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It Takes Two: Fiscal and Monetary Policy in Mexico

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Abstract

We model the interaction between fiscal and monetary policy and qualify their effects in a semi-structural small open economy model calibrated for Mexico. In our model, fiscal and monetary policy follow rules tied to specific targets. We estimate how fiscal policy, through deficits and public debt accumulation, and monetary policy, through the interest rate, directly affect the economy. We study the nature of the feedback between policy decisions and examine their indirect effects through the sovereign risk channel. We find that the response of monetary policy to stabilise the economy after a shock depends on how strict is the fiscal rule. A loose fiscal stance pushes a tighter monetary policy stance. Instead, the economy recovers faster when monetary and fiscal policy complement each other.

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1 Introduction

The intertwined channels of fiscal and monetary policy are a challenge for policymakers. By design, the fiscal authority and the central bank decide and implement each form of policy independently. But, policy decisions implemented without consideration of the other side can lead to policies that battle with one another. It is thus important to understand how fiscal and monetary policy interact and the nature of the feedback between them. Equally important are the relative strengths of the channels through which changes in the fiscal and monetary stances affect the economy. When monetary and fiscal policy complement one another the cost to stabilise the economy is lower.

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In this paper we propose a semi-structural model of the Mexican economy to analyse the response of fiscal and monetary policy to shocks and qualify their effects through estimation. Our model consists of three blocks: a monetary block, a fiscal block and an external block. The monetary block reflects the basis of commonly used monetary models for small open economies: the output gap, the Phillips curve, the uncovered interest rate parity and the monetary policy rule. The equations for the fiscal block are rooted in the government budget constraint: the accounting relationships linking government income, expenditure, deficit, debt, and fiscal rules. The external block describes how international variables move. We obtain the numerical values of the parameters through a combination of estimation and calibration.

One key difference from other models is that we explore the sovereign risk premium channel. We model the risk premium as a function of domestic government debt. Fiscal authorities affect financial conditions through the sovereign risk premium, which has an effect on investment. In addition, the risk premium affects the real exchange rate through the risk-adjusted uncovered interest parity. We find that after a fiscal expansion, the rise in risk premium will be very persistent, and so will its effects on output and the exchange rate. The risk premium channel can thus also be useful to explain why fiscal policy may be procyclical even when there is a fiscal rule. If the economy is in a recession and there is support from the fiscal side, that may help the economy in a countercyclical way. However, if there are doubts about fiscal sustainability, risk premiums will increase, dampening or even reversing the expansionary effect of fiscal policy. In an extreme case, fiscal actions may have a negative net effect on activity, becoming procyclical. This will present a dilemma for the monetary authority as it faces lower production and higher inflation driven by the pass-through of an exchange rate depreciation.

The sovereign risk premium channel is extremely relevant for Mexico. The country's reliance on oil for fiscal revenue has left its fiscal sustainability vulnerable for many decades. There are three major reasons: first, the country has one of the lowest tax revenues as a share of GDP among OECD countries and other EME peers. Second, there is a high degree of rigidity in a large proportion of public expenditures. Third, the country has had a low growth rate for decades, suggesting low potential growth.

We model fiscal and monetary policy through policy rules. These rules are reaction functions to deviation from specific targets. For monetary policy the target is inflation while for fiscal policy the target is either government's deficit or debt. Policies that are set following rules, unlike a discretionary approach, provide certainty to economic agents and help them plan and make more informed decisions. In Mexico, both authorities follow rules de facto, this is not only relevant for modelling purposes, but it is also considered when designing their policy responses since the reaction function of fiscal authorities can be included in the economic analysis of monetary authorities and vice versa. In our model, different fiscal rules provide monetary policy with varying degrees of room for manoeuvre to stabilise the economy after a shock. Therefore, if the fiscal authority follows a fiscal rule it affects the behaviour of monetary policy that face different costs in terms of activity and anchor inflation expectations. The results of this paper show that the stricter the fiscal rule, the easier is the job of monetary authorities to stabilise the economy after a shock. That is, it would not need to elevate rates to high levels. Also, in the extreme case of a completely exogenous and inertial government spending, the government takes longer to bring down its debt making it more difficult for monetary policy to reach its objective.

The rest of this paper is structured as follows. Section 2 reviews the fiscal and monetary developments in Mexico in recent decades, with a particular emphasis on fiscal rules and and accountability developments. Section 3 describes the model and its structure, and Section 4 explains the data and the estimation and calibration strategy. Section 5 presents the results of the impulse response functions and counterfactual exercises. Finally, Section 6 concludes.

2 Fiscal and Monetary Policy in Mexico

2.1 Fiscal Developments in Mexico after the Financial Crisis

Fiscal policy affects macroeconomic variables, such as inflation, employment and the exchange rate, through changes in government spending and taxation. However, the size of the fiscal multiplier is still a matter of debate (Ramey (2019)). In the case of Mexico, there is evidence that the fiscal multiplier is positive, but its value could vary with the business cycle.[1] In addition, differences between regions and income growth distribution could change the effect of fiscal policy on aggregate demand in Mexico.

Recent literature has explored the idea that a fiscal expansion might not have purely expansionary effects. After the GFC, countries around the world widened their government deficits to provide fiscal stimuli. In many countries, this led to higher debt-to-GDP ratios and sovereign default risk, as seen in the European sovereign debt crisis.[2] If a fiscal expansion is associated with increased uncertainty the effect could be softer and even negative (Hemming, Kell, and Mahfouz (2002)). A fiscal expansion fuelled by deficits could also negatively affect output through the effect of the risk premium on borrowing rates (Corsetti et al. (2013)). In addition, an increase in a country's risk profile might raise the likelihood of capital outflows, further affecting output and the real exchange rate. In general, fiscal expansions could have non-desired effects if they are perceived as unsustainable. That is one of the reasons why it is key that decisions be guided by a fiscal rule: a commitment to intertemporal discipline from authorities that leads to fiscal sustainability.

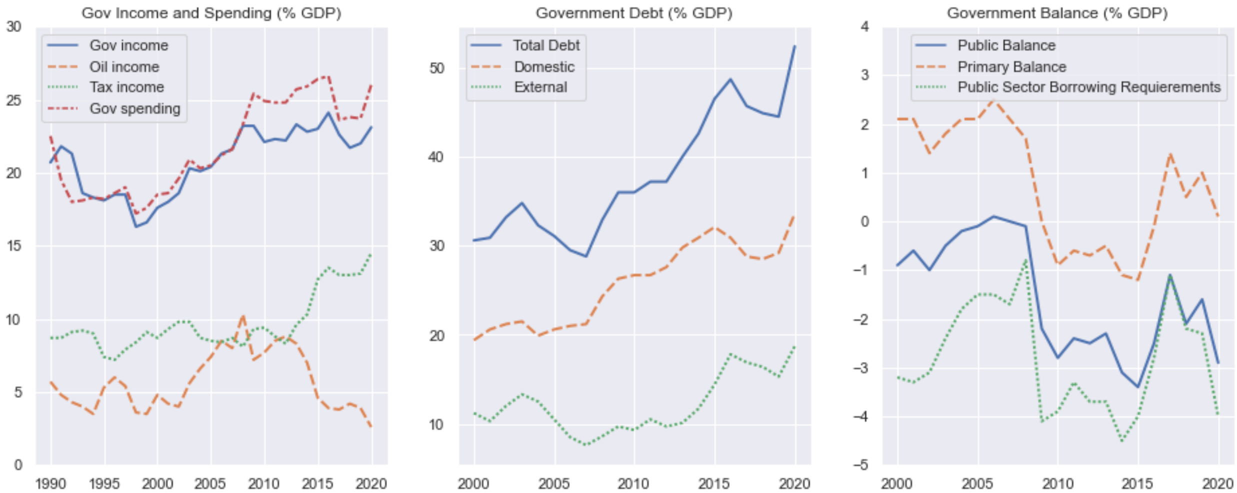
The channels through which fiscal policy can have a negative effect have been present throughout the history of EMEs. Mexico is one clear example. Debt has increased around 20 percentage points in the last decade, as the absence of fiscal reform has led to fragile tax income. Mexico's fiscal revenues have a high degree of dependence on oil-related income, although it has decreased in the last decade.[3] This dependence has been a source of macroeconomic vulnerability. Total tax revenue as a proportion of GDP has increased recently, from 22% in 2010 to 24% in 2020. But it is still low and expenditures are very rigid (Figure 1, left-hand panel panel). In past years, the government has adjusted public investment when a shock reduces tax income. Public spending on total investment decreased from 5.1% of GDP in 2015 to 2.8% in 2020.

[1]Guerra (2021) calculates a value around 0.6 that could approach 0.9 during recessions and drop to 0.2 during expansions.

[2]Francesco and Pagano (1990) studied how fiscal expansions might lead to contractionary effects through higher risk of default, increasing the channel of expectations of tax announcements and eliciting concerns over future deficit increases. Reinhart, Rogoff, and Savastano (1990) explain how investors are less tolerant of debt levels in EMEs with a history of default high inflation episodes.

[3]Oil revenue as percentage of total revenue decreased from around 35% in 2010 to 11% in 2020.

Figure 1: Fiscal Policy in Mexico



Source: Secretaría de Hacienda y Crédito Público (SHCP)

These low investment rates, along with other structural factors such as low productivity, have affected the economy's potential growth, in turn reducing future tax income. From 1990 to 2019, the IMF reduced Mexico's five-year growth forecast from 5% to 2%. This forecast does not consider the effect of the Covid-19 pandemic. Rating agencies have expressed concerns regarding these risks for many years. For example, S&P downgraded Mexico's rating on its sovereign debt twice in the last two decades, once in 2009 and again in 2020.

Current debt levels in Mexico are not a substantial risk to fiscal soundness but the present low discounted value of primary surplus raises vulnerabilities. Mexico's debt levels are not as high as those of its peers. There was an increase in public debt in 2012-16, when the government implemented an ambitious set of structural reforms (energy, labour, antitrust, and telecommunications reforms, among others) which were expected to increase the growth rate to 5% and generate sustainable tax revenue. However, some reforms were incomplete and others, including energy reform, have had setbacks, again jeopardising sustainable fiscal revenue (Figure 1, centre panel).

2.2 Fiscal Rules and Accountability Developments in Mexico

Mexican authorities have taken various steps to overcome the vulnerabilities of fiscal accounts. In the early 2000s, three rating agencies raised the country's sovereign debt rating to investment grade (Moody's in 2000 and S&P and Fitch in 2002). Among the most prominent factors contributing to the greater macroeconomic stability were better interaction between fiscal and monetary policies, improved fiscal discipline that led to lower and better debt dynamics, greater balance of payments resilience and the adoption of inflation targeting with a flexible exchange rate regime. Later, in 2006, the government implemented the Fiscal Responsibility Law (FRL), whose purpose was to achieve a zero fiscal deficit, with a margin of 1% of the net budget expenditure.[4] The FRL included exception clauses to allow deviations from fiscal targets in special circumstances, such as economic

[4]Article 17 of Mexican Congress 2016 states that: "Total net expenditure proposed by the executive branch in the Expenditure Budget, approved by the lower house and exercised in the fiscal year by the executors of expenditure, must contribute to balance the budget.", while article 11 states: "Government's deficit must be equal to zero."

recessions or sharp drops in oil prices and production. However, it excluded PEMEX investment, which was not considered in evaluating the fiscal target.[5]

In 2008 Mexico deviated from its balanced budget rule to provide fiscal stimulus to the economy during the GFC. The Mexican economy was severely affected, given that the U.S., its main trading partner, was the epicentre of the crisis (80% of Mexico's exports go to the U.S.). During this crisis there was a sharp contraction in output and a significant drop in public revenue. The fiscal authority was thus allowed under the FRL to expand the public deficit, with a commitment to its gradual reduction (Figure 1, right-hand panel).[6]

Debt-to-GDP increased by 7.2 percentage points, from 28.8% in 2007 to 36% in 2010, due to a series of deficits and a strong exchange rate depreciation. In 2009, two rating agencies (S&P and Fitch) downgraded the country's sovereign debt rating to just above investment grade. There were three reasons for the downgrade: limited room to manoeuvre for fiscal authorities (in the absence of counter-cyclical fiscal policy and automatic stabilisers), a high degree of dependence of public revenue on oil with an accompanying decrease in oil production, and a low tax base. Mexico's sovereign risk premium rose to levels above those observed in other EMEs. As measured by the EMBI+ index, it increased by more than 200 basis points at the end of 2008 and beginning of 2009. In 2013, the government announced that public deficits were going to continue. However, this time the government justified its decision with the need for resources to implement the structural reforms being approved by Congress. Those reforms were estimated to increase potential growth by up to 5%, and debt levels were expected to come down in subsequent years. However, the reforms did not generate the expected boost in growth. In addition, during the period 2014-16, the economy was affected by various internal and external shocks affecting the performance of public finance.

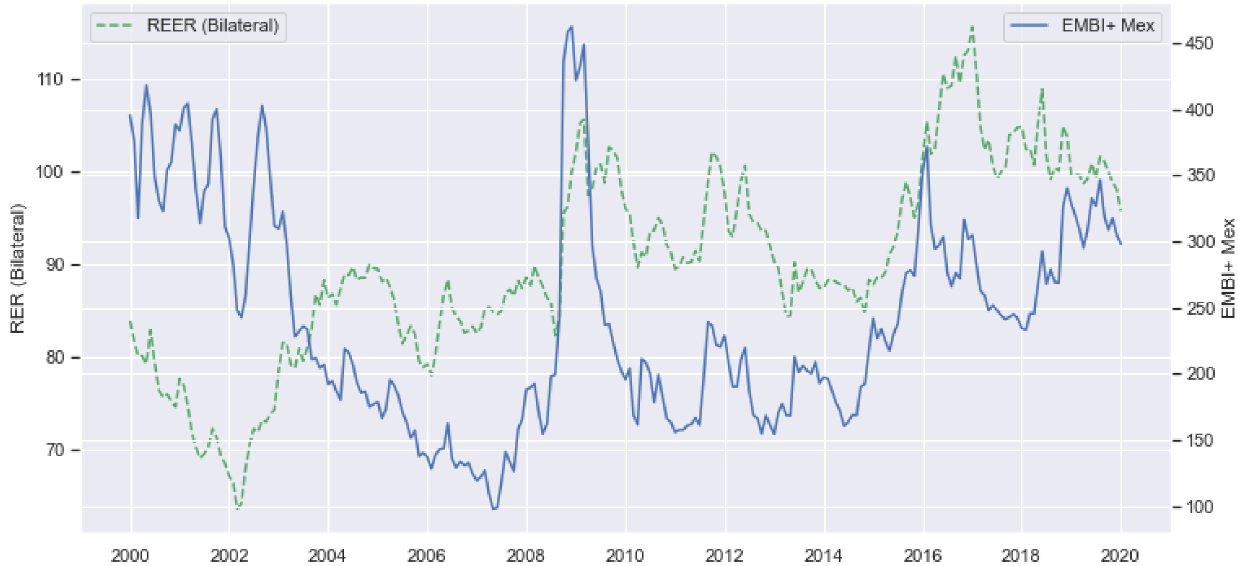
At the end of 2014, public sector finance was hit by falling international oil prices (Mexico's oil price went from 100 USD per barrel in June 2014 to 52 USD in April 2015). In addition, Pemex oil production showed a downward trend, which led to a sharp reduction in public sector oil revenue. This shock deteriorated the terms of trade and contributed to a sharp depreciation in the exchange rate (the real exchange rate depreciated 47% from June 2014 to December 2016) (Figure 2). The current account deficit in terms of GDP thus increased. During these years, a rise in risk premium compounded the negative effect on activity and exchange rate depreciation. With rising debt, oil price shocks and unfavourable financial and political conditions from abroad, the government faced fiscal sustainability concerns. In response, it implemented a tax reform in 2014 to increase taxes and provide for a more stable revenue source. This reform, combined with more stable government spending, reduced the public balance from 3.3% of GDP in 2014 to 1.1% of GDP in 2017.

In 2014 the definition for public sector borrowing requirements (PSBR) was modified to better reflect the dynamics of public debt. With this change, the PSBR considered the increase or decrease of net public financial assets. In addition, the FRL was reformed to define the medium-term annual fiscal target as a function of the PSBR, a broader definition of the public deficit. The reform did not specify the details for establishing and evaluating the target, but from 2015 to 2017 the de facto target was 2.5% of GDP and in 2018 it was 2%.

[5]Mexican Congress 2015 Art. 1 states: "For the 2015 fiscal year, the investment expenditure of the Federal Government and State productive enterprises will not be counted for purposes of the budget balance provided for in Article 17 of the Federal Budget and Fiscal Responsibility Law, up to an amount equivalent to 2.5% of the Gross Domestic Product, of which 2.0% corresponds to Petróleos Mexicanos and 0.5% to the Federal Electricity Commission and for high impact investments under the terms of the Federal Expenditure Budget 2015."

[6]The government sets its debt and deficit targets for future years in an official document presented before the Congress.

Figure 2: The Risk Premium in Mexico



Source: Banco de México and Bloomberg

Another important step toward increasing fiscal discipline was the 2015 amendment of the FRL. By law, the annual operational gains from the central bank balance must be transferred to the treasury once capital losses are covered. With the new law, at least 70% of the transfer must be used to pay public debt.[7] This action is emblematic of the importance of the interaction of fiscal and monetary policies and it reflects the overall budget constraints of the state. After a sharp depreciation that increases external debt, the government could receive resources from the central bank's operational gains from the depreciation to partially counteract the effect on that debt. The authorities have made an effort to implement a fiscal rule and they have improved communication regarding fiscal targets. However, the complexity of fiscal accounting makes it very difficult to evaluate the stance of fiscal policy over time. Finally, fiscal authorities do not have a de jure fiscal rule, but a de facto one.

2.3 Monetary Policy in Mexico

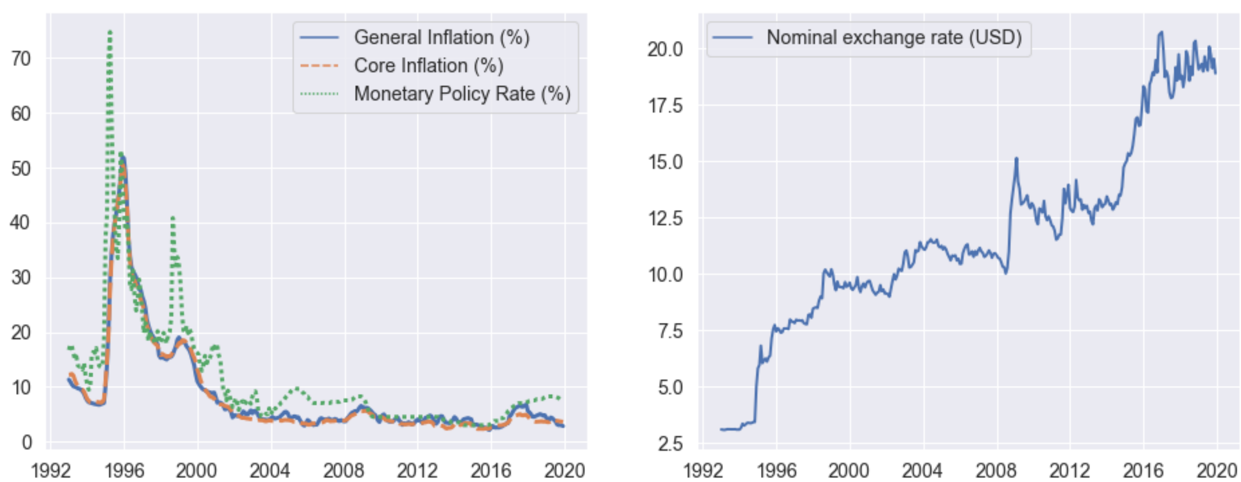
Monetary policy in Mexico has presented various changes over the years that have ultimately resulted in a nominal system that is better functioning and lower inflation. Immediately following the 1994 Tequila crisis, the Banco de México, which became autonomous that year, had to intervene in the foreign exchange market to avoid excess volatility and to build up international reserves (Ramos-Francia and Torres (2005)). In those years monetary policy maintained a clear restrictive bias to induce a sustainable decrease in inflation and inflation expectations, while at the same time it had to respond to inflationary shocks and improve transparency (Ramos-Francia and Torres (2005)). By 1998, monetary authorities maintained a restrictive stance through the policy instrument known as the *corto*, which was a negative overdraft target on the cumulative balance of commercial bank current accounts at the central bank (Sidaoui and Ramos-Francia (2008)). In 1999, the Banco de México set a medium-term inflation target aimed at a convergence with Mexico's main trading

[7] Announcement in Ministry of Finance 2016.

partners. In 2000, it began for the first time to use a definition of core inflation and began publishing quarterly inflation reports.

Since 2001, Banco de México has used an inflation targeting (IT) regime as a framework for monetary policy and to comply with its constitutional mandate to ensure price stability. Beginning in 2003, the annual inflation target was made a long-term inflation target of 3% of the National Consumer Price Index (INPC). In addition, it defined a variability interval of +/- 1% of this target. In 2003, it began publishing in advance the dates of monetary policy announcements, in line with international best practices. As of 2008, the Overnight Interbank Interest Rate has been used as the basis for monetary policy, instead of the *corto*. In 2011, it began publishing its minutes and fan charts of projections of the main macroeconomic variables. Since then, there have been additional adjustments in communication, including publication of the votes and names of Board members voting on each monetary policy decision and publication of transcripts of monetary policy discussions. The central bank undertook these adjustments to increase transparency and provide more information about the monetary policy reaction function, and to comply with its constitutional mandate to maintain price stability. Inflation has declined significantly, from 52% in 1995 to 2.83% in 2019, although more recently it has increased (Figure 3, left-hand panel).

Figure 3: Monetary Policy in Mexico



Source: Banco de México and BIS exchange rate statistics.

Some studies have documented changes in inflation and its dynamics over time. For example, Ramos-Francia and Torres (2005) show that the inflation targeting regime helped anchor inflation expectations and reduce inflation after the economy reached a sustainable fiscal position. Based on the adoption of this regime and the absence of fiscal dominance in the economy, the levels of inflation and its volatility and persistence have dropped considerably over the years (Chiquiar, Noriega, and Ramos-Francia (2007)). The pass-through effect of exchange rate fluctuations on inflation has decreased, which has consolidated the role of the exchange rate as an efficient adjustment variable when the economy is hit by external shocks (Cortés (2013) and Angeles, Cortés, and Sámano (2019)). The exchange rate has experienced periods of sharp increases that has not translated into persistent inflation (Figure 3, right-hand panel). Additionally, the effects on inflation of adjustments in relative prices of certain goods are now transitory (Banco de México (2013)). There has been a reduction in the effect of deviations from the inflation target on inflation expectations (Aguilar Argaez et al. (2014)). Finally, Aguilar-Argaez, Elizondo, and Roldán-Peña (2016) showed a gradual decrease in inflation expectations implicit in the long-term price quotes of market instruments and the associated inflation risk premium. All of these achievements have been crucial to obtaining a more efficient functioning of the pricing system, along with the floating exchange rate regime, a critical element of the macroeconomic framework, that has allowed a much faster and effective adjustment in the economy to different shocks (Figure 3, right-hand panel).

The interaction between fiscal and monetary policies in Mexico has been studied from several perspectives.[8] However, to our knowledge, our study is the first to examine the endogenous interaction between fiscal and monetary policies in Mexico using a dynamic model that includes the risk premium and the exchange rate effect on debt, inflation and fiscal deficit. In the following section we describe the model we use for this purpose.

3 A Small Open Economy Model with Fiscal and Monetary Rules for Mexico

Previous studies have analysed the interdependence between fiscal and monetary policy using neo-Keynesian dynamic general equilibrium models and game-theoretic models.[9] We construct a semi-structural model following McCallum and Nelson (1999) and Svensson (2000). In these models, the equations that represent the interaction between macroeconomic variables reflect agents behaving with rational expectations. These equations are similar to those found in microfounded neo-Keynesian models, even though we do not explicitly derive them from a utility maximisation problem.

In this paper we present a small open economy neo-Keynesian model that can be divided into three blocks: the monetary block, which describes the interaction between aggregate demand, aggregate supply, and the central bank; the fiscal block, which describes government spending, its sources, and its costs; and the external block, which describes the behaviour of variables outside the economy that are assumed to be exogenous. We model the external variables independently as AR(1) processes. The simplified equations correspond to the log-linearisation of the economy's steady state.

3.1 Monetary Block

The monetary block consists of the equations in a traditional small open economy model with rational expectation agents. The four equations are the IS curve, the Phillips curve, the uncovered interest rate parity, and the Taylor rule.

An IS curve determines the output gap (x_t). We derive this curve from an Euler equation as in Smets and Wouters (2007). The variables that affect the output gap are its expected value, a persistence factor derived from habit persistence, the ex-ante real interest rate ($i_t - E(\pi_{t+1})$), and

[8] For instance, Meza (2018) analyses the fiscal and monetary history of Mexico using a model of the government consolidated budget constraint for the period 1960-2016; Cadavid, André, and Ortiz (2018) examine the role of fiscal and monetary policy in the determination of inflation and government debt in the period 1981-2016; Aguilar-Argaez and Ramírez (2013) investigate the effect of oil-price shocks on macroeconomic variables in Mexico under two types of fiscal rules and an optimal monetary policy rule; and Lopez-Martin, Ramírez de Aguilar, and Sámano (2018) analyse the interaction of inflation, inflation expectations and fiscal deficits.

[9] For instance, Leith and Wren-Lewis (2000), Pérez and Hiebert (2004), and Zagaglia (2002) develop model simulations that include fiscal rules. Benigno and Woodford (2003) develop optimal policy rules from a linear-quadratic problem while Schmitt-Grohé and Martín Uribe (2003) study optimal rule in a dynamic macroeconomic setting.

a stochastic i.i.d. shock (ε_t^x). We add demand side effects of government spending ($\widehat{g}_t$), taxes ($\widehat{t}_t$), and variables that could affect net exports: the real exchange rate (s_t) and the U.S. output gap (x_t^{US}). Both affect positively the output gap. Finally, we include the risk premium (p_t) in the IS equation. For example, Corsetti et al. (2013) argue that sovereign risk has a contagion effect on the private interest rate spread, and that private borrowers in the economy thus face a higher interest rate, independent of the actions of the monetary authority.[10]

$$\begin{aligned} x_t = \alpha_0 + \alpha_1 x_{t-1} + \alpha_2 E[x_{t+1}] - \alpha_3(i_t - E[\pi_{t+1}]) + \alpha_4 s_t \\ + \alpha_5 \widehat{g}_t - \alpha_6 \widehat{t}_t - \alpha_7 p_t + \alpha_8 x_t^{US} + \varepsilon_t^x \end{aligned} \tag{IS curve}$$

The Phillips curve determines inflation (π_t) and is a function of past and expected inflation, the output gap, the real exchange rate, and an i.i.d. cost push shock (Smets and Wouters (2007) and Galí and Gertler (1999)). One key difference from traditional models is that our Phillips curve depends on the level, and not the change, in the real exchange rate. Galí and Blanchard (2007) get this effect by using imported goods as a factor of production and sticky wages. In this way the exchange rate has an effect on inflation beyond the period in which it depreciated.

$$\pi_t = \beta_1 \pi_{t-1} + (1-\beta_1)E[\pi_{t+1}] + \beta_2 x_t + \beta_3 s_t + \varepsilon_t^\pi \tag{Phillips curve}$$

Note that the Phillips curve is vertical in the long run, as the coefficient of expected inflation equals one minus the coefficient of past inflation. Another implication of this assumption is that inflation behaves similarly to a random walk, which implies that monetary policy must actively stabilise inflation for a single equilibrium to exist.

The uncovered interest rate parity determines the logarithm of the real exchange rate. It depends on its expected value and on the ex-ante relative real interest rate between Mexico and the U.S. The risk premium also plays a role in interest rate parity, introducing a wedge representing additional compensation to investors given a positive probability of sovereign default (Alberola et al. (2021) and Çufadar and Özatay (2017)). Through the expectations channel, persistent deviations from the local real risk-adjusted policy rate and its foreign counterpart can have important contemporaneous effects on the real exchange rate.

$$s_t = \gamma_1 E[s_{t+1}] - \gamma_2[(i_t - E[\pi_{t+1}]) - (i_t^{US} - E[\pi_{t+1}^{US}])] + \gamma_3 p_t + \varepsilon_t^s \tag{UIP}$$

Finally, a standard Taylor rule with persistence determines the monetary policy interest rate (i_t). In this equation i is the long-run level of the nominal interest rate and π^* is the inflation target.

$$i_t = \delta_1 i_{t-1} + (1-\delta_1)[i + \delta_2(\pi_t - \pi^*) + \delta_3 x_t] + \varepsilon_t^i \tag{Taylor rule}$$

Monetary policy affects economic variables through the interest rate. Changes in short-term interest rates affect economic activity, credit markets and financial conditions, all of which have an effect on fiscal income. Monetary policy also affects the yield curve and influences debt service. Monetary policy action (or inaction) could also affect the inflation risk premium embedded in long-term interest rates, as future inflationary pressures or de-anchored inflation expectations could be associated with a weaker macroeconomic policy stance.

[10]Another interpretation of this term is that it captures the crowding-out effect of private investment by public investment.

3.2 Fiscal Block

The equations for the fiscal block consist of the government budget constraint and other public finance identities. The government issues debt (B_t) in the domestic (B_t^h) and foreign market (B_t^f) to satisfy the budget constraint in each period. As in many EMEs, including Mexico, domestic and external debt are an important part of the government budget constraint. Then, we can express the budget constraint in terms of the evolution of debt:

$$\begin{aligned} B_{t-1} &= B_{t-1}^h + B_{t-1}^f(1 + dS_t^n) \\ B_t &= B_{t-1} + PSBR_t \end{aligned} \quad \text{(Government budget constraint)}$$

where $PSBR_t$ are public sector borrowing requirements- –a broad measure of public deficit– and dS_t^n is the nominal exchange rate depreciation. Public sector borrowing requirements consist of the primary deficit (the negative of the public balance) ($-PB_t$), public sector financial costs (FC_t), and other deficits (OD_t).

$$PSBR_t = -PB_t + FC_t + OD_t \quad \text{(Government deficit)}$$

The primary balance is the difference between government nominal income (T_t) and primary spending (G_t). Other deficits represent changes in the valuation of government assets and liabilities. For Mexico, these deficits are almost always positive and non-negligible. We take them into account so that debt dynamics match the data. Finally, public sector financial costs are debt service payments, which allow the model to take into account the effect of both domestic and foreign interest rates as well as the exchange rate. It also includes the risk premium as a higher probability of default will make it more expensive for the government to sell its debt.

$$PB_t = T_t - G_t \quad \text{(Primary balance)}$$

$$FC_t = B_{t-1}^h(1 + i_{t-1}^h) + B_{t-1}^f(1 + dS_t^n)(1 + i_{t-1}^f) + RP_t \quad \text{(Financial costs)}$$

Government nominal income (T_t) consists of tax revenue (T_t^{tax}), oil income (T_t^{oil}), and other income (T_t^{other}). Tax revenue equals the tax rate (τ_t) times nominal GDP (Y_t) and oil income equals oil production (Y_t^{pet}) times the international price of oil in dollars (P_t^{oilUS}) in terms of domestic currency (S_t^n). Other income is included mainly because it allows us to capture, for example, cases where the central bank transfers its annual operational gains to the finance ministry (SHCP).

$$\begin{aligned} T_t &= T_t^{tax} + T_t^{oil} + T_t^{other} \\ T_t^{tax} &= \tau_t \cdot Y_t \\ T_t^{oil} &= Y_t^{oil} \cdot P_t^{oilUSD} \cdot S_t^n \end{aligned} \quad \text{(Government income)}$$

We express variables as a percentage of potential real GDP ($z_t = \frac{Z_t}{P_t Y_t^*}$). In this way, they are stationary and expressed in the same units as the output gap. We then linearise the model around the steady state to obtain:[11]

$$
\begin{aligned}
t_t &= \lambda_1 x_t + \lambda_2 \tau_t + \lambda_3 x_t^{oil} + \lambda_4 p_t^{oil} + \lambda_5 s_t + \varepsilon_t^t && (1)\\
f_t &= \phi_1 d_{t-1} + \phi_2 i_{t-1} + \phi_3 i_{t-1}^{US} + \phi_4 p_{t-1} + \varepsilon_t^f && (2)\\
psbr_t &= -t_t + g_t + f_t + od_t + \varepsilon_t^d && (3)\\
b_t &= \kappa_1 b_{t-1} - \kappa_2 \pi_t + \kappa_3 (\Delta s_t^n - \pi_t^{US}) + psbr_t && (4)\\
b_t^h + b_t^f &= \left(\frac{1}{(1+\eta)(1+\pi_t)}\right) b_{t-1}^h + \left(\frac{1+\Delta s_t}{(1+\eta)(1+\pi_t^{US})}\right) b_{t-1}^f + psbr_t && (5)
\end{aligned}
$$

From the last equation, real domestic debt shrinks with domestic inflation and domestic potential GDP growth (η_t). Real foreign debt decreases with foreign inflation and domestic potential GDP growth. The value of foreign debt also fluctuates with change in the real exchange rate ($\Delta s_t = s_t - s_{t-1}$). In addition, we can see that since potential growth and the steady-state level of both domestic and foreign inflation are positive, for any level of debt different than zero, debt will naturally shrink. This implies that the steady state of both debt and the deficit can be positive, since the amount of real debt that shrinks at the steady state can be the same as the steady-state level of deficit. This equation also allows us to directly map a steady-state deficit level given the steady-state debt level, or vice versa. This characterisation explains why many countries can run permanent deficits and still be able to stabilise a positive level of debt. In this sense, debt will rise if the deficit is greater than its steady-state level.

3.3 Fiscal Rules and Risk Premium

Traditional models take government spending as an exogenous process. However, we will define government spending as the result of a fiscal rule that depends on the government's objective. We consider two rules. First, the deficit rule assumes that the government stabilises PSBR at its steady-state level. In addition, the government smooths changes in spending, as these changes can be costly.

$$g_t = \psi_1 g_{t-1} + (1-\psi_1)[t_t - f_t - od_t - psbr_{ss}] + \varepsilon_t^g \qquad \text{(Deficit rule)}$$

The second rule is the debt rule. In this case the government not only stabilises PSBR but also wants debt to return to its steady-state level. This rule is more ambitious, as it requires changes in spending of greater magnitude.

$$g_t = \psi_1 g_{t-1} + (1-\psi_1)[t_t - f_t - od_t - psbr_{ss} + \psi(b_t - b_{ss})] + \varepsilon_t^g \qquad \text{(Debt rule)}$$

A crucial component of this solid macroeconomic framework is the availability of buffers and policy flexibility to cope with external shocks. Indeed, rating agencies have expressed concerns regarding these risks for many years. They have highlighted the macroeconomic stability of the economy but also the weakness of the fiscal side and authorities' lack of flexibility in overcoming

[11] Appendix D shows the linearisation of these equations.

shocks. The recent pandemic may provide an example of this weakness. Sovereign risk, or country risk, is usually measured as the spread between the rate at which a sovereign government contracts debt in international markets and the risk-free rate. The spread is used in financial markets to indicate the risk of a government failing to fulfil its international financial obligations. The measure of country risk also affects the financing conditions of the domestic private sector, thus influencing economic activity of the country. In general, increases in sovereign risk translate into more stringent internal financial conditions for consumers and companies, which ends up affecting economic activity (Mendoza and Yue (2012), M. Uribe and Yue (2006)). Given the impact of sovereign risk on domestic financing costs and economic activity, the evolution of this variable, as well as its determinants, is important for the design of both fiscal and monetary policy.

The literature (Ghosh et al. (2013) and M. Uribe and Yue (2006)) recognises two main factors that lead to fluctuations in sovereign risk: the risk of economic default and risk appetite. The risk of default can be affected by domestic and external factors. Domestic factors are usually associated with fiscal policy and fiscal space. They depend on current and expected government expenditure, government revenue, economic activity, and in some cases the production levels of certain commodities that affect tax revenue, such as oil production in Mexico. External factors can be associated with global commodity prices, the economic activity of main trading partners, and other factors. Lizarazo (2013) argues that the risk premium not only reflects the probability of default, but also the conditions faced by international investors. The risk premium is also affected by changes in investors' wealth or risk aversion and changes in foreign assets' risk in investor's portfolio. Risk appetite is generally affected by global financial conditions (current and expected), global growth perspectives, uncertainty, and other factors. For example, Gilchrist et al. (2003) show that an important portion of the co-movement among sovereign spreads is accounted for by changes in global financial risk. In their model, an increase in global financial risk forces international banks to deleverage and reduce their investment in sovereign bonds. This in turn increases financing costs for governments, which increases sovereign risk.

Some studies show that for Mexico, the sovereign risk premium is affected by external and domestic factors.[12] The main external factors that explain risk premium movements are associated with changes in the VIX, the MOVE index and the price of oil. In domestic terms, economic activity, the primary deficit and exchange rate fluctuations are some of the factors behind these movements. The effect of oil prices and domestic factors are captured in our model through the effects on public debt.[13] In addition, public debt is a measure of government fiscal space. Higher levels of debt raise incentives for the government to default (Arellano (2008)). Then, as the probability of default increases, investors buying government debt require greater compensation. On the basis of these observations, and in order to have a more direct and easily captured effect in our model, we assume that the risk premium depends on the level of government debt and global risk (p_t^*).

$$p_t = \mu_1 d_t + \mu_2 p_t^* + \varepsilon_t^p \qquad \text{(Risk premium)}$$

As our measure of the risk premium, we use the J.P. Morgan EMBIG Mexico subindex, which is the difference between local debt, denominated in dollars, and U.S. Treasury bills. Our specification simplifies more general equations found in the literature. The variable used as a proxy for global risk is the VXO, which is interpreted as a reflection of financial market risk aversion, and which explains

[12] See, for example, Banco de México (2020) and Banxico (2015).

[13] Lower economic activity and oil prices lead to a wider public deficit, in both cases through lower taxes, and a wider public deficit adds more public debt. An exchange rate depreciation increases foreign debt, raising total debt.

to a great extent the co-movement of the risk spread faced by emerging market governments and U.S. corporate bonds.

We capture four channels through which monetary policy affects government debt: first, its effect on output, which affects tax revenue; second, its impact on the interest rate paid by the government on its financial liabilities; third, its effect on the real exchange rate, which alters the valuation of U.S. dollar-denominated debt; and fourth, its impact on the inflation trajectory, which deflates the real value of government debt. We find that the exchange rate channel is strong at first, but it rapidly fades as monetary policy returns to its equilibrium. By contrast, monetary policy has a strong and persistent effect on the value of local currency-denominated debt as it affects the price level.

4 Calibration and Estimation

We obtain the parameters of the model with a combination of calibration and estimation. First, we use quarterly data for Mexico corresponding to 2003Q1-2018Q4. In this period macro variables were stable and fiscal and monetary variables did not change considerably.[14] Second, we obtain the steady state of fiscal variables based on the criteria imposed by the Mexican finance ministry (SHCP).[15] Most of the parameters in the fiscal block are calibrated according to their linearisation and their accounting identities.[16] Third, parameters in the monetary block and the fiscal rule are estimated jointly using Bayesian estimation. As priors for the parameters we use values obtained when estimating each equation individually using the generalised method of moments. See the Appendix for tables with sources of information, symbols, and values of parameters.

5 Quantitative Results

We present five different shocks that have recently affected the Mexican economy. These exercises show how fiscal and monetary policy respond to shocks and help us to understand the interaction between the two. The five shocks are: a positive aggregate demand shock, a contractionary monetary policy shock, an expansionary fiscal shock, an increase in the global risk premium, and an increase in the price of oil.[17]

We show the impulse response function of a positive aggregate demand shock in Figure 4. In the monetary block a positive output gap has a direct but small effect on inflation through the equation of the Phillips curve. The monetary authorities face no dilemma over tightening their stance, as inflation and output are both increasing. Then, through the Taylor rule, the nominal and real interest rates increase. A higher interest rate appreciates the exchange rate through the UIP equation. In the fiscal block, a positive aggregate demand shock increases disposable income, which raises tax collection. The fiscal rule allows the government to expand spending while maintaining a positive primary balance. In this way, the government can reduce its borrowing requirements. The

[14] We do not include the Covid-19 pandemic because log-linearised models do not fare well when the economy deviates substantially from the steady state. The Covid-19 pandemic was a shock like no other and the effects would not be well represented by our model.

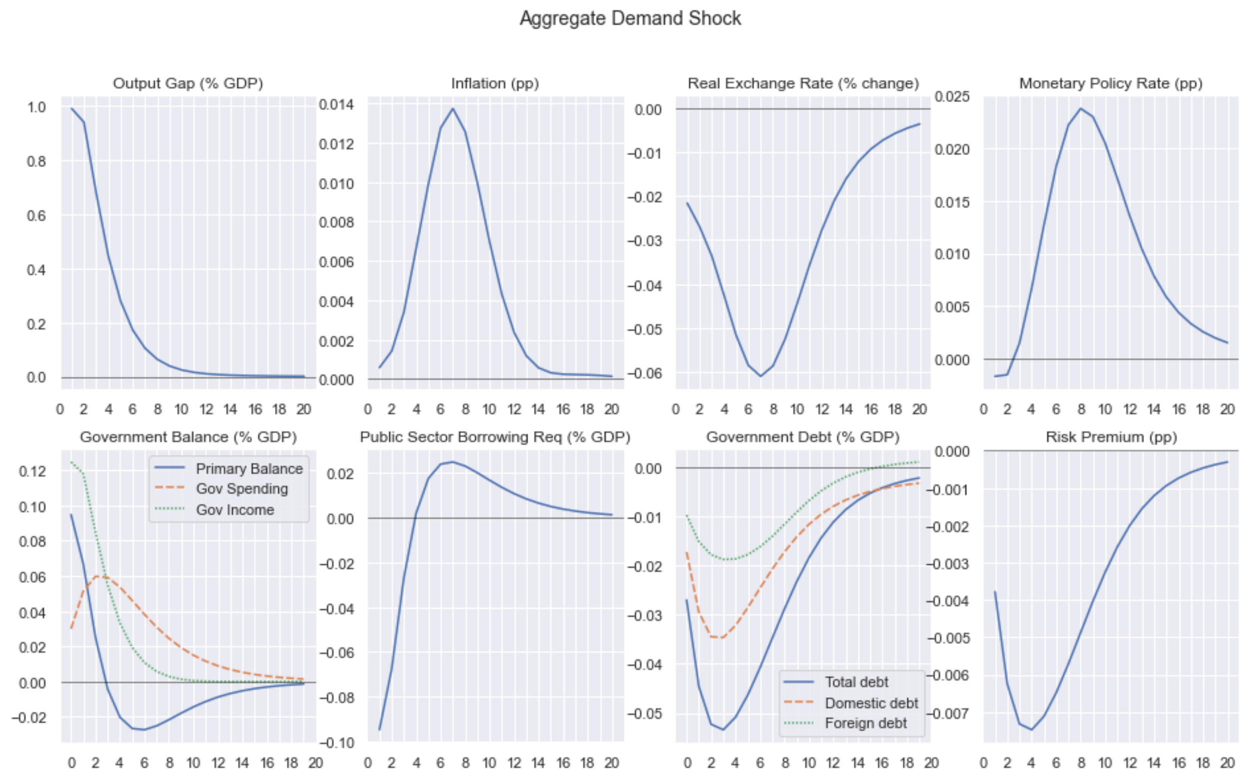
[15] See Appendix C. We also compare the observed values in 2016 and 2020 and expected for 2026 with the model steady state.

[16] See Appendix D for the linearisation of the accounting identities.

[17] In Appendix A we include diagrams of the transmission channels of each shock.

effects on the monetary and fiscal block variables lower government debt. Domestic debt deflates through inflation and foreign debt with the appreciation in the exchange rate. Total debt decreases because of the lower domestic and foreign debt and public sector borrowing requirements. Lower debt also reduces the risk premium, which has second-round effects on other variables that we will analyse in the context of the risk premium shock.

Figure 4: Impulse response to an expansionary aggregate demand shock.

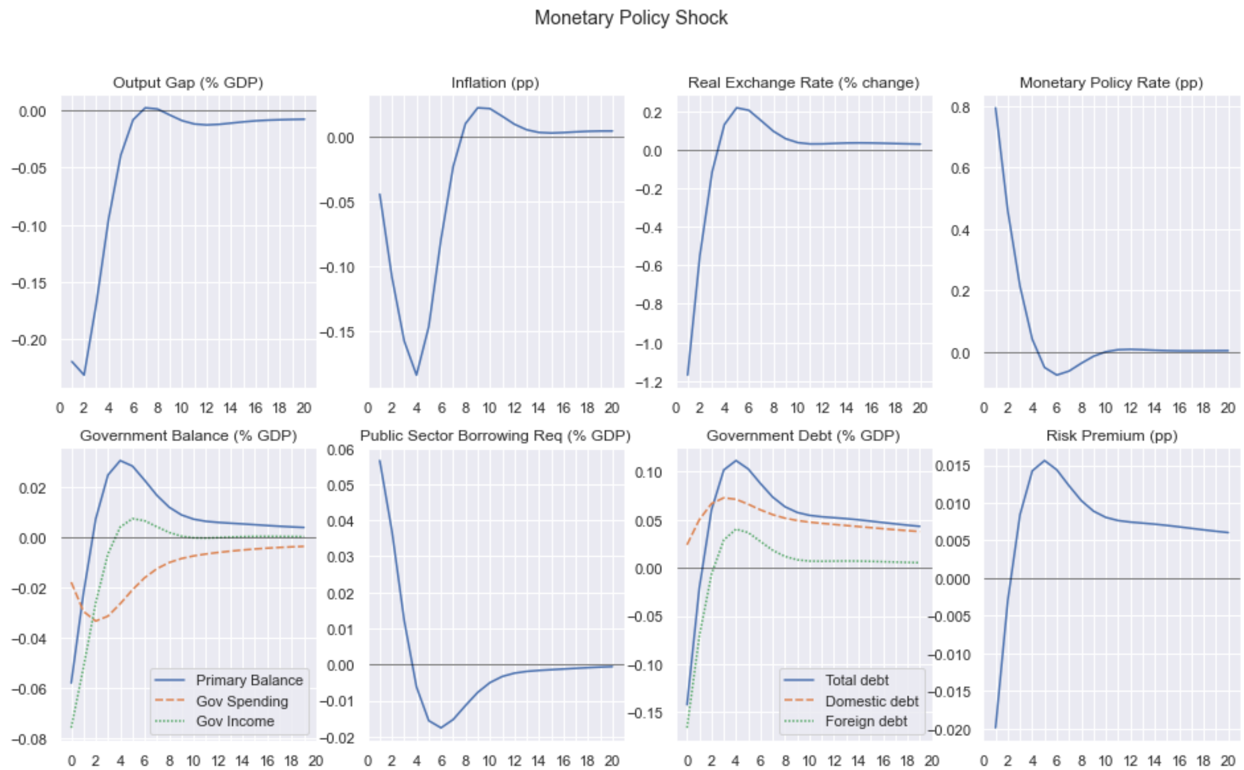


Response to a one standard deviation shock. Higher values for the exchange rate correspond to a depreciation. Inflation corresponds to the quarter on quarter change. The interest rate corresponds to the annual rate.

The positive aggregate demand shock exemplifies the fiscal rule's benefit of smoothing government spending. Consider, for example, the case where the government deficit is procyclical with the expansion of output. That is, government spending would offset higher tax revenue and increase borrowing requirements. This would lead to greater debt and a higher risk premium, feeding back negatively to output and the exchange rate. The central bank will be forced to react aggressively to stabilise the economy and rein in government spending through higher public sector financial costs. However, when the government smooths spending and lowers debt, it reduces the need for a sharp increase in the interest rate. Both policies work together in stabilising the economy.

The second shock is a contractionary monetary policy shock (Figure 5). In the monetary policy block, an interest rate hike appreciates the exchange rate and contracts output through the UIP equation and the IS curve, respectively. These two changes reduce inflation through the Phillips curve. In the fiscal block, an interest rate hike increases the public sector financial cost while lower output shrinks tax revenue. These two variables enter directly the fiscal rule, which leads to lower spending. Still, the primary balance weakens and public sector borrowing requirements increase. Domestic and foreign debt move in opposite directions, but the overall effect is an increase in public debt. On the one hand, the exchange rate appreciation shrinks foreign debt, and on the other hand, lower inflation increases domestic debt. In addition, increased public sector borrowing requirements increase both types of debt. Finally, growth in debt pushes up the risk premium.

Figure 5: Impulse response to a contractionary monetary policy shock.



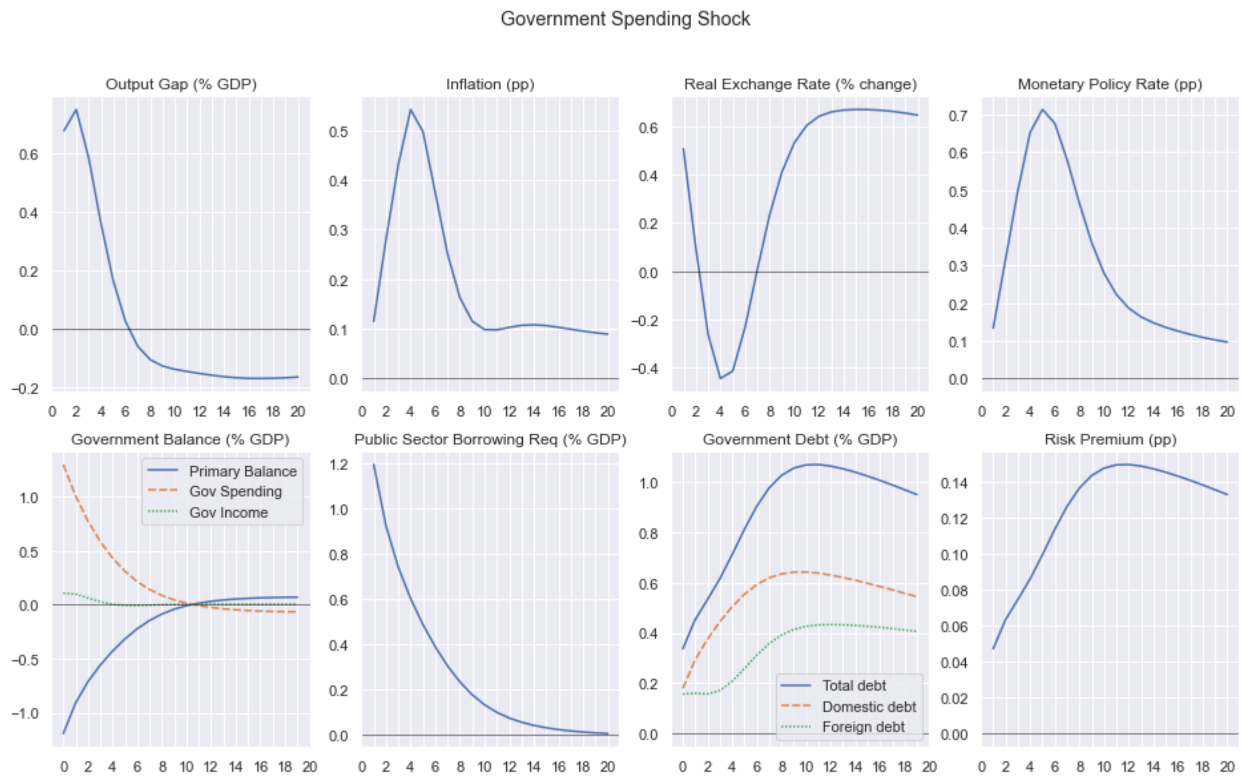
Response to a one standard deviation shock. Higher values for the exchange rate correspond to a depreciation. Inflation corresponds to the quarter on quarter change. The interest rate corresponds to the annual rate.

This exercise highlights the link between domestic financial conditions and public finances. An unexpected tightening in monetary policy negatively affects government finances as it increases public sector financial cost. The central bank might want to surprise markets, for example, by appreciating the exchange rate, lowering inflation, or dampening a domestic credit boom. But this would edge up the risk premium and could ultimately have the opposite of the desired effect.[18]

Next, we consider a discretionary increase in primary spending (Figure 6). As in the previous case, the policy response of the other authority could counter the desired effect. The direct effect is on aggregate demand through the IS equation. A positive output gap boosts tax revenue but not enough to balance the increase in government spending, and the primary balance turns negative. A positive output gap drives up inflation and forces the central bank to increase the policy rate. As in the first exercise, the central bank faces no dilemma over tightening its stance. This increases the public sector financial cost. Public sector borrowing requirements edge up from both sides. A negative primary balance and more expensive financial costs raise borrowing requirements. Public debt and the risk premium climb. Finally, the exchange rate depreciates with the shock due to a higher risk premium, and then appreciates in response to higher interest rates.

[18]For example, Alberola et al. (2021) consider conditions where a monetary tightening can lead to an exchange rate depreciation.

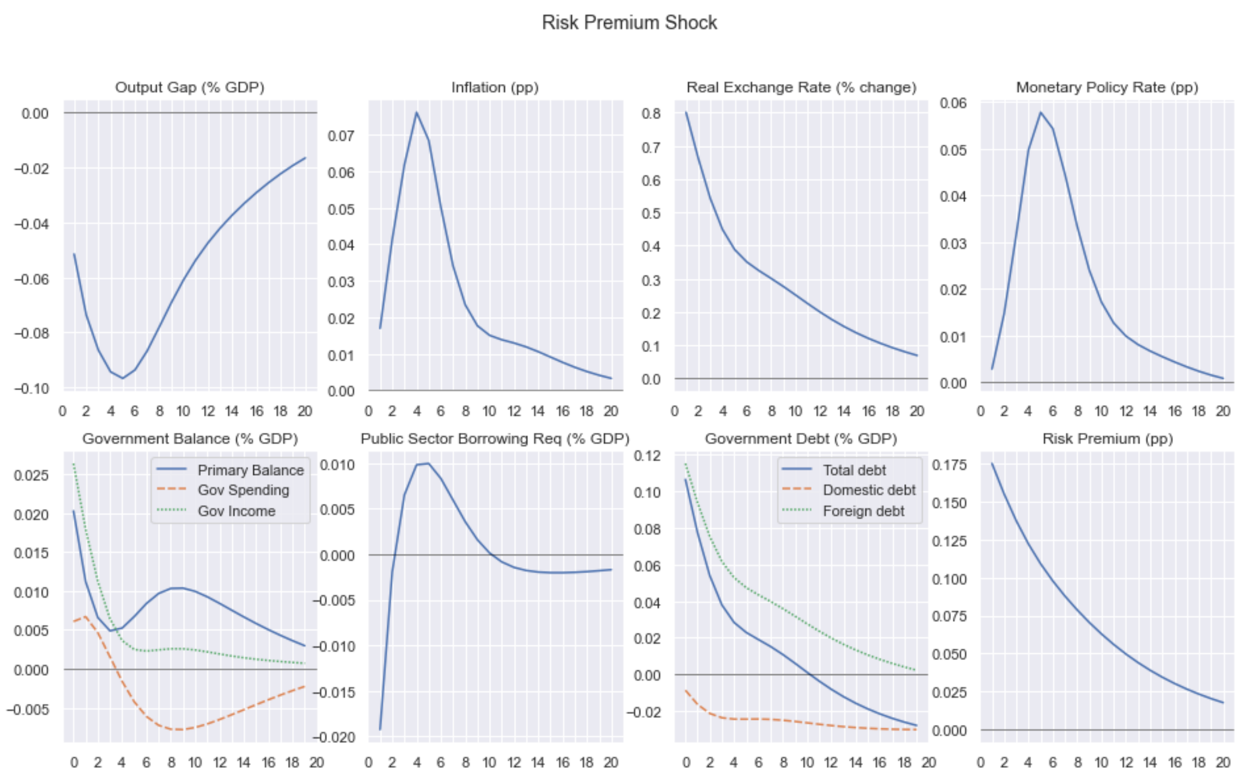
Figure 6: Impulse response to an expansionary government spending shock.



Response to a one standard deviation shock. Higher values for the exchange rate correspond to a depreciation. Inflation corresponds to the quarter on quarter change. The interest rate corresponds to the annual rate.

This exercise mirrors the earlier one. The government might want to stimulate growth through greater spending on such things as public works or clientelist programs. But two effects could lead to a worse outcome. First, government debt grows to finance the primary deficit, pushing up the risk premium. As the risk premium increases, output contracts. Second, the central bank tightens domestic financial conditions to control rising inflation, which then narrows the output gap. With an exogenous economic shock, as in the first example, both fiscal and monetary policy work together to stabilise the economy. By contrast, when the exogenous shock comes from one authority, the other authority has to react to stabilise the economy, reducing the initial effect of the shock.

Figure 7: Impulse response to a rise in global risk.

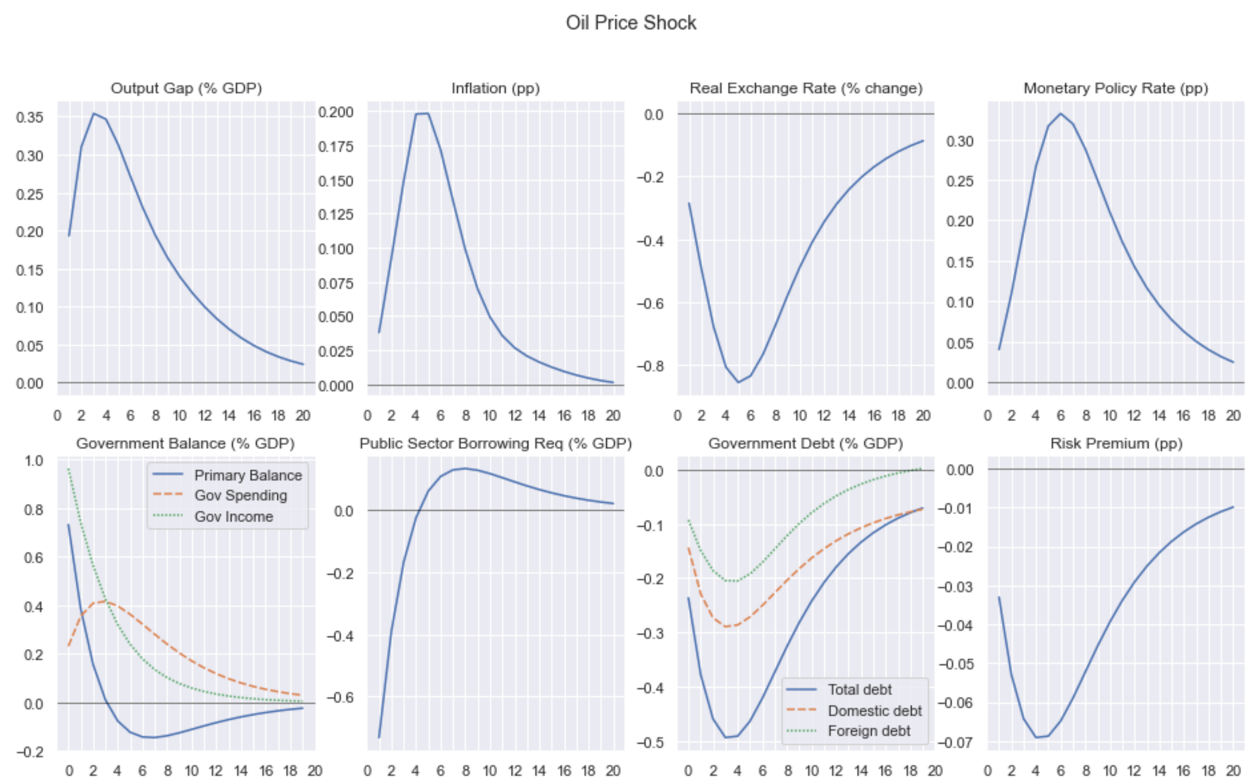


Response to a one standard deviation shock. Higher values for the exchange rate correspond to a depreciation. Inflation corresponds to the quarter on quarter change. The interest rate corresponds to the annual rate.

The fourth exercise considers the effects of a increase in the risk premium (Figure 7). In all of the previous exercises, the analysis stopped with the effect on the risk premium. However, there are important second-round effects, stemming from the change in the risk premium, that can amplify positive or negative effects on outcome variables and the reaction of policy authorities. The risk premium directly reduces output through the IS equation, depreciates the exchange rate through the UIP equation, and raises the public sector financial cost. In the IS equation the risk premium stands for the crowding-out effect of public debt on private investment. In the UIP equation it drives a wedge into the compensation of foreign investors for buying government debt, such as a higher compensation demanded for domestic assets. In the public sector financial cost, the risk premium accounts for the possibility that the government might default on its debt. Overall, it reflects a tightening of financial conditions. The response of the fiscal authority, driven by the fiscal rule, is to reduce spending. The government's aim is to offset the rise in financial costs and lower tax revenue, due to the negative output gap. The response of the monetary authority is to hike the policy rate. The central bank faces a dilemma, since inflation is increasing and output is decreasing. However, it tries to offset the rise in inflation driven by exchange rate depreciation. Finally, there are opposing effects on public debt, but the dominant ones are those that increase debt. On the one hand, less government spending (a positive primary balance) lessens the public sector borrowing requirements, and higher inflation deflates away domestic debt. On the other hand, a greater public sector financial cost increases borrowing requirements and exchange rate depreciation makes foreign debt more expensive. The latter effects dominate, increasing government debt.

This exercise also shows how monetary and fiscal policy can work together to counter the effects of a negative shock. Consider, for example, a surge in global uncertainty that leads to a sharp increase in the risk premium. Both policy authorities aim to reduce the vicious cycle of a higher risk premium leading to greater government debt, and vice versa. Both types of policy can compensate for the tightening of financial conditions: the government reduces spending to lessen its borrowing requirements, while the central bank raises the interest rate to offset exchange rate depreciation and greater foreign debt. If both authorities respond forcefully enough, together they can lessen public debt and counter the effect of increased global uncertainty.

Figure 8: Impulse response to an increase to the price of oil.



Response to a one standard deviation shock. Higher values for the exchange rate correspond to a depreciation. Inflation corresponds to the quarter on quarter change. The interest rate corresponds to the annual rate.

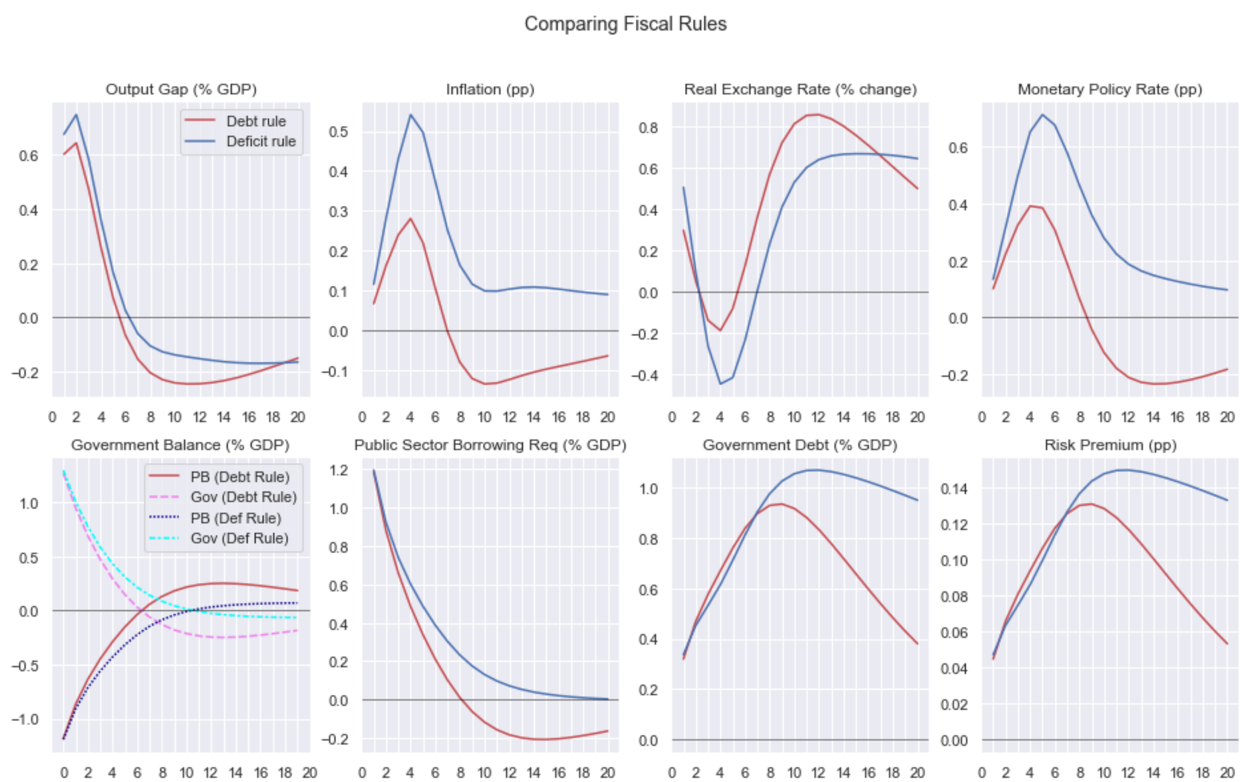
Our last exercise consists of a rise in the price of oil (Figure 8). For Mexico, this type of shock has two different effects. On the one hand, higher oil prices increase gasoline and gas prices, a negative supply shock. However, they also increase government tax revenue, which is a positive demand shock. Based on historical evidence, higher oil prices tend to be expansionary for Mexico.

Not only does the government receive more income, but the finances of the state-owned oil company (PEMEX) also improve. As PEMEX debt is implicitly guaranteed by the state, a healthier balance sheet also helps the government. The transmission mechanism and impulse responses are the same as in the first exercise.

5.1 Comparing Fiscal Rules

We compare the adjustment of government spending according to the fiscal rule. The debt rule implies that the government seeks to return its debt to the steady-state level in addition to lessening its borrowing requirements. In other words, bygones are not bygones: they must be reversed. Figure 9 compares the responses of the debt rule and the deficit rule to a government spending shock. With the debt rule, the government contracts its spending more to return debt more quickly to its steady-state level. This also has an important effect on the risk premium, which, after rising sharply, decreases more quickly. Another important difference is in the response of the monetary authority. With the debt rule, the monetary authority does not need to respond as aggressively as with the deficit rule, since the increase in inflation is smaller, the output gap is less positive and because the exchange rate appreciation is slighter. The former results from less government spending and the latter from a lower risk premium. This exercise illustrates how a stricter fiscal rule offers more degrees of manoeuvre to the monetary policy.

Figure 9: Comparing fiscal rules: government spending shock.



Response to a one standard deviation shock to government spending. Higher values for the exchange rate correspond to a depreciation. Inflation corresponds to the quarter on quarter change. The interest rate corresponds to the annual rate.

6 Conclusions

The design and implementation of monetary and fiscal policy should consider the interaction of each type of policy and its spillover into the economy. Fiscal and monetary decisions each influence the other's target through regular channels, such as economic activity, inflation and the exchange rate. But also through the sovereign risk channel, that affects the financial conditions of the economy. The sovereign risk premium is a key channel that is also affected by global financial conditions.

In this paper, we design and estimate a novel model tailored to the Mexican economy that captures these channels. It allows us to analyse their interaction in the Mexican economy, providing a powerful instrument for policy analysis. In particular, the model enables us to study how each policy complements or interferes with the other's stabilisation efforts. Especially that of monetary policy after a shock, considering that fiscal policy adjusts much more slowly. Indeed, a tighter fiscal stance allows monetary policy greater room for manoeuvre.

The most important findings are that a rise in risk premium will induce a complex environment for conducting monetary policy, in which inflation is high and output is low. Moreover, through the risk premium channel we explain why fiscal policy may be procyclical even with a fiscal rule. If the economy is in a recession and there is support from the fiscal side, this may help the economy in a countercyclical way. However, if there are doubts about fiscal sustainability, the risk premium will increase, dampening or even reversing the expansionary effect of fiscal policy. In an extreme case, fiscal actions may have a negative net effect on activity, becoming procyclical. We also find that monetary policy has a transitory effect on public debt by affecting the valuation of the real exchange rate, and a more persistent effect by affecting the inflation trajectory, which alters the real value of sovereign debt.

By working together both types of policy can compensate for the tightening of financial conditions: the government reduces spending to lessen its borrowing requirements, while the central bank raises the interest rate to offset exchange rate depreciation and greater foreign debt. If both authorities respond forcefully enough, together they can lessen public debt and counter the effect of increased global uncertainty.

These findings are important in light of recent macroeconomic developments in some emerging economies. In response to the Covid-19 pandemic, monetary and fiscal authorities in advanced and emerging market economies acted rapidly and strongly, in a coordinated way. Given that the size and nature of the shock is not a typical one over the business cycle, this type of episode cannot be analysed using our framework. However, it is still helpful to disentangle the channels through which the two types of policy interact in an open emerging economy and eventually design and communicate their exit strategies. This exit may not be coordinated, but each policy will have implications for the other that should be considered. As policies return to a (new) normal, rules like the ones described here will be crucial to keep and consolidate the confidence of investors and society, and have the necessary space and strength to take strong action in the face of an unusual shock. **It takes two** policies working together, as the authorities did in 2020, to counter the effects of such an extraordinary shock.

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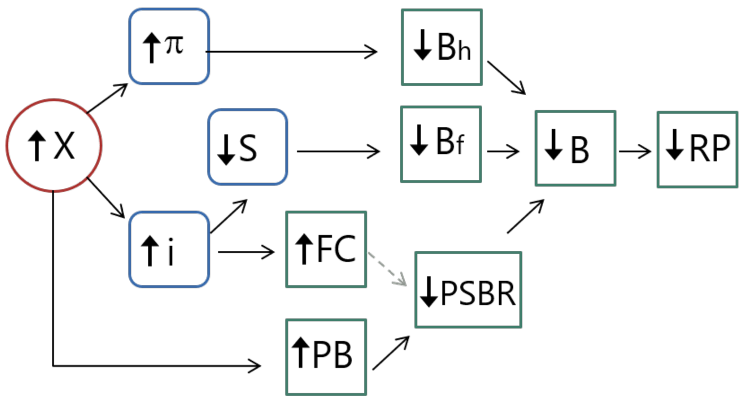
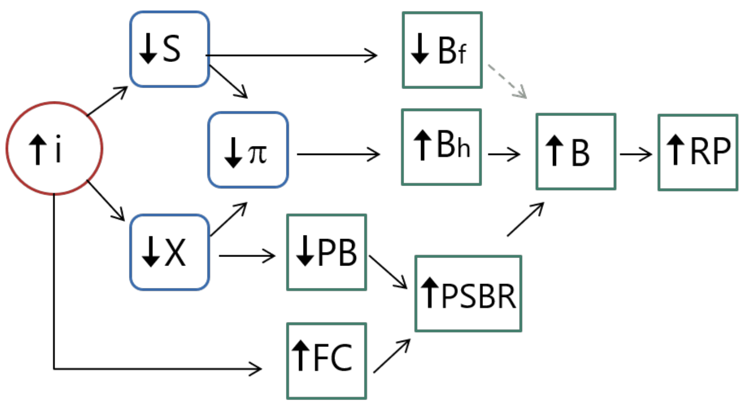
Appendix A Graphs

Figure 10: Transmission of an expansionary aggregate demand shock.



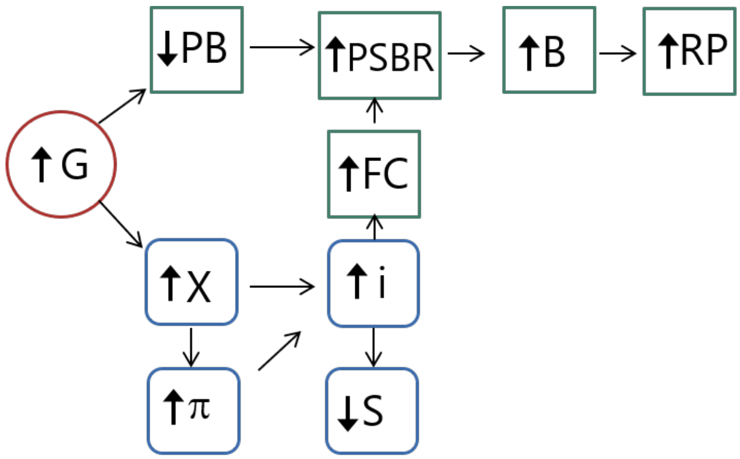
Note: i is the monetary policy rate, X the output gap, S the real exchange rate, π inflation, PB public balance, FC public sector financial cost, PSBR public sector borrowing requirements, Bh domestic debt, Bf foreign debt, B total debt, and RP risk premium. Dotted arrow signifies that the effect is weak.

Figure 11: Transmission of a contractionary monetary policy shock.



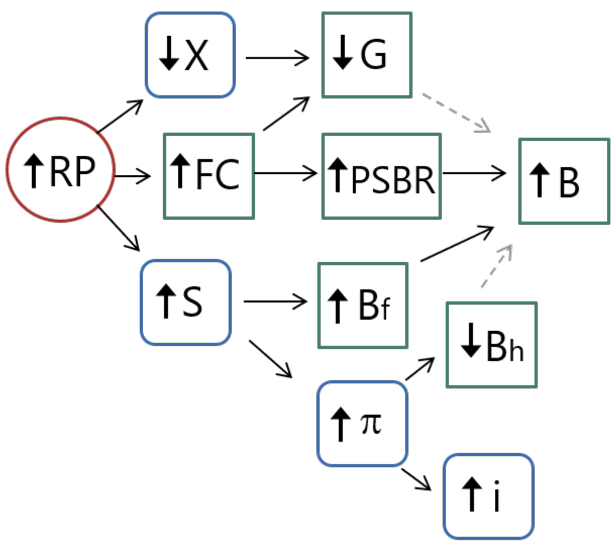
Note: i is the monetary policy rate, X the output gap, S the real exchange rate, π inflation, PB public balance, FC public sector financial cost, PSBR public sector borrowing requirements, Bh domestic debt, Bf foreign debt, B total debt, and RP risk premium. Dotted arrow signifies that the effect is weak.

Figure 12: Transmission of an expansionary government spending shock.



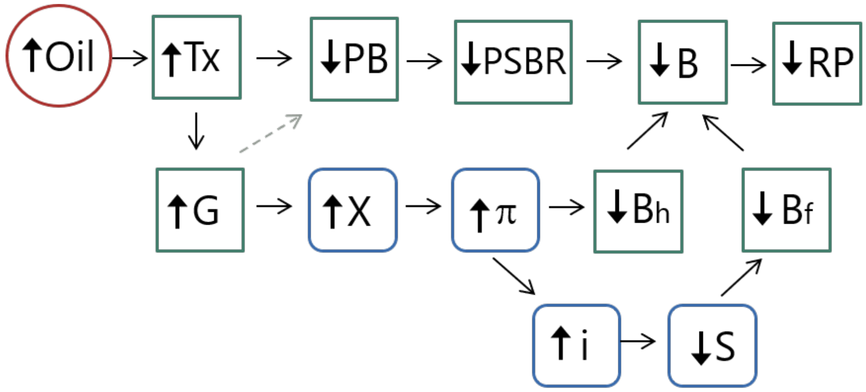
Note: i is the monetary policy rate, X the output gap, S the real exchange rate, π inflation, PB public balance, FC public sector financial cost, PSBR public sector borrowing requirements, Bh domestic debt, Bf foreign debt, B total debt, and RP risk premium.

Figure 13: Transmission of an increase in risk premium.



Note: i is the monetary policy rate, X the output gap, S the real exchange rate, π inflation, PB public balance, FC public sector financial cost, PSBR public sector borrowing requirements, Bh domestic debt, Bf foreign debt, B total debt, and RP risk premium. Dotted arrows signify that the effect is weak.

Figure 14: Transmission of an increase in the price of oil.



Note: i is the monetary policy rate, X the output gap, S the real exchange rate, π inflation, PB public balance, FC public sector financial cost, PSBR public sector borrowing requirements, Bh domestic debt, Bf foreign debt, B total debt, and RP risk premium. Dotted arrow signifies that the effect is weak.

Appendix B Tables

Table 1: Data Source

Series	**Source**
Real GDP	INEGI
Nominal GDP	INEGI
INPC core	INEGI
US-Mexico Exchange Rate	Bloomberg
Real GDP US	FRED
Nominal GDP US	FRED
Government Income	SHCP
Tax Income	SHCP
Oil Income	SHCP
Government Expenditure	SHCP
Public Financial Costs	SHCP
Public Deficit	SHCP
Total Deficit	SHCP
Total Debt	SHCP
Home Debt	SHCP
Foreign Debt	SHCP

Table 2: Data Specification

Variable	**Symbol**	**Description**
Output Gap	x_t	Detrended with an HP filter w/tail correction.
Core Inflation	π_t	Quarterly change and seasonal adjustment with X12.
Real Exchange Rate	s_t	The nominal exchange rate adjusted by the GDP deflators of the US and Mexico. Then a natural logarithm is applied.
Monetary Policy Rate	i_t	Adjusted to quarterly by taking the end-of-period rate.
Government Income	t_t	The monthly data is added quarterly and divided by the GDP deflator and by Trend GDP.
Tax Income	t_t^{tax}	Quarterly data (% GDP)
Oil Income	t_t^{oil}	Quarterly data (% GDP)
Government Expenditure	g_t	Quarterly data (% GDP)
Public Financial Costs	f_t	Quarterly data (% GDP)
Total Deficit	d_t	Quarterly data (% GDP)
Total Debt	b_t	Quarterly data (% GDP)

Table 3: Calibration

Symbol	Value	Description
Monetary block:		
Is curve		
α_1	0.37	Estimated
α_2	0.32	Estimated
α_3	0.12	Estimated
α_4	0.01	Estimated
α_5	0.30	Estimated
α_6	0.19	Estimated
α_7	0.31	Estimated
α_7	0.35	Estimated
Phillips curve		
β_1	0.30	Estimated
β_2	0.03	Estimated
β_2	0.01	Estimated
UIP		
γ_1	0.73	Estimated
γ_2	0.70	Estimated
γ_3	1.4	Estimated
Taylor rule		
δ_1	0.67	Estimated
i	5.5	Calibrated
δ_2	1.58	Estimated
δ_3	0.34	Estimated
Fiscal block:		
Government income		
λ_1	0.13	Calibrated
λ_2	τ_t	
λ_3	3.14	Calibrated
λ_4	0.07	Calibrated
λ_5	0.03	Calibrated
Public Financial Cost		
ϕ_1	0.055	Calibrated
ϕ_2	0.33	Calibrated
ϕ_3	0.16	Calibrated
ϕ_4	0.49	Calibrated
Total debt		
κ_1	0.98	Calibrated
κ_2	0.33	Calibrated
κ_3	0.16	Calibrated
Fiscal rules		
ψ_1	0.76	Estimated
Risk premium		
μ_1	0.06	Estimated
μ_2	0.99	Estimated

Appendix C The Fiscal Block Steady State

The steady-state levels of the fiscal block variables are related according to the accounting identities that characterise it:

- We start by defining the steady state (SS) of the PSBR and the public balance according to the figures considered by the finance ministry (SHCP) in its General Criteria for Economic Policy 2018 (2.5% and 2.0% of GDP respectively). By definition, the SS of the "other deficits" (0.5% of GDP) is the difference between the PSBR and the equilibrium public balance.
- Given the dynamic debt equation, we obtain the equilibrium debt level (49.7% of GDP) given the SS of the PSBR and our assumptions of potential economic growth (2.4%) and equilibrium inflation (3%).
- Given the historical proportion of internal and external debt, its equilibrium levels are obtained (33.8% and 15.9% of GDP, respectively).
- From the financial cost equation, using the SS of the debt and the equilibrium interest rates of Mexico (5.5%) and the United States (3%), we obtain the equilibrium financial cost (2.7% of GDP).
- From the PSBR, the "other deficits" and the equilibrium financial cost, the primary balance of the steady state is obtained (0.7% of GDP).
- Public revenue in the SS is obtained from the sum of its components in equilibrium (23.6%). Tax revenue (13.4% of GDP), oil revenues (4.4% of GDP), organisations and companies (3.8% of GDP), and other income (2.0% of GDP) are assumed to continue around the levels that have been observed in the previous two years.
- The balance primary expenditure (25.6% of GDP) is obtained from public revenue and the balance primary balance.

Table 4: Observed and steady state values

	Observed 2016	**Observed 2020**	**Expected (2026) SHCP**	**Model SS**
Real % GDP Growth	2.4	-8.5	2.5	**2.4**
CPI Inflation	2.8	3.4	3	**3**
GDP Deflator	5.6	2.9	3.4	**3**
Public Revenues	24.8	23.3	22.7	**23.6**
Tax Revenues	13.9	14	14.4	**13.4**
Oil Revenues	4	3.5	4.7	**4.4**
Public Spending	27.4	26.2	24.7	**25.6**
Financial cost	2.4	2.2	2.3	**2.7**
Primary Balance	-0.1	0.7	1.1	**0.7**
Public Balance	-2.6	-2.9	-2	**-2**
PSBR	-2.8	-4.7	-2.5	**-2.5**
HSPSBR	50.1	45.6	52.2	**49.7**

Appendix D Linearisation

Tax revenue

- The nominal equation $T_t^{trib} = \tau Y_t$ is deflated and divided by the potential GDP:

$$\widehat{T_t^{tax}} \equiv \frac{T_t^{tax}}{P_t Y_t^*} \cdot 100 = \frac{\tau Y_t}{P_t Y_t^*} \cdot 100 = 100\tau \frac{Y_t^r}{Y_t^*}.$$

- Decomposing the real GDP into its potential and cyclical factors obtains: $Y_t^r = Y_t^*(1 + \frac{x_t}{100})$, such that

$$\widehat{T_t^{tax}} = 100\tau \left(1 + \frac{x_t}{100}\right) = 100\tau + \tau x_t \quad \text{and} \quad \tau = \frac{\widehat{T_{ss}^{tax}}}{100}.$$

- Let $\tau_0 = 100\tau$; $\tau_1 = \tau$ and adding an error term, tax revenue is expressed as:

$$\widehat{T_t^{tax}} = \tau_0 + \tau_1 x_1 + \varepsilon_t^{tax}.$$

Oil revenue

- We start with the nominal restriction:

$$T_t^{oil} = Y_t^{oil} \cdot P_t^{oil} \cdot S_t^n.$$

- The restriction is divided by the price index to express it in real terms, and the oil price is expressed in real terms:

$$\frac{T_t^{oil}}{P_t} = Y_t^{oil} \cdot \frac{P_t^{oil}}{P_t^{US}} P_t^{US} \cdot \frac{S_t^n}{P_t} = Y_t^{oil} \cdot p_t^{oil} \cdot S_t^n \cdot \frac{P_t^{US}}{P_t}$$

- Since $s_t \equiv S_t^n \cdot \frac{P_t^{US}}{P_t}$:

$$\frac{T_t^{oil}}{P_t} = x_t^{oil} \cdot p_t^{oil} \cdot s_t.$$

- Dividing by potential GDP:

$$\widehat{T_t^{oil}} \equiv \frac{T_t^{oil}}{P_t Y_t^*} = \frac{x_t^{oil}}{Y_t^*} \cdot p_t^{oil} \cdot s_t = \widetilde{x_t^{oil}} \cdot p^{oil} \cdot s_t.$$

- Doing a first-order Taylor approximation obtains:

$$\widehat{T_t^{oil}} = \widehat{T_{ss}^{oil}} + (\widetilde{x_{ss}^{oil}} \cdot s_{ss})(p_t^{oil} - p_{ss}^{oil}) + (p_{ss}^{oil} \cdot s_{ss})(\widetilde{x_t^{oil}} - \widetilde{x_{ss}^{oil}}) + (p_{ss}^{oil} \cdot \widetilde{x_{ss}^{oil}}) \cdot (s_t - s_{ss}),$$

- Grouping all constant terms on a intercept obtains:

$$\widehat{T_t^{oil}} = \lambda_0 + \lambda_1 \widetilde{x_t^{oil}} + \lambda_2 p_t^{oil} + \lambda_3 s_t + \varepsilon_t^t.$$

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