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**EMIGRANT REMITTANCES AND THE REAL
EXCHANGE RATE IN GUATEMALA: AN
ADJUSTMENT-COST STORY**

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Emigrant Remittances and the Real Exchange Rate in Guatemala: An Adjustment-Costs Story*

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Abstract

Emigrant remittances have been growing around the world since 1970, but in the past few years their growth rate has enlarged significantly. In Guatemala, remittances have increased more than four times as a share of the GDP over the last decade and this trend has coincided with an appreciation of the real exchange rate. In this paper, we develop a stochastic, dynamic, general equilibrium model, useful to explain the determinants of the real exchange rate. We study the relationship between the real exchange rate and the demand side of the economy; specifically, its relationship with remittances in a fully optimizing model. Our model includes adjustment costs for capital intended to capture an equilibrium real exchange rate compatible with the short run conditions and it generates a short-run equilibrium real exchange rate appreciation, a tradable sector contraction, and a nontradable sector expansion, similar to those that are observed in national accounts data. The results also suggest that, in Guatemala, economic agents perceive the observed shift in the remittances flow as permanent.

Key words: Emigrant Remittances, Real Exchange Rate, Guatemala.

JEL: F22; F31; F41; J61

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1 Introduction

Emigrant remittances have been growing around the world since 1970, but in the past few years, its growth rate has enlarged significantly. According to World Bank (2006), remittances received by developing countries, estimated using officially recorded data¹, grew up to US\$ 167 billion in 2005 (a 73% increase from 2001) . They have become an important component of the balance of payments for many developing countries and its importance as a source of foreign exchange is reflected in the fact that remittances growth has outpaced private capital flows and official development assistance over the past decade. For some countries in 2004, remittances were larger than public and private capital inflows and, for some others, even larger than total merchandise exports. This process has not been unfamiliar to Guatemala; remittances have increased their nominal value more than six times over the last decade and their importance as a source of foreign exchange has grown considerably (see Figure 1).

This phenomenon has attracted the attention not only of researchers and policy makers, but also of donors, commercial banks, money-transfer operators and micro-finance institutions, among others. This wide spread interest on remittances should not be a surprise since the topic of remittances has many edges and can be seen from very different points of view. Given the magnitude of workers' remittances and the rising share of foreign income that they represent, we could ask: what are the microeconomic implications, the macroeconomic effects, and the social consequences of these transfers of wealth? It would be very interesting *per se* trying to answer, for example, how remittances help in poverty reduction, or what the social consequences of having disintegrated families are (because some members had to emigrate seeking better economic opportunities). In fact, a large portion of the existing literature on remittances has focused on the motivation for these transfers and their microeconomic implications, but it has been largely silent on the macroeconomic effects of these flows, at least in the context of a fully specified general equilibrium model².

Undoubtedly, international migration can generate substantial welfare gains for migrants and their countries of origin. For instance, Adams (2004) reports that remittances reduce the level, depth and severity of poverty in Guatemala. However, when workers' remittances are considerably large relative to the size of the receiving economy, they may also bring a number of undesired problems. Among others, we

¹The use of officially recorded data tends to underestimate the real magnitude of remittance flows because a substantial portion of these flows is transferred through informal operators or hand carried by travelers (informal channels).

²More than 260 publications with the word "remittances" in their title and more than 500 publications related to this issue can be found on the Econlit database. Notwithstanding, most of them give a statistical and/or econometric treatment to this issue; only 4 publications were found that study the issue of remittances within a general equilibrium framework.

are concerned with the idea that large and sustained remittance inflows can cause an appreciation of the real exchange rate and make the production of tradable goods less profitable, a *Dutch-Disease-like* phenomenon. In Guatemala, there is a special concern about the effects of remittances over the real exchange rate because the latter has been appreciating in the past few years; we have observed an accumulated appreciation of 28.5% in the 2001-06 period, coinciding with a surge in remittances. The idea that remittances can result in a real exchange rate appreciation can be found in many publications of the World Bank; e.g., Fajnzylber and Lopez (2006) show that in seven of the eight Latin American countries with the highest remittances-to-income ratio (Guatemala included, see Figure 2), it is possible to observe a real exchange rate appreciation that runs parallel to an increase in the remittances-to-income ratio. Also, Amuedo-Dorantes and Pozo (2004) find that a doubling of transfers in the form of workers' remittances result in a real exchange rate appreciation of about 22% in their panel of 13 Latin American and Caribbean countries. More generally, related ideas in the literature can be found. For example Neary (1988), writing about the effects of a transfer over the real exchange rate, points out that an incoming transfer is likely to induce a real appreciation and affirms that this statement has been confirmed empirically by Michaely (1981).

The real exchange rate appreciation is associated with a loss in external competitiveness, but it also has the potential to generate a number of additional macroeconomic effects. What results clear is that remittances will have to be accommodated within the macroeconomic flows of the economy, so the need to understand the impact of remittances on macroeconomic variables is readily apparent. In this paper, we follow closely the work of Catalán (2006) where the same problem is treated within a dynamic, stochastic general equilibrium model that takes labor in each sector as a differentiated good. Here we attempt to improve our understanding of the macroeconomic effects of remittance flows by exploring how they affect the real exchange rate in the Guatemalan economy using a DSGE model that considers an inelastic labor supply.

1.1 Remittances

In some way, remittances are the economic expression of migration. In Guatemala, according to OIM (2003), the migratory flow began slowly in the 1970's motivated partially by the effects of the earthquake of 1976. In the 80's, the number of emigrants was multiplied by four mainly because of the economic crisis and political violence prevailing at that time. The migratory pattern kept its pace and in the 90's the number of emigrants was trebled. Between 1995 and 2002, more than 90,000 Guatemalans left the country each year, which in average means approximately 250 people per day. This flow led, according to OIM (2006), to an estimate of 1.4 million

Guatemalans residing abroad in 2006. The majority of these emigrants chose the United States as a destiny; 98.2 % of remittance senders live in that country.

Both the population residing abroad and the international emigration rate³ increase each year (as shown on Figure 3). This increasing number of Guatemalans living abroad results relevant to our study because 94% of the Guatemalan emigrants send remittances to their relatives left behind. As mentioned in the introduction, the level of remittances has increased largely in the past five years, and if the emigration pattern keeps its pace, we might think that the remittances flow will also maintain its positive tendency. Hitherto, remittances are the most important single source of foreign exchange in Guatemala, more important than other traditional sources of foreign exchange, like tourism or coffee and sugar exports (the two main export products, see Figure 4). They represent the second largest foreign exchange source measured as a share of total foreign exchange, just behind total exports, and more important than net capital flows (FDI included, see Figure 5).

The emigrant workers' remittances are a well studied phenomenon in Guatemala, at least at a microeconomic level. Adams (2004) uses a large, nationally representative household survey -ENIGFAM⁴- to analyze the impact of internal⁵ and international remittances on poverty in Guatemala. In his study, four key findings emerge: first, both internal and international remittances represent important components of household income in Guatemala. Second, both types of remittances reduce the level, depth, and severity of poverty. Third, remittances have a greater impact on reducing the severity rather than the level of poverty in Guatemala. Finally, his study shows that including remittances in household income has little impact on income inequality. With the receipt of remittances in Guatemala, income inequality remains relatively stable (Gini coefficient ≈ 0.49).

Adams (2005) also uses the ENIGFAM survey to analyze how the receipt of remittances affects the marginal spending behavior of households on various consumption and investment goods. Contrary to other studies, he finds that the majority of remittance earnings are not spent on consumption goods. He reports that while households without remittances spend 58.9 percent of their increments to expenditure on consumption goods, households receiving international remittances only spend 55.9 percent. In other words, at the margin, households receiving remittances spend less on consumption than do households without remittances. Adams also finds that the marginal spending behavior of households receiving remittances is qualitatively different from that of households which do not receive remittances. Instead of spending more on consumption, households receiving remittances tend to spend more on

³The ratio of the population residing abroad over total population of Guatemala.

⁴The national survey of income and expenditure of households from Guatemala. ENIGFAM, by its acronyms in Spanish.

⁵Remittances held within the Guatemalan territory, usually from urban areas to rural ones.

investment than on consumption goods. For example, receiving households spend considerably more on education (although absolute levels of expenditure on education are small). Another relevant finding of his work is that his analysis confirms other studies' findings regarding the amount of remittance money that goes into housing. At the margin, households receiving international remittances spend 2.2 percent more of their income on housing than those households which do not receive remittances.

It is important to recall that the previous analysis holds "at the margin", therefore, with the observed surge in remittances we could expect Adams' findings to be confirmed, which results very interesting from the standpoint of our investigation in the following sense: The increment in remittance flows could augment the demand of nontraded goods (e.g. education and housing) driving up their prices, which in turn modifies the relative price between traded and nontraded goods and affects the real exchange rate. This idea cannot be addressed without the caveat that, in absolute terms, the remittances are mainly used on consumption goods which include both tradables and nontradables. According to OIM (2006), 50.3 percent of remittance money is used for consumption (43.1% for food; 3.0% for clothing; 1% for transportation), 21.5 percent is used for investment and savings, 14.1 percent for intermediate consumption and 14.2% is destined for health and education.

1.2 Real Exchange Rate

In Guatemala, as mentioned above and shown on Figure 6, the real exchange rate⁶ has been appreciating in the last five years (coinciding with the surge in remittances, see Figure 7). The real exchange rate -RER- occupies a very important role in the economy; for example, an appreciation is usually associated with a loss in external competitiveness, but also it has the potential to generate a number of additional macroeconomic effects⁷, among which we can mention the following: a worsening of the current account deficit, weaker monetary control, and sectorial misallocation of investment.

Despite the importance of the real exchange rate in macroeconomics, there is no definition or measurement of the RER that is universally accepted. Theoretically, the RER has been defined as the nominal exchange rate amended by the external to internal price ratio. This definition corresponds to the idea that variations of the nominal exchange rate lack a precise meaning in a world with inflation, so variations in the value of external and internal currencies (measured by their respective inflation rates) must be taken into account; in this context, some researchers consider the RER as the purchasing power parity exchange rate, Edwards (1990). On the basis of

⁶ Measured using the IMF's real effective exchange rate index.

⁷ All of them, subject to actions and reaction of policy makers and the behavior of many related variables.

this definition, people thought of real exchange rate movements as being deviations from PPP, often thinking of them as reflecting misalignments rather than equilibrium responses to real shocks. Despite the fact that the "PPP-RER" is a very common way to measure the real exchange rate, all the problems related to the PPP theory are inherited by this measurement of the real exchange rate. More recently the RER has been defined as the relative price between nontradable and tradable goods (perhaps nowadays the typical theoretical definition), and it is proposed as a better indicator of external competitiveness. This definition of the real exchange rate is not exempt of criticisms. For example, Harberger (2004) argues that the definition of the RER as the relative price of nontradables – (P_N/P_T) – can get us into trouble when the disturbances in question are changes in the international prices of particular tradable goods or when we are interested in the consequences of imposing import tariffs or export taxes.

In spite of critics, for the purposes of the present investigation, the (P_N/P_T) – type appears to be a sufficient and correct definition of the RER, so in what follows, this definition of the RER is going to be used, unless something else is said explicitly. It is important to point out that, according to Edwards (1990), variations of both definitions⁸ of the RER can differ, even go in opposite directions.

1.2.1 The Equilibrium Real Exchange Rate

We consider essential, in the sake of clarity, to define what we understand by the equilibrium real exchange rate -ERER-. In the literature there are a number of definitions for the ERER, here we brief a few of them and point out an important distinction between the long run ERER and the RER of equilibrium in the short run.

The first definition comes from Dornbusch (1980). He develops an open economy model to study how the equilibrium real exchange rate is determined. In the simplest version of his model, he considers an economy with two goods, one tradable and the other nontradable, and he defines the equilibrium real exchange rate as the relative price between this two goods at which all markets clear. Mundell (1971) provides a formal analysis of the determination of the equilibrium real exchange rate; despite the fact that he does not explicitly use the RER term in his study, his analysis describes rigorously the determination of the relative price between nontradable and tradable goods, and defines the ERER as the relative price between international and internal goods that clears simultaneously the money, the international good, and the internal good markets. The equilibrium real exchange rate has also been defined as "the relative price of nontraded to traded goods consistent with balance-of-payments equilibrium", Neary (1988). Finally, Harberger (2004) believes that the real exchange rate is the principal equilibrating variable of a country's trade and payments.

⁸The "PPP-RER" and the (P_N/P_T) – type.

We agree with Harberger that the real exchange rate is an equilibrating variable. We believe that the real exchange rate is essentially an equilibrium variable, a relative price at which internal and external markets clear. We also believe that the equilibrium real exchange rate does not have to be constant, it has to react to important kinds of real disturbances, and here is where we want to make an important distinction. On the one hand, if we think that in the long run there is enough time to allow the adjustment of all productive inputs (capital, labor, land, etc.) and consequently make them perfectly mobile, then it is reasonable to think that the only real disturbances that matter are those coming from changes in the relative productivity of tradable and nontradable sectors. This is a key insight of the celebrated Balassa-Samuelson Model⁹. With perfectly mobile and homogenous capital and labor, the relative price of nontradables is governed entirely by the production side of the economy, therefore, the long run equilibrium real exchange rate is probably going to be affected only by productivity disturbances. On the other hand, in the short run there is not enough time for productive factors to adjust, factor adjustment is a costly and time consuming endeavor. Then, as pointed by Edwards (1990), we could think of a particular value of the RER which reflects an equilibrium situation in the short run regardless it might be misaligned with respect the long run equilibrium. For example, a temporary income transfer from abroad is going to increase the RER that makes possible an equilibrium between internal and external sectors, but it is going to be misaligned with respect to the long run equilibrium until the effects of the transfer disappear. Actually in the short run, the equilibrium exchange rate is going to be exposed to a long list of real disturbances, among which we can mention: productivity shifts, import or export restrictions, rises in real prices of export goods, capital inflows and, of course, remittances.

Based on previous arguments, after presenting some stylized facts of the Guatemalan economy, we develop a general equilibrium model intended to characterize the short run equilibrium RER and establish a theoretical relationship between short run ERER and remittances.

1.3 Guatemalan Economy: Stylized Facts.

In this section we explore some stylized facts of the Guatemalan economy. We mainly use the results and data of the recently implemented *1993 System of National Accounts*¹⁰ -SNA93-. This system is a conceptual framework that sets the international

⁹Balassa (1964) and Samuelson (1964) intended to explain why the absolute version of PPP is flawed as a theory of exchange rates. One of the basic predictions of the Balassa-Samuelson Model is that productivity differentials determine the domestic relative price of nontradables -the real exchange rate-.

¹⁰Published jointly by the United Nations, the Commission of the European Communities, the International Monetary Fund, the Organization for Economic Co-operation and Development, and

statistical standard for the measurement of the market economy. It provides an accounting framework within which economic data can be compiled and presented in a format that is designed for purposes of economic analysis, decision-taking and policy-making. One of the characteristics of this system that we took advantage of, is that within the compilation framework, the system considers a product nomenclature divided in three levels; the first level is conformed by 65 groups of products, the second level includes 226 products, and the third level comprises 7,308 products. We took the 226 products from the second level, and classified them between tradables and nontradables, then we constructed measurements of production, consumption and investment for both sectors: tradable and nontradable¹¹. We also measure the real exchange rate ($(P_N/P_T) - type$) using the ratio between the implicit output deflator of each sector, and compare its variations with those of the aggregate variables.

In absolute terms, aggregate variables (production, consumption and investment) have grown over the past five years (see Figures 8 through 10). But if we observe these variables in terms of the share of the total GDP that they represent, an interesting story emerges. First, with the observed appreciation, we could expect the nontradable sector to expand and tradable sector to contract¹²; although this is not observed in absolute terms, as a share of total GDP we do observe that the tradable production diminishes while the RER is appreciating; the same pattern can be observed in tradable investment and tradable consumption: as the RER appreciates, investment in tradable sector and tradable consumption reduce their participation in total investment and consumption respectively (see Figures 11 through 13). Only one exception can be observed on year 2004, when tradable production and investment increased while the RER was appreciating.

In contrast, nontradable production, investment and consumption, increase together with the appreciation of the RER. Nontradable production increases as the RER appreciates, the same situation is observed in nontradable sector investment and consumption. Again, the only one exception is observed in year 2004 when both nontradable production and investment decreased for that year despite the RER was appreciating, see Figures 14 through 16.

the World Bank. Implemented in Guatemala by the Economic Statistics Department of Banco de Guatemala.

¹¹In order to perform this classification, we used two criteria: first, we classify goods that are extremely costly to transport as nontradables, but because this is not a clear cut division, we used a second criterion: all goods for which their trade-to-production ratio was below 10 percent, were classified as nontradables. "Trade" for each product represents the addition of its imports and exports.

¹²If we believe that the appreciation of the real exchange rate is consequence of the surge in remittances, not of an increased productivity in tradable sector.

2 The Model

We develop a stochastic, dynamic, general equilibrium model, useful to explain the determinants of the real exchange rate. We want to study the relationship between the RER and the demand side of the economy; specifically, its relationship with remittances in a fully optimizing model. We develop a model that includes adjustment costs for capital intended to capture an equilibrium exchange rate compatible with the short run conditions. Because of the absence of policy interventions and nominal rigidities (which in the short-run may be important in practice), both the steady state values and the deviations from it reflect optimal decisions of the economic agents (their best responses given the constraints they face) so the dynamics of the model's variables are *equilibrium dynamics*, and we consider the RER that emerges from our model, as the "short-run equilibrium real exchange rate".

A small open economy that produces two goods, tradables and nontradables, is considered. The main difference between these two goods is that the supply of nontradables is determined exclusively by domestic production, while the supply of tradables does not face this constraint, since it is possible to export or import an unbounded quantity of this good. Outputs of both goods are determined by constant returns to scale production functions that employ capital and labor as inputs. Both goods are traded in competitive markets where their relative price is determined. The tradable good is used as numeraire. Assuming a small open economy means that the economy can finance its aggregate expenditure not only internally, but also issuing debt at the international financial market without influencing the international interest rate. We also assume that unanticipated shocks to productivity can occur in both sectors, so the rental price of capital can differ from capital's marginal product ex post, because we suppose that capital must be installed one period ahead of its use.

We are modeling a real economy, so we focus entirely on the relative price of the nontradable good in terms of the tradable one, not on nominal prices. We do not include a government, since we are not interested on fiscal issues. We are also assuming that there are no nominal rigidities and no monetary side of the economy (of course, there is no feedback from the monetary side to the real side of the economy).

Household's preferences are defined over the two consumption goods. Total endowment of time is normalized to unity and labor supply is assumed to be inelastic. Because we are interested in a model that is compatible with the short run conditions, we introduce capital adjustment costs. This allows us to capture the consequences of the fact that in the short run productive inputs do not adjust immediately. We assume that there are two types of capital, tradable and nontradable, and each one must be produced within the corresponding sector. The law of motion for the capital

stock, in both sectors, will include adjustment costs to investment¹³; the specification of the adjustment cost function is such that when the economy is in steady state there are no adjustment costs.

2.1 Households

The economy is inhabited by infinitely lived households, who obtain utility from consumption of a tradable good $-C_{T,t}-$, and a nontradable good $-C_{N,t}-$. Households seek to maximize the expected value of their lifetime utility function $\sum_{t=0}^{\infty} \beta^t U(C_{T,t}, C_{N,t})$, where $\beta \in (0, 1)$ is the subjective discount factor and $U(C_{T,t}, C_{N,t})$ is the utility in period t , defined as:

$$U(C_{T,t}, C_{N,t}) = a \cdot \log(C_{T,t}) + (1-a) \cdot \log(C_{N,t}) \quad (1)$$

As aforementioned, we normalize to unity the total endowment of time and assume that households offer labor services inelastically to both sectors. Work hours are compensated with a wage w_t . They own the stock of capital installed in tradable $-k_{T,t}-$ and nontradable $-k_{N,t}-$ sectors, which they rent at the tradable-denominated rental prices r_t^T and r_t^N , respectively. They receive income transfers from abroad $-Rem_t-$ (remittances) and we introduce them in the model as a share of aggregate output (Y_t): $RSH_t = \frac{Rem_t}{Y_t}$. We assume that households are able to borrow or lend freely in international financial markets by buying or issuing risk-free bonds denominated in the tradable good and paying the interest rate i_t ; total foreign liabilities are introduced as a share of aggregate output $-f_t-$. Because households own the capital, they use some of their resources for capital formation, so we define $x_{T,t}$ and $x_{N,t}$ as gross investment in each sector. Finally, a is a weight parameter.

The budget constraint for households, normalized by P_t^T (price of the tradable good), can be written as:

$$C_{T,t} + Q_t \cdot C_{N,t} + (1 + i_t) f_t \cdot Y_t + x_{T,t} + Q_t \cdot x_{N,t} = w_t + \dots \quad (2)$$

$$\dots r_t^T k_{T,t} + r_t^N k_{N,t} + f_{t+1} \cdot Y_{t+1} + RSH_t \cdot Y_t$$

where $Q_t = \frac{P_t^N}{P_t^T}$, is the relative price of nontradables in terms of tradables.

¹³Without which investment flows appear to be implausibly volatile.

2.2 Some Definitions and Conventions

Capital stock is formed separately within each sector and there is a sector-specific law of motion for capital:

$$k_{T,t+1} - (1 - \delta) \cdot k_{T,t} - g_T \left(\frac{x_{T,t}}{k_{T,t}} \right) \cdot k_{T,t} = 0 \quad (3)$$

$$k_{N,t+1} - (1 - \delta) \cdot k_{N,t} - g_N \left(\frac{x_{N,t}}{k_{N,t}} \right) \cdot k_{N,t} = 0 \quad (4)$$

Where:

$$g_J \left(\frac{x_{J,t}}{k_{J,t}} \right) = c_2 \left(\frac{x_{J,t}}{k_{J,t}} \right)^2 + c_1 \left(\frac{x_{J,t}}{k_{J,t}} \right) + c_0; \quad J = T, N.$$

Function $g_J(\bullet)$ is concave¹⁴ and twice continuously differentiable, it reflects investment adjustment costs in capital. Parameter c_2 is set in order to replicate investment's volatility and parameters c_1 and c_0 are determined by de fact that there are no adjustment costs at the steady state. Parameter $\delta \in (0, 1)$ is the depreciation rate of capital that we assume it to be equal across sectors.

Households are subject to a "no-ponzi game" constraint of the form:

$$\lim_{j \rightarrow \infty} E_t \frac{f_{t+j}}{\prod_{s=0}^j (1 + i_s)} \leq 0 \quad (5)$$

Finally, we assume that the following equation must hold in equilibrium:

$$i_t = i_t^* + \psi \left(\exp(f_t - \bar{f}) - 1 \right) \quad (6)$$

Where i_t^* is the international risk-free interest rate, \bar{f} is the steady state level of net foreign debt position and ψ is a scale parameter. With this equation we are assuming that international financial markets are not complete, which is evident by observing that foreign financing cost is increasing with the net foreign debt position. This can be interpreted as households facing a country specific risk premium.

The households' problem can be summarized as follow:

¹⁴Since c_2 is negative.

$$\begin{aligned} & \max \\ & \{C_{T,t}, C_{N,t}, x_{T,t}, x_{N,t}, k_{T,t+1}, k_{N,t+1}, f_{t+1}\} \\ & E_t \left\{ \sum_{t=0}^{\infty} \beta^t [a \cdot \log(C_{T,t}) + (1-a) \cdot \log(C_{N,t})] \right\} \end{aligned}$$

Subject to equations: (2) – (5). Letting λ_t , η_t and θ_t denote the Lagrange multipliers on (2), (3) and (4) respectively, the first-order conditions of the households' maximization problem are (2) to (5) holding with equality and:

$$\frac{\partial U}{\partial C_{T,t}} = \beta \cdot E_t [\lambda_{t+1}] \quad (7)$$

$$\frac{\partial U}{\partial C_{N,t}} = \beta \cdot Q_t \cdot E_t [\lambda_{t+1}] \quad (8)$$

$$\eta_t = \beta \cdot E_t \left[\lambda_{t+1} \cdot r_t^T + \eta_{t+1} \left(g_T + \frac{\partial g_T}{\partial k_{T,t}} \cdot k_{T,t} \right) + \eta_{t+1} (1 - \delta_T) \right] \quad (9)$$

$$\theta_t = \beta \cdot E_t \left[\lambda_{t+1} \cdot r_t^N + \theta_{t+1} \left(g_N + \frac{\partial g_N}{\partial k_{N,t}} \cdot k_{N,t} \right) + \theta_{t+1} (1 - \delta_N) \right] \quad (10)$$

$$\lambda_t = \beta \cdot E_t [\lambda_{t+1}] \cdot (1 + i_t) \quad (11)$$

$$E_t [\lambda_{t+1}] = E_t [\eta_{t+1}] \cdot \frac{\partial g_T}{\partial x_{T,t}} \cdot k_{T,t} \quad (12)$$

$$Q_t \cdot E_t [\lambda_{t+1}] = E_t [\theta_{t+1}] \cdot \frac{\partial g_N}{\partial x_{N,t}} \cdot k_{N,t} \quad (13)$$

2.3 Firms

There are two firms that seek to maximize their benefits by choosing optimal levels of labor, given the salary, and optimal levels of capital, given capital's rental rate. The first firm produces a tradable good and the second one a nontradable good. Both goods can be used for consumption and investment; one unit of the consumption good can be transformed into a unit of capital at the cost imposed by g_J ; $J = N, T$. In each sector, the corresponding firm operates a Cobb-Douglas production function with constant returns to scale.

2.3.1 Tradable Sector

There is a single firm that produces a tradable good combining labor and capital in the production function: $y_t^T = z_t \cdot (k_t^T)^{\alpha^T} \cdot (h_t^T)^{1-\alpha^T}$. Because we are normalizing by the tradables' price $-P_t^T-$, the problem that the firm solves, period by period, can be presented as:

$$\max_{\{k_t^T, h_t^T\}} \Pi_t^T = y_t^T - r_t^T \cdot k_t^T - w_t \cdot h_t^T$$

Where z_t is a stochastic productivity factor. Parameter $\alpha^T \in (0, 1)$ determines capital's participation within the production function. We can write the firm's first-order conditions for capital and labor, respectively, as

$$r_t^T = \alpha^T \cdot z_t \cdot (k_t^T)^{\alpha^T-1} (h_t^T)^{1-\alpha^T} \quad (14)$$

$$w_t = (1 - \alpha^T) \cdot z_t \cdot (k_t^T)^{\alpha^T} (h_t^T)^{-\alpha^T} \quad (15)$$

2.3.2 Nontradable Sector

There is a single firm that also uses capital and labor as inputs to produce a nontradable good. It has access to the technology described by a Cobb-Douglas production function of the form: $y_t^N = A_t \cdot (k_t^N)^{\alpha^N} \cdot (h_t^N)^{1-\alpha^N}$. It sells its output at a price P_t^N , so the problem that the firm solves in every period is given by,

$$\max_{\{k_t^N, h_t^N\}} \Pi_t^N = Q_t \cdot y_t^N - r_t^N \cdot k_t^N - w_t \cdot h_t^N$$

Where A_t is a stochastic productivity factor and $\alpha^N \in (0, 1)$ is the parameter that determines the participation of capital and labor respectively within the production function. We can write the firm's first-order conditions for capital and labor, respectively, as

$$r_t^N = Q_t \cdot \alpha^N \cdot A_t \cdot (k_t^N)^{\alpha^N-1} (h_t^N)^{1-\alpha^N} \quad (16)$$

$$w_t = Q_t \cdot (1 - \alpha^N) \cdot A_t \cdot (k_t^N)^{\alpha^N} (h_t^N)^{-\alpha^N} \quad (17)$$

Where $Q_t = \frac{P_t^N}{P_t^T}$, as before.

2.4 Exogenous Stochastic Processes

We model three sources of uncertainty: The first two are productivity shocks in each sector, tradable and nontradable; the third one is a stochastic process for foreign transfers. As usual, we assume that all shocks follow an autoregressive process of order one.

$$z_{t+1} = (1 - \rho_z) \cdot z_{ee} + \rho_z \cdot z_t + \varepsilon_{t+1}^z \quad (18)$$

$$A_{t+1} = (1 - \rho_A) \cdot A_{ee} + \rho_A \cdot A_t + \varepsilon_{t+1}^A \quad (19)$$

$$RSH_{t+1} = (1 - \rho_R) \cdot RSH_{ee} + \rho_R \cdot RSH_t + \varepsilon_{t+1}^R \quad (20)$$

Where $\rho_j \in (0, 1)$ for $j = z, A, R$. We assume:

$$\varepsilon_t^j \sim N(0, \sigma_{\varepsilon_j}^2)$$

i.e. all random shocks are white noise.

2.5 Market Clearing

In equilibrium, all markets must clear. For capital and labor markets this means:

$$K_t^T = k_t^T = k_{T,t}; \quad \forall t \quad (21)$$

$$K_t^N = k_t^N = k_{N,t}; \quad \forall t \quad (22)$$

$$h_t^T + h_t^N = 1 \quad (23)$$

The clearing condition for the nontradable's market is easy to define, because it is constrained by domestic production,

$$C_{N,t} + x_{N,t} = y_t^N; \quad \forall t \quad (24)$$

The tradable sector does not face this constraint, so in equilibrium, it must be true that:

$$C_{T,t} + (1 + i_t) f_t \cdot Y_t + x_{T,t} = y_t^T + f_{t+1} \cdot Y_{t+1} + RSH_t \cdot Y_t; \quad \forall t \quad (25)$$

With this market clearing conditions, the exogenous stochastic processes and the optimal conditions described before for each agent in the economy, we fully characterize our artificial economy.

3 Solution Algorithm and Calibration

3.1 Solution

In order to solve the model, after some simplification, we transformed the complete system of equations by expressing it in terms of logarithmic deviations from the steady state, *i.e.* we used transformed variables: $\bar{j}_t = \log\left(\frac{j_t}{j_{ee}}\right)$ for every variable j . Then we made a first-order approximation using a Taylor's expansion, and solved the model using the method of Klein (2000). We obtained matrices \mathbf{P} and \mathbf{F} , using Klein's algorithm, which generated the dynamic solution by iterating on the following two linear equations:

$$\begin{aligned} \mathbf{x}_t &= \mathbf{P} \cdot \mathbf{x}_{t-1} + \mathbf{B} \cdot \omega_t \\ \mathbf{y}_t &= \mathbf{F} \cdot \mathbf{x}_t \end{aligned}$$

Where \mathbf{y} is a vector composed by controls and co-state variables, \mathbf{x} is a vector of endogenous and exogenous states, \mathbf{F} characterizes the policy function (including the optimal dynamics of co-state variables) and \mathbf{P} is a transition matrix for the states. Matrix \mathbf{B} determines which variables can experience an exogenous shock and in what magnitude and ω_t is an innovation vector.

3.2 Calibration

We set the parameter values so that the behavior of the model economy matches the features of some measurements that are taken from the Guatemalan economy, in as many dimensions as there are unknown parameters. Some of the parameters are of common use in the literature and some others deserve a more detailed explanation. To perform this calibration, we use information from national accounts, the national survey of income and expenditure of households -ENIGFAM-, and the national survey

of income and employment -ENEI¹⁵. We employ some relationships obtained from the deterministic steady state in order to be consistent with the model. It is important to mention that the information that comes out of the -SNA93- is very rich and allows separation of data into many levels. Unfortunately, the frequency is annual and for Guatemala it is only available for 5 years (2001-05). The data for these few years is enough to estimate some parameters, but for others, especially those that need econometric estimation, the information available is insufficient. A detailed explanation about the calibration of model's parameters can be found in the Appendix.

Table 1: Parameter Values

i^*	β	a	α^T	α^N	δ	$Remee$
0.00735	0.9927	0.4138	0.3349	0.2912	0.012	0.02595
	$Remee_2$	ρ_R	σ_{ε^R}	ψ		
	0.1025	0.8914	0.1782	0.00081		

4 Model Results

We believe that it can not be said, *a priori*, if the change in the remittances flow observed in the Guatemalan data for this decade is going to be permanent or temporary. Thus, we report the response of the model to an unanticipated and temporary shock to the remittances-to-income ratio $-RSH_t-$ and the response of the model to a permanent change in the level of the same ratio. We perform these exercises in order to evaluate if the reaction of the real exchange rate (and other endogenous variables) correspond to a setting in which rational agents perceive the change in the flow of remittances as temporary or to one in which they perceive it as permanent. This process will also help us to evaluate the capacity of the model to mimic observed data in the Guatemalan economy.

4.1 Impulse Response: Temporary Shock to Remittances-to-Income Ratio

We report the response of the model to a transitory, but persistent remittances-to-income ratio shock¹⁶. When RSH_t increases, an appreciation of the equilibrium

¹⁵By its acronyms in Spanish.

¹⁶A 7.7 standard deviations shock is needed to generate an increase of 308 percent in the remittances-to-income ratio. This corresponds to the observed shift in the remittances-to-income ratio, from 2.5% in 2001 to 10.2% in 2006.

real exchange rate is observed, see Figures 17(a) and 17(b). The enlarged flow of remittances provides the household with additional disposable income, and the household spreads these resources over the two consumption goods and investment in both sectors. The work hours devoted to nontradable sector show an increase of almost 2% and the work hours in tradable sector decrease in 4.4%. Also the "gift" received by households allows them to increase consumption and investment in both sectors at the same time; nontradable consumption shows a contemporaneous increase of 1.05% while tradable consumption shows an increase of 3.3%. Investment is also higher in tradable sector (7.7%) than in nontradable sector (3.8%). The economy accumulates net foreign assets, which in turn, drive down the risk premium of the interest rate. Remittance flows also affect production of both goods; nontradable production increases contemporaneously with the shock (about 2% over its steady state value), while tradable production decreases for about twenty quarters after the shock (then goes a little bit over its steady state value).

It is interesting to notice that after the shock we do observe an equilibrium real exchange rate appreciation, but it is rather small (2.2%), and the optimum path followed by the RER after the shock is a depreciation path, totally different from the appreciation observed year after year since 2001. This depreciation "story" emerges even when the model includes quadratic investment costs, no matter how big or small the shock is. When the shock is transitory, we observe a small contemporaneous appreciation and then a story of depreciation until the RER converges to its steady state.

4.2 Permanent Increase in Remittances-to-Income Ratio

In this subsection, a permanent change in the remittances-to-income ratio is simulated. We want to model the transition dynamics of the equilibrium real exchange rate that emerge from shifting the steady state value of the remittances-to-income ratio that prevailed before 2001 (2.595%) to the current level of remittances-to-income ratio (10.2%). We are making two assumptions here. The first assumption is obviously that the observed increase in the remittances flow is going to be permanent; the second one is that remittances will stabilize in some value; we are assuming that this value is near the current ten percent of GDP. Despite this is an arbitrary assumption, we believe that from the perspective of the present investigation, it is of no use trying to guess if the remittances flow is going to keep growing or if it is going to stabilize in one or another value. We work based on what we have observed (i.e. an increase in the remittances-to-income ratio of 308%, going from 2.5% to 10.2%).

We show in Figures 18(a) and 18(b) the transition displayed by the model's variables. In these Figures, the red dashed line represents the previous steady state; the blue solid line represents the resulting steady state after the exogenous change

in the steady state value of RSH and the black dotted line represents the transition dynamics. The first thing to notice is that when we simulate a permanent change in the remittances-to-income ratio not only we do observe a stronger appreciation of the short run EREER, but also an "appreciation story" afterwards. In other words, the dynamics followed by the EREER show an appreciation for several quarters, as the one that we have witnessed in the Guatemalan economy. It results very interesting that when we model a permanent change in the RSH we observe the appreciation dynamics that we do not observe when a temporary shock is simulated. This result gives us the idea that the economic agents in Guatemala perceive the change in the remittances-to-income ratio as permanent.

Both consumptions (tradable and non tradable) are higher in the new steady state; both tradable and nontradable consumptions in steady state increase more than 8% percent, but the first one (tradable consumption) rises faster and it even goes above its new steady state before it converges. Also in the new steady state, less tradable capital is used; a 20% reduction is observed. Non-tradable capital's new steady state is 8% higher than the previous one, but it converges slowly. Labor hours behave as expected. On the one hand, because households receive an increased endowment of the tradable good in the form of a foreign transfer, they do not need to produce large amounts of this good. On the other hand, non-tradable consumption is constrained by domestic production, so the only way in which households can increase their non-tradable consumption in the new steady state is that the economy produces more non-tradable good, for which they increase the work hours (and capital) in the non-tradable sector. Regarding to production, we observe that non-tradable output increases more than 8% with respect to its original steady state while tradable production's new steady state is 20% lower than its previous value. Total output decreases in the long run, but shows a boom for several quarters going above its original steady state. In the whole process, the economy accumulates foreign liabilities which are reimbursed before the transition ends.

In addition, we want to evaluate how the results of the model compare to what has been observed in the Guatemalan economy. The most important fact that we wanted the model to mimic was the marked RER appreciation of the last 6 years and we also wanted to establish if this observed RER appreciation was somewhat generated or caused by the (also observed) surge in emigrant remittances. Figure 18(a) shows that when we simulate the shift in the remittances-to-income ratio as permanent, the model generates a persistent EREER appreciation that increase for 24 quarters, then it stays around an appreciation of 6% for nine more quarters and starts to converge to its (unchanged) steady state. We take this quarterly EREER generated by the model, and convert it into an annual index, then we take this index and compare it with the (P_N/P_T) - type RER index obtained from the -SNA93-. As shown on Figure 19, the model generates an appreciation of the short-run EREER of 5% percent which is weaker than the observed RER appreciation (12.4%).

The model generates a contraction in tradable sector similar to that observed in the national accounts. According to the model, tradable production reduces its share of total GDP in 14.9 percent, going from 35.5% (of total GDP) in the first year to 30.2% in the fifth year while tradable production in national accounts reduces its share in 7.2 percent (going from 37.1% in 2001 to 34.5% in 2005, see Figure 20). We also observe in the national accounts data that nontradable production has increased its share of total output in 4.26% from 2001 to 2005; the model replicates this fact very well. On Figure 21 we can see that nontradable production generated by the model rises from 65.2% to 70.%, accounting an increase of 7% percent in the same period. Regarding to model's investment both, tradable and non tradable (as shares of total GDP), appear to be stable; investment in tradable sector increases from 5 to 6 percent in the model, while it fluctuates between 11 and 12 percent in national accounts (see Figure 22). Nontradable investment fluctuates around 8% and 9.5% in national accounts while it fluctuates between ten and eleven percent in the model, see Figure 23. Tradable consumption in national accounts represent an average for 2001-2005 period of 41.2% of total GDP, fluctuating between 40.9% and 41.5% so it appears to be very stable. It can be seen in Figure 24 that in our model, tradable consumption represents a smaller fraction of total output, 31.4% in average for the five year period and it increases during the five year period going from 30.4% to 32.2%. Finally, nontradable consumption seems to increase as a share of total GDP in both, the national accounts and the model. It represents 55% of total GDP in national accounts and 57.1% of total output in our model, both averages of the five year period, see Figure 25.

5 Final Remarks

Our work began trying to characterize some aspects of the Guatemalan economy, and we did some interesting discoveries. The first one is that tradable production (as total output share) has been contracting during a period in which the remittances flow has enlarged and the real exchange rate has been appreciating, years 2001-2005. Also nontradable production (as total output share) has been expanding during the same period and under the same conditions (an increase in remittances flow and RER appreciation). These findings are very suggestive that the observed real exchange rate appreciation was influenced primarily by demand factors. Let us consider one of the most common determinants of the real exchange rate that can be found in the literature: *differential technological process*. One of the basic predictions of the Balassa-Samuelson model is that productivity differentials determine the domestic relative price of nontradables; movements of the relative price of nontradables reflect divergent trends of productivity between tradable and nontradable productions. Now, suppose that the observed appreciation in Guatemala arises from a Balassa-Samuelson effect, let us say, from higher productivity in the tradable sector.

Then we should observe an expanding tradable sector seizing the greater productivity and a nontradable sector experiencing a contraction. But what we actually observe is totally the opposite, an expansion in nontradable sector and a contraction in tradable sector. This behavior (of tradable and nontradable productions) is better associated with the argument that a positive transfer of resources to a country hurts its competitiveness in world markets; the reduction of the tradable sector takes place because the transfer appreciates the country's real exchange rate, Obstfeld and Rogoff (1996).

The real exchange rate appreciation has imposed an unintended economic cost on the producers of tradable goods in Guatemala. This is analogous to the concern raised in the well known Dutch Disease case, where resource discoveries result in real exchange rate appreciation and the subsequent shifting of resources from the tradable to the nontradable sectors of the economy. Another finding is that the observed appreciation is not as sturdy as suggested by the IMF's "real effective exchange rate" (21.6%)¹⁷. We measure the real exchange rate using the ratio between the implicit output deflator of each sector and we obtained a smaller real appreciation (12.4%)¹⁸.

Then we develop a stochastic dynamic general equilibrium model that generates a short-run EREER appreciation, a tradable sector contraction, and a nontradable expansion, similar to those that are observed in national accounts data. Using this data, we raise the possibility of emigrant remittance flows appreciating the real exchange rate and, hence, reducing Guatemala's competitiveness in world markets. With our model, we provide an analytic framework within which this can occur, where capital adjustment costs play an important role in mimicking the dynamics of the observed real exchange rate. In addition, our model implies that in a world of rational and optimizing agents, the observed dynamic of the real exchange rate can be mimicked only when the increment in remittances is modeled as permanent; this result suggests that in Guatemala, economic agents perceive the observed shift in the remittances flow as permanent.

It is important to notice that the model generates a short-run EREER appreciation (5%) that is weaker than the observed RER appreciation (12.4%). We believe that this 5% is an appreciation of the short-run **equilibrium** real exchange rate, and therefore, economic policies directed to reduce such appreciation would be ineffective and could result merely in a loss of resources. This is important because the rest of the observed appreciation could be related to transitory factors or temporary overvaluations that impose higher costs to the tradable sector and tend to reduce its growth prospects. This overvaluation of the real exchange rate may perhaps be subject of policy intervention. The first course of action in which one could think is sterilization, but if sterilizing operations are required on a sustained basis, they may prove unfeasible mainly because the unsustainable quasi-fiscal costs that these

¹⁷2001 - 2005 period.

¹⁸See Harberger (2004) and Montiel, P. (1999) for an explanation of why symmetric and PPP-based approaches of the real exchange rate are flawed.

operations could imply when remittances are considerably large. Other government interventions, like efforts aimed at making domestic markets more efficient and more flexible (especially productive factor markets), could ease exchange rate pressures without imposing other macroeconomic costs. It is essential to keep in mind that policy makers will have to accept some real exchange rate appreciation, to us the short-run ERER appreciation, because of the substantial and sustained nature of remittances flows in Guatemala.

It is important to better understand the different impacts of remittances over the receiving economy in order to formulate economic policies that take full advantage of these transfers of wealth and enhance its development impact. In such sense, this paper constitutes part of an extensive research agenda whose primary objective is to achieve a better understanding of the effects of demand shocks over the equilibrium real exchange rate. In the model presented here the shift in remittances, either transitory or permanent, does not affect the long run equilibrium real exchange rate (the steady state value of the RER); we believe that an interesting next step could be exploring if demand shocks are capable of generating a permanent ERER appreciation, given some non-competitive market structures or segmented input markets. For the moment, we conclude saying that it is ironic that emigrant remittances, intended to relief poverty and benefit the relatives left behind may, in turn, compromise Guatemala's international competitiveness through a Dutch-Disease-like phenomenon.

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Figures

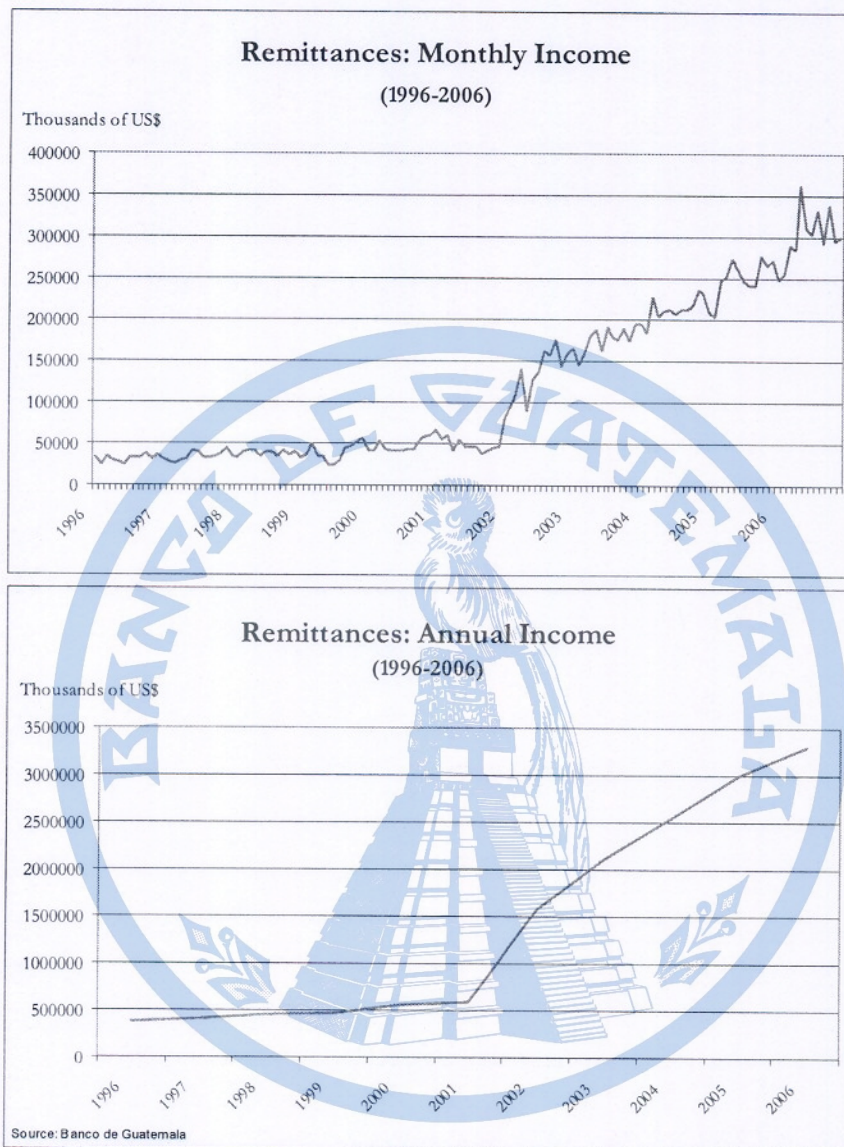


Figure 1.

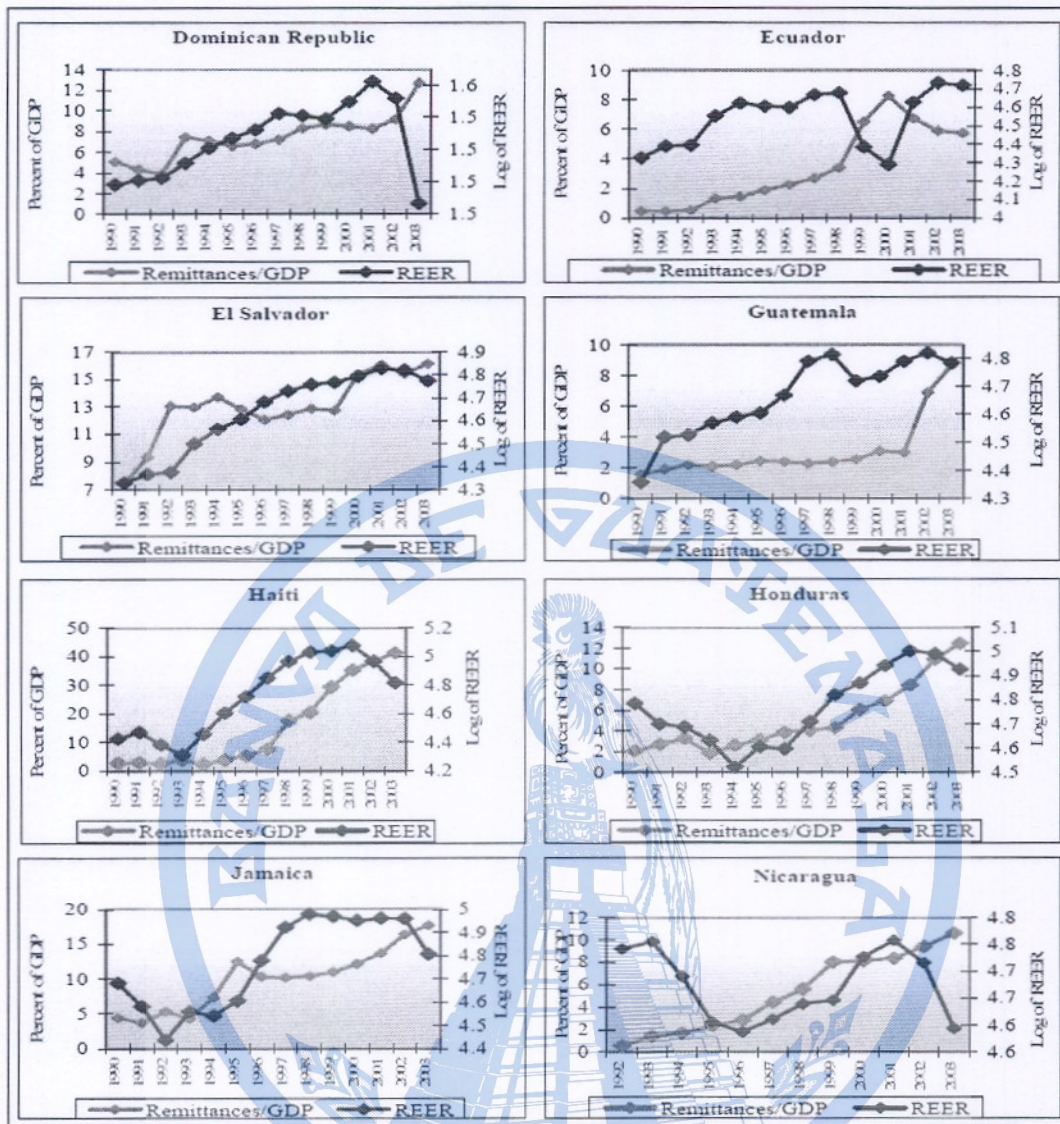


Figure 2. Source: Fajnzylber and Lopez (2006)

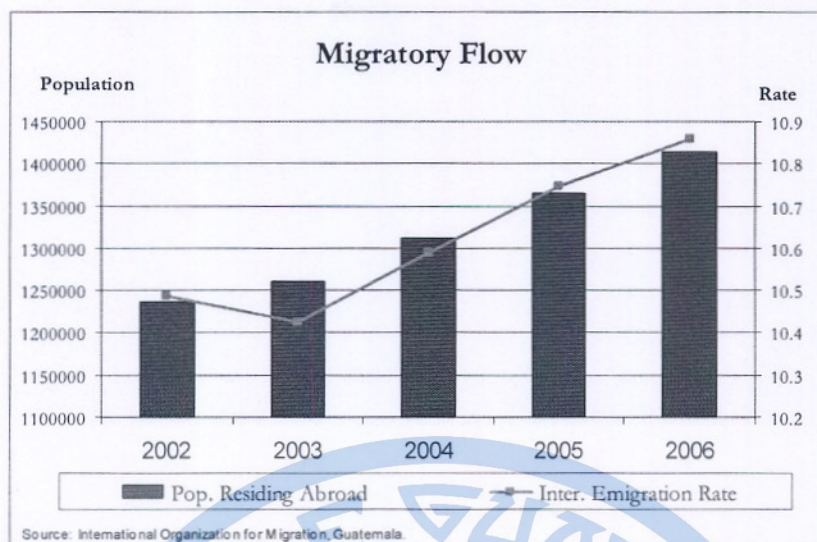


Figure 3.

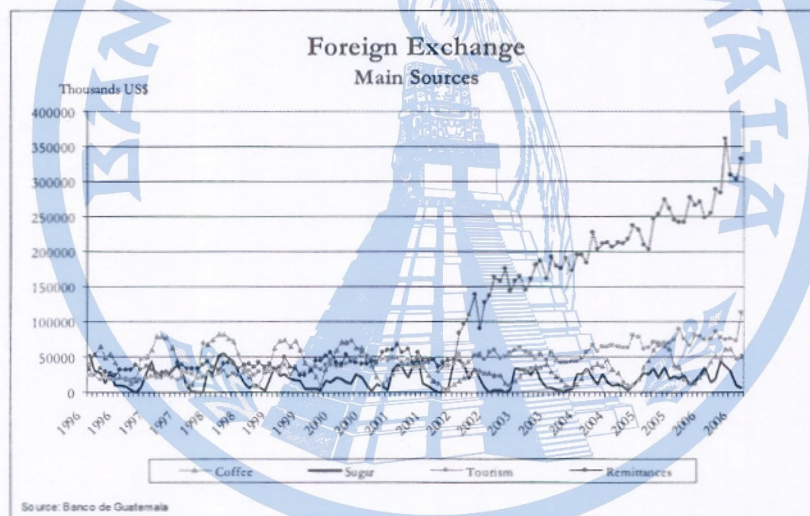


Figure 4.

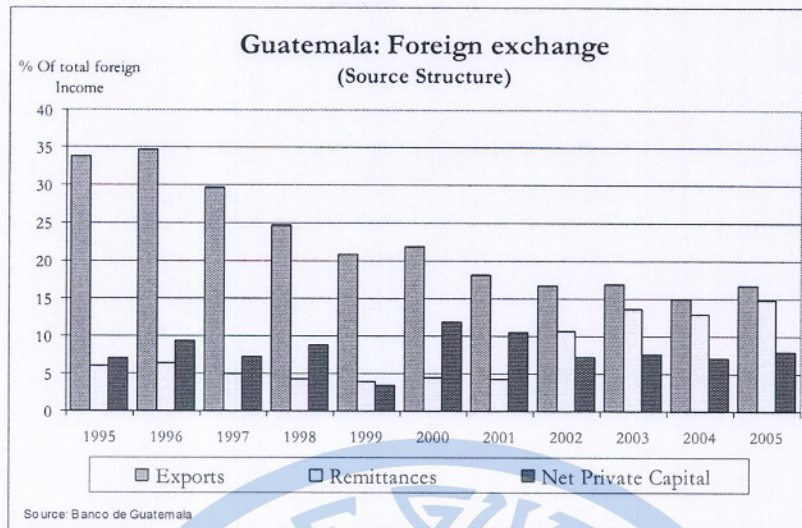


Figure 5.

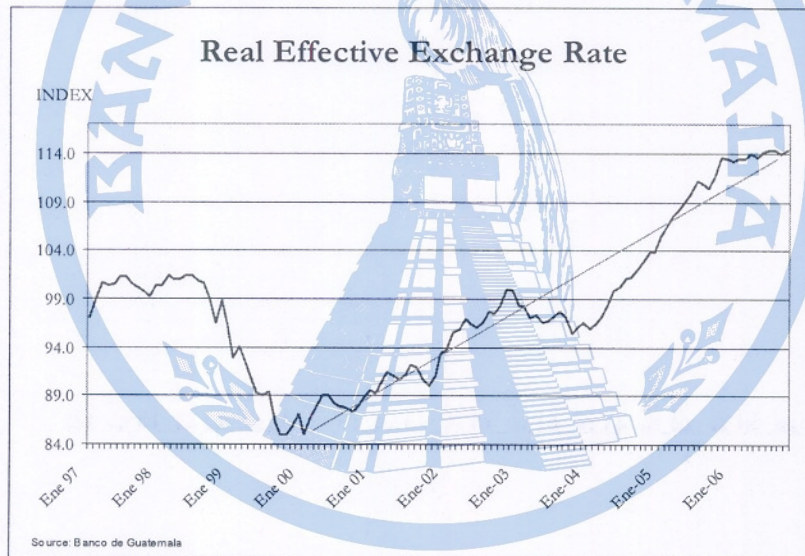


Figure 6.

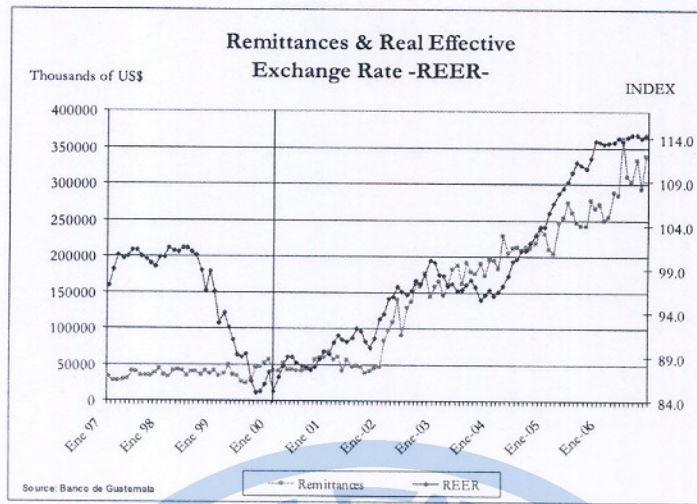


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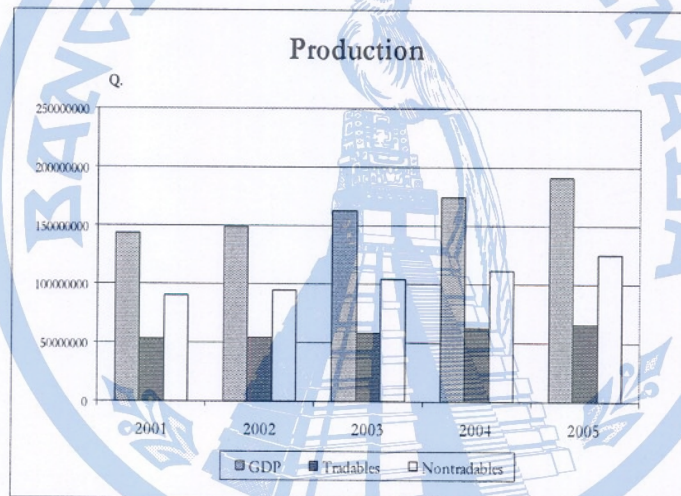


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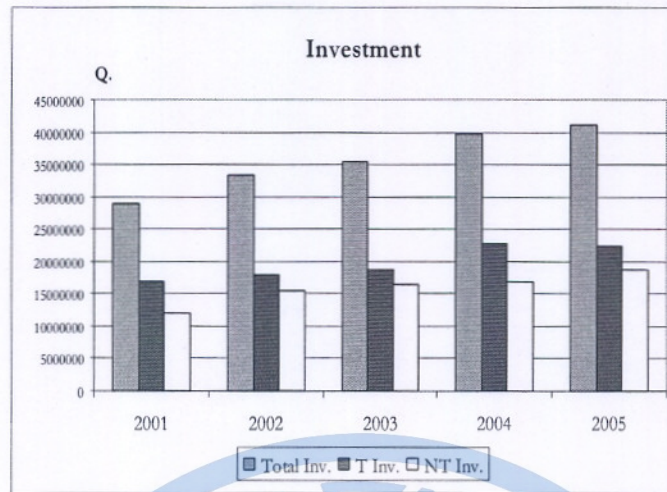


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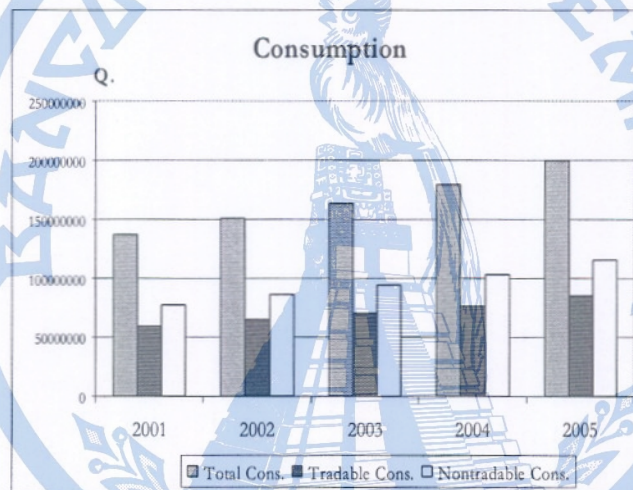


Figure 10.

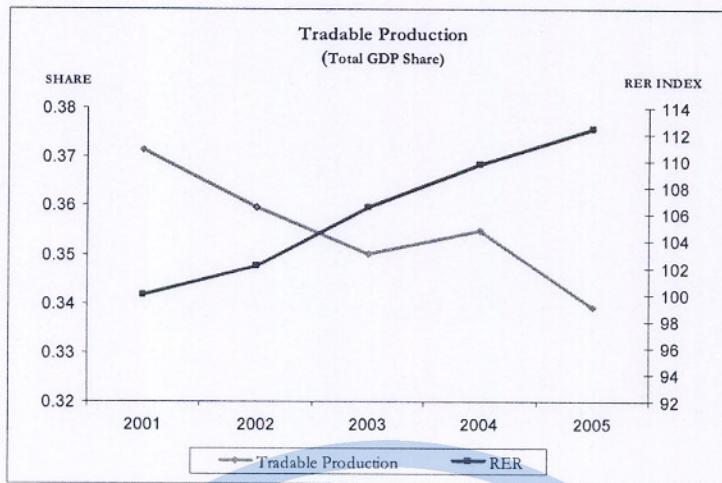


Figure 11.

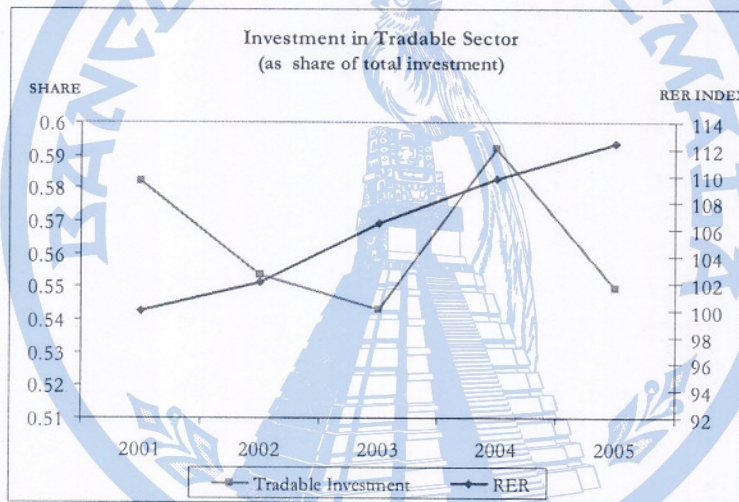


Figure 12.

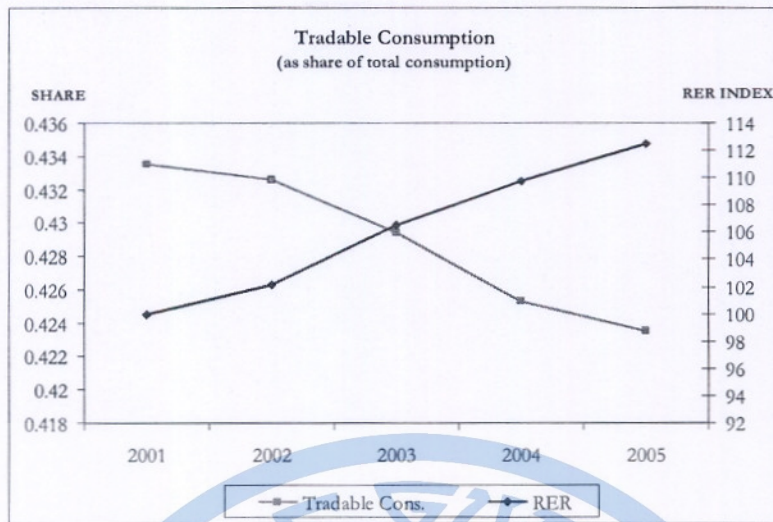


Figure 13.

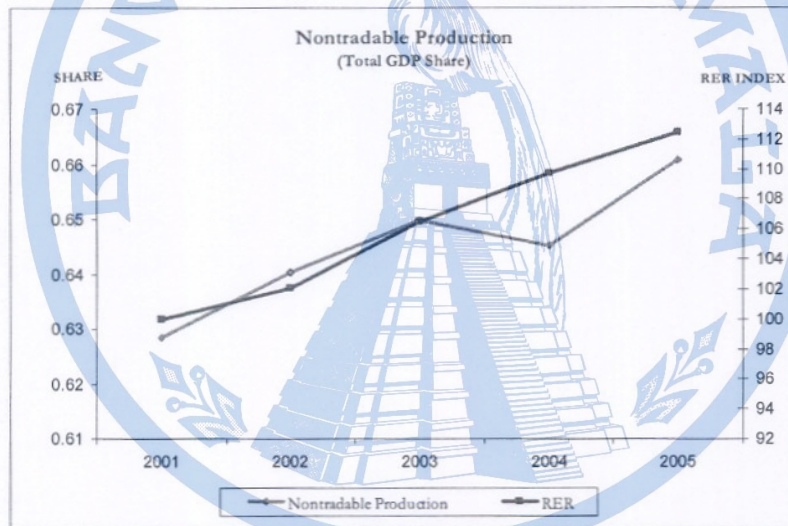


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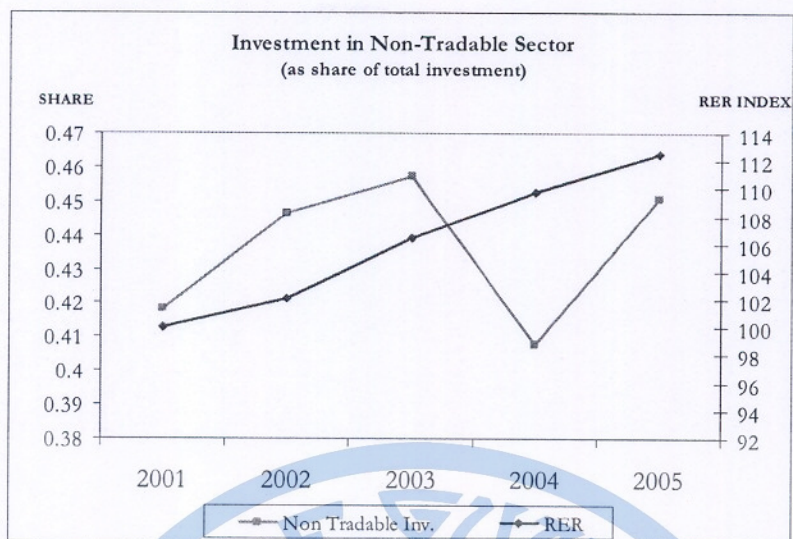


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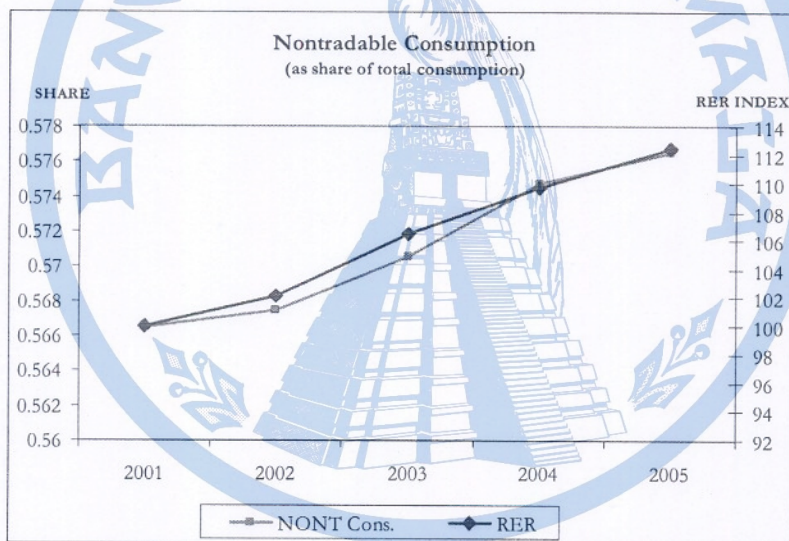


Figure 16.

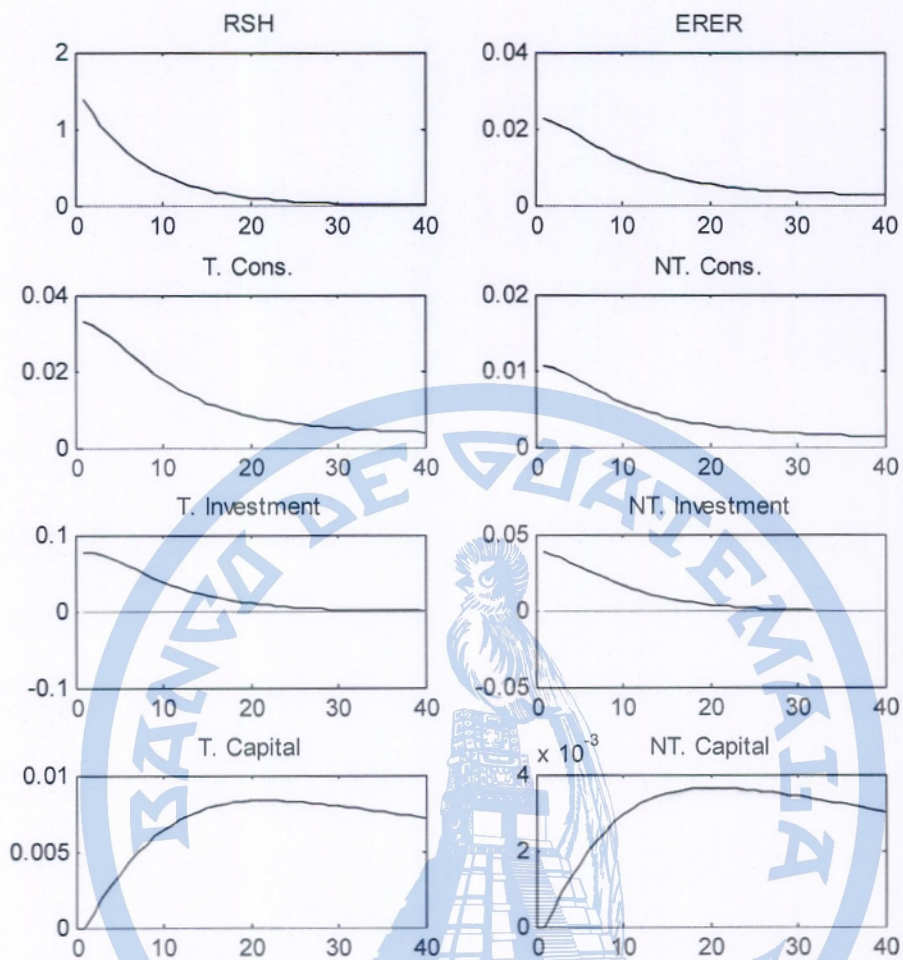


Figure 17(a). Remittances-to-Income Ratio Shock

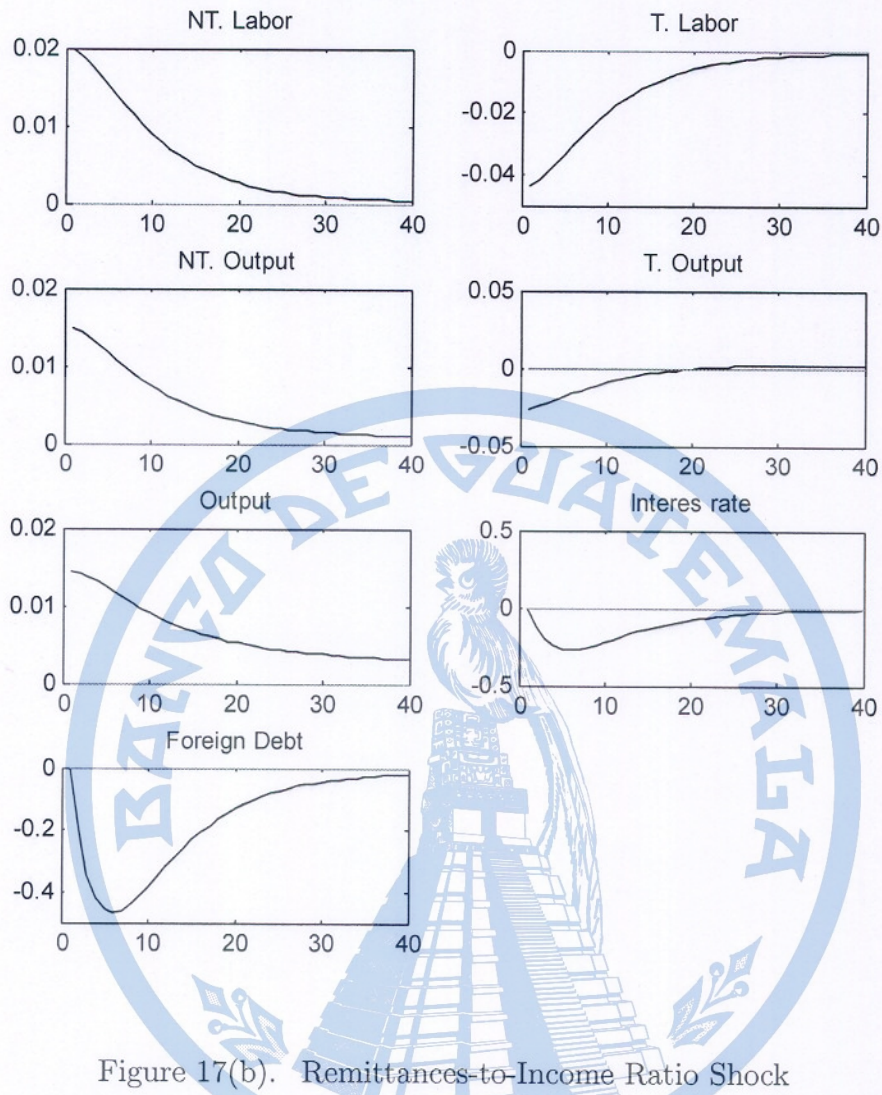


Figure 17(b). Remittances-to-Income Ratio Shock

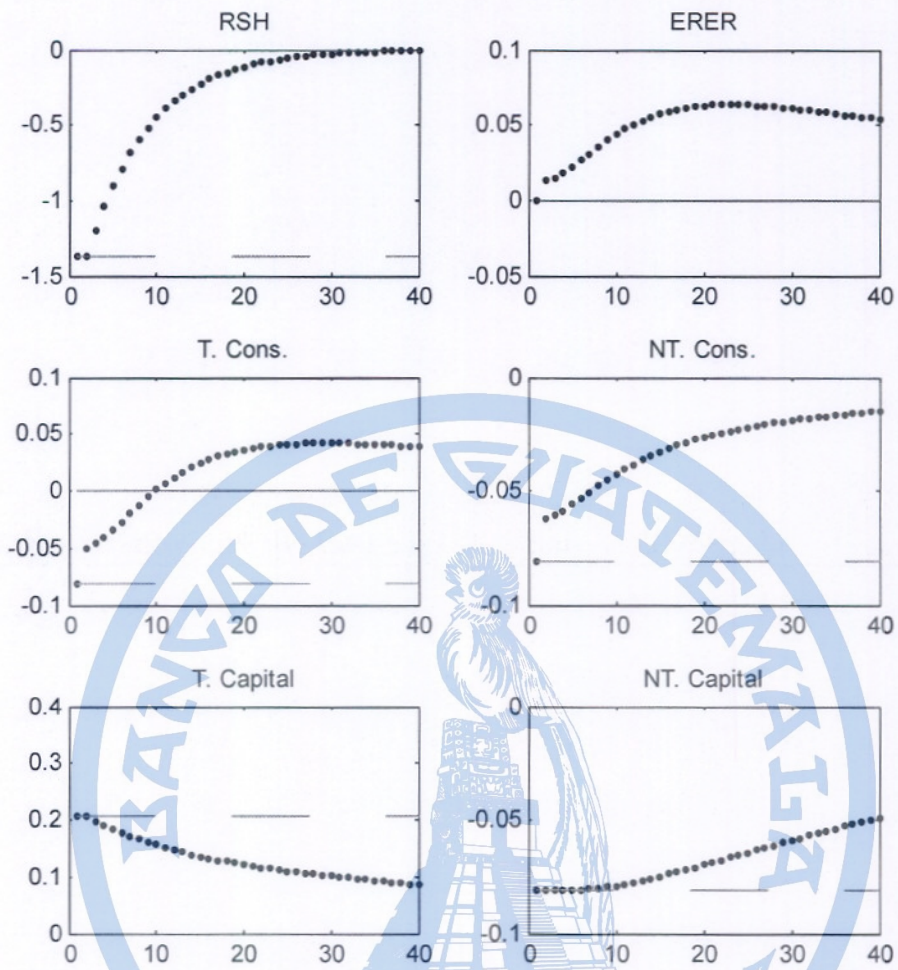


Figure 18(a). Permanent Change in *RSH*'s Steady State

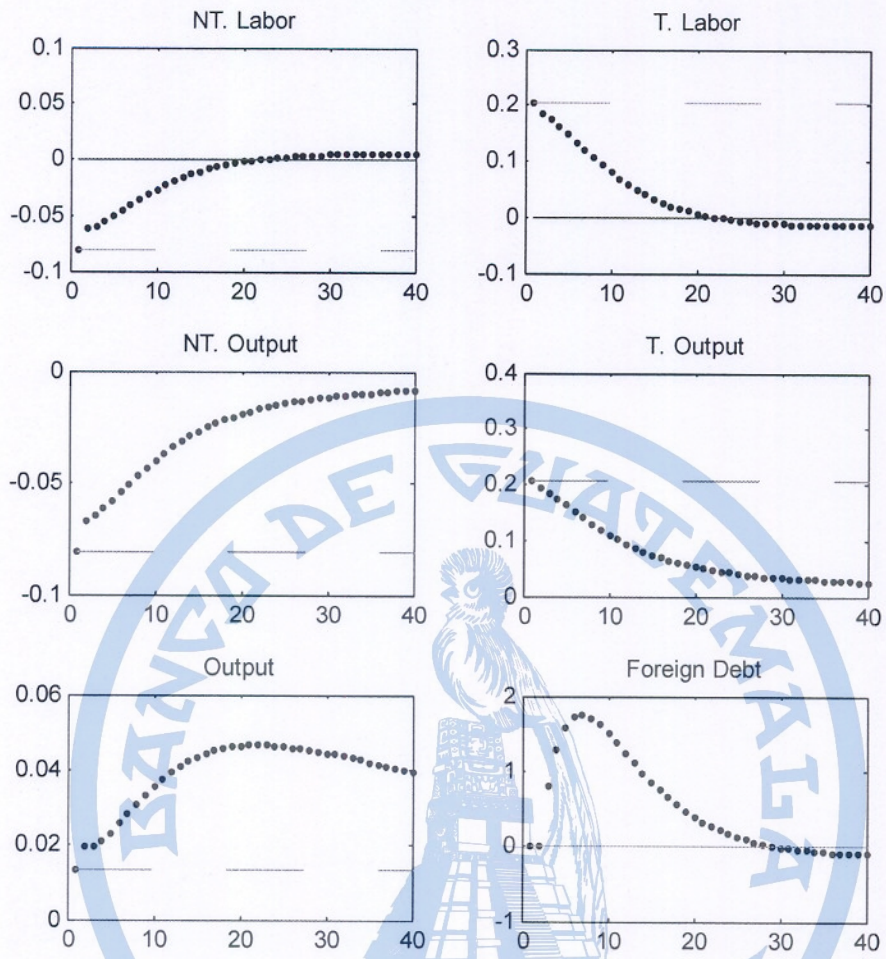


Figure 18(b). Permanent Change in *RSH's* Steady State

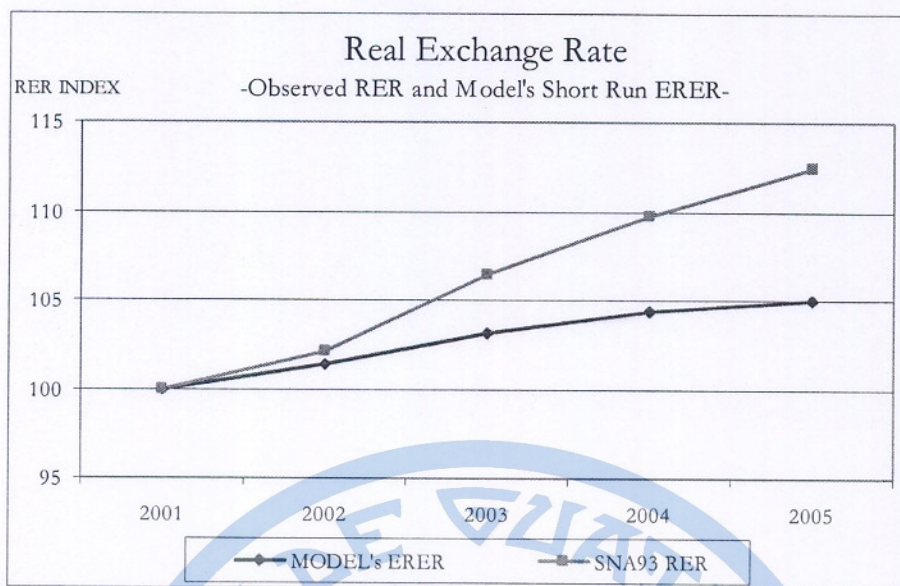


Figure 19.

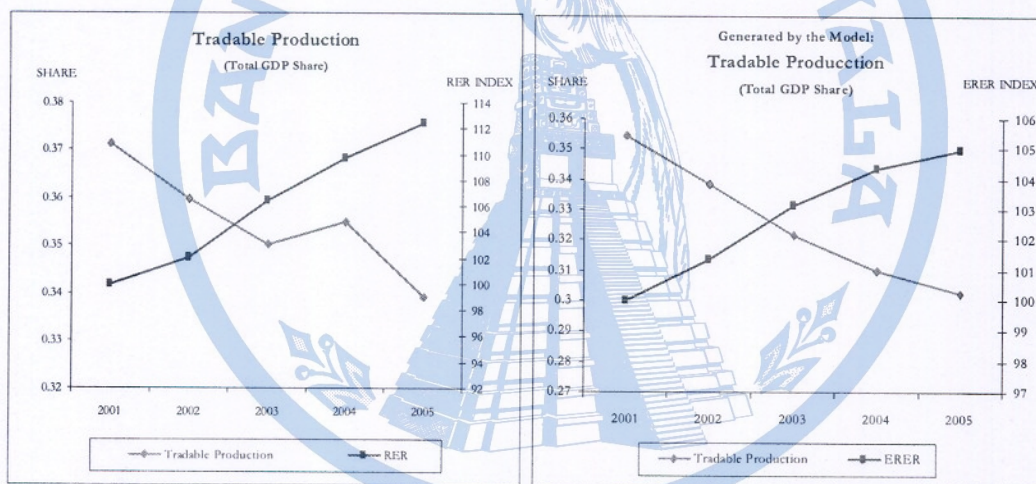


Figure 20.

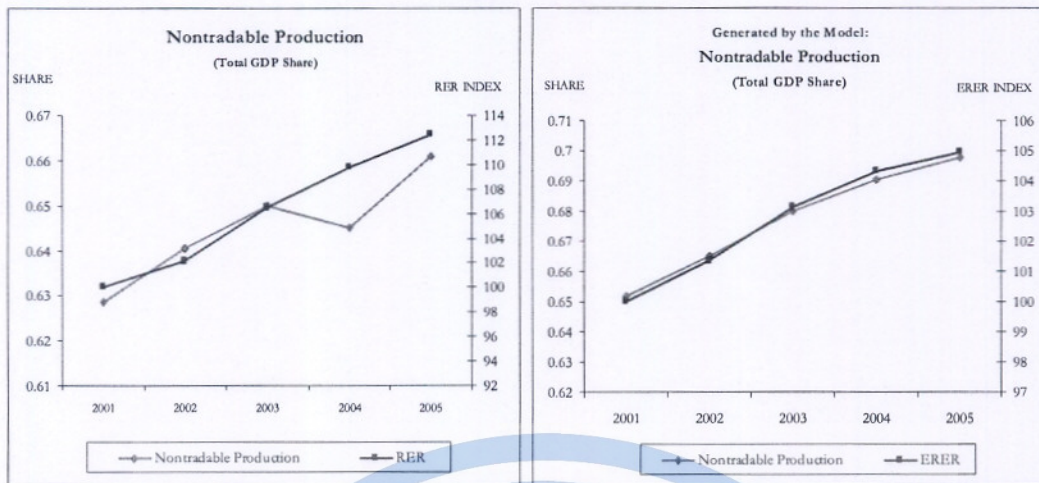


Figure 21.

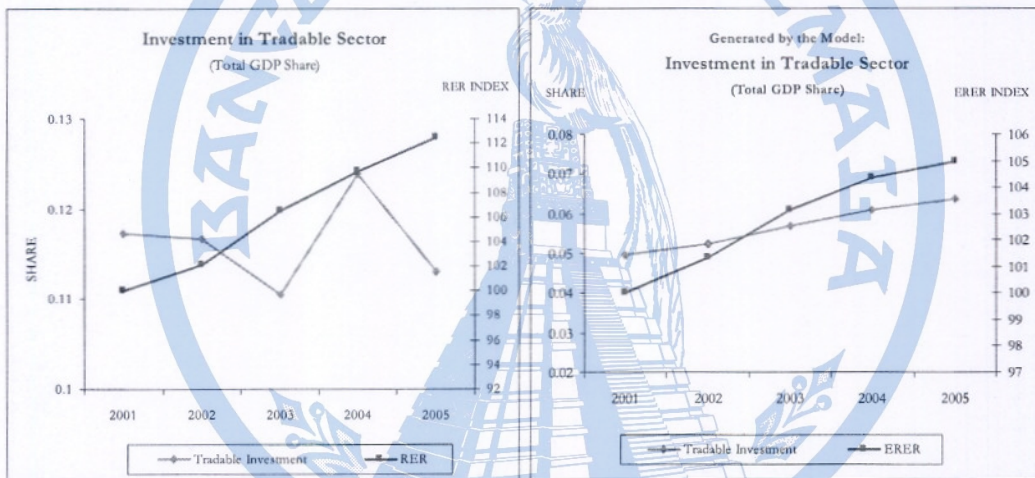


Figure 22.

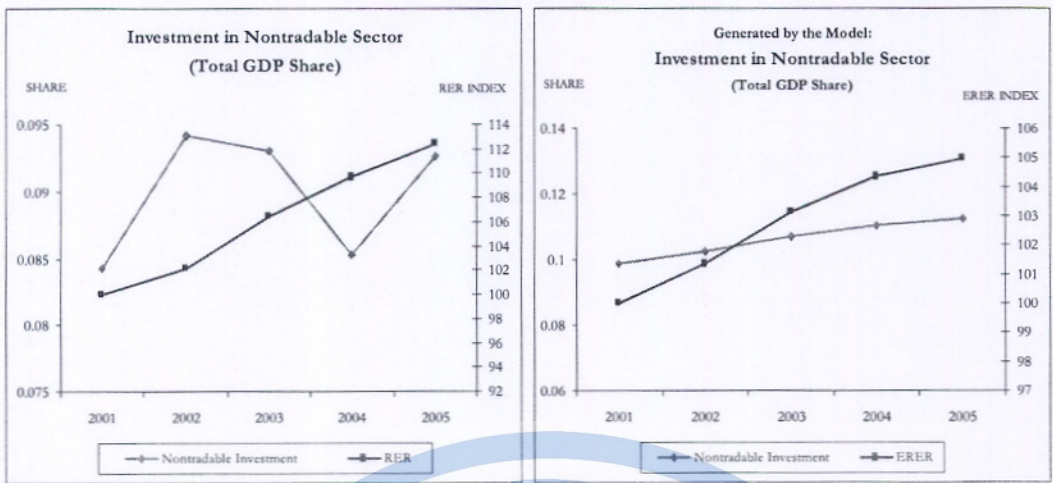


Figure 23.

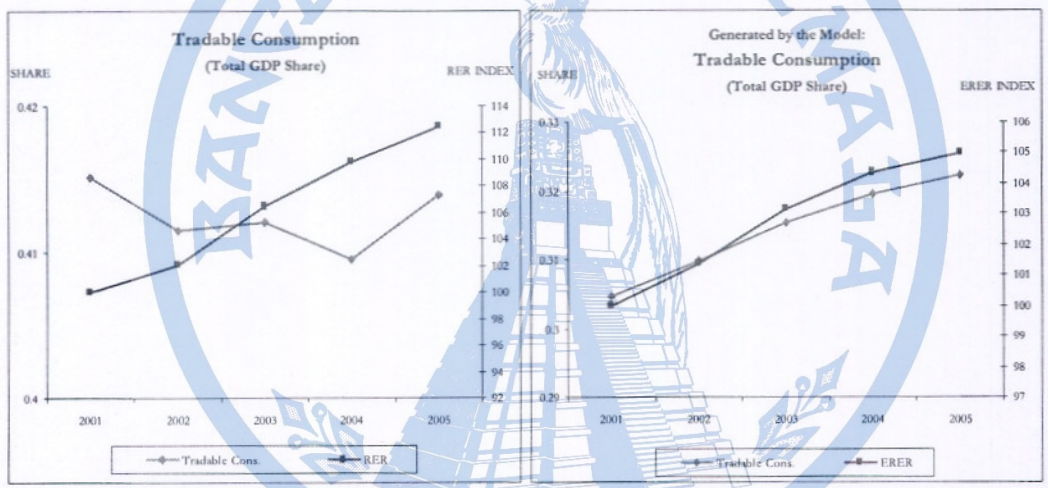


Figure 24.

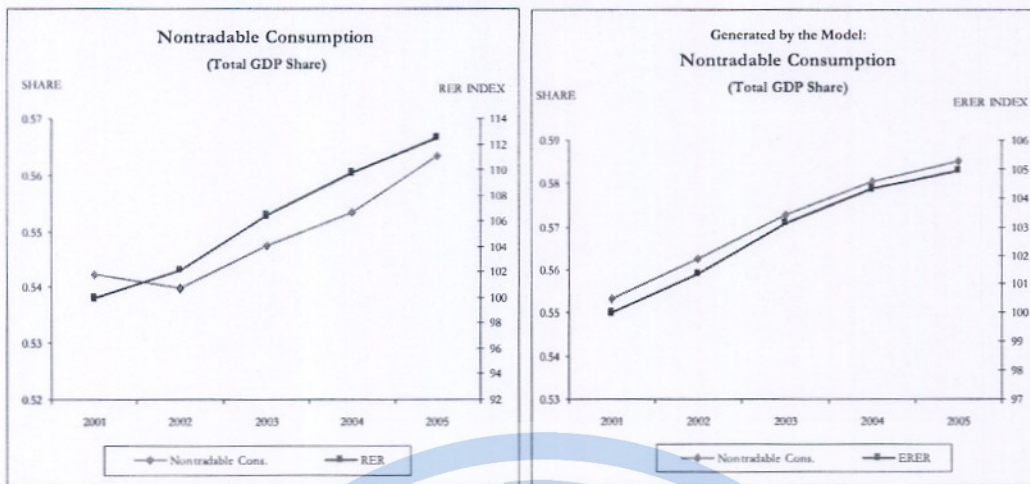


Figure 25.



A Appendix: Calibration

Because the production functions are Cobb-Douglas (in both sectors) and they exhibit constant returns to scale, each input is paid its marginal product. In this case, the parameter $(1 - \alpha^j)$ is referred to as the labor's share and α^j is the capital's share (both in sector j), because they will earn that fraction of output. These parameters are of common use in the literature so we take the values used for the Colombian¹⁹ economy: $(1 - \alpha^T) = 0.6651$. Which implies a participation of capital in the production function of $\alpha^T = 0.3349$. Also, for the nontradable sector we use a labor's share of $(1 - \alpha^N) = 0.7088$. Which in turn, implies a participation of capital of: $\alpha^N = 0.2912$. The steady state level of net foreign asset position $-\bar{f}$ is calibrated in such a way that the model imitates the ratio of trade balance-to-output of the Guatemalan data (16.74%) in the 1995-2006 period. We set the scale parameter of the risk premium in a value that allows the model to exhibit the same variability of the trade balance-to-output ratio that is observed in the Guatemalan economy, this is $\psi = 0.00081$. Capital's quarterly depreciation rate is set to 0.012 which is equivalent to an annual depreciation rate of 0.048.

A.1 Participation of tradable consumption $C_{T,t}$ and non-tradable consumption $C_{N,t}$ in the utility function of households:

(a)

From households' first-order conditions, we take equations (7) and (8) in steady state, and combining them we get:

$$\frac{C_{N,ee}}{C_{T,ee}} \cdot \frac{a}{(1-a)} = \frac{1}{Q_{ee}} \quad (26)$$

From this relationship, we can find the value of parameter a that is consistent with the model. We add up the final consumption expenditure in both sectors and take averages to obtain the relationship $\left(\frac{C_{T,t}}{C_{N,t}}\right) = 1.33418$. For $\bar{Q}_t = \left(\frac{P_t^N}{P_t^T}\right) = 1.06162$, we use the implicit output deflator of tradable and non-tradable sectors obtained from national accounts. Then, using equation (26) we solve for $a = 0.4138$.

¹⁹See Hamman and Rodriguez (2006). We did not calibrate this parameters with Guatemalan data because in order to find labor and capital shares for each sector, we need information of the input-output matrix of national accounts and by the time we calibrated our model this matrix was not available.

A.2 Steady state value of net foreign asset position: (f_{ee})

In order to calibrate the steady state value of debt in our model, we first took the definition of trade balance of the model and the equation that governs the accumulation of external debt inside the model, eq. (25):

$$TB_t = y_t^T - C_{T,t} - x_{T,t} \quad (27)$$

$$C_{T,t} + (1 + i_t) f_t \cdot Y_t + x_{T,t} = y_t^T + f_{t+1} \cdot Y_{t+1} + RSH_t \cdot Y_t; \quad (28)$$

Taking (28) in steady state:

$$C_{T,ee} + (1 + i_{ee}) f_{ee} \cdot Y_{ee} + x_{T,ee} = y_{ee}^T + f_{ee} \cdot Y_{ee} + RSH_{ee} \cdot Y_{ee}; \quad (29)$$

and rearranging we get,

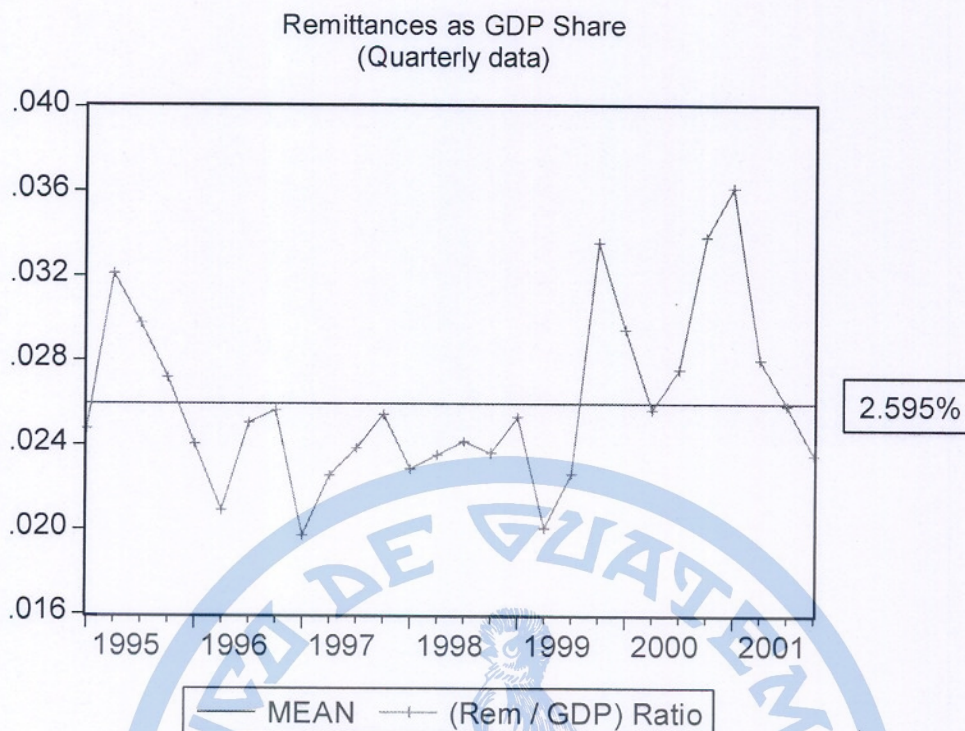
$$i_{ee} f_{ee} = \frac{y_{ee}^T - C_{T,ee} - x_{T,ee}}{Y_{ee}} + RSH_{ee}; \quad (30)$$

So, we would have a debt-to-GDP ratio:

$$i_{ee} f_{ee} = \left(\frac{TB_t}{Y_t} \right) + RSH_{ee} \quad (31)$$

A.3 Steady state value of remittances: (R_{mee})

We took quarterly data and estimated the remittances to GDP ratio for the period 1995 - 2001. In this period, the ratio appears to be stationary, as suggested by the following graph:



Also we confirm the stationarity of this ratio by a Dickey-Fuller Test, which rejected at a 5% significance level the null hypothesis that remittance to GDP ratio had a unit root. The mean level of this ratio appears to be 2.595%, so we set the steady state level of remittances to $Rem_{ee} = 0.02595$. The evolution of remittances in recent years can be interpreted as a transition to a higher steady state value of remittances flow, so we use the 2006 level of remittance-to-GDP ratio (10.2%) as the new steady state value, $Rem_{ee_2} = 0.10259$.

A.4 International risk-free interest rate: (i^*)

We took the 3-month US Treasury bill as the riskless asset, and its rate as proxy of the international risk-free interest rate. We computed the average of the annual rate of return for the past 6 years (2.9391%), and then calculated a quarterly equivalent rate, to set $i^* = 0.0073$.

A.5 Subjective discount factor (β) :

The subjective discount factor is determined by eq. (11) in steady state, it is easy to see from that equation that:

$$\beta = \frac{1}{1 + i^*} \quad (32)$$

With an international risk-free quarterly interest rate of 0.0073, we have that $\beta = 0.9927$.

A.6 Remittances shock persistence (ρ_R) :

We take quarterly data of remittances – Rem_t – and estimate by OLS:

$$\log\left(\frac{Rem_t}{Rem_{ee}}\right) = \rho_R \cdot \log\left(\frac{Rem_{t-1}}{Rem_{ee}}\right) + \varepsilon_t^R \quad (33)$$

We used logarithmic deviations from the steady state instead of the plain variable, to be in consonance with the model where variables are transformed in this way. From the regression, we obtained the estimators $\hat{\rho}_R$ and $\hat{\sigma}_{\varepsilon^R}$ that were used as the values of parameters ρ_R and σ_{ε^R} , respectively. From this procedure, we set $\rho_R = 0.891437$ and $\sigma_{\varepsilon^R} = 0.178223$.

A.7 Parameters values:

Parameter Values						
i^*	β	a	α^T	α^N	δ	Rem_{ee}
0.00735	0.9927	0.4138	0.3349	0.2912	0.012	0.02595
	Rem_{ee_2}	ρ_R	σ_{ε^R}	ψ		
	0.1025	0.8914	0.1782	0.00081		