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BUSINESS CYCLE IMPLICATIONS OF REMITTANCES AND INFORMALITY: THE CASE OF MEXICO

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Abstract

This thesis investigates the business cycle implications of remittances and informality for the Mexican economy. To explain the stylized facts for formal and informal employment, international relative prices, and remittances we develop a two-sector, open-economy Real Business Cycle model with remittance flows. The thesis looks at the combination of shocks that can best explain the stylized facts. It is shown that foreign demand shocks are essential to explain the behavior of formal employment and international relative prices, but a puzzle of countercyclical informal employment remains.

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Introduction

In developing economies like Mexico, two prominent characteristics set them apart from their developed counterparts: a substantial informal sector and a significant inflow of remittances from overseas. This thesis aims to shed light on these two important characteristics by first deriving their stylized facts observed for the Mexican economy. Second, the thesis develops an open-economy Real Business Cycle (RBC) model that incorporates an informal sector and remittance flows into the modeling framework. Using this model, the thesis identifies the combination of shocks that enables the model to best match the key features of the data.

To obtain the stylized facts for Mexico, data on output, remittance flows, the real exchange rate, the terms of trade, total employment and informal employment was collected. The stylized facts can be summarized as follows. First, remittance flows are shown to be highly volatile over the business cycle. Second, remittance flows, the terms of trade and the real exchange rate are counter-cyclical variables. Third, all measures of employment including informal employment are pro-cyclical variables.

In order to explain the stylized facts derived from the data, this thesis develops a theoretical framework for a small open-economy that includes both an informal and a formal sector. The informal sector is assumed to have lower productivity compared to the formal sector. Additionally, remittances are an exogenous variable, incorporated into the model as a positive income shock for households. The production process involves intermediate goods producing firms and a final goods producer, with only the latter being able to import foreign goods. It is also assumed that the government always runs

a balanced budget and that taxes are collected only from the formal sector. Financial markets are assumed to be incomplete and similar to Schmitt-Grohé and Uribe (2003) we employ a debt-elastic interest rate to ensure stationarity. The equilibrium conditions of the model are log-linearized and we use DYNARE to solve the model numerically. The model allows for several different shocks to affect the economy: formal productivity shocks that can be imperfectly transmitted to the informal sector in some specifications, as well as interest rate and foreign demand shocks. Remittances are assumed to be correlated with either productivity shocks or interest rate shocks, and the shock processes are set so that the model can broadly replicate the second moments for remittances.

The key results are as follows. Neither formal productivity, nor interest rate shocks are able to explain the business cycle data satisfactorily. Both shock specifications produce counterfactual predictions with regard to international relative prices (the terms of trade and the real exchange rate) and formal employment, while also generating insufficient volatility for the employment variables. A sensitivity analysis was conducted and revealed that variations in the elasticity of substitution between formal and informal goods does not lead to improved model outcomes. Similarly, adjusting the trade elasticity parameter to lower values does not improve the model's results, but increasing the trade elasticity can lead to better outcomes for the correlation between formal employment and output. Foreign demand shocks are shown to be crucial for the ability of the model to generate countercyclical behavior for the terms of trade and the real exchange rate. They also improve the volatility of all variables. This suggests that foreign demand shocks are an important factor for understanding the business cycle for developing economies. However, a puzzle arises whereby informal employment becomes countercyclical under foreign demand shocks, which is not consistent with the data.

Several previous works focusing on the business cycle implications of informality exists in the literature. There is also a small literature that investigates the implications of remittance flows. To the best of our knowledge, no previous research has investigated jointly both informality and remittances. The work of Chami et al. (2006) focuses on the influence of counter-cyclical remittances on fiscal and monetary policy, and the business cycle. They conclude that remittances increase disposable income and welfare but increase output and labor correlation generating a more volatile business cycle. Countercyclical

remittances provide consumption insurance against income shocks. The main message is the increase in business cycle volatility due to the higher correlation between output and labor as countercyclical remittances provide income to the households during periods of economic contraction. The countercyclical characteristic of remittances used in this work is supported by the stylized facts for the Mexican economy.

Durdu and Sayan (2008) develop a DSGE model with financial rigidities (borrowing constraint) to allow for sudden stops. The authors calibrate the model that incorporates remittances for the Mexican and Turkish economies. Similar to the model developed in the second chapter, remittances are treated as income shocks to the households. They argue that data shows that remittances are counter-cyclical in the case of the Mexican economy and pro-cyclical for the Turkish economy. Remittances provide a smoothing effect for the business cycle if they are countercyclical and they amplify the business cycle if they are procyclical in the presence of borrowing constraints. This result is in contrast to Chami et al. (2006) where they find that counter-cyclical remittances generate a more volatile business cycle and is likely due to the introduction of borrowing constraints.

From a different point of view and with different objectives Mandelman and Zlate (2008) develop a two country RBC model that focuses on migration dynamics and business cycles. The authors highlight the insurance role of remittances for the receiving country. Immigration behaves in a pro-cyclical manner with the developed country cycle and remittances flows from the developed country are also pro-cyclical. Another approach taken by Jansen et al. (2012), finds that remittances shocks increase consumption, produce a persistent decline in labor, and a temporal decline in output and investment. The emphasize that if remittances where redirected towards investment the negative impact on output would be reduced.

In terms of informality and the business cycle, Fernández and Meza (2015) build a RBC model with formal and informal labor markets for the Mexican economy. In their model informality plays an amplification role for productivity shocks, as they are imperfectly propagated from the formal to the informal sector. The authors also argues that bad measurements of informal activity contributes to the higher volatility of output in the Mexican economy.

Restrepo-Echavarria (2014) also develops a two-sector small open economy RBC model. The author looks at the effects of the informal sector for measurement of the business cycle. The key finding is that incorrect measurement of the informal economy can generate artificially large volatility of consumption. She finds that the reason for the artificially high consumption volatility under a poorly measured informal sector is that formal and informal goods are close substitutes.

In line with Restrepo-Echavarria (2014), Horvath (2018) also builds an open economy RBC model with two sectors. The author finds that there is a positive relationship between the relative volatility of consumption and output and the size of the informal sector. He also shows that there is a positive relationship between the relative volatility of consumption and output and countercyclical interest rates.

An other article exploring the business cycle implications of informality is by Leyva and Urrutia (2020). The authors propose a small open economy RBC model with labor market frictions and an informal sector. Thy calibrate the model for the Mexican economy and show that interest rate shocks are a key to obtain a countercyclical informality rate. The authors argue that a reduction in labor regulation might be able to reduce the volatility of output.

This thesis combines the two-sector approach from Fernández and Meza (2015) and allows for remittance flows as exogenous income shocks to the households in the spirit of Durdu and Sayan (2008). Since we are interested in explaining the behavior of the terms of trade and the real exchange rate, the model is additionally extended to allow for international relative prices along the lines of Thoenissen (2011). The high elasticity of substitution used in the baseline model follows from Restrepo-Echavarria (2014).

The thesis is structured into three main chapters. In Chapter 1, the stylized facts relating to remittances, formal and informal employment and international relative prices are derived for Mexico, a representative developing economy, providing a foundation for the subsequent analysis. Chapter 2 develops a Real Business Cycle model that incorporates the concepts of informality and remittances, serving as the theoretical framework for the study. Chapter 3 delves into the specifics of the shock processes, parameter calibration,

and presents the results. This chapter provides an evaluation of the model's performance in explaining the observed data. Finally, the conclusions are summarized, where the main findings and implications of the research are discussed.

Additionally, the appendix supplements the main body of the thesis by including information on data sources, an exploration of a model without an informal sector, and aditional results from the sensitivity analysis. This additional material enhances the comprehensiveness of the research and allows for a more thorough examination of the topic at hand.

Chapter 1

Stylized Facts

This chapter presents the stylized facts about the relationship between remittances, informality and the business cycle for the Mexican economy. The first section describes the data, and the steps that were taken to calculate the set of second moments. The second section presents the set of second moments and the stylized facts for total employment, informal employment, formal employment, output, the real exchange rate, the terms of trade and remittance flows.

1.1 Data

Mexico has reliable data on remittance flows and informality. The variables of interest included in the data set are the following: output, remittance flows, the real exchange rate, total employment and three measures of informal employment with their corresponding measures of formal employment. The first variable included in the data set was output for the period 1993-Q1 to 2022-Q3 obtained from INEGI (2023). To obtain the cyclical component, natural logarithms of the output series were calculated before applying the Hodrick-Prescott (HP) filter. The second variable in the dataset was remittances, which were obtained from BANXICO (2023) for the period 1993-Q1 to 2022-Q3. Following Sayan

(2004) U.S Dollar remittances were converted to Mexican Pesos using the average exchange rate for each quarter, which were then deflated using the Implicit Price Index, (with 2013 = 100) from INEGI (2023).The series was then deseasonalized, natural logarithms were taken and finally, it was HP filtered to obtain the cyclical component.

The third variable in the set was the real exchange rate, obtained from BANXICO (2023) for the period 1993-Q1 to 2022-Q3. This is the only variable with monthly frequency, so it was converted into a quarterly series by taking the average of the quarter. As a second step, it was deseasonalized, natural logarithms were taken and the series was HP-filtered to find the cyclical component. The terms of trade and total employment span from 2005-Q1 to 2022-Q3, which were taken from BANXICO (2023) and INEGI (2023), respectively. The variables were deseasonalized, natural logarithms were taken, and were HP filtered.

The following variables are different measures of informality, which are available from INEGI (2023). All of them were obtained by multiplying total employment by the respective informal labor rate, after that the variables were deseasonalized, natural logarithms were taken, and were HP filtered. il^1 is the main informality measure given by INEGI (2023). il^2 is the number of self employed workers and il^3 is the number of workers without labor benefits. The remaining variables are the corresponding three measures of formality fl^1, fl^2, and fl^3, which were obtained from subtracting each measure of informality from total employment.

1.2 Second Moments

Table 1 reports the second moments (standard deviation and correlations) for the data set (1993-2022, unless specified otherwise). It shows that all variables are more volatile than output, except for total employment and all measures of formal employment. Remittances are the most volatile variable, followed by the real exchange rate. Remittances, the real exchange rate, and the terms of trade are counter-cyclical variables. All other variables are pro-cyclical to different degrees.

Second moments						
	$\sigma_i(\%)$	σ_i/σ_Y	$\rho(i,Y)$	$\rho(il^1,i)$	$\rho(il^3,i)$	$\rho(rem,i)$
Y	2.79	1.000	1.000	0.753	0.644	-0.258
rem	9.51	3.397	-0.258	-0.097	-0.097	1.000
rer	8.38	2.997	-0.529	-0.327	-0.305	0.672
tot	3.08	1.103	-0.223	-0.179	-0.048	-0.047
te	2.70	0.965	0.835	0.939	0.849	-0.123
il^1	3.38	1.209	0.753	1.000	0.889	-0.097
il^2	4.79	1.714	0.766	0.949	0.826	-0.097
il^3	5.01	1.792	0.644	0.889	1.000	-0.097
fl^1	2.29	0.818	0.874	0.897	0.746	-0.114
fl^2	2.10	0.753	0.774	0.755	0.783	-0.106
fl^3	2.29	0.818	0.874	0.897	0.746	-0.114

Table 1.1: Set of second moments, all variables deseasonalized, in logs and HP filtered for the cyclical component. $\sigma_i(\%)$ is the standard deviation of variable i in percentage. σ_i/σ_Y is the relative volatility of variable i with respect to output, and $\rho(i,j)$ represents the correlation between variables i and j.

The correlation between informal employment and remittances is small but slightly negative, whereas the the terms of trade and the real exchange rate are negatively correlated with informal employment. Informal employment is positively correlated with other measures of informality, total employment, and formal employment regardless of the definition of informality used.

Remittances are positively correlated with the real exchange rate and are negatively correlated with all other variables, the highest correlation in absolute value is with output, followed by total employment (when total employment falls remittances rise). These findings are in line with the ones presented by Durdu and Sayan (2008).

Based on the above the following stylized facts can be drawn:

- The most volatile variable is remittances.
- Remittances, the real exchange rate, and terms of trade are counter-cyclical variables.
- Total employment, all measures of informal and formal employment are pro-cyclical

variables. This is in contrast with the findings of Fernández and Meza (2015), who found that informal employment is countercyclical for a shorter sample (2000 - 2010).

- All measures of formal employment are less volatile than output, and all other variables (except total employment) are more volatile than output.
- Informal employment is negatively correlated with the real exchange rate, and the terms of trade and slightly negatively correlated with remittances.
- All employment-related variables are positively correlated with informal employment.
- Remittances are positively correlated with the real exchange rate and negatively correlated with all other variables.

Chapter 2

An RBC Model with Remittances and Informality

This chapter develops a Real Business Cycle model that incorporates remittances and informality. The model is derived from the ideas presented by Fernández and Meza (2015), who included a formal and informal sector to try to explain the business cycle of Mexico. The model of the previous authors was then modified to incorporate remittances, following the ideas presented by Durdu and Sayan (2008). Finally, the open economy features of the model are based on Thoenissen (2011) which are needed to explain the stylized facts about the real exchange rate and the terms of trade.

The model is a small open economy with both a formal and an informal sector. It uses a representative agent framework, where the economy is populated by a homogeneous, infinitely-lived household with a measure of one. The representative agent owns the factors of production, including formal and informal capital, and supplies formal and informal labor. Remittances are considered as exogenous income shocks to the households, following Durdu and Sayan (2008). Households produce informal goods, while for formal goods, there is an intermediate goods producer and a final goods producer. The intermediate goods producer is assumed to be more productive than the informal goods producer (household). This assumption aligns with the productivity differences between

the formal and informal sectors found by Medina and Schneider (2018). The final goods producer requires a mix of home and foreign-produced intermediate goods to produce the formal final good. Finally, the government collects taxes from activities in the formal sector and always maintains a balanced budget.

2.1 The Representative Household

The representative household derives utility from aggregate consumption C_t^A and leisure $1 - h_t^A$, where h_t^A represents aggregate labor. The expected lifetime utility of the household can be expressed as follows:

$$U_i = E_0 \sum_{t=0}^{\infty} \beta^t u\left(C_t^A, h_t^A\right), \tag{2.1}$$

where E_0 denotes the expectation operator. The representative household assigns different values to consumption and leisure in the present and future periods, with β representing the household's time preference.

The utility function is assumed to be logarithmic and separable. The period utility function is as follows:

$$u\left(C_t^A, h_t^A\right) = \mu \log\left(C_t^A\right) + (1-\mu)\log\left(1 - h_t^A\right). \tag{2.2}$$

The term μ represents the share of utility obtained from aggregate consumption.

Following Fernández and Meza (2015), aggregate consumption is the CES aggregator of formal C_t^F and informal C_t^I final goods consumption, weighted by $a \in [0,1]$:

$$C_t^A = \left[a\left(C_t^F\right)^e + (1-a)\left(C_t^I\right)^e\right]^{1/e}, \tag{2.3}$$

where the parameter e affects the elasticity of substitution between formal and informal goods $\frac{1}{1-e}$.

Aggregate employment h_t^A is defined as the sum of formal labor h_t^F and informal labor h_t^I as follows:

$$h_t^A = h_t^F + h_t^I. \tag{2.4}$$

To construct the period budget constraint, the household can issue debt denoted as D_{t+1}, which is discounted at the rate R_t. At the beginning of each period, the household possesses a stock of debt represented by D_t. Additionally, P_t^F signifies the price of the final formal good, while P_t^I represents the price of the informal good. The household allocates expenditure towards investment goods from both the formal sector, denoted as I_t^F, and the informal sector, denoted as I_t^I. Furthermore, the household consumes goods from the formal sector C_t^F as well as the informal sector C_t^I.

The government applies a tax rate of τ^F to the income derived from labor in the formal sector, expressed as $W_t h_t^F$, and the income obtained from capital rentals, represented by $rr_t K_t^F$. The period budget constraint includes remittances, denoted as Rem_t, following the approach outlined in Durdu and Sayan (2008). The household receives stochastic exogenous remittances each period, which remain untaxed by the government. Furthermore, the representative household obtains intermediate formal firm profits denoted as Π_t. Finally, the household generates income from its production activities within the informal sector, denoted as Y_t^I. Consequently, the period budget constraint can be defined as follows:

$$\frac{D_{t+1}}{R_t} = D_t + C_t^F + \frac{P_t^I}{P_t^F} C_t^I + I_t^F + \frac{P_t^I}{P_t^F} I_t^I - \frac{P_t^I}{P_t^F} Y_t^I - \left(W_t h_t^F + r r_t K_t^F\right)\left(1 - \tau^F\right) - Rem_t - \Pi_t. \quad (2.5)$$

As mentioned previously, the representative household produces goods within the informal sector. It is assumed that the production technology within the informal is Cobb-Douglas.

$$Y_t^I = A_t^I \left(K_t^I\right)^{\alpha_I} \left(h_t^I\right)^{1-\alpha_I}. \quad (2.6)$$

The variable A_t^I represents a stationary productivity shock specific to the informal sector, while K_t^I denotes the level of informal capital. The parameter $\alpha_I \in (0,1)$ indicates the share of output attributed to informal capital.

Formal capital, denoted as K_{t+1}^F, is accumulated in each period through the sum of formal investment I_t^F and the stock of formal capital K_t^F, minus the depreciation $K_t^F \delta^F$, where the formal capital depreciation rate is $\delta^F \in (0,1)$. The accumulation process can be expressed as follows:

$$K_{t+1}^F = I_t^F + K_t^F \left(1 - \delta^F\right). \quad (2.7)$$

The accumulation of informal capital, denoted as K_{t+1}^I, follows a similar process:

$$K_{t+1}^I = I_t^I + K_t^I \left(1 - \delta^I\right). \quad (2.8)$$

To obtain the first-order conditions for the household, the period utility function (2.2) was first substituted into the lifetime utility function (2.1) yielding the following expression:

$$U_i = E_0 \sum_{t=0}^{\infty} \beta^t \left[\mu \log\left(C_t^A\right) + (1-\mu)\log\left(1 - h_t^A\right)\right]. \tag{2.9}$$

As a second step, the CES aggregator of consumption (2.3), and the definition of aggregate employment (2.4) were also substituted into (2.9) to get the following expression:

$$U_i = E_0 \sum_{t=0}^{\infty} \beta^t (\mu \log\left(\left[a\left(C_t^F\right)^e + (1-a)\left(C_t^I\right)^e\right]^{1/e}\right) + (1-\mu)\log\left(1 - (h_t^F + h_t^I)\right)). \tag{2.10}$$

The household maximizes (2.10) subject to (2.5) - (2.8). The Lagrangian is given by:

$$\begin{aligned}\mathcal{L} = E_0 \sum_{t=0}^{\infty} \beta^t \Bigg\{ & (\mu \log\left[\left(a\left(C_t^F\right)^e + (1-a)\left(C_t^I\right)^e\right]^{1/e}\right] + (1-\mu)\log\left[1 - (h_t^F + h_t^I)\right]) \\ & + \lambda_t \Bigg[\frac{D_{t+1}}{R_t} + (W_t h_t^F + rr_t K_t^F)(1-\tau^F) + Rem_t + \Pi_t - D_t \\ & - C_t^F - \frac{P_t^I}{P_t^F} C_t^I - \left[K_{t+1}^F - K_t^F(1-\delta^F)\right] \\ & - \frac{P_t^I}{P_t^F}\left[K_{t+1}^I - K_t^I(1-\delta^I)\right] + \frac{P_t^I}{P_t^F}\left(A_t^I\left(K_t^I\right)^{\alpha_I}\left(h_t^I\right)^{1-\alpha_I}\right)\Bigg\},\end{aligned} \tag{2.11}$$

where λ_t denotes the Lagrange multiplier. The following seven first order conditions were derived:

$$\frac{\partial L}{\partial C_t^F} = \mu \frac{a(C_t^F)^{e-1}}{a(C_t^F)^e + (1-a)(C_t^I)^e} - \lambda_t = 0 \tag{2.12}$$

$$\frac{\partial L}{\partial C_t^I} = \mu \frac{(1-a)(C_t^I)^{e-1}}{a(C_t^F)^e + (1-a)(C_t^I)^e} - \lambda_t \frac{P_t^I}{P_t^F} = 0 \tag{2.13}$$

$$\frac{\partial L}{\partial h_t^F} = -\frac{1-\mu}{1-(h_t^F + h_t^I)} + \lambda_t (1-\tau^F) W_t = 0 \tag{2.14}$$

$$\frac{\partial L}{\partial h_t^I} = -\frac{1-\mu}{1-(h_t^F + h_t^I)} + \lambda_t \frac{P_t^I}{P_t^F} (1-\alpha_I) A_t^I (K_t^I)^{\alpha_I} (h_t^I)^{-\alpha_I} = 0 \tag{2.15}$$

$$\frac{\partial L}{\partial K_{t+1}^F} = -\lambda_t + \beta E_t \left\{ \lambda_{t+1} (rr_{t+1}(1-\tau^F) + (1-\delta^F)) \right\} = 0 \tag{2.16}$$

$$\frac{\partial L}{\partial K_{t+1}^I} = -\lambda_t \frac{P_t^I}{P_t^F} + \beta E_t \left\{ \lambda_{t+1} \frac{P_{t+1}^I}{P_{t+1}^F} \left(\alpha_I A_{t+1}^I \left(K_{t+1}^I \right)^{\alpha_I - 1} \left(h_{t+1}^I \right)^{1-\alpha_I} + \left(1-\delta^I \right) \right) \right\} = 0 \tag{2.17}$$

$$\frac{\partial L}{\partial D_{t+1}} = \lambda_t \frac{1}{R_t} - \beta E_t \lambda_{t+1} = 0. \tag{2.18}$$

2.2 Formal Intermediate Goods Sector

The representative firm in the intermediate sector aims to maximize its profits Π_t each period by setting $P_{H,t}$. These profits are determined by the production of intermediate goods Y_t^F, labor expenses W_t, and capital costs rr_t. The formal intermediate firm is also required to pay taxes on their wage bill, which is represented by τ^N. The profit function for the intermediate firm can be expressed as follows:

$$\Pi_t = \frac{P_{H,t}}{P_t^F} Y_t^F - \left(1 + \tau^N\right) W_t h_t^F - r r_t K_t^F. \tag{2.19}$$

The formal firm operates under a Cobb-Douglas production technology, utilizing formal capital K_t^F and formal labor h_t^F for production. The formal sector is affected by a stationary productivity shock denoted by A_t^F. The parameter $\alpha_F \in (0,1)$ represents the share of intermediate output attributable to formal capital. The production technology in the formal sector can be described as follows:

$$Y_t^F = A_t^F \left(K_t^F\right)^{\alpha_F} \left(h_t^F\right)^{1-\alpha_F}. \tag{2.20}$$

In order to derive the price of formal capital and the wage in the formal sector, the profit maximization problem was formulated as an unconstrained maximization problem by substituting equation (2.20) into equation (2.19). This process resulted in the following objective function:

$$\Pi_t = \frac{P_{H,t}}{P_t^F} A_t^F \left(K_t^F\right)^{\alpha_F} \left(h_t^F\right)^{1-\alpha_F} - \left(1 + \tau^N\right) W_t h_t^F - r r_t K_t^F. \tag{2.21}$$

From the first-order conditions, two optimality conditions are obtained. The first condition relates to the price of formal capital and demonstrates that the price of capital decreases when the capital stock increases. It also reveals that an increase in the relative price of the intermediate formal good leads to an increase in the price of formal capital:

$$r r_t = \frac{P_{H,t}}{P_t^F} \alpha_F A_t^F \left(K_t^F\right)^{\alpha_F - 1} \left(h_t^F\right)^{1-\alpha_F}. \tag{2.22}$$

The second optimality condition was derived for the price of formal labor:

$$W_t = \frac{P_{H,t}}{P_t^F} \frac{(1-\alpha_F) A_t^F \left(K_t^F\right)^{\alpha_F} \left(h_t^F\right)^{-\alpha_F}}{1+\tau^N}. \tag{2.23}$$

This condition reveals that the formal wage decreases as the labor supply in the formal sector increases. Additionally, the formal wage is reduced when there is an increase in the tax rate applied to the wage bill. Conversely, the formal wage increases in response to an increase in the relative price of the intermediate formal good.

2.3 The Formal Final Production Sector

Building upon the concepts presented in Thoenissen (2011), the final formal firm is capable of importing goods from the global market. The production of the final formal good uses as inputs intermediate home goods $C_{H,t}$ and foreign goods $C_{W,t}$:

$$C_t^F = \left[v C_{H,t}^{\frac{\theta-1}{\theta}} + (1-v) C_{W,t}^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}. \tag{2.24}$$

The parameter $v > 0.5$ represents the degree of home bias, indicating the preference for domestic goods, while the parameter $\theta > 0$ quantifies the elasticity of substitution between home and foreign intermediate goods.

The final formal firm is assumed to be competitive, and chooses the optimal quantity of home intermediate goods and foreign intermediate goods. The optimal input demands for the final goods producer are the following:

$$C_{H,t} = v \left(\frac{P_{H,t}}{P_t^F} \right)^{-\theta} C_t^F, \quad C_{W,t} = (1-v) \left(\frac{P_{W,t}}{P_t^F} \right)^{-\theta} C_t^F. \tag{2.25}$$

Based on the intermediate input demands of the formal final firm, the price index for the formal goods market can be derived as follows:

$$(P_t^F)^{1-\theta} = \left[v P_{H,t}^{1-\theta} + (1-v) P_{W,t}^{1-\theta} \right]. \tag{2.26}$$

The price index $P_{H,t}$ denotes the price of the home intermediate good and $P_{W,t}$ is the price of the intermediate good from the rest of the world.

2.4 The Real Exchange Rate and the Terms of Trade

It is assumed that the law of one price holds for all intermediate goods. The terms of trade is defined as the ratio of import prices to export prices in the intermediate sector:

$$T_t = \frac{P_{W,t}}{P_{H,t}}. \tag{2.27}$$

The real exchange rate is defined as the price of the foreign consumption basket measured in terms of the home currency. Consistent with the earlier sections, the parameter v quantifies the extent of home bias in consumption exhibited by the final goods producer:

$$\begin{aligned} RS_t &= \left(\frac{P_{W,t}}{P_{H,t}} \right)^v \\ RS_t &= (T_t)^v . \end{aligned} \tag{2.28}$$

2.5 Government

Government gets revenues from two sources: formal intermediate firms and formal income from the representative agent. It levies taxes at a rate of τ^N on wage bills in the formal sector and on formal households' income at a rate of τ^F. The government does not issue debt and must balance its budget each period. The government's period revenue can be expressed as follows:

$$G_t = \tau^N W_t h_t^F + \left(W_t h_t^F + r r_t K_t^F \right) \tau^F, \tag{2.29}$$

where G_t denotes the (exogenous) level of government spending in the economy.

2.6 International Financial Market

Financial markets are assumed to be incomplete, and households are only able to buy and sell international risk-free debt. The incomplete asset markets assumption suffers from a unit root problem. To address the unit root problem, a debt-elastic interest rate is adopted (similar to Schmitt-Grohé and Uribe (2003)).

$$R_t = R^* + \psi \left(e^{D_{t+1} - \bar{d}} - 1 \right) + u_t. \tag{2.30}$$

The domestic period interest rate is influenced by the long-run world interest rate R_t^* and deviations from the long-run (i.e, steady state) debt level $\bar{d}$. The parameter ψ reflects the sensitivity of the interest rate to deviations from the long-run level of debt. This type of interest rate closely reflects the reality for emerging economies, where increasing levels of debt are often accompanied by higher interest rates. Additionally, u_t represents a stationary shock to the interest rate.

2.7 Market Clearing

The intermediate formal goods market must clear. The producer of intermediate goods has the ability to export its products to the rest of the world, where $C^*_{H,t}$ represents the demand for home intermediate goods by the rest of the world. The market clearing condition for the intermediate goods market can be expressed as follows:

$$Y^F_t = C_{H,t} + C^*_{H,t}. \tag{2.31}$$

The resource constraint of the economy was derived by incorporating the intermediate firm profits (2.19), the government budget constraint (2.29) and the intermediate goods market clearing condition (2.31) into the household budget constraint (2.5). This process resulted in the following expression:

$$\frac{P_{H,t}}{P^F_t} Y^F_t = C^F_t + I^F_t + G_t + D_t - \frac{D_{t+1}}{R_t} - Rem_t. \tag{2.32}$$

Informal final goods can only be sold within the domestic economy, hence the market clearing condition for the informal goods market can be expressed as follows:

$$Y^I_t = C^I_t + I^I_t. \tag{2.33}$$

2.8 Competitive Equilibrium

Given the initial conditions K^F_0, K^I_0, and D_0, formal and informal productivity shocks A^F_t, A^I_t, interest rate shocks u_t, remittances shocks Rem_t and foreign demand shocks $C^*_{H,t}$, an equilibrium is a set of:

- Allocations: $C_t^A, C_t^F, C_t^I, h_t^A, h_t^F, h_t^I, Y_t^I, Y_t^F, K_t^F, K_t^I, I_t^F, I_t^I, C_t^W, C_t^H, D_t, G_t$
- Prices: $\frac{P_t^I}{P_t^F}, \frac{P_{H,t}}{P_t^F}, rr_t, W_t, T_t, RS_t, R_t, \lambda_t$

This set of allocations and prices must:

1. Solve the household problem given the laws of motion for capital.
2. Solve the intermediate formal firm's profit maximization problem.
3. Solve the final goods formal firm's profit maximization problem.
4. Government satisfies its budget constraint.
5. All markets clear.

2.9 Set of Log-Linearized Equations

To facilitate the solution of the nonlinear model and compute the theoretical second moments using Dynare, the equilibrium conditions were log-linearized around the steady state. Each equation in the set of log-linearized equations can be interpreted as representing the percentage deviations from the steady-state value of the corresponding variable.

The steady state is defined as a zero inflation steady state, where the terms of trade equals $T = 1$ and prices satisfy $P_H = P_W = P^F$, since the law of one price holds in the steady state. Furthermore, in the steady state, there are shocks, and we have $C_H^{ss} = C_H^{*ss}$. Finally, since G is assumed to always be at its steady state value, it follows that its log-linear value is $\hat{G} = 0$.

2.9.1 Log-Linearized Equations for the Household

Aggregate consumption:

$$\hat{C}_t^{\ A} = a\frac{C^{F^{ss}}}{C^{A^{ss}}}\hat{C}_t^F + (1-a)\frac{C^{I^{ss}}}{C^{A^{ss}}}\hat{C}_t^I \tag{2.34}$$

where:

$$\frac{C^{F^{ss}}}{C^{A^{ss}}} = \left(a + (1-a)\left(\frac{C^{I^{ss}}}{C^{F^{ss}}}\right)^e\right)^{-\frac{1}{e}}$$

$$\frac{C^{I^{ss}}}{C^{A^{ss}}} = \left(a(\frac{C^{I^{ss}}}{C^{F^{ss}}})^{-e} + 1 - a\right)^{-\frac{1}{e}}$$

$$\frac{C^{I^{ss}}}{C^{F^{ss}}} = \frac{C^{I^{ss}}}{Y^{I^{ss}}}\left(\frac{C^{F^{ss}}}{Y^{F^{ss}}}\right)^{-1}\frac{Y^{I^{ss}}}{Y^{F^{ss}}}.$$

Aggregate labor:

$$\hat{h}_t^A = \frac{h^{F^{ss}}}{h^{A^{ss}}}\hat{h_t}^F + \frac{h^{I^{ss}}}{h^{A^{ss}}}\hat{h}_t^I. \tag{2.35}$$

Informal sector production:

$$\hat{Y}_t^I = \hat{A}_t^I + \alpha_I\hat{K}_t^I + (1-\alpha_I)\hat{h}_t^I. \tag{2.36}$$

Formal capital law of motion:

$$\hat{K}^F_{t+1} = \delta^F \hat{I}^F_t + \hat{K}^F_t \left(1 - \delta^F\right). \tag{2.37}$$

Informal capital law of motion:

$$\hat{K}^I_{t+1} = \delta^I \hat{I}^I_t + \hat{K}^I_t \left(1 - \delta^I\right). \tag{2.38}$$

Household first order conditions:

$$(e-1)\hat{C}^F_t - e\hat{C}^A_t = \hat{\lambda}_t \tag{2.39}$$

$$(e-1)\hat{C}^I_t - e\hat{C}^A_t = \hat{\lambda}_t + (\hat{P}^I_t - \hat{P}^F_t) \tag{2.40}$$

$$\hat{\lambda}_t + \hat{W}_t = \left(\frac{h^{A^{ss}}}{1 - h^{A^{ss}}}\right) \hat{h}^A_t \tag{2.41}$$

$$\hat{\lambda}_t + (\hat{P}^I_t - \hat{P}^F_t) + \hat{Y}^I_t - \hat{h}^I_t = \left(\frac{h^{A^{ss}}}{1 - h^{A^{ss}}}\right) \hat{h}^A_t \tag{2.42}$$

$$\hat{\lambda}_t = \left(1 - \beta(1 - \delta^F)\right) E_t[\hat{rr}_{t+1}] + E_t\left[\hat{\lambda}_{t+1}\right] \tag{2.43}$$

$$\hat{\lambda}_t + (\hat{P}^I_t - \hat{P}^F_t) = \left(1 - \beta(1 - \delta^I)\right)\left(E_t\left[\hat{Y}^I_{t+1}\right] - E_t\left[\hat{K}^I_{t+1}\right]\right) + E_t\left[\hat{\lambda}_{t+1}\right] + E_t\left[\hat{P}^I_{t+1} - \hat{P}^F_{t+1}\right] \tag{2.44}$$

$$\hat{\lambda}_t - \hat{R}_t = E_t\left[\hat{\lambda}_{t+1}\right]. \tag{2.45}$$

2.9.2 Log-Linearized Equations for the Formal Intermediate Goods Sector

Formal firm production:

$$\hat{Y}_t^F = \hat{A}_t^F + \alpha_F \hat{K}_t^F + (1-\alpha_F)\hat{h}_t^F. \tag{2.46}$$

Optimality conditions:

$$\hat{rr}_t = \hat{Y}_t^F - \hat{K}_t^F - (1-v)\hat{T}_t \tag{2.47}$$

$$\hat{W}_t = \hat{Y}_t^F - \hat{h}_t^F - (1-v)\hat{T}_t. \tag{2.48}$$

2.9.3 Log-Linearized Equations for the Formal Final Production Sector

Optimality conditions:

$$\hat{C}_{H,t} = \theta(1-v)\hat{T}_t + \hat{C}_t^F \tag{2.49}$$

$$\hat{C}_{W,t} = -\theta v \hat{T}_t + \hat{C}_t^F. \tag{2.50}$$

2.9.4 Log-Linearized Equations for the Real Exchange Rate and the Terms of Trade

Real exchange rate:

$$\hat{RS}_t = v \hat{T}_t. \tag{2.51}$$

Terms of trade:

$$\hat{T}_t = \hat{P}_{W,t} - \hat{P}_{H,t}. \tag{2.52}$$

2.9.5 Log-Linearized Equation for the Interest Rate

$$\hat{R}_t = \frac{\psi}{R^*} \bar{d} \hat{D}_{t+1} + \hat{u}_t. \tag{2.53}$$

2.9.6 Log-Linearized Equations for the Market Clearing Conditions

Intermediate goods market:

$$\hat{Y}_t^F = \frac{C_H^{ss}}{Y^{F^{ss}}} \hat{C}_{H,t} + \frac{C_H^{*^{ss}}}{Y^{F^{ss}}} \hat{C}_{H,t}^*. \tag{2.54}$$

Resource constraint:

$$\hat{Y}_t^F - (1-v)\hat{T}_t = \frac{C_F^{ss}}{Y^{F^{ss}}}\hat{C}_t^F + \frac{\beta(1-\tau^F)\alpha_F\delta^F}{1-\beta(1-\delta^F)}\hat{I}_t^F + \bar{d}\hat{D}_t - \frac{\bar{d}}{R^*}\left(\hat{D}_{t+1} - \hat{R}_t\right) - \frac{Rem^{ss}}{Y^{F^{ss}}}\hat{Rem}_t \tag{2.55}$$

where:

$$\frac{C^{F^{ss}}}{Y^{F^{ss}}} = 1 - \frac{\beta(1-\tau^F)\alpha_F\delta^F}{1-\beta(1-\delta^F)} + \frac{Rem^{ss}}{Y^{F^{ss}}} - \bar{d}\left(1 - \frac{1}{R}\right) - \frac{G^{ss}}{Y^{F^{ss}}}. \tag{2.56}$$

Informal goods market:

$$\hat{Y}_t^I = \frac{C_I^{ss}}{Y^{I^{ss}}}\hat{C}_t^I + \frac{\beta\alpha_I\delta^I}{1-\beta(1-\delta^I)}\hat{I}_t^I \tag{2.57}$$

where:

$$\frac{C_I^{ss}}{Y^{I^{ss}}} = 1 - \frac{\beta\alpha_I\delta^I}{1-\beta(1-\delta^I)}. \tag{2.58}$$

2.9.7 Summary

The log-linearized version of the model includes 22 endogenous variables $\hat{C}_t^A, \hat{C}_t^F, \hat{C}_t^I, \hat{C}_{H,t}, \hat{C}_{W,t}, \hat{h}_t^A, \hat{h}_t^I, \hat{h}_t^F, \hat{Y}_t^I, \hat{Y}_t^F, \hat{K}_{t+1}^F, \hat{K}_{t+1}^I, \hat{I}_t^F, \hat{I}_t^I, \hat{W}_t, \hat{rr}_t, \hat{R}_t, \hat{T}_t, \hat{D}_{t+1}, \hat{\lambda}_t, \hat{P}_t^I - \hat{P}_t^F, \hat{RS}_t$ and 22 equations, summarizing by:

- Aggregate consumption and aggregate labor: 2 equations

- Informal goods production: 1 equation
- Formal and informal capital laws of motion: 2 equations
- Household first order conditions: 7 equations
- Formal firm production: 1 equation
- Intermediate formal firm optimality conditions: 2 equations
- Final formal firm optimality conditions: 2 equations
- Financial market: 1 equation
- Real exchange rate: 1 equation
- Market clearing conditions: 3 equations

Chapter 3

Results

3.1 Shocks in the RBC model with Informality

We considered two different specifications for how shocks to formal technology affect the informal sector. The first one assumes that shocks to formal sector productivity do not pass through to the informal sector. The second approach follows Fernández and Meza (2015), where productivity shocks are imperfectly transmitted from the formal sector to the informal sector.

In this second approach, shocks to informal sector productivity depend on two factors. First, the shock process is influenced by the previous value of the informal productivity process weighted by $(1 - \rho_{h^I,Y^F})$, where ρ_{h^I,Y^F} represents the degree of pass-through of formal shocks to the informal sector. Second, it is influenced by γ, which represents the productivity difference between formal and informal technology:

$$\hat{A}_t^I = (1 - \rho_{h^I,Y^F})\hat{A}_{t-1}^I + \rho_{h^I,Y^F}\gamma\hat{A}_t^F. \tag{3.1}$$

Following the work of Durdu and Sayan (2008), who calibrated an endowment model for the Mexican economy, productivity shocks and remittance shocks are assumed to be correlated.

In Chapter 1, the stylized facts indicate a negative correlation between remittances and output. The shocks to formal sector productivity and remittances are assumed to have a zero mean and exhibit time persistence, as well as correlation in the current period. The shock processes for A_t^F and Rem_t are defined as follows:

$$\hat{A}_t^F = \rho_{\hat{A}^F} \hat{A}_{t-1}^F + \epsilon_t^{A^F} \tag{3.2}$$

$$\hat{Rem}_t = \rho_{\hat{Rem}} \hat{Rem}_{t-1} + \epsilon_t^{Rem} \tag{3.3}$$

where the correlation $\rho(\epsilon_t^{A^F}, \epsilon_t^{Rem}) < 0$.

We also assume a positive correlation between interest rate shocks and remittances shocks. This assumption is justified due to the financial motive of remittances flows, a positive interest rate shock makes the country that experienced it more likely to receive positive financial flows.The shock processes for u_t and Rem_t are defined as follows:

$$\hat{u}_t = \rho_{\hat{u}} \hat{u}_{t-1} + \epsilon_t^u \tag{3.4}$$

$$\hat{Rem}_t = \rho_{\hat{Rem}} \hat{Rem}_{t-1} + \epsilon_t^{Rem} \tag{3.5}$$

where $corr(\epsilon_t^u, \epsilon_t^{Rem}) > 0$.

3.2 Parameter Calibration

The model parameters were calibrated by combining standard values, data from stylized facts, and parameters used in existing literature. A summary of the parameter calibration can be found in Table 3.1. The parameter representing the weight of formal consumption in the consumption basket, denoted as a, was calibrated based on the theoretical findings of Fernández and Meza (2015). The assigned value for this parameter is $a = 0.683$.

The formal capital-output share, denoted as α_F, is set according to the findings of Aguiar and Gopinath (2007) as $\alpha_F = 0.32$. For the informal sector, the capital-output share, denoted as α_i, is determined based on Restrepo-Echavarria (2014), who discusses the challenges in accurately measuring the share of the informal sector captured by national statistics agencies. It is reasonable to assume that the informal sector is less capital-intensive than the formal sector; hence, α_i is set to 0.20.

In line with Fernández and Meza (2015), the depreciation rate for both formal and informal capital is assumed to be the same due to the lack of available data on informal capital depreciation. The depreciation rate for capital is set at $\delta^F = \delta^I = 0.05$, following the suggested rate for capital depreciation in emerging economies by Aguiar and Gopinath (2007). Standard values for β and ϕ are adopted from Aguiar and Gopinath (2007). They set the rate of time preference as $\beta = 0.98$. The world gross interest rate, denoted as R^*, is implied by the value of β as $\frac{1}{\beta}$. The authors also chose a small value of $\phi = 0.001$ for the interest rate debt elasticity.

The tax rate parameters are taken from Fernández and Meza (2015). The income tax rate, denoted as τ^F, is derived by the authors as the ratio of aggregate individual income tax revenue to the sum of wages, salaries, and household income from capital. They determined $\tau^F = 0.072$. The tax rate on the wage bill, denoted as τ^N, was calculated using data on tax collection, specifically the payments made by firms as social contributions, and wage income. Fernández and Meza (2015) set $\tau^N = 0.114$. The (steady-state) government spending to output ratio is taken from Alba and McKnight (2022) and set to be $\frac{G}{Y^F} = 0.13$.

The parameter that captures the sensitivity of aggregate consumption to changes in formal and informal consumption is calibrated based on the findings of Restrepo-Echavarria (2014). She justifies the high elasticity of substitution between formal and informal goods by providing examples of informal market products that aim to imitate formal goods. Given that households perceive formal and informal goods as close substitutes, the elasticity of substitution between formal and informal values calibrated by her is $\frac{1}{1-e} = 8$, implying a value of $e = 0.875$.

The trade elasticity parameter is set following Benigno and Thoenissen (2008), who choose a value of $\theta = 2$ in their model. If this parameter is lowered, it implies that home and foreign intermediate goods become complementary goods. The degree of home bias parameter is set to $v = 0.63$, which represents the average value of consumption home bias observed for the Mexican economy. This value is obtained from data on total consumption and output.

The parameters for the shock process were taken from Durdu and Sayan (2008), the persistence of the productivity shock is set to be $\rho_{A^F} = 0.687$. The persistence parameter of the remittances shock is set following the same author as $\rho_{Rem} = 0.2$. The persistence parameter for the interest rate shock is set as $\rho_u = 0.5$. The productivity difference between formal and informal technologies is set as $\gamma = 0.375$ following the calibration of Fernández and Meza (2015). The parameter $\rho_{h^I,Y^F} = 0.64$ is set as the correlation between informal labor and formal output from the data set. The standard deviation of the formal productivity shock (0.027) and interest rate shock (0.006) are set to match the volatility of formal output.

The share of debt to formal output in the steady state was set at $\bar{d} = 0.1$, in line with Aguiar and Gopinath (2007). The formal and informal labor shares were calculated from the data by setting $h_F = 1/3$, resulting in $\frac{h^F}{h^A} = 0.774$ and $\frac{h^I}{h^A} = 0.226$. The aggregate labor ratio was computed as $\frac{h^A}{1-h^A} = 0.757$. Assuming $C_{H,t} = C^*_{H,t}$, the ratio between foreign demand for local intermediate goods and formal output was found to be 1/2. The remittances to output ratio was estimated from the data as $\frac{Rem}{Y} = 0.005$. Lastly, following Medina and Schneider (2018), the formal to informal labor ratio was set at $\frac{Y^I}{Y^F} = 0.31$.

Parameter Calibration			
Parameter	Value	Description	Source
a	0.6831	Weight of formal consumption	Fernández and Meza (2015)
α_f	0.32	Formal capital output share	Aguiar and Gopinath (2007)
α_i	0.2	Informal capital output share	Restrepo-Echavarria (2014)
δ^f	0.05	Depreciation rate of formal capital	Aguiar and Gopinath (2007)
δ^I	0.05	Depreciation rate of informal capital	Aguiar and Gopinath (2007)
e	0.875	Sensitivity of C^A to changes in C^F and C^I	Restrepo-Echavarria (2014)
β	0.98	Rate of time preference	Aguiar and Gopinath (2007)
θ	2	Trade elasticity	Benigno and Thoenissen (2008)
v	0.63	Home bias parameter	Data set
ϕ	0.001	Interest rate debt elasticity	Aguiar and Gopinath (2007)
R^*	1.020	World interest rate	Implied
τ^F	0.07223	Tax on income	Fernández and Meza (2015)
τ^N	0.1142	Tax on wage bill	Fernández and Meza (2015)
$\bar{d}$	0.1	Debt to (formal) output ratio	Aguiar and Gopinath (2007)
ρ_{A^F}	0.687	Persistence of the formal productivity shock	Durdu and Sayan (2008)
ρ_{Rem}	0.2	Persistence of remittances shock	Durdu and Sayan (2008)
ρ_u	0.5	Interest rate shocks persistence	Standard
γ	0.375	Productivity difference between technologies	Fernández and Meza (2015)
ρ_{h^I,Y^F}	0.64	Correlation between informal labor and output	Data set
$\frac{h^A}{1-h^A}$	0.757	Aggregate labor ratio	Data set
σ_{Rem}	0.095	Standard deviation of remittances	Data set
$\frac{C^*_H}{Y^F}$	0.5	Exports to GDP ratio by assumptions	Assumption
$\frac{h^F}{h^A}$	0.774	Formal labor share	Implied by $h^F = 1/3$ and h^I/h^A
$\frac{h^I}{h^A}$	0.226	Informal labor share	Data set
$\frac{Rem}{Y}$	0.005	Remittances to (formal) output ratio	Data set
$\frac{Y^I}{Y^F}$	0.31	Formal to informal output ratio	Medina and Schneider (2018)
$\frac{G}{Y^F}$	0.13	Government spending as share of output	Alba and McKnight (2022)

Table 3.1: Baseline calibration, standard deviation of the formal productivity shock (0.027) and interest rate shock (0.006) set to match the volatility of output.

3.3 Unveiling the Dynamics of the Mexican Business Cycle

The approach taken in this section is as follows. The first model specification aims to account for the stylized facts by considering business cycle dynamics that arise from formal and informal productivity and remittance shocks. The second specification considers the role of interest rate shocks and remittance shocks. Lastly, the third specification explores

the importance of foreign demand shocks in explaining the Mexican business cycle.

3.3.1 Formal Productivity and Remittances Shocks

The results from this exercise are presented in table 3.2. The standard deviation of formal output is set for the model to match the standard deviation of output found in the data. The correlation between remittance shocks and formal productivity shocks is set to explain the remittance flows countercyclical behavior. We consider three versions of the model: no passthrough (of the formal productivity shocks to the informal sector), incomplete passthrough and independence between the productivity shock and the remittances shock, with the incomplete passthrough being the main model specification. For all three shock specifications, the model does not yield satisfactory results. While it generates sufficient volatility in remittances and the terms of trade, the model cannot generate sufficient volatility for employment under the assumptions of no passthrough and imperfect passthrough.

Examining the relative volatilities of variables with respect to output, the model with no passthrough and imperfect passthrough achieves satisfactory results for remittances, terms of trade, and the real exchange rate, but falls short in capturing the volatility of formal and informal employment. Furthermore, the model fails to generate countercyclical terms of trade and real exchange rate, as observed in the data. The main shock specification generates countercyclical formal employment with procyclical aggregate and informal employment.

In terms of autocorrelation, all shock specifications closely match the data for formal output and terms of trade. However, the model generates a lower autocorrelation for remittances compared to the data. Additionally, both aggregate employment and informal employment exhibit higher autocorrelation in the model than in the data.

The shock specification that assumes independent shocks generates countercyclical aggregate and informal employment. This shock specification can also generate higher relative volatility in informal employment suggesting that an independent shock process

is required to increase the volatility of employment. However, this shock specification (by design) cannot generate countercyclical remittances. Only the model assuming no passthrough of formal productivity shocks exhibits slightly procyclical employment in all measures. The results are also unsatisfactory for the model without informal employment.

Business Cycle Moments: Data, Benchmark Model and Model with no Informal Labor					
Productivity Shocks					
Moments	Data for the Mexican Economy				
Standard Deviation (%)		No passthrough	Passthrough	Independent shocks	No informality
Y^F	2.79	2.79	2.79	2.79	2.79
Y^I	0.00	0.01	3.55	9.56	
Rem	9.51	9.19	9.19	9.19	9.19
T	3.08	7.540	7.58	7.33	7.54
h^A	2.70	0.00	0.36	1.02	
h^F	2.29	0.00	0.43	1.13	0.00
h^I	5.01	0.01	3.00	8.15	
S.D/S.D Output					
$\sigma_{Y^I}/\sigma_{Y^F}$		0.004	1.272	3.427	
$\sigma_{Rem}/\sigma_{Y^F}$	3.397	3.294	3.294	3.294	3.294
σ_T/σ_{Y^F}	1.103	2.703	2.717	2.627	2.703
$\sigma_{h^F}/\sigma_{Y^F}$	0.818	0.000	0.154	0.405	0.000
$\sigma_{h^I}/\sigma_{Y^F}$	1.792	0.004	1.075	2.921	
σ_{RS}/σ_{Y^F}	2.997	1.703	1.710	1.656	1.703
Correlation with output					
Y^I		0.142	0.830	-0.296	
Rem	-0.258	-0.216	-0.225	0.000	-0.216
T	-0.223	1.000	0.998	0.988	1.000
h^A	0.835	0.196	0.941	-0.263	
h^F	0.874	0.111	-0.727	0.307	0.194
h^I	0.644	0.167	0.863	-0.290	
RS	-0.529	1.000	0.998	0.988	1.000
Autocorrelation (1st order)					
Y^F	0.604	0.539	0.504	0.561	0.539
Y^I		0.812	0.794	0.635	
Rem	0.582	0.109	0.109	0.109	0.109
T	0.459	0.539	0.525	0.539	0.539
h^A	0.300	0.719	0.720	0.534	
h^F	0.413	0.912	0.840	0.710	0.722
h^I	0.134	0.772	0.776	0.608	
RS	0.749	0.539	0.525	0.539	0.539

Table 3.2: Set of second moments from the data, model with correlated shocks and no passthrough, model with correlated shocks and imperfect passthrough, model with independent shocks and model without informality. Only remittances and productivity shocks considered.

3.3.2 Interest Rate and Remittances Shocks

The results from this second exercise are presented in table 3.3. The model incorporating interest rate and remittance shocks also fails to produce satisfactory results. Although it generates sufficient volatility in remittance flows and the terms of trade, similar to the previous case, it generates inadequate volatility in all employment measures. Furthermore, when examining the relative volatilities of variables with respect to output, the model yields positive results for remittances, terms of trade, and the real exchange rate, as observed in the model with formal productivity shocks and remittances. However, it once again falls short in capturing the relative volatilities of formal and informal employment.

Moreover, like the previous case, the model fails to generate countercyclical terms of trade, and the real exchange rate, as evidenced by the data. The model only produces slightly countercyclical remittances. The results for the correlation between output and aggregate and formal employment contradict the data, as the model generates countercyclical aggregate and formal employment.

In terms of autocorrelations, none of the model specifications, except for the model without an informal sector, accurately match the data for all variables. The inferior performance of the model with remittance shocks and interest rate shocks compared to the model with productivity shocks and remittance shocks is evident. However, neither of them achieves satisfactory results.

3.3.3 Model Dynamics

As discussed above, the performance of the model under both formal productivity shocks, and interest rate shocks, is unsatisfactory. The aim of this section is to show that the adjustment mechanism of the model under both shocks is inconsistent with the data. Specifically, this section will explore the reason behind obtaining correlations for formal employment, the terms of trade and the real exchange rate inconsistent with the data.

Business Cycle Moments: Data, Benchmark Model and Model with no Informal Labor				
Interest rate shock				
Moments	Data for the Mexican Economy			
Standard Deviation (%)		Model	Independent shocks	No informality
Y^F	2.79	2.79	2.79	2.79
Y^I		1.48	1.47	
Rem	9.50	9.19	9.19	9.19
T	3.08	7.37	7.58	7.49
h^A	2.70	0.20	0.20	
h^F	2.29	0.16	0.16	0.27
h^I	5.02	1.37	1.37	
S.D/S.D Output				
$\sigma_{Y^I}/\sigma_{Y^F}$		0.530	0.527	
$\sigma_{Rem}/\sigma_{Y^F}$	3.397	3.294	3.294	3.294
σ_T/σ_{Y^F}	1.103	2.642	2.717	2.685
$\sigma_{h^F}/\sigma_{Y^F}$	0.818	0.057	0.057	0.097
$\sigma_{h^I}/\sigma_{Y^F}$	1.792	0.491	0.491	
σ_{RS}/σ_{Y^F}	0.030	0.017	0.017	0.017
Correlation with output				
Y^I		0.221	0.221	
Rem	-0.258	-0.024	0.000	-0.003
T	-0.223	0.942	0.942	0.985
h^A	0.835	-0.008	-0.009	
h^F	0.874	-0.370	-0.370	-0.126
h^I	0.644	0.141	0.141	
RS	-0.529	0.942	0.942	0.985
Autocorrelation (1st order)				
Y^F	0.604	0.373	0.373	0.337
Y^I		0.772	0.771	
Rem	0.582	0.109	0.109	0.109
T	0.459	0.132	0.132	0.378
h^A	0.300	0.720	0.719	
h^F	0.413	0.796	0.796	0.488
h^I	0.134	0.742	0.741	
RS	0.749	0.132	0.132	0.232

Table 3.3: Set of second moments from the data, model with correlated shocks, model with independent shocks and model without informality. Only remittances and interest rate shocks considered.

Let's begin with the case of formal productivity, assuming imperfect passthrough. Figure 3.1 illustrates the impulse response functions for aggregate, formal, and informal employment, as well as formal and informal output, the terms of trade, and the real exchange rate to a 1% positive formal productivity shock with incomplete passthrough to the informal sector.

A positive shock to formal productivity, temporarily raises both formal and informal output above their steady state levels. The increase in formal sector productivity boosts the supply of formal intermediate goods, leading to a decrease in their price. Consequently, the terms of trade worsen as the price of home goods decreases. This mechanism is inconsistent with the data, where an increase in domestic output is associated with an appreciation of the terms of trade.

The deterioration in the terms of trade implies that home goods are now cheaper and demand by foreigners rise, it also means that imports are now more expensive, so the demand by the home country falls. Although the wage in the formal sector increases due to higher productivity, employment in the formal sector declines.

On the other hand, remittance shocks exhibit a negative correlation with formal productivity shocks. Therefore, when formal productivity rises, remittance flows decline, resulting in a decrease in household income.There are three contributing factors to the decrease in formal employment. Firstly, the shock is transmitted to the informal sector, leading to an increase in income generated from informal activities and making them more attractive. Secondly, the productivity increase itself enhances the productivity of each unit of formal labor, reducing the demand for labor. Thirdly, remittance shocks exhibit a countercyclical behavior, so remittance flows fall when there is a positive productivity shock, reducing household income and making activities in the informal sector even more attractive, leading to increased informal employment and decreased formal employment..

The second transmission mechanism to be considered is the one for interest rate shocks. Figure 3.2 illustrates the impulse response functions for a negative 1% interest rate shock. Interest rate shocks primarily affect household decisions. An increase in the interest rate tightens the household's budget constraint by raising borrowing costs. This initial tightening of the budget constraint leads to a reduction in investment and capital in both sectors. However, after one period, the increase in the shadow price (λ) raises the rental cost of capital, thereby making investment in the formal sector more appealing and increasing formal capital.

The initial decline in the capital stock results in reduced formal and informal output

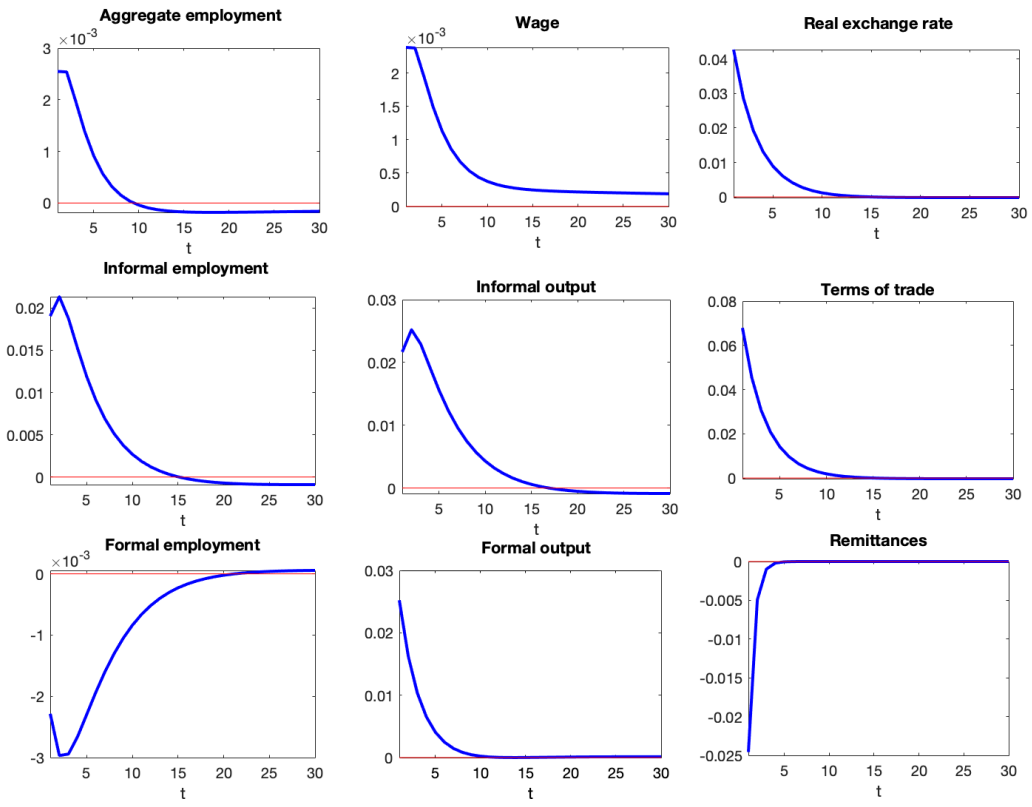

Figure 3.1: Impulse response functions for a positive 1% shock in formal productivity (imperfect passthrough to the informal sector)

after the first period. With the increase in the rental cost of capital after the first period, the formal sector becomes more attractive for hiring additional employees, leading to an increase in formal employment. However, the dynamics are different for informal employment. In this case, the return to the steady state after the initial decline is slower, and the same holds true for informal output.

The reduction in formal output after the first period, reduces the supply of the formal intermediate good, causing its price to increase and leading to a decline (appreciation) in the terms of trade. As the capital stock and output gradually return to the steady state, the terms of trade and the real exchange rate also begin to recover. After an initial depreciation of the terms of trade a big appreciation occurs, this appreciation of the terms of trade coincides with the decline in output after the first period. After the decline in

output and the appreciation in the terms of trade, both variables approach their steady state values, illustrating the counterfactual positive correlation obtained between output and the terms of trade.

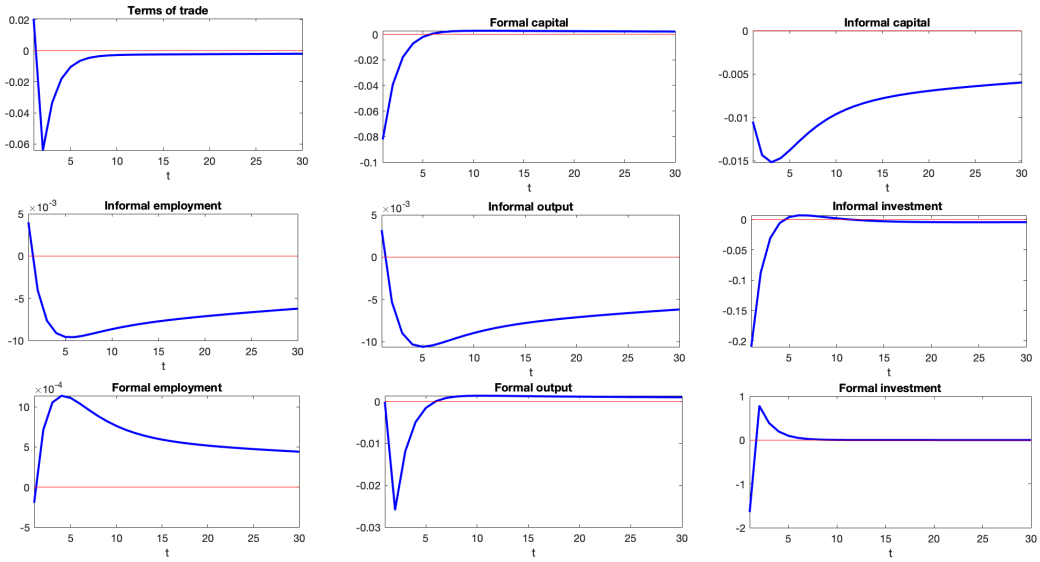

Figure 3.2: Impulse response functions for a negative 1% interest rate shock

3.3.4 Sensitivity Analysis

A sensitivity analysis was conducted to test the robustness of the model's results, with two key parameters being varied. The first parameter altered was e, which affects the elasticity of substitution between formal and informal goods. The second parameter modified was θ, which represents the trade elasticity, and different values were tested to assess the model's sensitivity.

Initially, the sensitivity analysis was conducted for the model with formal productivity and remittance shocks. The first parameter adjusted was the trade elasticity, and a lower value of $\theta = 0.39$ resulted in significantly higher volatilities for informal output, terms of trade, and formal and informal employment. However, this lower trade elasticity did not rectify the counterfactual outcomes produced by the model, as aggregate employment and

formal employment remain countercyclical, while the terms of trade and the real exchange rate continued to be procyclical. Similar results arise even with a lower trade elasticity. A higher value of $\theta = 3$ was also tested. Under this calibration, the model generated a lower than the baseline volatility for the terms of trade but still higher than the data, the volatility for formal employment obtained under this calibration is lower than the one displayed by the data. The highlight of this higher value for the trade elasticity is that the model is now able to generate procyclical aggregate, formal and informal employment, which is in line with the data. The model is still not able to generate counter cyclical terms of trade, in fact, they are perfectly correlated with output under this calibration. Detailed results from the changes in θ can be found in Table C.1 of the appendix.

The second parameter tested was the elasticity of substitution between formal and informal goods. A lower trade elasticity value of 2 ($e = 0.5$) produced results that were overall similar to those obtained from the baseline calibration. The primary distinction was a higher volatility in all employment measures, which better approximated the data. However, the issues with the model's outcomes persisted under this calibration, as formal employment remained countercyclical, while terms of trade and the real exchange rate remained procyclical. Conversely, a higher elasticity value of 16 ($e = 15/16$) was also considered, and it generated outcomes that closely resembled the baseline calibration. The only notable difference here was a reduction in the negative correlation between formal employment and output. The results from the changes in e can be found in Table C.2 of the appendix.

The same sensitivity analysis was then conducted for the model with interest rate and remittance shocks. The results for changes in the trade elasticity can be found in Table C.3 of the appendix, while the results for changes in the elasticity of substitution between formal and informal goods are displayed in Table C.4. Setting a lower value of $\theta = 0.39$ generated higher volatility in informal output, as well as increased volatility in the terms of trade and formal and informal employment. These outcomes were similar to those observed with productivity shocks. Although the model under this calibration still produced countercyclical aggregate and formal employment, the negative correlation between them was reduced (in absolute value). The real exchange rate and terms of trade remained procyclical but with lower correlations. The calibration with

$\theta = 3$ generated better results, the model was able to generate procyclical aggregate and formal employment, like in the case with formal productivity shocks the model is not able to generate enough formal employment volatility, it is also not able to generate countercyclical terms of trade.

For the elasticity of substitution between formal and informal goods, a lower value of 2 ($e = 0.5$) resulted in lower volatility in informal output and informal employment. However, under this calibration, aggregate and formal employment remained countercyclical, and the terms of trade and the real exchange rate remained procyclical. A higher value for the elasticity of substitution of 16 ($e = 15/16$) was also tested, and the most significant difference from the baseline calibration was that aggregate employment exhibited a slight procyclical pattern, and formal employment became less countercyclical. However, the overall results still did not align satisfactorily with the data.

The analysis demonstrates that the previously presented results are robust across different values for the trade elasticity and the elasticity of substitution between formal and informal goods. It is evident that productivity shocks and interest rate shocks, in isolation, are inadequate for explaining the data.

3.3.5 Foreign demand shocks: a key factor in explaining the data

A crucial element absent from both preceding specifications is foreign demand shocks. Therefore, foreign demand shocks were incorporated into both previous specifications to illustrate how their inclusion enables the model to more effectively elucidate the stylized facts presented in the first chapter. Foreign demand shocks are assumed to have a persistence parameter of 0.88 and a standard deviation of 0.049 in both, productivity and interest rate shocks.

Formal Productivity, Remittances and Foreign Demand Shocks

A summary of the results obtained from this approach can be found in Table 3.4. The model incorporating formal productivity, remittance shocks, and foreign demand shocks successfully explains most of the stylized facts presented in the first chapter. It generates relative output volatilities that closely aligns with the data for remittances, the terms of trade, formal and informal employment.

The model successfully generates countercyclical patterns for remittances, the terms of trade, and the real exchange rate. Additionally, it replicates the desirable pro-cyclical behavior of aggregate and formal employment across all three shock specifications.

In terms of autocorrelation, all model specifications closely match the data for formal output, terms of trade, and formal employment. The inclusion of foreign demand shocks emerges as a key factor contributing to the model's strong performance. Moreover, the incorporation of an informal sector is essential to aligning the model's results with the data, as evidenced by the superior performance of the model with informality compared to the model without it.

The results are better than the ones produced with the baseline shock specification, but they lead to a puzzle with regard to informal employment. When foreign demand shocks are introduced informal employment and output exhibit a negative correlation, which is against the data. The model is then able to explain the data for international relative prices, but it cannot explain the procyclical behavior of informal employment.

Remittances and Foreign Demand Shocks

A summary of the results for foreign demand, interest rate, and remittances shocks can be found in Table 3.5. The inclusion of foreign demand shocks has also enhanced the model's performance when considering interest rate shocks and remittances shocks. The model successfully replicates the relative volatilities of remittances, the terms of trade, formal

Business Cycle Moments: Data, Benchmark Model and Model with no Informal Labor					
Productivity and foreign demand shocks					
Moments	Data for the Mexican Economy	Model			
Standard Deviation (%)		No passthrough	Passthrough	Independent shocks	No informality
Y^F	2.79	2.79	2.79	2.79	2.79
Y^I		5.19	5.42	6.67	
Rem	9.51	9.19	9.19	9.19	9.19
T	3.08	5.21	5.19	5.12	0.01
h^A	2.70	0.61	0.63	0.76	
h^F	2.29	2.44	2.45	2.49	1.43
h^I	5.01	5.94	6.09	6.93	
S.D/S.D Output					
$\sigma_{Y^I}/\sigma_{Y^F}$		1.860	1.943	2.391	
$\sigma_{Rem}/\sigma_{Y^F}$	3.397	3.294	3.294	3.294	0.033
σ_T/σ_{Y^F}	1.103	1.867	1.860	1.835	0.000
$\sigma_{h^F}/\sigma_{Y^F}$	0.818	0.875	0.878	0.892	0.005
$\sigma_{h^I}/\sigma_{Y^F}$	1.792	2.129	2.183	2.484	
σ_{RS}/σ_{Y^F}	2.997	1.176	1.172	1.158	1.878
Correlation with output					
Y^I		-0.866	-0.728	-0.757	
Rem	-0.258	-0.096	-0.098	0.000	-0.166
T	-0.223	-0.179	-0.190	-0.203	0.189
h^A	0.835	0.734	0.816	0.528	
h^F	0.874	0.856	0.832	0.868	0.571
h^I	0.644	-0.868	-0.769	-0.812	
RS	-0.529	-0.179	-0.190	-0.203	0.189
Autocorrelation (1st order)					
Y^F	0.604	0.777	0.772	0.783	0.658
Y^I		0.789	0.790	0.728	
Rem	0.582	0.109	0.109	0.109	0.109
T	0.459	0.373	0.366	0.539	0.467
h^A	0.300	0.700	0.701	0.643	
h^F	0.413	0.714	0.715	0.714	0.682
h^I	0.134	0.744	0.746	0.708	
RS	0.749	0.373	0.366	0.368	0.467

Table 3.4: Set of second moments from the data, model with correlated shocks and no passthrough, model with correlated shocks and imperfect passthrough, model with independent shocks and model without informality. Remittances, productivity and foreign demand shocks considered.

employment, informal employment, and the real exchange rate with respect to output.

The model also replicates the negative correlation between output and remittances, the terms of trade, and the real exchange rate. Furthermore, the model generates a positive correlation between output and aggregate employment, as well as formal employment. These results hold true for both the model with correlated shocks and the model with independent shocks.

The inclusion of foreign demand shocks assists the model incorporating interest rate

and remittances shocks in explaining the data. The results exhibit improvement across almost all categories, underscoring the significance of external shocks in a model featuring an informal sector, with the caveat that the model is not able to explain the procyclical behavior of informal employment generating a puzzle.

Business Cycle Moments: Data, Benchmark Model and Model with no Informal Labor				
Interest rate shocks and foreign demand shocks				
Moments	Data for the Mexican Economy			
Standard Deviation (%)		Model	Independent shocks	No informality
Y^F	2.79	2.79	2.79	2.79
Y^I		5.23	5.23	
Rem	9.51	9.19	9.19	9.19
T	3.09	5.12	5.12	8.27
h^A	2.70	0.62	0.62	
h^F	2.29	2.45	2.45	1.44
h^I	5.02	5.97	5.97	
S.D/S.D Output				
$\sigma_{Y^I}/\sigma_{Y^F}$		1.875	1.875	
$\sigma_{Rem}/\sigma_{Y^F}$	3.397	3.294	3.294	3.294
σ_T/σ_{Y^F}	1.103	1.835	1.835	2.964
$\sigma_{h^F}/\sigma_{Y^F}$	0.818	0.878	0.878	0.516
$\sigma_{h^I}/\sigma_{Y^F}$	1.792	2.140	2.140	
σ_{RS}/σ_{Y^F}	2.997	1.158	1.158	1.867
Correlation with output				
Y^I		-0.850	-0.850	
Rem	-0.258	-0.024	-0.010	-0.003
T	-0.223	-0.216	-0.216	0.175
h^A	0.835	0.728	0.728	
h^F	0.874	0.854	0.854	0.552
h^I	0.644	-0.860	-0.860	
RS	-0.529	-0.216	-0.216	0.175
Autocorrelation (1st order)				
Y^F	0.604	0.747	0.747	0.540
Y^I		0.789	0.789	
Rem	0.582	0.109	0.109	0.109
T	0.459	0.207	0.207	0.319
h^A	0.300	0.700	0.700	
h^F	0.413	0.714	0.714	0.678
h^I	0.134	0.744	0.744	
RS	0.749	0.207	0.207	0.319

Table 3.5: Set of second moments from the data, model with correlated shocks, model with independent shocks and model without informality. Remittances, interest rate shocks and foreign demand shocks considered.

Model Dynamics

As previously demonstrated, the introduction of foreign demand shocks allows the model to better explain the stylized facts derived from the data. Figure 3.3 displays the impulse response functions for a 1% positive foreign demand shock for aggregate, formal and informal employment, as well as formal output, the terms of trade, the real exchange rate, and the real wage.

A positive foreign demand shock increases the demand for domestic intermediate goods, consequently raising both formal capital and formal labor demands. The surge in formal labor demand leads to increased formal employment. This explains why the model now generates pro-cyclical formal employment when foreign demand shocks are included.

With the increased demand for domestic intermediate goods and the subsequent price rise, the terms of trade experience a fall (improvement). Through the same mechanism, the real exchange rate also decreases. This mechanism now enables the model to account for the countercyclicality of the terms of trade and the real exchange rate. However, this improved model performance comes with a compromise with respect to informal employment, as the external demand shock positively affects formal output and formal employment increasing the real wage, formal activities become more attractive, reducing employment in the informal sector, therefore, generating countercyclical employment.

As previously demonstrated, including foreign demand shocks along with remittances and formal productivity shocks, as well as with remittances and interest rate shocks, significantly improves the model's performance. Consequently, foreign demand shocks play a crucial role in the model's ability to explain the data.

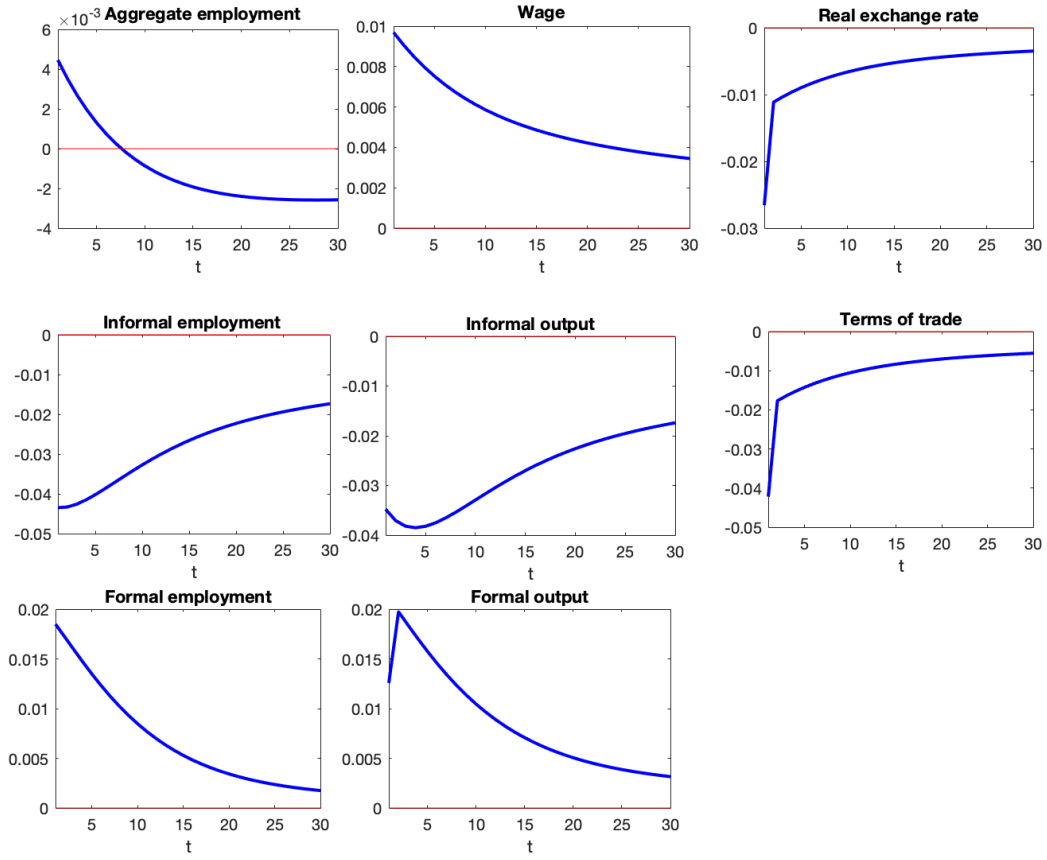

Figure 3.3: Impulse response functions for a 1 % positive foreign demand shock.

Sensitivity Analysis

In order to test if different parameter values for the external shock process change the findings of the previous section a sensitivity analysis was performed. The correlations between output and remittances, the terms of trade, the real exchange rate, aggregate, formal and informal employment were computed for different values of the persistence parameter of the foreign demand shock, as well as different values for the standard deviation of the shock. The results from this analysis are presented in table 3.6.

First, for the case of formal productivity shocks, a lower persistence parameter for the foreign demand shock changes the sign of the correlation between output and informal

output, informal employment, the terms of trade and the real exchange rate. With lower persistence, the presence of foreign demand shocks is no longer able to explain the data for international prices, but it can explain the procyclical behavior of informal employment. The results of the baseline calibration are robust for higher values for the persistence parameter.

A lower and a higher values for the standard deviation of the foreign demand shocks are also tested. The results from the baseline set up for the foreign demand shocks are robust for higher standard deviations but not to lower standard deviation values. A lower value for the standard deviation generates procyclical informal labor, but the model is no longer able to explain the data for international prices.

The second sensitivity analysis changes the same parameters for the case with interest rate shocks. The results are very similar to the ones obtained for the sensitivity analysis for the case with formal productivity shocks. The results from the baseline calibration hold for higher persistence or higher standard deviation of the foreign demand shocks. The results are not robust for lower persistence or lower standard deviations.

Overall, the above analysis suggests that foreign demand shocks must be sufficiently volatile and persistent, in order to replicate many of the key features of the data.

Sensitivity Analysis			
Productivity and foreign demand shocks			
Persistance			
Correlation with output	$\rho = 0.4$	$\rho = 0.88$	$\rho = 0.93$
Y^I	0.2485	-0.7282	-0.9144
Rem	-0.1945	-0.0983	-0.0503
T	0.5639	-0.1898	-0.5218
h^A	0.7375	0.8158	0.758
h^F	0.3499	0.8319	0.9251
h^I	0.1054	-0.7691	-0.9206
RS	0.5639	-0.1898	-0.5218
Standard deviation			
Correlation with output	$\sigma = 0.02$	$\sigma = 0.049$	$\sigma = 0.08$
Y^I	0.4612	-0.7282	-0.9659
Rem	-0.209	-0.0983	-0.0001
T	0.8495	-0.1898	-0.677
h^A	0.8829	0.8158	0.8184
h^F	0.0701	0.8319	0.955
h^I	0.3754	-0.7691	-0.9684
RS	0.8495	-0.1898	-0.677
Interest rate and foreign demand shocks			
Persistance			
Correlation with output	$\rho = 0.4$	$\rho = 0.88$	$\rho = 0.93$
Y^I	-0.3474	-0.8502	-0.9436
Rem	-0.0204	-0.0235	-0.0052
T	0.5104	-0.2162	-0.5411
h^A	0.4481	0.7283	0.7292
h^F	0.4593	0.854	0.9328
h^I	-0.4133	-0.8603	-0.9428
RS		-0.2162	-0.5411
Standard deviation			
Correlation with output	$\sigma = 0.02$	$\sigma = 0.049$	$\sigma = 0.08$
Y^I	-0.1855	-0.8502	-0.9659
Rem	-0.0219	-0.0235	-0.0001
T	0.7951	-0.2162	-0.677
h^A	0.2368	0.7283	0.8184
h^F	0.2957	0.854	0.955
h^I	-0.2528	-0.8603	-0.9684
RS	0.7951	-0.2162	-0.677

Table 3.6: Sensitivity analysis for foreign demand shocks.

Conclusions

The thesis has explored a small open-economy RBC model that incorporates an informal sector, as well as various shocks such as formal productivity, interest rate, foreign demand, and remittances. Different specifications were examined, including cases with imperfect passthrough of formal productivity shocks to the informal sector. The aim was to identify which shocks could effectively explain the observed data and provide insights into the stylized facts of the Mexican economy.

The research has yielded several significant findings. The primary and most notable finding is that, the presence of foreign demand shocks is essential to explain the stylized facts specific to the Mexican economy. Without incorporating foreign demand shocks, the model was unable to account for the procyclicality of formal employment and the countercyclicality of international relative prices (terms of trade and real exchange rate) displayed by the data.

A second important finding is that the results for the model without foreign demand shocks are robust for higher and lower values for the elasticity of substitution between formal and informal goods, they are also robust for lower values of the trade elasticity parameter. For higher trade elasticity values, the model is able to account for the procyclicality of all measures of employment (formal and informal), but is still unable to account for the countercyclical behavior of international prices. The importance of external demand shocks and the sensitivity of the model's results for higher values of the trade elasticity parameter highlight the role of the external sector in the model.

A third important finding is that, when foreign demand shocks are introduced and the overall model performance improves, a puzzle regarding informal employment arises. Informal employment exhibits a procyclical behavior from the data and the model generates countercyclical informal employment.

It was also found that the results for the model with foreign demand shocks require the shocks to have a sufficiently large persistence parameter, as lower values of this parameter generate procyclical international relative prices, which is counterfactual. Foreign demand shock are also required to have a sufficiently large standard deviation to account for the countercyclicality of international relative prices.

Overall, these findings underscore the crucial role of foreign demand shocks and the significance of incorporating an informal sector when attempting to capture the dynamics and characteristics of the Mexican economy. The results emphasize the necessity of considering these factors to achieve a more accurate representation of the observed data and provide a comprehensive understanding of the Mexican economy, but as stated before, the inclusion of this shock generates a puzzle with regards to the procyclical informal employment that is generated. For further research, it would be a good idea to look at the performance of non-stationary productivity shocks (so-called trend shocks) to see if they are able to resolve this puzzle.

Appendix A

Data Description

Variables Information						
Variable	Name	Units	Source	Key	Periodicity	Deseasonalized
Y	Output	Millions of Pesos	INEGI	493911	Quarterly	Yes
rem^{*}	Remittances	Millions of Dollars	Banxico	SE28528	Quarterly	No
rer	Real Exchange Rate	Index	Banxico	CR60	Monthly	No
$tot^{*}*$	Terms of tade	Index	Banxico	CA739	Quarterly	No
$te^{*}*$	Total Employment	Number of peaple	INEGI	446570	Quarterly	No
$til^{*}*$	Informal Labor Rate	Percentage	INEGI	447707	Quarterly	No
il^{2**}	Informal Labor (self-employed workers)	Number of peaple	INEGI	446575	Quarterly	No
il^{3**}	Informal Labor (workers without labor benefits)	Number of peaple	INEGI	446659	Quarterly	No
il^{1**}	Informal Labor INEGI = $til * te$					
$fl^{1}**$	Formal labor INEGI = $te - il^{1**}$					
fl^{2**}	Formal Labor (non-self-employed workers) = $te - il^{2**}$					
fl^{3**}	Formal Labor (workers with labor benefits) = $te - il^{3**}$					
*	SE28528 was used from 1996-Q1 to 2022-Q3, and from 1993-Q1 to 1995-Q4 SE36616 was used					
**	Data from 2005-Q1 to 2022-Q3					
Data from 1993-Q1 to 2022-3 unless specified other wise						

Table A.1: Raw variables description

Appendix B

Model Without Informality

B.1 Non-Linear Model

Lifetime utility of the households:

$$U_i = E_0 \sum_{t=0}^{\infty} \beta^t u\left(C_t, h_t\right) \tag{B.1}$$

Utility function:

$$u\left(C_t, h_t\right) = \mu \log\left(C_t\right) + (1-\mu) \log\left(1-h_t\right) \tag{B.2}$$

Budget constraint:

$$\frac{D_{t+1}}{R_t} = D_t + C_t + I_t - \left(W_t h_t + r r_t K_t\right)\left(1-\tau^F\right) - Rem_t - \Pi_t \tag{B.3}$$

Capital law of motion:

$$K_{t+1} = I_t + K_t(1-\delta) \tag{B.4}$$

FOC:

$$\frac{\mu}{C_t} - \lambda_t = 0 \tag{B.5}$$

$$-\frac{1-\mu}{1-h_t} + \lambda_t(1-\tau^F)W_t = 0 \tag{B.6}$$

$$-\lambda_t + \beta E_t\left\{\lambda_{t+1}\left(rr_{t+1}\left(1-\tau^F\right)+(1-\delta)\right)\right\} = 0 \tag{B.7}$$

$$\lambda_t \frac{1}{R_t} - \beta E_t \lambda_{t+1} = 0 \tag{B.8}$$

Intermediate goods sector:

Profits:

$$\Pi_t = \frac{P_{H,t}}{P_t} Y_t - \left(1+\tau^N\right) W_t h_t - rr_t K_t \tag{B.9}$$

Production:

$$Y_t = A_t (K_t)^{\alpha} (h_t)^{1-\alpha} \tag{B.10}$$

Optimality conditions:

$$rr_t = \frac{P_{H,t}}{P_t} \alpha A_t \left(K_t\right)^{\alpha-1} \left(h_t\right)^{1-\alpha} \tag{B.11}$$

$$W_t = \frac{P_{H,t}}{P_t} \frac{\left(1-\alpha\right) A_t \left(K_t\right)^{\alpha} \left(h_t\right)^{-\alpha}}{1+\tau^N} \tag{B.12}$$

Final production:

Final consumption:

$$C_t = \left[v C_{H,t}^{\frac{\theta-1}{\theta}} + (1-v) C_{W,t}^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \tag{B.13}$$

Optimal input demand:

$$C_{H,t} = v \left(\frac{P_{H,t}}{P_t} \right)^{-\theta} C_t, \quad C_{W,t} = (1-v) \left(\frac{P_{W,t}}{P_t} \right)^{-\theta} C_t \tag{B.14}$$

Price index:

$$\left(P_t\right)^{1-\theta} = \left[v P_{H,t}^{1-\theta} + (1-v) P_{W,t}^{1-\theta} \right] \tag{B.15}$$

Terms of trade:

$$T_t = \frac{P_{W,t}}{P_{H,t}} \tag{B.16}$$

Real Exchange Rate:

$$RS_t = \left(\frac{P_{W,t}}{P_{H,t}}\right)^v$$
$$RS_t = (T_t)^v \tag{B.17}$$

Government:

$$G_t = \tau^N W_t h_t + (W_t h_t + rr_t K_t)\,\tau^F \tag{B.18}$$

Interest Rate:

$$R_t = R^* + \psi\left(e^{D_{t+1}-\bar{d}} - 1\right) + u_t \tag{B.19}$$

Market clearing:

Intermediate goods market:

$$Y_t = C_{H,t} + C^*_{H,t} \tag{B.20}$$

Resource constraint:

$$\frac{P_{H,t}}{P_t} Y_t = C_t + I_t + G_t + D_t - \frac{D_{t+1}}{R_t} - \text{Rem}_t \tag{B.21}$$

B.2 Log-Linearized Model

Household:

Capital law of motion:

$$\hat{K}_{t+1} = \delta \hat{I}_t + \hat{K}_t (1 - \delta) \tag{B.22}$$

FOC:

$$-\hat{C}_t = \hat{\lambda}_t \tag{B.23}$$

$$\hat{\lambda}_t + \hat{W}_t = \frac{h^{ss}}{1 - h^{ss}} \hat{h}_t \tag{B.24}$$

$$\hat{\lambda}_t = (1 - \beta (1 - \delta)) E_t [\hat{r}_{t+1}] + E_t \left[\hat{\lambda}_{t+1} \right] \tag{B.25}$$

$$\hat{\lambda}_t - \hat{R}_t = E_t \left[\hat{\lambda}_{t+1} \right] \tag{B.26}$$

Intermediate sector:

Production:

$$\hat{Y}_t = \hat{A}_t + \alpha \hat{K}_t + (1 - \alpha) \hat{h}_t \tag{B.27}$$

Optimality conditions:

$$\hat{rr}_t = \hat{Y}_t - \hat{K}_t - (1-v)\hat{T}_t \tag{B.28}$$

$$\hat{W}_t = \hat{Y}_t - \hat{h}_t - (1-v)\hat{T}_t \tag{B.29}$$

Final production:

Optimality conditions:

$$\hat{C}_{H,t} = \theta(1-v)\hat{T}_t + \hat{C}_t \tag{B.30}$$

$$\hat{C}_{W,t} = -\theta v\hat{T}_t + \hat{C}_t \tag{B.31}$$

Real exchange rate:

$$\hat{RS}_t = v\hat{T}_t \tag{B.32}$$

Terms of trade:

$$\hat{T}_t = \hat{P}_{W,t} - \hat{P}_{H,t} \tag{B.33}$$

Interest rate:

$$\hat{R}_t = \frac{\psi}{R^*}\bar{d}\hat{D}_{t+1} + \hat{u}_t \tag{B.34}$$

Market clearing conditions:

Intermediate goods market:

$$\hat{Y}_t = \frac{C_H^{ss}}{YF^{ss}}\hat{C}_{H,t} + \frac{C_H^{*^{ss}}}{YF^{ss}}\hat{C}^*_{H,t} \tag{B.35}$$

Resource constraint:

$$\hat{Y}_t - (1-v)\hat{T}_t = \frac{C^{ss}}{Y^{ss}}\hat{C}_t + \frac{\delta\beta\alpha(1-\tau^F)}{1-\beta(1-\delta)}\hat{I}_t + \bar{d}\hat{D}t - \frac{\bar{d}}{R^*}\left(\hat{D}t + 1 - \hat{R}t\right) - \frac{Rem^{ss}}{Y^{ss}}\hat{Rem}t \tag{B.36}$$

Appendix C

Sensitivity Analysis

C.1 Formal Productivity and Remittances Shocks

C.2 Interest Rate Shocks

Sensitivity Analysis: Trade Elasticity				
Formal productivity shocks				
Moments	Data for the Mexican Economy	$\theta = 0.39$	$\theta = 2$	$\theta = 3$
Standard Deviation (%)		Passthrough	Passthrough	Passthrough
Y^F	2.799	2.790	2.790	2.790
Y^I		24.950	3.550	1.790
Rem	9.510	9.190	9.190	9.190
T	3.087	39.080	7.580	4.940
h^A	2.701	2.400	0.360	5.400
h^F	2.291	9.830	0.430	0.460
h^I	5.016	26.140	3.000	1.140
S.D/S.D Output				
$\sigma_{Y^I}/\sigma_{Y^F}$		8.943	1.272	0.642
$\sigma_{Rem}/\sigma_{Y^F}$	3.397	3.294	3.294	3.294
σ_T/σ_{Y^F}	1.103	14.007	2.717	1.771
$\sigma_{h^F}/\sigma_{Y^F}$	0.818	3.523	0.154	0.165
$\sigma_{h^I}/\sigma_{Y^F}$	1.792	9.369	1.075	0.409
σ_{RS}/σ_{Y^F}	2.997	8.824	1.710	1.118
Correlation with output				
Y^I		0.196	0.830	0.831
Rem	-0.258	-0.211	-0.225	-0.211
T	-0.223	0.650	0.998	1.000
h^A	0.835	-0.915	0.941	0.991
h^F	0.874	-0.525	-0.727	0.946
h^I	0.644	0.302	0.863	0.783
RS	-0.529	0.650	0.998	1.000
Autocorrelation (1st order)				
Y^F	0.604	0.543	0.504	0.572
Y^I		0.667	0.794	0.842
Rem	0.582	0.109	0.109	0.109
T	0.459	0.349	0.525	0.584
h^A	0.300	0.194	0.720	0.664
h^F	0.413	0.433	0.840	0.471
h^I	0.134	0.599	0.776	0.863
RS	0.749	0.349	0.525	0.584

Table C.1: Sensitivity analysis: changes in the trade elasticity for the model with productivity and remittances shocks.

Sensitivity Analysis: Elasticity of Substitution Formal and Informal Goods				
Formal productivity shocks				
Moments	Data for the Mexican Economy	$e = 0.5$	$e = 0.875$	$e = 15/16$
Standard Deviation (%)		Passthrough	Passthrough	Passthrough
Y^F	2.79	2.79	2.79	2.79
Y^I		5.41	3.55	4.30
Rem	9.51	9.19	9.19	9.19
T	3.08	10.33	7.58	7.36
h^A	2.70	2.30	0.36	0.45
h^F	2.29	1.19	0.43	0.57
h^I	5.01	4.96	3.00	3.75
S.D/S.D Output				
$\sigma_{Y^I}/\sigma_{Y^F}$		1.939	1.272	1.541
$\sigma_{Rem}/\sigma_{Y^F}$	3.397	3.294	3.294	3.294
σ_T/σ_{Y^F}	1.103	3.703	2.717	2.638
$\sigma_{h^F}/\sigma_{Y^F}$	0.818	0.427	0.154	0.204
$\sigma_{h^I}/\sigma_{Y^F}$	1.792	1.778	1.075	1.344
σ_{RS}/σ_{Y^F}	2.997	2.333	1.710	1.663
Correlation with output				
Y^I		0.806	0.830	0.713
Rem	-0.258	-0.234	-0.225	-0.229
T	-0.223	0.993	0.998	0.993
h^A	0.835	0.581	0.941	0.905
h^F	0.874	-0.897	-0.727	-0.479
h^I	0.644	0.854	0.863	0.735
RS	-0.529	0.993	0.998	0.993
Autocorrelation (1st order)				
Y^F	0.604	0.456	0.504	0.490
Y^I		0.764	0.794	0.836
Rem	0.582	0.109	0.109	0.109
T	0.459	0.484	0.525	0.526
h^A	0.300	0.812	0.720	0.733
h^F	0.413	0.661	0.840	0.897
h^I	0.134	0.728	0.776	0.829
RS	0.749	0.484	0.525	0.526

Table C.2: Sensitivity analysis: changes in the elasticity of substitution between informal and formal goods for the model with productivity and remittances shocks.

Sensitivity Analysis: Trade Elasticity				
Interest rate shocks				
Moments	Data for the Mexican Economy	$\theta = 0.39$	$\theta = 1.5$	$\theta = 3$
Standard Deviation (%)				Passthrough
Y^F	2.799	2.790	2.790	2.790
Y^I		0.860	2.58	1.790
Rem	9.510	9.190	9.190	9.190
T	3.087	4.900	9.760	4.940
h^A	2.701	0.360	0.330	5.400
h^F	2.291	0.630	0.830	0.460
h^I	5.016	1.070	2.520	1.140
S.D/S.D Output				
$\sigma_{Y^I}/\sigma_{Y^F}$		0.308	0.925	0.642
$\sigma_{Rem}/\sigma_{Y^F}$	3.397	3.294	3.294	3.294
σ_T/σ_{Y^F}	1.103	1.756	3.498	1.771
$\sigma_{h^F}/\sigma_{Y^F}$	0.818	0.226	0.297	0.165
$\sigma_{h^I}/\sigma_{Y^F}$	1.792	0.384	0.903	0.409
σ_{RS}/σ_{Y^F}	2.997	5.333	8.824	1.118
Correlation with output				
Y^I		-0.078	0.403	-0.619
Rem	-0.258	-0.170	-0.041	-0.008
T	-0.223	0.327	0.905	0.970
h^A	0.835	-0.462	-0.836	0.790
h^F	0.874	-0.234	-0.812	0.976
h^I	0.644	0.010	0.435	-0.792
RS	-0.529	0.327	0.905	0.970
Autocorrelation (1st order)				
Y^F	0.604	0.716	0.416	0.338
Y^I		0.600	0.676	0.695
Rem	0.582	0.109	0.109	0.109
T	0.459	0.113	0.123	0.148
h^A	0.300	-0.044	0.509	0.040
h^F	0.413	0.167	0.260	0.114
h^I	0.134	0.518	0.598	0.618
RS	0.749	0.113	0.123	0.148

Table C.3: Sensitivity analysis: changes in the trade elasticity for the model with interest rate and remittances shocks.

Sensitivity Analysis: Elasticity of Substitution Formal and Informal Goods				
Interest rate shocks				
Moments	Data for the Mexican Economy	$e = 0.5$	$e = 0.875$	$e = 15/16$
Standard Deviation (%)				
Y^F	2.79	2.79	2.79	2.79
Y^I		0.29	1.48	2.81
Rem	9.51	9.19	9.19	9.19
T	3.08	7.48	7.37	7.31
h^A	2.70	0.18	0.20	0.22
h^F	2.29	0.29	0.16	0.53
h^I	5.01	0.31	1.37	2.73
S.D/S.D Output				
$\sigma_{Y^I}/\sigma_{Y^F}$		0.104	0.530	1.007
$\sigma_{Rem}/\sigma_{Y^F}$	3.397	3.294	3.294	3.294
σ_T/σ_{Y^F}	1.103	2.681	2.642	2.620
$\sigma_{h^F}/\sigma_{Y^F}$	0.818	0.104	0.057	0.190
$\sigma_{h^I}/\sigma_{Y^F}$	1.792	0.111	0.491	0.978
σ_{RS}/σ_{Y^F}	2.997	1.688	0.017	1.649
Correlation with output				
Y^I		0.488	0.221	0.148
Rem	-0.258	-0.002	-0.024	-0.046
T	-0.223	0.980	0.942	0.881
h^A	0.835	-0.081	-0.008	0.108
h^F	0.874	-0.179	-0.370	-0.034
h^I	0.644	0.366	0.141	0.061
RS	-0.529	0.980	0.942	0.881
Autocorrelation (1st order)				
Y^F	0.604	0.330	0.373	0.415
Y^I		0.625	0.772	0.690
Rem	0.582	0.109	0.109	0.109
T	0.459	0.204	0.132	0.069
h^A	0.300	0.581	0.720	0.827
h^F	0.413	0.434	0.796	0.519
h^I	0.134	0.395	0.742	0.637
RS	0.749	0.204	0.132	0.069

Table C.4: Sensitivity analysis: changes in the elasticity of substitution between informal and formal goods for the model with interest rate and remittances shocks.

Bibliography

Aguiar, M. and Gopinath, G. (2007). Emerging market business cycles: The cycle is the trend. *Journal of Political Economy*, (1):69–102.

Alba, C. and McKnight, S. (2022). Laffer curves in emerging market economies: The role of informality. *Journal of Macroeconomics*, 72:103411.

BANXICO (2023). Sistema de informacion economica. Accessed: 2023-01.

Benigno, G. and Thoenissen, C. (2008). Consumption and real exchange rates with incomplete markets and non-traded goods. *Journal of International Money and Finance*, (6):926–948.

Chami, R., Cosimano, T. F., and Gapen, M. T. (2006). Beware of emigrants bearing gifts: Optimal fiscal and monetary policy in the presence of remittances. *IMF Working Paper*, (WP/06/61).

Durdu, C. B. and Sayan, S. (2008). Emerging market business cycles with remittance fluctuations. *Board of Governors of the Federal Reserve System International Finance Discussion Papers*, (946).

Fernández, A. and Meza, F. (2015). Informal employment and business cycles in emerging economies: The case of mexico. *Review of Economic Dynamics*, 18(2):381–405.

Horvath, J. (2018). Business cycles, informal economy, and interest rates in emerging countries. *Journal of Macroeconomics*, 55:96–116.

INEGI (2023). Banco de informacion economica. Accessed: 2023-01.

Jansen, D. W., Vacaflores, D. E., and Naufal, G. S. (2012). The macroeconomic consequences of remittances. *International Scholarly Research Network Economics*.

Leyva, G. and Urrutia, C. (2020). Informality, labor regulation, and the business cycle. *Journal of International Economics*, 126:103340.

Mandelman, F. S. and Zlate, A. (2008). Immigration, remittances, and business cycles. *Federal Reserve Bank of Atlanta Working Paper Series*, (25a).

Medina and Schneider (2018). Shadow economies around the world: What did we learn over the last 20 years? *IMF Working Paper*, (18/17).

Restrepo-Echavarria, P. (2014). Macroeconomic volatility: The role of the informal economy. *European Economic Review*, 70:454–469.

Sayan, S. (2004). Guest workers' remittances and output fluctuations in host and home countries: The case of remittances from turkish workers in germany. *Emerging Markets Finance & Trade*, 40(6).

Schmitt-Grohé, S. and Uribe, M. (2003). Closing small open economy models. *Journal of International Economics*, 61:163–185.

Thoenissen, C. (2011). Exchange rate dynamics, asset market structure, and the role of the trade elasticity. *Macroeconomic Dynamics*, 15(1):119–143.

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