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ABSTRACT

A “sudden stop” of foreign capital flows in a developing country tends to be followed by a switch from trade deficits to surpluses, a sharp depreciation of the real exchange rate, and a decrease in output and total factor productivity. We further document that there is substantial reallocation taking place across the nontradable and tradable good sectors. Using Mexico’s 1994-95 crises as an archetypal example, we find that output falls more in the nontradable goods sector and recovers more slowly than in the tradable goods sector as labor and capital are shifted from the nontradable to the tradable good sector. We construct a multisector model in which it is costly to shift resources across sectors, and calibrate it to the Mexican economy. In contrast to other models of sudden stops, we do not model any other shocks affecting the economy, which allows us to isolate the effects of the sudden stop. When the calibrated model is subjected to a sudden stop of capital inflows it is able to replicate the sectoral patterns we find in the data and account for the movements in the real exchange rate and the relative price of tradables and nontradables.

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1. Introduction

Episodes in which foreign lenders will no longer extend credit to a country – *sudden stops* in the language of Guillermo Calvo – continue to plague economies trying to deal with the lack of credit, and economists trying to understand their causes and effects. Many authors have focused on why these sudden stops occur and what economic fundamentals may drive these episodes. In this paper, we instead analyze the effects that accompany these sudden stops, with a focus on how they differ across sectors that produce tradable goods or nontradable goods. We then construct a simple quantitative model in which a country produces tradable and nontradable goods and calibrate it to Mexico in 1989. When we subject the model to a sudden stop (the debt crises in 1994-95) it can reproduce the behavior of the real exchange rate, the trade balance, and the price of nontradable goods. When the sudden stop is the only exogenous shock, the model cannot reproduce the observed decline in output, but a model augmented with a calibrated total factor productivity (TFP) shock generates a large decrease in output without damaging the model's ability to account for the trade balance and relative prices.

There have been numerous theories and models put forth to explain why sudden stops occur; see, for example, Calvo (1988), Calvo (1998), Kaminsky and Reinhart (1999) and Cole and Kehoe (2000). In many of the models constructed to analyze a government's decision to default on its debt or a foreign lender's willingness to lend the authors must take as exogenous the real effects of the default. This is usually a matter of necessity; models of sudden stops typically involve dynamic decision problems that are difficult to analyze. Taking the consequence of the decisions as exogenous is usually necessary to gain tractability. In contrast, a second line of inquiry has focused on the effects of sudden stops, taking the sudden stop as given.

Empirically, papers such as Calvo and Talvi (2005), Guidotti, Sturzenegger and Villar (2004), Chari, Kehoe and McGrattan (2005), and Meza and Quintin (2003) have looked at the effects of sudden stops on the aggregate economy. These studies have documented the declines in GDP and TFP that accompany sudden stops. Burstein, Eichenbaum and Rebelo (2005) and Mendoza (2005) study the real exchange rate devaluations from

sudden stops and the large role that nontradable good prices play in these devaluations. In this paper, we focus on the effects of a sudden stop on the disaggregated economy. When credit is restricted, we find that output in the tradable good sector falls by less than output in the nontradable good sector and that labor and investment move from the nontradable good to the tradable good sector. We also find that changes in the relative price of tradable to nontradable goods account for 20 percent of the movement in real exchange rates. We document these characteristics for the sudden stop in Mexico in 1994-95.

Building on the differential effects of a sudden stop on the 2 sectors that we find in the data, we construct a model that features both tradable and nontradable good sectors. A key component of the model is costly labor adjustment. In a model with these features, an unforeseen sudden stop leaves the economy with a suboptimal allocation of labor and capital across the two sectors. The country – which was financing imports through foreign borrowing – now faces a relatively scarce supply of tradable goods, driving up their price relative to nontradable goods, creating an incentive to move resources into the tradable goods sector to increase production. The real frictions lead to only partial adjustment of labor and capital between the two sectors. When we calibrate the model to the Mexican economy and subject it to a sudden stop the model can replicate the sectoral patterns that we see in the data, as well as the trade balance and the real exchange rate. The baseline model, which features only one exogenous shock – the sudden stop – is not able to reproduce the observed decline in output and TFP.

Accounting for the declines in GDP and TFP that coincide with sudden stops is challenging. Chari et al. (2005) show that standard equilibrium models predict not an output decrease, but an output *increase* from an abrupt tightening of collateral constraints. They note that generating an output decrease requires frictions that have negative effects on output large enough to overcome the natural response to a decrease in credit. The costs of moving labor and capital across sectors in our model do provide a direct channel through which sudden stops could affect output and TFP. Moving labor uses up output, leading to a decrease in GDP. Since GDP is falling and the amount of

labor being employed is constant, these costs manifest themselves as decreases in measured TFP. In our calibrated model, however, the costs actually incurred are not large enough to account for the change in GDP or the decrease in TFP.

Mendoza and Smith (2004) and Neumeyer and Perri (2005) introduce financial frictions into small open economy models by requiring firms to borrow funds to pay in advance for labor or imported inputs and these models are able to account for many of the characteristics of emerging market economies. Meza and Quintin (2003) allow for labor hoarding and variable capital utilization. Our approach differs in two respects; while their models focused on single good environments, we model two sectors so that we can make predictions about the effects of sudden stops on tradable and nontradable industries; we also take the sudden stop to be the only exogenous force in the model, while the others incorporate more shocks by assuming an exogenous processes for TFP or interest rates. As an extension, we consider a specification of our model in which the economy is subject to an aggregate TFP shock of the same magnitude as that in the data. We find that the augmented model can also account for a large share of the decline in output without distorting our ability to account for prices and trade flows. Though we do not view this shock to TFP as an appealing explanation for the decline in output, we consider it an important robustness check.

Calvo (1998) appeals to the same kinds of changes in tradable and nontradable good prices that we do, but envisions these changes generating effects through banks having made loans at the pre-crisis relative prices. Under the new relative prices, some of these loans are nonperforming. We abstract from the banking sector in this model to quantitatively assess how far a standard model can go in explaining the effects of sudden stops. As discussed above, this simple model can go a long way in accounting for the effects of a sudden stop, though the effects of a sudden stop may work through the banking sector in important ways as far as generating declining output.

We also discuss another commonly cited idea that changes in the terms of trade (real exchange rate) that accompany sudden stops make imported intermediates more

expensive and act like a decrease in TFP. We show that under standard national accounting definitions of GDP, changes in the terms of trade cannot have a first order effect on GDP, and thus cannot affect TFP. Though there may be second order effects if the change in the terms of trade is large enough, our quantitative model – which does display a large change in the terms of trade following the sudden stop – suggests that these effects were not at work in Mexico during the crisis.

In Section 2 we document the facts surrounding the sudden stop in Mexico in 1994-95. Section 3 discusses, and dismisses, the idea that deteriorations of the terms of trade can show up as changes in GDP or TFP. Sections 4 and 5 lay out our multisector model and calibrate it to Mexico in 1989. Section 6 discusses the results of this model and compares its predictions to the data while section 7 and 8 consider extensions to the model. Section 9 concludes.

2. The Mexican Debt Crisis

In this section we highlight the empirical properties of Mexico's opening to foreign capital in the late 1980s – the *apertura* – and the sudden stop in 1994-95. We choose to focus on Mexico because it is an archetypical example of a sudden stop and a country with the needed sectoral data. Preliminary analysis into other episodes suggests that the facts we document here are widely applicable to countries in debt crisis and we leave to future work compiling these facts for a large number of countries. We find that a sudden stop of foreign capital inflows is usually followed by (i) a switch from trade deficits to trade surpluses, (ii) a sharp depreciation of the real exchange rate, (iii) an increase in the price of tradable good relative to nontradable, and (iv) a shift in employment and output from the nontradable goods sector to the tradable goods sector.

Figure 1 plots the balance of Mexico's financial account less net foreign direct investment as a share of GDP. The data is taken from the balance of payments accounts and includes net portfolio investment and the net inflows of banks and the government. As Mexico opened its capital markets, the country went from being a net lender to a net borrower. In the second quarter of 1994 there was a decline in borrowing that brought

net inflows to -0.96 percent of GDP, but the decline was reversed in the third quarter and Mexico was accumulating external capital at the same rate it was a year before. In the last quarter of 1994 Mexico's sudden stop occurs and the financial account falls to -0.95 percent of GDP and bottoms out in the first quarter of 1995 at -4.62 percent of GDP. Capital inflows temporarily spiked in the third quarter of 1996 and the first quarter of 1997 before returning to steady inflows in the late 1990s.

A natural question to ask is whether or not there were foreseeable conditions in Mexico that may have led to this abrupt withdrawal of credit. To address this question we plot the interest rate paid by Mexico on foreign debt in Figure 2. We measure the interest rate in two parts. The first part is the U.S. Treasury bill rate. The second component is the Mexico-specific interest rate spread. This series is the J.P. Morgan Emerging Market Bond Index spread on Brady Bonds computed after stripping out the collateralized principal. This component is widely used to measure country specific risk premia. The sum of these two components is the interest rate on external borrowing by Mexico. Two things are clear from the figure: changes in the rate paid by Mexico are due almost entirely to country specific factors and the risk premia on Mexican debt did not increase before the crisis. In November of 1994 the risk premia on Mexican debt was 4.56 percent, which was less than the average spread from 1991 through November of 1994. Not until December, the first month of the crisis, did the risk premia increase to 8.90 percent and then peak at 16.37 in March of 1994. The behavior of interest rates makes it clear that this sudden really was sudden and largely unforeseen.

Most of the empirical research on sudden stops has focused on the economies at the aggregate level. In this section we divide the aggregate economy into two sectors, one which produces goods that are tradable and one that produces goods that are nontradable. The classification of a good, much less an industry, as either tradable or nontradable is difficult, but we follow Stockman and Tesar (1995) and Betts and Kehoe (2001) in assigning the agriculture, mining, and manufacturing sectors as producing tradable goods and construction and services to be nontradable.

At the onset of the sudden stop, the trade balance immediately went into surplus. As can be seen in Figure 3 the trade balance went from -8.4 percent of GDP in 1994 to a 2.7 percent surplus in 1995 and stayed positive until 1997. Mexico continued running trade deficits, although they were smaller in magnitude after the sudden stop. The adjustment to the trade balance during a sudden stop is a robust fact; Guidotti et al. (2004) study 313 sudden stop episodes and find that the current account adjusts in 265 of them.

The sudden stops in these countries were also accompanied by large devaluations of the real exchange rate. We define the real exchange rate for Mexico, vis-à-vis the United States as

$$RER_{mex,us} = NER_{mex,us} \frac{P_{us}}{P_{mex}}, \quad (1)$$

Where $NER_{mex,us}$ is the Peso to Dollar exchange rate and P_j is inflation in country j , as measured using gross output deflators. We plot the log real exchange rate for Mexico in Figure 4. After opening to foreign capital, the Peso-Dollar real exchange rate appreciates by 38 percent from 1988-1994. At the onset of the sudden stop, the real exchange rate depreciates by 31 percent from 1994 to 1995 and appreciates as the sudden stop ends, returning to its 1994 level around the year 2000.

We can decompose the movements of the real exchange rate into its sectoral components. To do this, we decompose the real exchange rate in (1) as

$$RER_{mex,us} = \left(NER_{mex,us} \frac{P_{us}^T}{P_{mex}^T} \right) \left(\frac{P_{mex}^T}{P_{mex}} / \frac{P_{us}^T}{P_{us}} \right) = RER_{mex,us}^T \times RER_{mex,us}^N, \quad (2)$$

where we define the price of tradable goods, P^T , as the gross output deflator for agriculture, mining, and manufacturing. The first term in the decomposition measures deviations from the law of one price. If the law of one price held, this term would be identically one. The second term in the decomposition is the relative price of nontradable to tradable goods and does not include the nominal exchange rate. Taking logs we have

$$rer_{mex,us} = rer_{mex,us}^T + rer_{mex,us}^N. \quad (3)$$

We plot rer^N for Mexico vis-à-vis the U.S. in Figure 4. When Mexico opens to foreign capital in the late 1980s, the relative price of tradable to nontradable goods falls by 16 percent from 1988-1994. This accounts for about 40 percent of the appreciation of the real exchange rate. During the sudden stop, the price of tradable goods increases by 6 percent relative to nontradable goods, accounting for 20 percent of the real exchange rate depreciation.

In Figure 5 we plot value added for the tradable and nontradable good sectors in Mexico. As can be seen, value added in the nontradable good sectors falls more than in the tradable good sectors and recovers at a much slower rate. In Mexico, tradable good value added falls half as much as nontradable good value added and grows faster for the next 5 years. The shift in production from the nontradable sector to the tradable sector is the focus of our analysis and the key ingredient in our model below.

The shift from nontradable good production can also be seen in the allocation of labor across the two sectors. Figure 6 plots the share of tradable good employment in total employment in Mexico. In Mexico, as in most industrialized countries, there is a steady trend of labor leaving the tradable good sector for the nontradable good sector. During the sudden stop, though, there is an abrupt stop in the movement of workers out of the tradable good sector, which amounts to – relative to the trend – a reallocation of workers to the tradable good sector. In the model that follows, we will abstract from the secular trend in employment, so we focus on the linear detrended path for employment, as seen in Figure 7. The 5.72 percent increase in tradable good employment, as can be seen in the figure, is the statistic we would like our model to reproduce.

The sectoral data shows that there is more going on during a sudden stop than can be seen at the aggregate level. In response to a sudden stop, the relative price of tradable to nontradable goods increases, leading to a shift of resources away from the nontradable good sectors and into the tradable goods sectors. In the next section we construct a general equilibrium model to help us account for the features of the data we have highlighted here.

3. Model

We model Mexico as a small open economy with perfect foresight over the paths of world interest rates, TFP growth rates, and population growth. In 1988 the economy is closed to foreign capital inflows. The economy opens to foreign capital – the apertura – in 1990 and receives large capital inflows. Four years later, Mexico experiences a sudden stop; foreign investors unexpectedly stop lending to the country in 1995. Our model is based on the one first used in Fernandez de Cordoba and Kehoe (2000) to study Spain opening to international capital and later by Bems and Jönsson (2005) as applied to the integration of the Baltic States into international capital markets.

Consumers

The country is populated by a continuum of identical consumers, n_t , whose growth is taken as exogenous and foreseen. We differentiate the total population from the working age population; we denote the working age population ℓ_t and match it to the evolution of people aged 15-64 in Mexico. Consumers derive utility from consuming tradable goods, c_T , and nontradable goods, c_N . The consumers inelastically supply labor at wage rate, w_t , invest in capital, and borrow and lend internationally when the economy is open to foreign capital. The consumers' problem can be written

$$\max_{\{c_{jt}, i_{jt}, b_{t+1}\}} \sum_{t=0}^{\infty} \beta^t n_t \left(\left[\varepsilon \left(\frac{c_{Tt}}{n_t} \right)^\rho + (1-\varepsilon) \left(\frac{c_{Nt}}{n_t} \right)^\rho \right]^{\frac{\psi}{\rho}} - 1 \right) / \psi$$

$$\text{s.t. } p_{Tt} c_{Tt} + p_{Nt} c_{Nt} + q_t i_{Dt} + q_t i_{Nt} + b_{t+1} = w_t \ell_t + (1+r_t) b_t + r_{Dt} k_{Dt} + r_{Nt} k_{Nt} + T_t$$

$$c_{Tt} \geq 0, c_{Nt} \geq 0, b_t \geq -A$$

$$b_0, k_{D0}, k_{N0} \text{ given.}$$

When the economy is closed to foreign capital, the interest rate r_t is endogenously determined by domestic conditions. When the economy is open to foreign capital the interest rate in Mexico is $r^* + \sigma_t^{mex}$, where the world interest rate is r^* and the country risk premium is σ_t^{mex} . Bonds are denominated in units of the imported good, which

implies that a real devaluation makes debt more expensive in terms of domestically produced goods. Consumers augment the capital stocks in the domestic tradable goods sector, k_D , and the nontradable good sector, k_N , through investment i_D and i_N . Consumers rent capital to domestic firms at rate r_{kt} . Consumers receive a lump sum transfer, T_t , of tariff revenues collected on imports.

Production

There are 5 types of goods in the model: a domestically produced tradable good, y_D , an imported good, m , a composite tradable good, y_T (made up of the domestically produced tradable and imports), a domestically produced nontradable good, y_N , and an investment good, y_I . All goods are sold in perfectly competitive markets.

The domestic tradable good and the nontradable good are produced using capital, labor, the composite tradable good, and the nontradable good. The maximization problem solved by the producer of the domestic tradable good can be written

$$\begin{aligned} \max \sum_{\tau=t}^{\infty} \beta^{\tau} \frac{U_{\tau}^{c_T} p_{T,0}}{U_0^{c_T} p_{T,\tau}} & \left[p_{D\tau} y_{D\tau} - p_{D\tau} \Theta_D(\ell_{D\tau}, \ell_{D\tau-1}) \ell_{D\tau-1} - r_{D\tau} k_{D\tau} - w_{\tau} \ell_{D\tau} \right] \\ \text{s.t. } y_{D\tau} &= \min \left[z_{TD\tau} / a_{TD}, z_{ND\tau} / a_{ND}, A_D k_{D\tau}^{\alpha_D} (\gamma^{\tau} \ell_{D\tau})^{1-\alpha_D} \right] \end{aligned}$$

where z_{TD} and z_{ND} are, respectively, the amounts of the composite tradable and nontradable good used in production of the domestic tradable good and a_{TD} and a_{ND} are the associated share parameters. Labor augmenting productivity grows at rate $\gamma - 1$.

A firm gives up some output if it chooses to adjust employment. The adjustment function takes the quadratic form consistent with Sargent (1978) and Cooper and Willis (2003) that has been successful at matching aggregate employment volatilities,

$$\Theta_D(\ell_{D\tau}, \ell_{D\tau-1}) = \gamma^{\tau} \theta_D \left(\frac{\ell_{D\tau}}{\ell_{D\tau-1}} - 1 \right)^2. \quad (4)$$

We assume that these costs grow at the same rate as productivity, $\gamma - 1$, which implies that these costs are nontrivial along the model's balanced growth path. Nonconvex models of labor adjustment, as in Cooper, Haltiwanger and Willis (2004), have been shown to be important for matching firm level observations on employment, but our focus on aggregate quantities justifies the more tractable quadratic form. The firm level decisions being made during a sudden stop are certainly interesting, but we leave those to future research. Analogously, the producer of the nontradable good solves

$$\begin{aligned} \max \sum_{\tau=t}^{\infty} \beta^{\tau} \frac{U_{\tau}^{c_T} p_{T,0}}{U_0^{c_T} p_{T,\tau}} & \left[p_{N\tau} y_{N\tau} - p_{N\tau} \Theta_N(\ell_{N\tau}, \ell_{N\tau-1}) \ell_{N\tau-1} - r_{N\tau} k_{N\tau} - w_{\tau} \ell_{N\tau} \right] \\ \text{s.t. } y_{N\tau} &= \min \left[z_{TN\tau} / a_{TN}, z_{NN\tau} / a_{NN}, A_N k_{N\tau}^{\alpha_N} (\gamma^{\tau} \ell_{N\tau})^{1-\alpha_N} \right] \\ \Theta_N(\ell_{N\tau}, \ell_{N\tau-1}) &= \gamma^{\tau} \theta_N \left(\frac{\ell_{N\tau}}{\ell_{N\tau-1}} - 1 \right)^2. \end{aligned}$$

The composite tradable good is made up of the imported tradable good and the domestically produced tradable good using a standard Armington Aggregator production function. The composite tradable good producer solves

$$\begin{aligned} \max p_{Tt} y_{Tt} - p_{Dt} x_{Dt} - (1 + \tau_t) m_t \\ \text{s.t. } y_{Tt} &= M \left(\mu x_{Dt}^{\zeta} + (1 - \mu) m_t^{\zeta} \right)^{\frac{1}{\zeta}}. \end{aligned}$$

The parameter μ governs the share of imports in production and the elasticity of substitution between domestically produced goods and imports is $1/(1 - \zeta)$. Note that the numeraire in this model is the imported good, making its f.o.b. price unity, but the imports are subject to domestically levied tariffs, τ . The price of a unit of the composite tradable good has the usual form,

$$p_{Tt} = \frac{1}{M} \left(\mu^{\frac{1}{1-\zeta}} p_{Dt}^{\frac{-\zeta}{1-\zeta}} + (1 - \mu)^{\frac{1}{1-\zeta}} (1 + \tau_t)^{\frac{-\zeta}{1-\zeta}} \right)^{\frac{1-\zeta}{-\zeta}}. \quad (5)$$

Investment goods are produced using the composite tradable good and the nontradable good using a Cobb-Douglas production function. The investment good producing firm's problem can be written

$$\begin{aligned} \max \quad & q_t y_{It} - p_{Nt} z_{Nt} - p_{Tt} z_{Tt} \\ & y_{It} = \Phi z_{Tt}^\phi z_{Nt}^{1-\phi}, \end{aligned}$$

where q is the price of the investment good.

Lastly, foreign demand for the domestically produced tradable good is

$$x_{Ft} = D_t \left((1 + \tau_{Ft}) p_{Dt} \right)^{\frac{-1}{1-\zeta}},$$

where τ_F is the tariff imposed by the rest of the world on imports. This export demand function implies that the rest of the world has a composite tradable production function that is also of the Armington form and has the same elasticity of substitution between imports and domestic goods. As there is growth in population and technology in Mexico, so is there growth in the rest of the world. This is modeled as the factor D growing over time, increasing the world demand for the goods produced in Mexico.

Market Clearing

Market clearing in the domestic tradable good market requires

$$x_{Dt} + x_{Ft} = y_{Dt} - \Theta_D(\ell_{Dt}, \ell_{Dt-1}) \ell_{Dt-1}.$$

Market clearing in the nontradable good market requires

$$c_{Nt} + z_{Nt} + z_{NDt} + z_{NNt} = y_{Nt} - \Theta_N(\ell_{Nt}, \ell_{Nt-1}) \ell_{Nt-1}.$$

Market clearing in the composite tradable good market requires

$$c_{Tt} + z_{TIt} + z_{TDt} + z_{TNt} = y_{Tt}.$$

Market clearing in the investment good market requires

$$i_{Dt} + i_{Nt} = y_{It}.$$

Balance of payments in this economy requires

$$m_t + b_{t+1} = p_{Dt} x_{Ft} + (1 + r^* + \sigma_t^{mex}) b_t.$$

4. Calibration

We assign values to the model's parameters so that the model replicates key features of the Mexican economy. The multisector nature of this model requires data on the interactions between the tradable and nontradable sectors in the economy. We construct an input-output matrix for Mexico in 1989 to summarize these interactions, as shown in Table 1. Unless otherwise stated, we calibrate the model to 1989 data, so we drop the t subscript in what follows. We take the United States to stand in for the rest of the world; in 1994 the U.S. accounted for 69 percent of total merchandise imports to Mexico and 84 percent of Mexico's exports went to the United States. The U.S. was Mexico's largest lender as well, making up 62 percent of foreign direct investment into Mexico in 1994. We summarize the baseline model's calibration in Table 4.

Production Parameters

We choose the exogenous growth rate of TFP, γ , to be 1.02, which implies that the GDP per working age person grows at 2 percent per year along the balanced growth path. The parameters in the production functions for the domestic tradable and nontradable are computed from the input-output matrix in Table 1. The intermediate good share parameters are set to match the share of intermediate goods used in the input-output matrix. For example, to compute a_{TD} , the share of the tradable good used in the production of the domestic tradable good, we take the amount of the tradable good used as an input to tradable good production and divide it by the gross output (value added plus intermediate consumption) of the tradable good sector,

$$a_{TD,t} = z_{TD,t} / y_{D,t}.$$

Given the Cobb-Douglas form of the capital and labor aggregate used in production, the parameters α_D and α_N are calculated as the return to capital in the sector divided by value added in the sector. With $\gamma^0 = 1$, the scale parameters in the capital labor aggregate are computed as

$$A_j = \frac{y_j}{k_j^{\alpha_j} \ell_j^{1-\alpha_j}} \quad j = D, N.$$

The cost of adjusting the labor used in the tradable and nontradable good sectors requires specifying parameters θ_D and θ_N , as can be seen in equation (4). We restrict the two parameters to be equal and choose the value so that the shift in labor into the tradable good sector is 5.72 percent, as it is in the detrended data in Figure 7.

Calibrating the investment good technology requires choosing the share parameter, ϕ , and the scale parameter, Φ . The first order conditions from the investment firm's problem can be manipulated to yield the usual formula for the share of tradable goods in investment good production,

$$\phi = \frac{P_T z_{TI}}{q_t y_t}. \quad (6)$$

The numerator of the right hand side of (6) is the use of tradable goods in investment and the denominator is the total gross output of the investment sector. These values can be read directly from the input-output matrix in Table 1.

Calibrating the Armington Aggregator, is straightforward once the elasticity of substitution between imports and domestic tradables, $1/(1-\zeta)$, is chosen. As discussed in Ruhl (2003), there is debate over this elasticity as business cycle models tend to imply low elasticities, while analysis of trade policy episodes suggests elasticities much higher. We choose $\zeta = 0.5$, implying an elasticity of 2.0 and discuss the sensitivity of our results to this parameter choice below. Given a value of ζ the first order conditions from the firm's problem yield

$$\frac{\mu}{1-\mu} = \frac{P_D}{1+\tau} \left(\frac{m}{x_D} \right)^{\zeta-1}.$$

With prices normalized to 1 in the base year, μ can be calculated using data on the value of imports and the value of domestically produced tradable goods used in producing tradable goods. The scale parameter, M , is chosen so that the price of the composite tradable good in (5) is unity. The export demand function scale parameter, D , is chosen so that year 0 exports in the model are the same as exports reported in the 1989 input output matrix.

Consumer Parameters

We set the period in our model to be one year, and choose the discount factor, β , to be consistent with annual real interest rates in the United States, our proxy for the rest of the world. We choose the world interest rate in the balanced growth path, r^* , to be 5.0 percent per year which implies $\beta = \gamma^{1-\rho} / (1+r^*) = 0.99$. Following Kravis, Heston and Summers (1982) and Stockman and Tesar (1995), we set $\rho = -1$ so that the elasticity of substitution between tradable and nontradable goods in consumption is 0.5. The parameter ε governs the share of tradable and nontradable goods in consumption. The first order conditions from the consumer's problem yields the familiar condition,

$$\frac{\varepsilon}{1-\varepsilon} = \frac{p_T}{p_N} \left(\frac{c_T}{c_N} \right)^{1-\rho}.$$

Normalizing the base year prices to be 1, the value of ε can be computed using the final consumption of tradable and nontradable goods from the input-output matrix in Table 1. The risk aversion parameter, ψ , is set to -1 so that the intertemporal elasticity of substitution is 0.5. We choose the rate of depreciation, δ , so that depreciation as fraction of GDP is 0.106, the same as in the Mexican data in 1989. In 1989 Mexico ran a small trade surplus of 0.87 percent of GDP. We set the initial stock of bonds held by the consumer, b_0 , so that the model replicates this statistic.

Exogenous Processes

To account for any changes that might be due to the North American Free Trade Agreement, we include falling tariffs in the model. We model Mexican tariffs on U.S. goods as being 10 percent until 1994, at which time they fall to 5 percent. From 1994-2004 the tariff rates falls by 0.5 percentage points a year, until it is zero. U.S. tariffs on Mexico are 3 percent until 1994, at which time they fall to 1.5 percent. From there, tariffs fall by 0.15 percentage points per year until they reach zero in 2004. Both tariffs remain at 0 forever after 2004.

As can be seen in Figure 8, the interest rate at which Mexico could borrow fell from 19 percent in December of 1990 to about 7 percent in 1994. These higher interest rates are usually regarded as country specific risk premia, and the gradual elimination of these premia reflect the idea that Mexico gradually gained credibility as it instituted structural changes. Since we do not model the structural changes taking place in the Mexican economy, we take as exogenous a time varying risk premia on the rate at which Mexico can borrow from the rest of the world. This approach is also used in Bems and Jönsson (2005).

We use the J.P. Morgan Emerging Market Bond Index spread on Brady Bonds as our measure of the Mexican risk premia. The premia spikes in 1995, reflecting the increased country risk following the default. Since the post-1994 premia would not have occurred if the country hadn't defaulted, we assume that agents believed the path of risk premia to be that same as in the data up to 1994, and gradually decline to zero by 2007. Once the sudden stop has occurred, agents perfectly foresee the path of risk premia that are the same as in the data until 1998, at which point they gradually decline to zero by 2007. Our data start in 1991, so we assume that the risk premia for the 1988-1991 are the same as in 1991.

5. Baseline Model Results

Before subjecting the model to a sudden stop, it is useful to briefly study the model without a sudden stop. Without the sudden stop, the exogenous variables in the model are the number of working aged and adult equivalent persons, the tariff rates, and the growth rate of TFP. The initial capital stocks are set to their 1989 values and the population growth rates are taken from the data. When Mexico opens to capital flows its stock of capital is much lower than it will be in the balanced growth path. This can be seen in Figure 9, where the capital output ratio is plotted for the model without a sudden stop. Figure 10 shows how Mexico quickly accumulates capital until it reaches the balanced growth path, after which the accumulation slows and the capital output ratio is constant.

Open capital markets allow Mexico to borrow from abroad to finance investment by importing traded goods. After opening to foreign borrowing, the agents run trade deficits early and switch to trade surpluses as they begin paying on the debt, as is shown in Figure 10. Essentially, the dynamics are those of the neoclassical growth model in a small open economy; poor countries borrow to help smooth consumption while building up their capital stocks.

Sudden Stop

To solve for the model's equilibrium when a sudden stop occurs, we first compute the equilibrium of the model when Mexico opens to international capital flows and expects to stay open, as in the previous section. Using the equilibrium values for the capital and labor stocks in 1994 we resolve the model from 1994 onward, imposing that no borrowing is possible in 1995 and 1996. Solving the model in this way assumes that agents do not foresee the sudden stop, but have perfect foresight over the length of the sudden stop and the path of world interest rates.

When the sudden stop occurs, tradable goods, which were being financed by a trade deficit, are now relatively scarce and the price of tradable goods relative to nontradable goods increases. Since this sudden stop is unforeseen, the economy does not have capital and labor properly allocated across the two sectors. Labor and capital are costly to move, so agents choose to only partially adjust to the change. The results of this model are summarized in Figure 11.

Figure 11(a) plots the trade balance, as a fraction of GDP, in both the model and the data. As in all of the graphs that follow, the data are plotted as a solid line and the model's variable is plotted as a dashed line. The model does a good job of reproducing the shape of trade balance. The trade balance goes negative when the country opens to capital flows and sharply reverses when the sudden stop occurs. As the sudden stop ends, the trade balance returns to a deficit in both the model and the data, though it takes longer to return to a deficit in the model. Figure 11(b) plots the detrended movements in the share of labor that is used in the tradable good sector. The parameter in the labor adjustment

function was chosen so that the magnitude of the shift of labor is the same in the model as in the data, but the shape and timing of the shift are determined by the model. In the model the shift of labor into the tradable good sector happens quicker than in the data, peaking in 1996 compared to 2000 in the data, but overall the model can account for reallocation of labor following a sudden stop.

Figures 11(c) and 11(d) display the model's predictions for prices compared with the data. Figure 11(c) plots the log real exchange rate. The real exchange rate in the model does not appreciate as quickly as in the data when Mexico opens to capital flows, but the model's real exchange rate displays the same sharp depreciation as the data when the economy is subjected to a sudden stop. In the model, the real exchange rate depreciates by 29 percent compared to the 31 percent depreciation in the data. As the sudden stop ends, the real exchange rate reappreciates, as in the data, though less so. When the model is subjected to a sudden stop, the price of tradable goods relative to nontradable goods increases, which can be seen in Figure 11(d), which displays the (bilateral) relative price of nontradable goods to tradable goods, rer^N . From 1994 to 1995 the price of tradable goods in the model increases by 14 percent compared to 6 percent in the data. These calculations imply that the deviations from the law of one price in the model increase by about 17 percent, reflecting the change in the terms of trade as U.S. produced imports grew more expensive. In the data, the law of one price deviation increased by 25 percent. Overall, the model does a good job of capturing the behavior of prices in Mexico.

Figures 11(e) and 11(f) compare the paths of output in the tradable and nontradable sectors in the model and the data. The model does feature the shift of production from the nontradable to the tradable goods sector, but it fails to capture the falling output in the tradable good sector. Output in the nontradable goods sector does fall, but not by as much as it does in the data. We discuss this feature of the model in section 7.

6. Sensitivity

[To be added]

7. Output and Productivity

The baseline model does a very good job of accounting for the trade balance, relative prices, and real exchange rates. As is evident in Figure 11(e) the model is less successful in reproducing the output dynamics in Mexico. Though the output of nontradable goods falls during the sudden stop, the tradable goods sector grows. In the data, both sector experience falling output from 1994-1995.

Output and Productivity in Mexico

The aggregate effect of the sectors' decline in GDP can be seen in Figure 12. GDP per working age person fell by 9.0 percent from 1994 to 1995 in Mexico, which coincided with a 7.6 percent decline in TFP. Output recovered following the sudden stop, growing more than twice as fast in 1995-2001 than in 1988-1994. There is a growing literature studying the output effects of sudden stops in one-good economies. In a similar manner, we can use the neoclassical growth model to decompose the changes in output per working age person into changes in labor effort, capital accumulation and the residual, TFP. To do so, we use an aggregate production function of the form,

$$Y_t = A_t K_t^\alpha L_t^{1-\alpha} \quad (7)$$

where Y_t is output, A_t is total factor productivity K_t is capital and L_t is hours worked in period t . Following Hayashi and Prescott (2002) and Kehoe and Prescott (2002), we write the production function in terms of output per working age person and measures of factor inputs that are constant along a balanced growth path,

$$\frac{Y_t}{N_t} = A_t^{\frac{1}{1-\alpha}} \left(\frac{K_t}{Y_t} \right)^{\frac{\alpha}{1-\alpha}} \frac{L_t}{N_t}, \quad (8)$$

where N_t is the working age population.

To compute (8) we use real GDP as our measure of output, the population aged 15-64 as the working age population, hours worked data, and capital stocks constructed from real investment. To construct the capital stocks, beginning with a value of the capital stock in 1950, we cumulate real investment according to

$$K_{t+1} = (1 - \delta)K_t + I_t \quad (9)$$

with the depreciation rate equal to 0.035 for Mexico. We choose the initial capital stock, K_{1950} , so that the capital output ratio in 1950 is the same as the average capital output ratio from 1951-1960. With output, labor inputs and capital stocks, we compute TFP as the residual

$$A_t = \frac{Y_t}{K_t^\alpha L_t^{1-\alpha}}. \quad (10)$$

The results of our growth accounting for Mexico are presented in Table 3. In the period leading up to the sudden stop, output per working age person grew at an average rate of 0.72 percent per year, about two-thirds of which can be accounted for by TFP growth and about one-third of which can be accounted for by an increase in the rate of capital accumulation. The dramatic effect of the sudden stop can be seen in the second line of the table, as output per working age person falls 9.02 percent. During this period the TFP factor falls by even more, 11.34 percent, while the capital factor increases by 4.31 percent and the labor factor falls by about 2 percent. Since the end of the crisis, Mexico has averaged a growth rate of output per working age person of 1.52 percent per year, with most of the growth being accounted for by growth in TFP.

As we have seen in Table 1, a sudden stop of foreign capital inflows are followed by sharp declines in aggregate output and TFP. Movements in the capital output ratio and hours worked tend to be much smaller. These results are similar to those in Meza and Quintin (2003) which also uses a growth accounting framework to study sudden stops in Mexico and countries affected by the Asian crisis in the late 1990s. These results make it clear that any theory that hopes to explain the drop in output following a sudden stop must also deliver a sharp decline in aggregate TFP.

A Model with Exogenous TFP Effects

Our simple model, in which a sudden stop acts on an economy through the interaction of traded and nontraded goods, is successful in reproducing many aspects of the Mexican crisis, but is unable to account for the change in GDP. In this section, we consider a version of the model in which we allow for an exogenous TFP shock. TFP shocks are a

key component of much of the literature on sudden stops; for example, Mendoza and Smith (2004), Meza and Quintin (2003), and Neumeyer and Perri (2005) use shocks to TFP in generating the effects of sudden stops. Our simple exercise here is not to suggest that a large shock to TFP was the driving force behind the fall in output in Mexico, but rather to show that our model is capable of delivering decreases in aggregate output while still accounting for prices and trade flows.

We take the model from section 4 in which the economy is subjected to an exogenous and unforeseen sudden stop as well as perfectly foreseen, time varying risk premia. We introduce variation in TFP at the aggregate level by allowing the scale parameter in the labor capital aggregate to vary with time,

$$y_{D\tau} = \min \left[z_{TD\tau} / a_{TD}, z_{ND\tau} / a_{ND}, A_D k_{D\tau}^{\alpha_D} \left((v_\tau \gamma)^\tau \ell_{D\tau} \right)^{1-\alpha_D} \right]$$

$$y_{N\tau} = \min \left[z_{TN\tau} / a_{TN}, z_{NN\tau} / a_{NN}, A_N k_{N\tau}^{\alpha_N} \left((v_\tau \gamma)^\tau \ell_{N\tau} \right)^{1-\alpha_N} \right].$$

The shock to total factor productivity, v_t , is the same across industries. We assume that v is equal to 1 for all years before 1995, and is equal to 0.86 for all years 1995 and later. When we construct aggregate TFP measure in our model in the same way we constructed the in the data, we recover a fall in TFP from 1994-1995 that is the same as in the data. The TFP series recovered from the model, along with the model's aggregate GDP, is shown in Figure 13.

The model is solved as in the previous specifications and we assume that agents are surprised by the TFP shock in the same way they are surprised about the sudden stop; agents do not foresee the TFP drop, but they perfectly foresee the path of TFP afterward. As can be seen, the fall in TFP leads to a 4.8 percent decrease in GDP per working age person, accounting for 53 percent of the decline in GDP in the data. As can be seen from panels a. through d. in Figure 14, the results regarding the trade balance, the real exchange rate and the allocation of labor change very little from those in the model without an exogenous change in TFP. In panel e. it can be seen that the change in TFP makes output in the nontradable sector fall even more than before, accounting for almost

the entire decline in nontradable output in the data. In the traded good sector, output falls also, in contrast to the model without the decrease in TFP. Tradable good output falls less than nontradable good output, as in the data, and recovers from the drop by growing faster than nontradable good output, another feature of the data. Overall, the changes in TFP make the model fit the data – particularly the data on output – better.

That large changes in TFP can account for large changes in output in models like this is not a new result. For example, many of the papers in Kehoe and Prescott (2006) have shown that the large declines in output that make up “great depressions” can be accounted for by TFP. We do not, however, believe that, for an exogenous reason unrelated to the sudden stop, TFP fell by 7 percent in 1995, but we leave identifying the inefficiencies set into motion by the sudden stop to future work, such as those used in Mendoza (2006). Rather, our intention in this section is to show that when the model is modified to produce a large decline in aggregate output, our results concerning prices and trade flows are largely unchanged.

8. Conclusion

In this paper we study sudden stops from a relatively new perspective: we focus on the effects of sudden stops on tradable goods sectors relative to nontradable good sectors. Looking at the data in this way we find that the nontradable good sector suffers a larger decline in output and a slower recovery from the sudden stop. We document how resources are transferred from the nontradables sector to the tradables sector and how the relative price of the two goods changes. These facts provide insights into how sudden stops may move through the economy; namely, through relative price effects.

We constructed a simple model with tradable and nontradable goods and calibrated it to Mexico in 1989. When we subject the model to a sudden stop – and nothing else – we find the model can account for 94 percent of the depreciation in real exchange rates and 95 percent of the trade balance reversal. The model also does a good job of capturing the output shift from the nontradables sector to the tradables sector. Though the simple model can account for the behavior of the disaggregated economy, the model cannot

account for the changes in aggregate TFP and GDP. Stronger frictions that decrease output and productivity are need. The model presented here provides a simple framework in which these frictions can be added in future work.

Table 1

Commodity	Input			Final Demand				Total Demand
	Tradable	Nontradable	Total intermediate demand	Consumption	Investment	Exports	Total final demand	
Tradable	27.24	9.02	36.26	23.78	11.13	15.85	50.75	87.01
Nontradable	9.76	19.42	29.18	52.33	11.90	0.00	64.23	93.41
Total intermediate consumption	37.00	28.44	65.44	76.11	23.03	15.85	114.9	180.4
Employee compensation	17.48	41.72	59.20	0.00	0.00	0.00	0.00	59.20
Return to capital	16.05	23.25	39.30	0.00	0.00	0.00	0.00	39.30
Value added	33.53	64.97	98.50	0.00	0.00	0.00	0.00	98.50
Imports	14.98	0.00	14.98	0.00	0.00	0.00	0.00	14.98
Tariffs	1.50	0.00	1.50	0.00	0.00	0.00	0.00	1.50
Total Gross Output	87.01	93.41	180.4	76.11	23.03	15.85	114.9	295.4

Table 2

Parameter	Value	Statistic	Target
Consumer Parameters			
b_0	-5.4	trade balance to GDP, in percent	0.87
β	0.99	real world interest rate, in percent	5.00
ε	0.17	tradable good share in consumption	0.31
ρ	-1.00	elasticity of subs. tradable and nontradable goods in consumption	0.50
ψ	-1.00	intertemporal elasticity of substitution	0.50
δ	0.06	Depreciation-GDP ratio	0.11
Producer Parameters			
a_{TD}	0.38	share of tradable inputs in domestic tradable production	0.38
a_{ND}	0.14	share of nontradable inputs in domestic tradable production	0.14
a_{TN}	0.10	share of tradable inputs in domestic nontradable production	0.10
a_{NN}	0.21	share of nontradable inputs in domestic nontradable production	0.21
A_N	1.62	scale production to nontradable value added in base year	64.97
A_D	2.08	scale production to domestic tradable value added in base year	33.53
α_N	0.36	capital's share of nontradable good income	0.36
γ	1.02	growth rate of GDP per capita, in percent	2.00
α_D	0.48	capital's share of domestic tradable good income	0.48
θ_N, θ_D	5.01	change in tradable goods share of total employment, in percent	5.72
Trade Parameters			
M	1.91	normalize tradable composite price	1.00
μ	0.63	ratio of imports to intermediate use of domestic tradable good	0.55
ζ	0.50	elasticity of substitution between domestic tradable and imports	2.00
D	16.81	scale export demand to equal exports in base year	14.98

Table 3

	Average growth rates in Mexico (percent)			
	Output per working age person	TFP factor	Capital factor	Labor factor
	Y_t/N_t	$A_t^{\frac{1}{1-\alpha}}$	$(K_t/Y_t)^{\frac{\alpha}{1-\alpha}}$	L_t/N_t
1990-1994	0.715	0.449	0.278	-0.011
1994-1995	-9.022	-11.342	4.314	-1.993
1995-2004	1.523	1.307	-0.069	0.285

Appendix

Foreseen “Sudden” Stop

Although interest rates, as seen in Figure 2, provide strong evidence that the sudden stop in Mexico was an unforeseen event, in this section we examine the predictions of the model when the sudden stop is known one year in advance. To do so, we solve the model for the equilibrium in which there is no sudden stop, as in the baseline and risk premia models. We then resolve the model starting in 1993 imposing that no further borrowing is allowed in 1995 and 1996. This information structure assumes that agents have perfect foresight over the oncoming sudden stop, but have 1 year in which to adjust for it.

We present the results from the “no surprise” model in Figure A1. In each subfigure we plot the “no surprise model,” the “surprise model,” which is the baseline model, and the data. In Figure A1(a) we see that when agents have a year’s time to adjust for the sudden stop they cutback on their borrowing early, which we do not see in the data. The same pattern holds for the shift of labor across sectors in A1(b) and the movements in relative prices in A1(c) and A1(d). The intuition for the result is simple: agents foresee the coming sudden stop and realize that the convex nature of adjustment costs makes it optimal to begin adjusting early to minimize the size of the adjustments in any period. The outcome of this foresight is that all of the features in the data that turn sharply at the onset of the sudden stop now come one period earlier. As is clear from the figures, allowing for the sudden stop to be anticipated worsens the model’s ability to match the data.

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Figure 1

Mexico: external financial flows

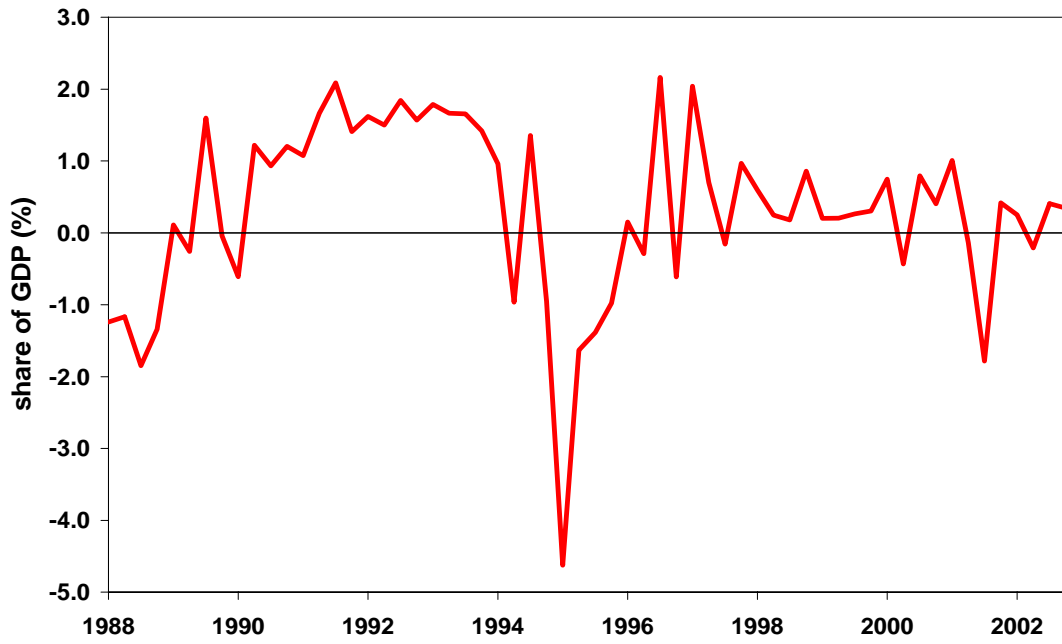


Figure 2

Mexico: interest rates (dollar denominated debt)

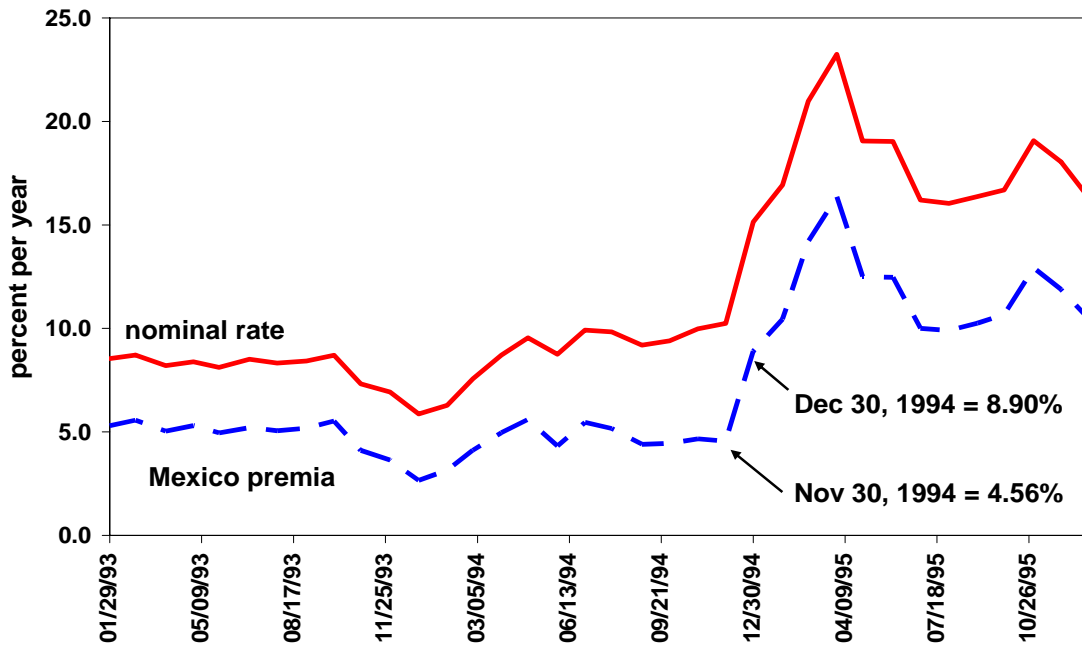


Figure 3

Mexico: trade balance

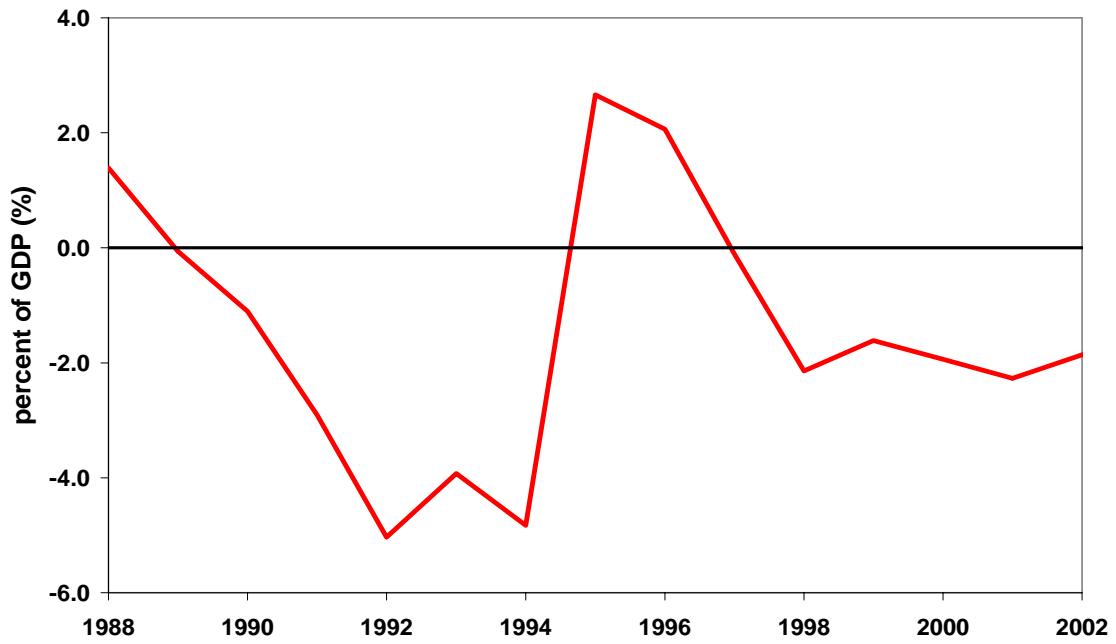


Figure 4

Mexico-U.S. real exchange rate

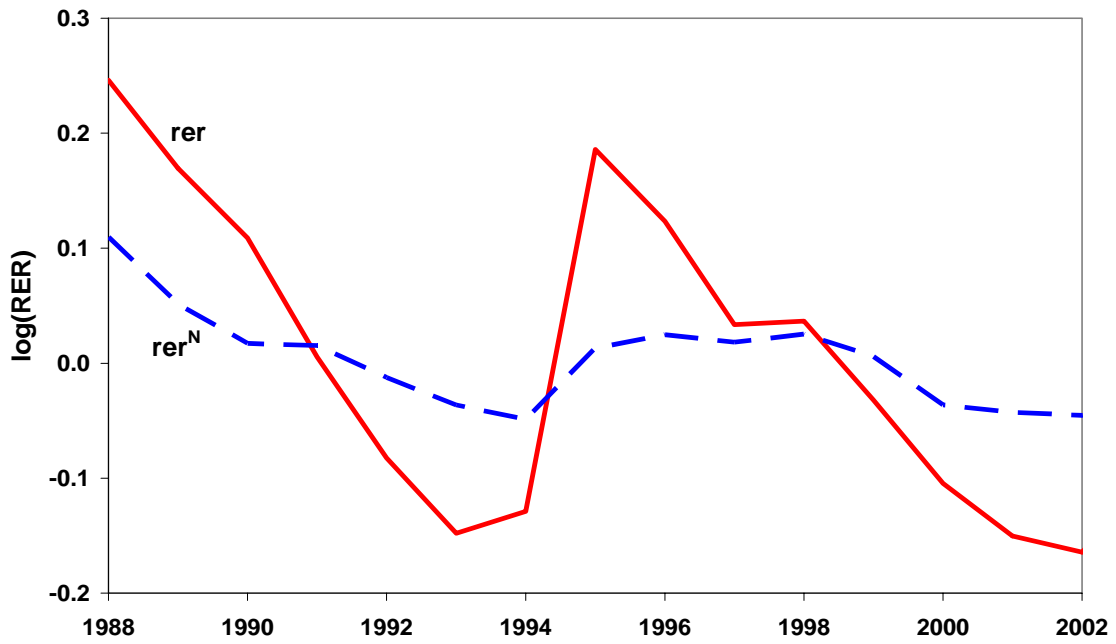


Figure 5

Mexico: sectoral value added

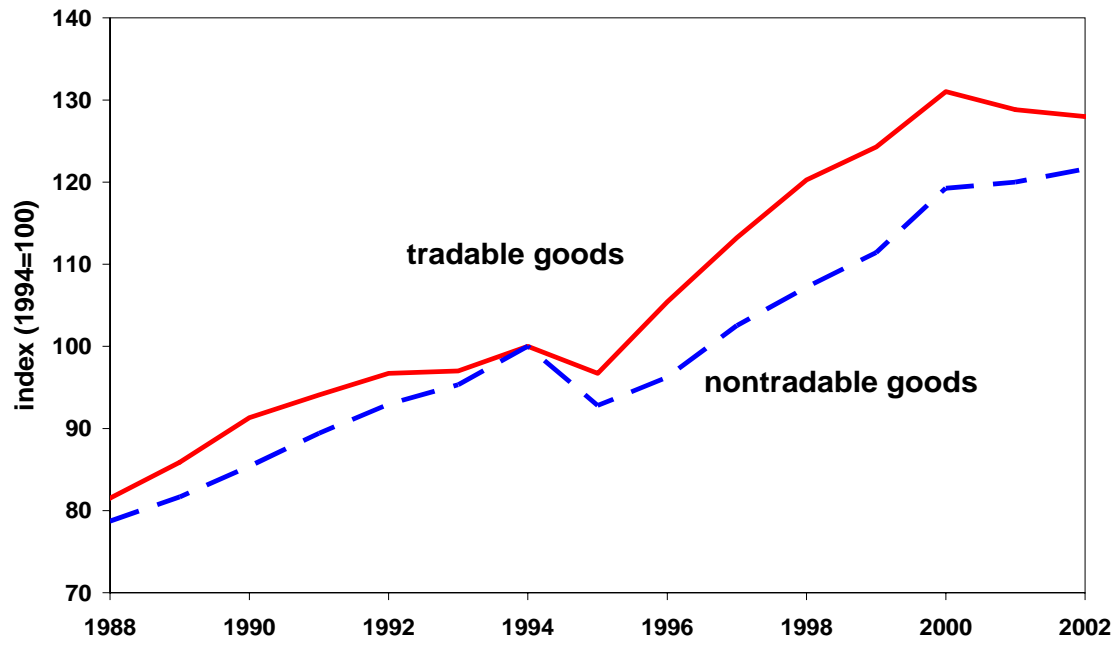


Figure 6
Mexico: traded good employment

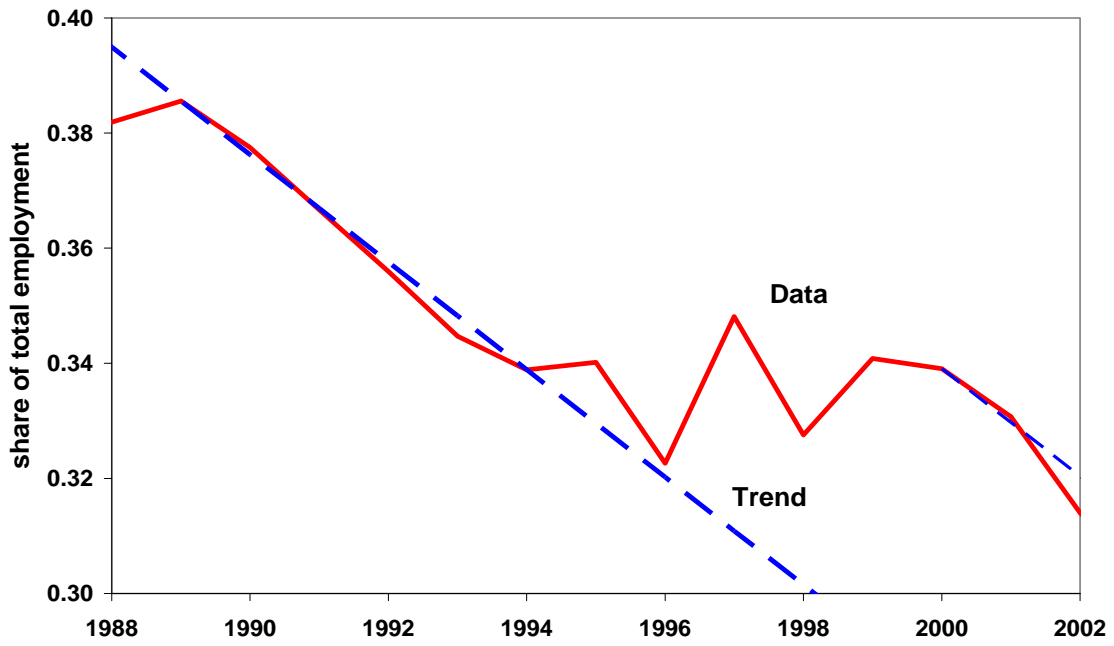


Figure 7
Mexico: traded good employment

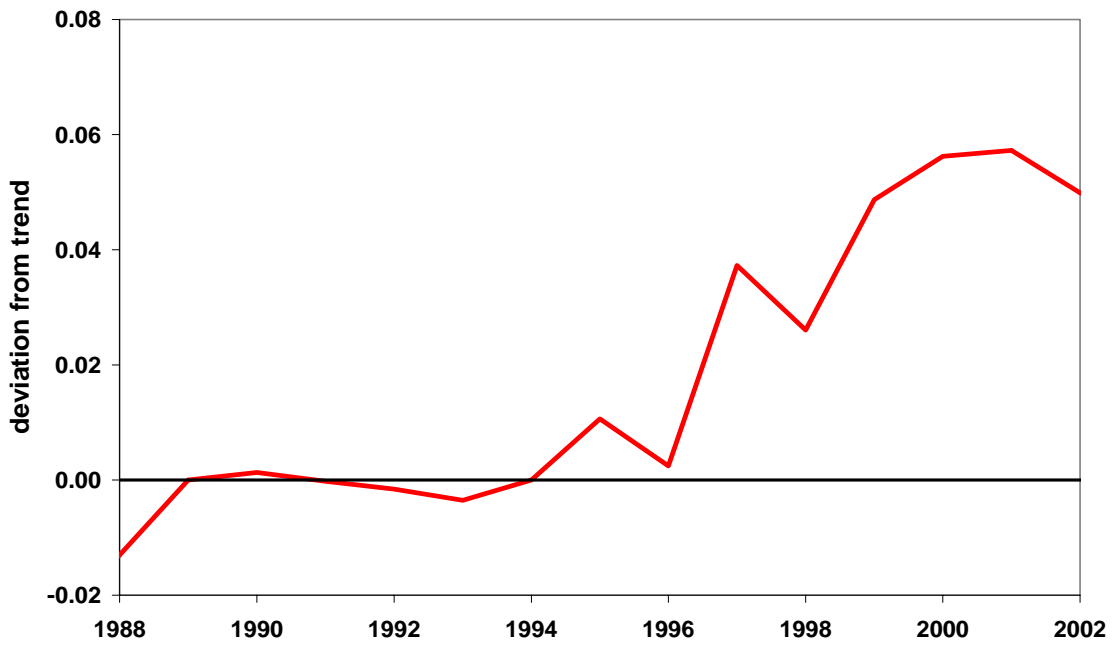


Figure 8

Mexico: interest rates

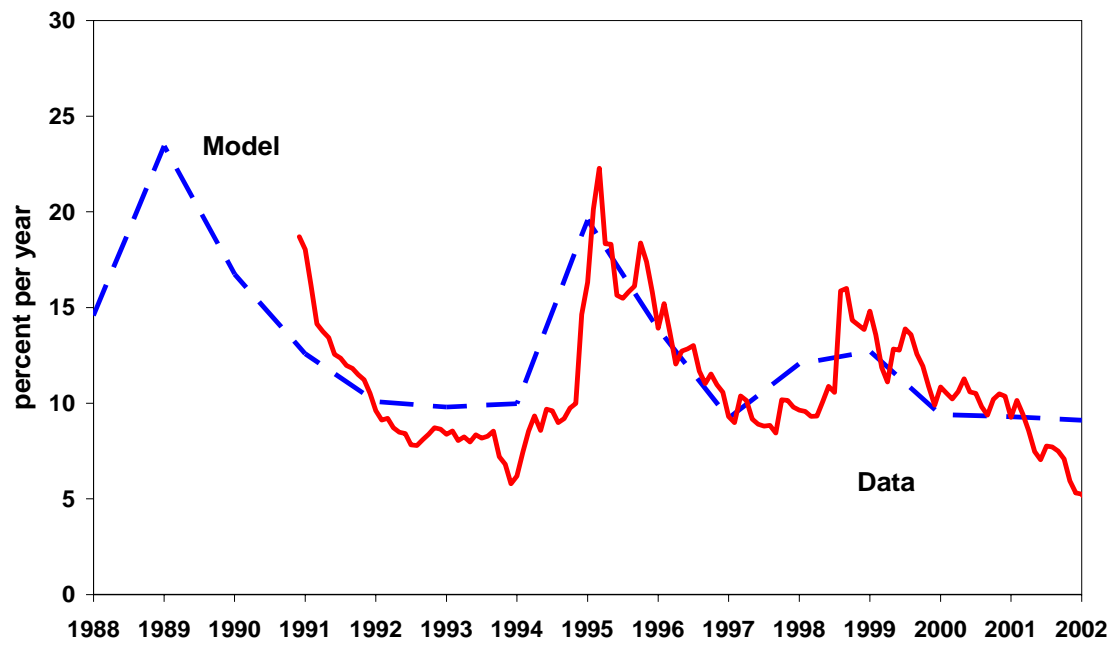


Figure 9
Capital output ratio

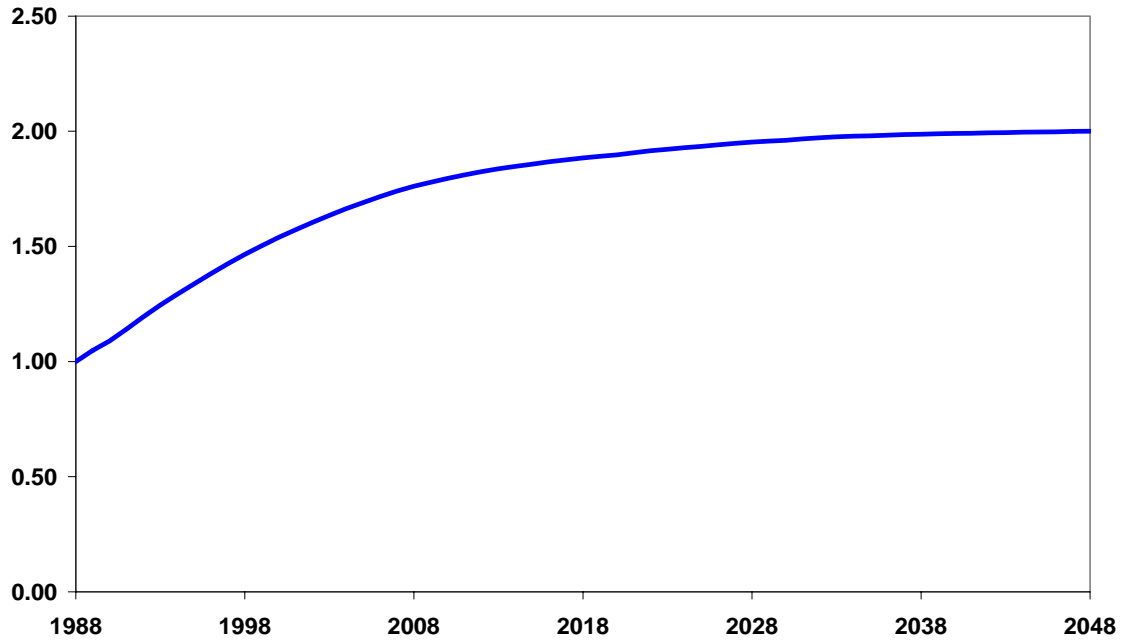


Figure 10
Mexico: trade balance

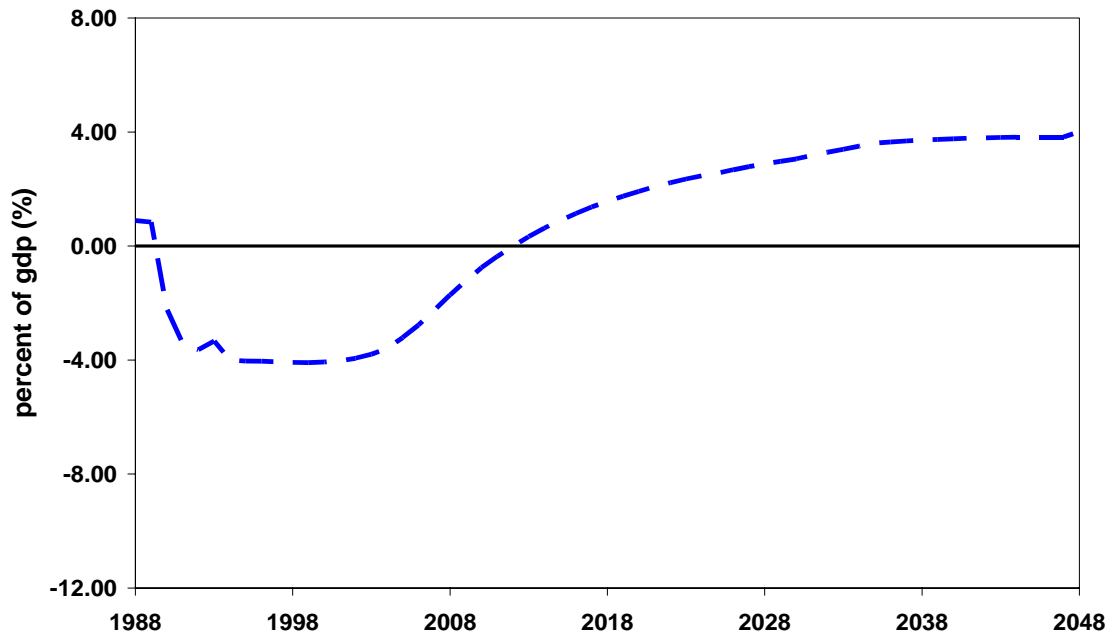


Figure 11

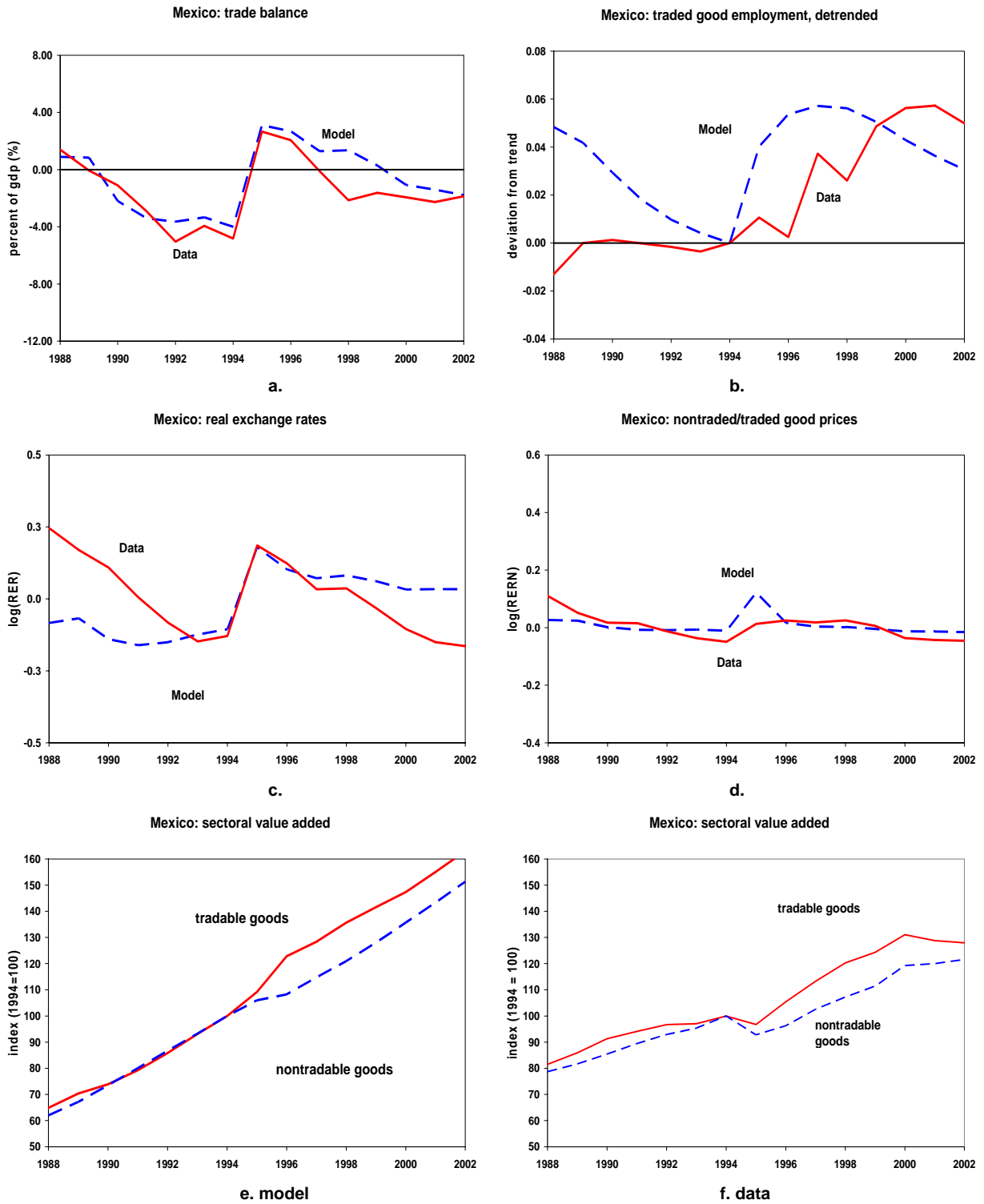


Figure 12: Data
Mexico: output and TFP

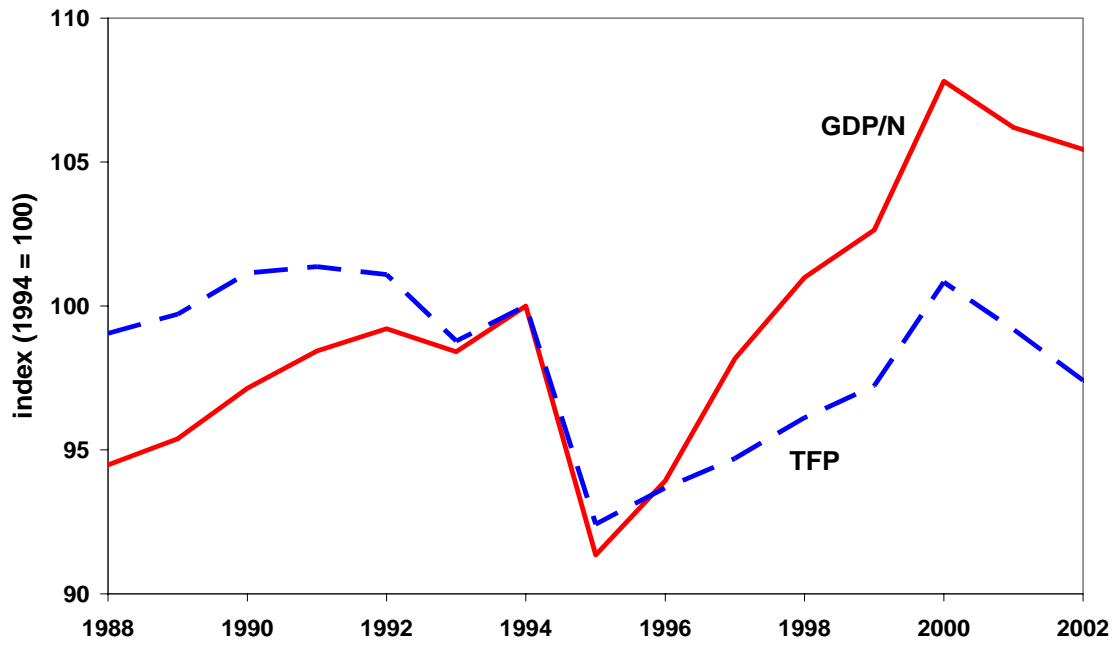


Figure 13: Model
Mexico: output and TFP

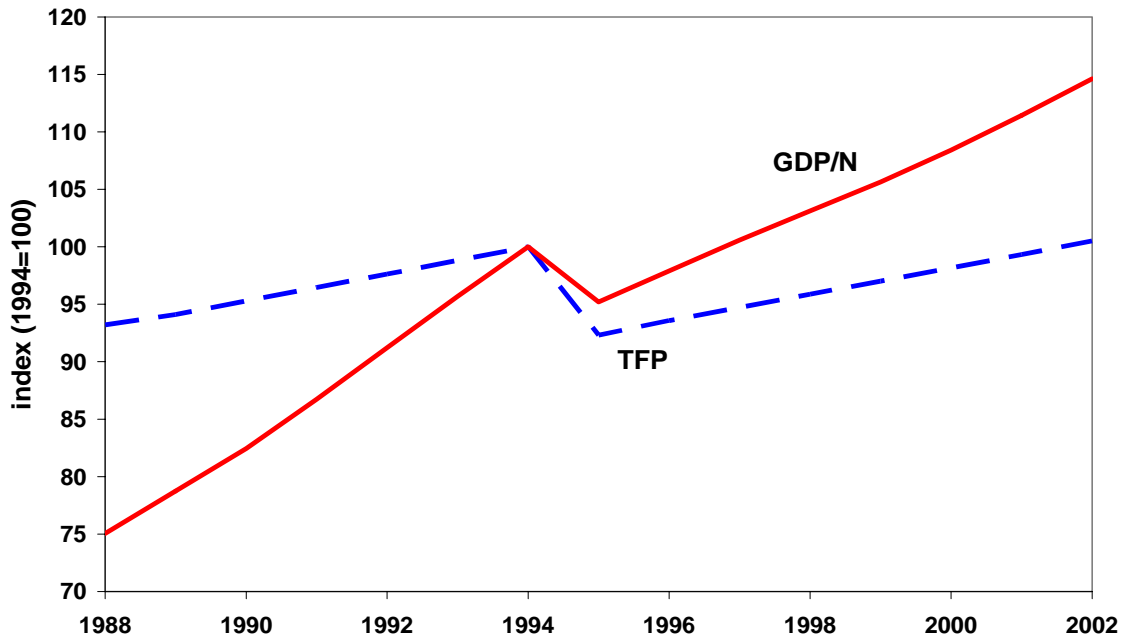


Figure 14

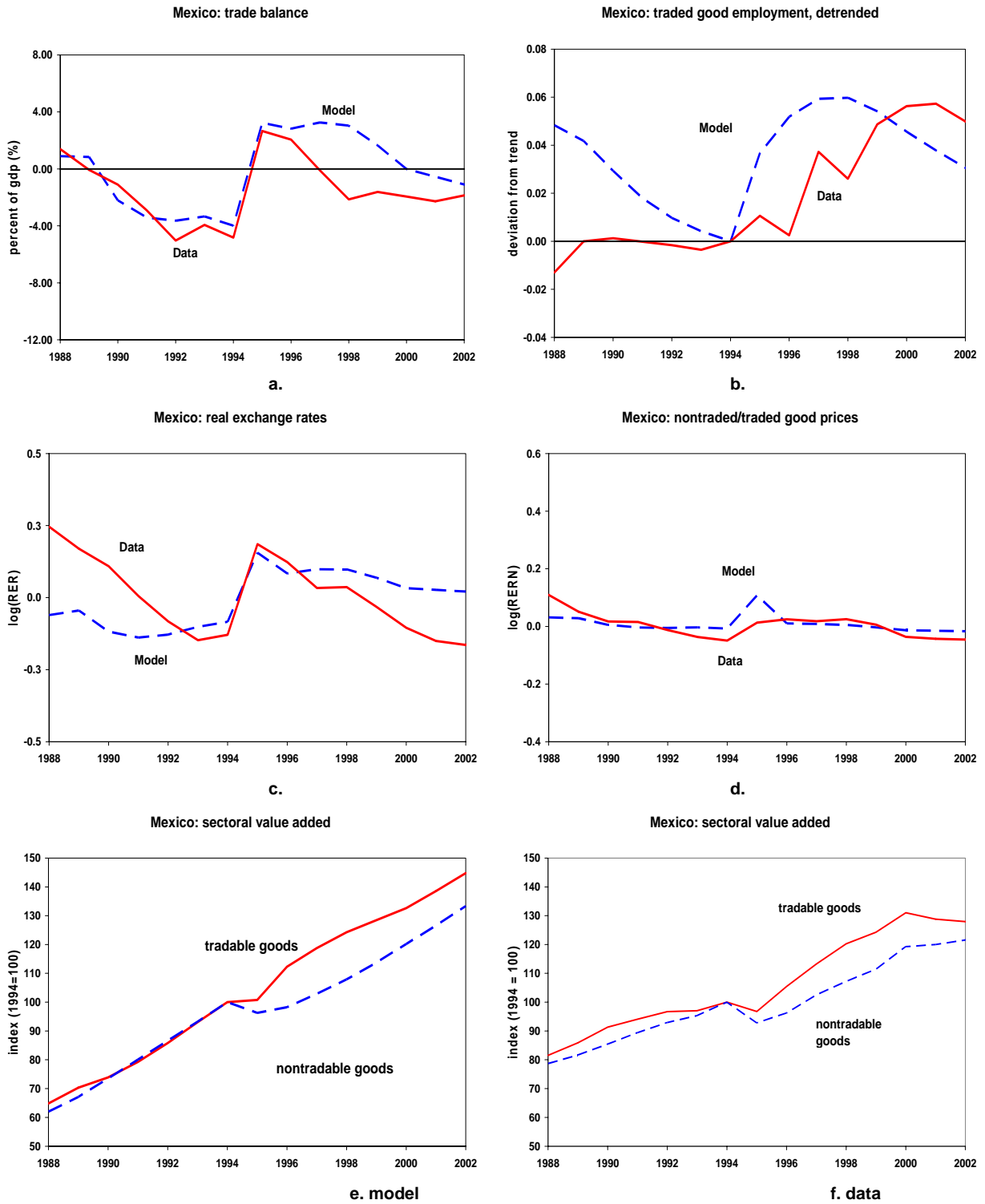


Figure A1 [to be revised]

