tradable Sector			
1988-93	3.5%	2.7%	0.2%	2.1%
1993-98	4.4%	4.7%	1.1%	1.5%
1998-02	1.5%	-0.1%	-0.5%	1.9%
1988-2002	3.3%	2.6%	0.3%	1.8%
	Non-tradable Sector			
1988-93	4.0%	6.2%	4.0%	-0.8%
1993-98	2.4%	2.3%	2.8%	-0.5%
1998-02	3.3%	6.5%	1.3%	0.2%
1988-2002	3.2%	5.1%	2.8%	-0.4%

Table 2. Sectoral Growth Accounting

	Latin American Countries				
Avg. yearly change	Mexico (88-02)	Venezuela (88-01)	Brazil (88-98)	Chile (88-00)	Argentina (88-01)
Real exchange rate[a]	-3.6%	-4.1%	-3.4%[b]	-2.0%	-1.8%[b]
Labor reallocation[c]: L^T/L^N	-2.4%	-3.6%	-4.2%[d]	-3.1%	-3.6%[d]
	Central and Eastern European Countries				
Avg. yearly change	Bulgaria (92-02)	Romania (92-02)	Czech R. (92-02)	Poland (92-02)	Hungary (92-02)
Real exchange rate[a]	-7.7%	-6.6%	-5.5%	-4.6%	-3.0%
Labor reallocation[c]: L^T/L^N	-2.5%	-2.1%[d]	-2.1%[d]	-4.1%[d]	-3.1%

[a] CPI based real effective exchange rate from IMF International Financial Statistics, unless indicated. A minus sign indicates an appreciation. For Mexico we use the RER presented in Figure 2.

[b] Trade weighted real exchange rate from JP Morgan. Source: Haver Analytics.

[c] Constructed using ILO Laborstat's employment by industry. For Mexico we used our own calculations.

[d] 92-98 for Brazil, 96-01 for Argentina, 94-02 for Romania and Poland, and 93-02 for the Czech Republic.

Table 3. Real Appreciation and Labor Reallocation in Selected Countries

Statistic		**Parameter**	
Labor income share in tradable sector	0.52	α_T	0.48
Labor income share in non-tradable sector	0.65	α_N	0.35
Elasticity of substitution T and N goods	0.5	ρ	-1.0
Ratio of tradable to non-tradable goods in domestic demand	0.55	γ	0.23
Long run world interest rate	4.5%	β	0.957
Intertemporal elasticity of substitution	0.5	σ	2.0
Depreciation rate	0.05	δ	0.05
Stationary fraction of labor in tradable sector	40%	A_0^T/A_0^N	0.516
Stationary fraction of net exports in GDP	2.3%	B_0	-0.045
Minimum distance between data and model			
- Total real GDP per worker		ψ	32.25
- Relative wage between T and N sectors		ϕ	145.64

Table 4. Calibration of the Model

Change (%) 88-02	**Price of Tradables**	**Relative Labor T/N**
Data	-32.1%	-28.9%
Benchmark Economy	-19.1%	-24.9%
- No Productivity Shocks	-12.5%	-16.5%
- No Adjustment Costs for Labor	-16.2%	-38.3%
- Adding Remittances	-19.1%	-25.2%
- Adding Changes in Reserves	-18.6%	-26.2%
- Adding Government Spending	-18.2%	-22.3%

Table 5. Accounting for the Mexican Appreciation

Statistic		**Parameter**	
Elasticity of substitution between tradable goods and imports	2	ζ	0.5
Ratio of imports to tradable goods	0.56	μ	0.57
Ratio of tradable to non-tradable goods in domestic demand	0.55	γ	0.30
Stationary fraction of labor in tradable sector	40%	A_0^T/A_0^N	1.391
Stationary fraction of net exports in GDP	2.3%	B_0	-0.126
Minimum distance between data and model			
- Total real GDP per worker		ψ	36.55
- Relative wage between T and N sectors		ϕ	178.66

Table 6. Calibration of the Model with Terms of Trade Shocks

Change (%) 88-02	**Price of Tradables**	**Relative Labor T/N**
Data	-32.1%	-28.9%
Benchmark Economy	-19.1%	-25.2%
Model with Terms of Trade Shocks	-17.5%	-25.3%
- Adding Import Tariffs Reduction	-16.6%	-25.2%

Table 7. Accounting Using the Model with International Goods Differentiation

References

Acosta, P., E. Lartey, and F. Mandelman, 2007, "Remittances and the Dutch Disease," *Federal Reserve Bank of Atlanta Working Paper.*

Amuedo-Dorantes, C., and S. Pozo, 2004, "Workers' Remittances and the Real Exchange Rate: A Paradox of Gifts," *World Development,* Vol. 32, pp. 1407-17.

Asea, P.K., and E.G. Mendoza, 1994, "The Balassa-Samuelson Model: A General-Equilibrium Appraisal," *Review of International Economics.*

Balvers, R.J., and J. H. Bergstrand, 2002, "Government Expenditure and Equilibrium Real Exchange Rates," *Journal of International Money and Finance*, Vol. 21, pp. 667-92.

Canzoneri, M.B., Cumby, R.E., and B. Diba, 1999, "Relative Labor Productivity and the Real Exchange Rate in the Long Run: Evidence for a Panel of OECD countries," *Journal of International Economics*, 47, 245-66.

Cashin, P., Cespedes, L.F., and R. Sahay, 2004, "Commodity Currencies and the Real Exchange Rate," *Journal of Development Economics*, Vol. 75, pp. 239– 68.

Choudhri, E.U., and M.S. Khan, 2005, "Real Exchange Rates in Developing Countries: Are. Balassa–Samuelson Effects Present?", *IMF Staff Papers*, 52.

De Gregorio, J., and H. Wolf, 1994, "Terms of Trade, Productivity and the Real Exchange Rate," *NBER Working Paper* 4807.

Durdu, C.B., and S. Sayan, 2008, "Emerging Market Business Cycles with Remittance Fluctuations," *IMF Staff Papers*, forthcoming.

Edwards, S. and S. Van Wijnbergen, 1987, "Tariffs, the Real Exchange Rate and the Terms of Trade: On Two Popular Propositions in International Economics", *Oxford Economic Papers*, Vol. 39.

Engel, C., 1999, "Accounting for U.S. Real Exchange Rate Changes," *Journal of Political Economy*, Vol. 107, pp. 507-38.

Garcia-Verdú, R., 2005, "Factor Shares From Household Survey Data," *Banco de Mexico Working Paper,* Number 5, October.

Gollin, D., 2002, "Getting Income Shares Right," *Journal of Political Economy*, Vol. 110(2), pp. 458-74.

Guerrieri, V. and D. Acemoglu, 2008, "Capital Deepening and Non-Balanced Economic Growth," *Journal of Political Economy*, Vol. 116, pp. 467-98.

Halpern, Laszlo, and C. Wyplosz, 2001). "Economic Transformation and Real Exchange Rates in the 2000s: The Balassa-Samuelson Connection", Chapter 6 of *Economic Survey of Europe, 2001, No. 1*, Geneva, Switzerland:United Nations.

Kehoe, T.J., and K.J. Ruhl, 2009, "Sudden Stops, Sectoral Reallocations and the Real Exchange Rate," *Federal Reserve Bank of Minneapolis Staff Report 414*, January.

Mendoza, E.G., 2005, "Real Exchange Rate Volatility and the Price of Nontradable Goods in Economies Prone to Sudden Stops," *Economía*, Fall.

Mendoza, E.G., and V. Yue, 2008, "A Solution to the Default Risk - Business Cycle Disconnect," *mimeo.*

Meza, F., 2008, "Financial Crisis, Fiscal Policy and the 1995 GDP Contraction in Mexico," *Journal of Money, Credit and Banking*, Vol. 40, pp. 1239-61.

Meza, F. and E. Quintin, 2007, "Factor Utilization and the Real Impact of Financial Crises," *The B.E. Journal of Macroeconomics*, Advances, Vol. 7(1).

Ngai, L.R. and C. Pissarides, 2007, "Structural Change in a Multisector Model of Growth," *American Economic Review*, Vol. 97, 429-43.

Pratap, S. and E. Quintin, 2009, "Financial Crises and Labor Market Turbulence," *mimeo.*

Pratap, S., and C. Urrutia, 2008, "Financial Frictions and Total Factor Productivity: Accounting for the Real Effects of Financial Crises," *mimeo.*

Ricci, L.A., Milesi-Ferretti, G., and J. Lee, 2008, "Real Exchange Rates and Fundamentals: A Cross-Country Perspective," *IMF Working Paper*, January.

Rodrik, D., 2006, "The Social Cost of Foreign Exchange Reserves," *International Economic Journal*, Vol. 20(3), pp 253-66.

Ruhl, K.J., 2008, "The International Elasticity Puzzle," *mimeo.*

Stockman, A.C. and L. Tesar, 1995, "Tastes and Technology in a Two-Country Model of the Business Cycle: Explaining International Comovements," *American Economic Review*, Vol. 85(1), pp. 168–85.