THE INTERDEPENDENCE OF FISCAL AND MONETARY POLICY

POLICY MIX IN A SMALL OPEN EMERGING ECONOMY WITH COMMODITY PRICES

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Abstract

The article analyzes the interaction between monetary and fiscal policy in Mexico. A semi-structural model for a small open economy, based on Aguilar & Ramírez-Bulos (2018), is calibrated for Mexico using quarterly data from 2001 to 2020. The fiscal policy block models the fiscal deficit depending on output, an endogenous sovereign risk premium, a state-owned oil company and public debt dynamics with domestic and foreign components. A fiscal rule is assumed whereby the deficit has an upper bound. The monetary policy follows a Taylor rule. We study the effects of different shocks on the economy such as a worsen in commodity prices, an expansion of public spending, an increase in the risk premium, a hike in the interest rate and a real exchange rate depreciation. We show that, remarkably, the risk premium channel transmit threats on the fiscal block to the monetary block, calling for the central bank to stabilize inflation. Whereas, starting at the economy's steady state, an exogenous monetary policy shock affects the fiscal block mainly through the interest rate influencing the debt service, leading to a fiscal response to stabilize deficit.

JEL Codes: C61, C68, E17, E47, E52, E62, E63, F41, H62, H63.

Keywords: small open economy, emerging economy, policy mix, commodity prices, risk premium.

*The views and conclusions presented in this papers are exclusively the responsibility of the authors and do not necessarily reflect those of Banco de México.

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1 Introduction

Lately, during the Global Financial Crisis (GFC), and more recently, for the Covid-19 crisis, negative commodity prices shocks have considerably affected the global economy, particularly emerging market economies that export commodities. Additionally, given the stronger integration of emerging market economies with global financial markets, the global cyclical conditions and interest rates in advanced economies play a key role on both domestic fiscal and monetary policy. Through the lens of a small open emerging economy that exports goods and commodities, we determine what would be the response of both fiscal and monetary policy-makers to different shocks, either locally and globally, in order to maintain the budget balanced and the inflation stable, respectively.

We study the case of Mexico. Mexico is a typical small open emerging-market economy and has a strong fiscal component linked to oil prices since Mexico's government owns PEMEX, the main firm allowed to extract and exploit oil in Mexico. Let us put the magnitude of the fiscal component in perspective: in 2019, total exports of Mexican economy represented almost 40% of GDP among which 77% of exports aimed at the US economy, and 16.4% of total exports are commodities. As for the fiscal accounts, oil revenue from PEMEX between 1990 and 2019 represents almost 6% of GDP and 28% of total government revenue.[1] After the GFC and the Covid-19 crisis, the public revenues and debt linked to oil industry have been negatively affected due to the international prices of oil registering a considerable drop, and to the downgrade of PEMEX's debt rating, which in turn has negatively impacted the country risk premium.[2]

Note that the impact of oil price shocks on inflation has declined over time due mostly to a better conduct of monetary policy in most advanced and emerging countries (Choi et al. 2018). However, Chatziantoniou & Filis (2014) stress that financial markets are more sensitive to an increase in oil price when those markets are newly established or when they are less liquid. These characteristics apply to Mexico since, in comparison to advanced economies, the Mexican financial market (Bolsa Mexicana de Valores) remains small and sensitive to external shocks and needs further instruments to increase its liquidity and efficiency (Skelton 2011).

In existing DSGE models, oil prices enter as a mere supply shock, hence a boom in the oil sector constrains factor markets and crowds out non-oil activity, corresponding to the phenomenon of the so-called Dutch disease. However, Bergholt (2014) and Bergholt et al. (2019) introduce a DSGE model that allows demand shocks driven by oil prices,

[1] See the Timely Public Finances Statistics, Ministry of Finance, April 2020.

[2] As a measure of sovereign risk premium in this model for Mexico, we use the EMBI-G spread (Emerging Market Bond Index Global elaborated by JP Morgan) that should reflect the fiscal performance. This particular index reflects the stock of debt including PEMEX's debt. Furthermore it is commonly used in the literature, measures the sovereign default risk and is constructed as excess promised returns on the US treasury, including Brady bonds, loans, and dollar-denominated Eurobonds with a face value of at least $500 million.

depending of the structure of the economy. This type of model also generates a real appreciation of local currency for positive oil-price shocks due to the gains in terms of trade, and generates a boost in non-oil activity. In our analysis, we consider oil-price shocks as a demand shock that better resembles to Mexican economic structure because the oil-price shock is similar to a government spending shock, constituting an oil-specific demand shock (Kilian 2009, Stevens 2015, Bergholt et al. 2019). One issue in many models reproducing the effects of oil-price shocks on the macroeconomic activity is that they can only analyze a positive oil-price shock, assuming a negative oil price shocks leads to asymmetric consequences (Bergholt 2014). The model used in this paper considers an oil price shock as a demand shock that incorporates endogenous sovereign risk premium proxied by the EMBI-G that allows to model positive and negative oil-price shocks.

The model used in this paper is based on the work of Aguilar & Ramírez-Bulos (2014, 2018). The authors first study two different fiscal rules and their effect on social welfare and then examine the effect of fiscal policy on monetary policy. The model in this article shows the interaction between fiscal and monetary policy for a small open emerging market economy exporting commodities when addressing each of the policy objectives and their effect on the main macroeconomic variables using quarterly data from 2001 to 2020 for Mexico. We further add to this literature by considering, for an emerging market small open economy, the interaction between different transmission channels belonging to both fiscal and monetary blocks that eventually impact activity and inflation. Extending Aguilar & Ramírez-Bulos (2014, 2018), we adapt their model thereby allowing us to identify further mechanisms with an important role in the relation between the policy interest rate, the aggregate public debt, and the risk premium and where the variables can converge to their steady state value faster in the model used in this article, after shocks. In particular, we obtain different responses. In this model, an exogenous increase in the risk premium, e.g., derived from a higher level of uncertainty, leads to a reduction in public spending and, given that tax revenues fall more rapidly, an increase in the fiscal deficit (measured by the Public Sector Borrowing Requirements, PSBR). This result contrasts with Aguilar & Ramírez-Bulos (2014, 2018) where initially, on impact, the fiscal balance is improved and the public spending increases, although in later periods, public spending drops and fiscal balance deteriorates. In particular, the increase in the risk premium leads to a depreciation of the exchange rate and, consequently, an increase in inflation. It also translates into a drop in economic activity, since uncertainty inhibits private investment, and therefore a fall in tax revenues. The latter implies an increase in the public debt service and a deterioration of the fiscal balance. The main result that we obtain is that shocks that are positively impacting public spending leads to a rise in the policy interest rate due to inflationary pressures. A further interesting result is that setting the policy interest rate after a given shock can affect the evolution of public finance, yielding a fiscal deficit.

In the event of supply and demand shocks affecting both fiscal and monetary blocks, we describe the conduct of policy making that helps the economy to go back to the steady state faster than in Aguilar & Ramírez-Bulos (2018). We assume that the fiscal policy always remains passive in the sense of Leeper (1991, 2016), meaning that the fiscal policy aims to have balanced public finances even in the event of shocks. Maintaining this hypothesis, after a positive shock on risk premium or a depreciation of the domestic currency, the central bank has to increase the interest rate to stabilize inflationary pressures. In addition, after a positive shock of public primary spending, a shock deteriorating fiscal position, or an increase in oil prices, the central bank should raise its interest rate to face inflationary pressures.

The rest of the paper is organized as follows. Section 2 presents the current debates in the literature of policy-mix. Section 3 analyzes the recent evolution of fiscal policy in Mexico and sovereign risk, as well as the data used for the model and some brief descriptive statistics. Section 4 describes the model structure and its main characteristics, including the calibration for the parameters. Section 5 presents Impulse-Response functions that illustrate the model mechanisms, and discusses interactions between both policies and other promising research ideas. Section 6 concludes.

2 Related Literature

Extending the work of Aguilar & Ramírez-Bulos (2014, 2018), we consider oil-prices shocks since commodities prices affect the Consumer Price Index (CPI), and as they contribute to public revenues, the consequences occur on both monetary and fiscal policy. Such interactions raise the question of finding the most efficient policy mix. As largely debated in the literature, two possible combinations of policy mix (Leeper, 1991, 2016) exist, one where the active monetary policy targets inflation by moving nominal interest rate more than proportionately with inflation, while the passive fiscal policy manages tax collecting moving positively alongside with government debt in order to cover real debt service and total debt. A second possible combination for policy mix is when the central bank sets its nominal interest rate in a passive way responding to inflation less than one-for-one to avoid interest payments of public debt from destabilizing the debt service, whereas the fiscal policy does not make taxes reacting automatically to the level of public debt.

Furthermore, the indebtedness and the probability of going into default is a prominent debate in the sovereign default literature in emerging economies. A wide strand of its literature supports that default is extremely likely to happen if both policies are active in the sense of Leeper (1991, 2016). That is, the monetary authority implements an inflation targeting strategy and the tax policy stays exogenous (Uribe 2006). However, in emerging market economies, the predicted level of government debt at which the sovereign default can occur is much lower than the debt level at which sovereign risk premium is observed in developed countries (Bi 2012). Furthermore, for emerging market economies, the lower level of productivity not only reduces tax revenues, leading to higher levels of public borrowing, but also shifts down the state-dependent distribution of fiscal limits. The latter raises the default probability even if the debt stock remained at the same level. In short, a higher stock of debt, along with the lower distributions of fiscal limits, pushes up the sovereign borrowing cost, which worsens the government budget. This mechanism can produce, for example, a higher risk premium during a recession.

The literature suggests there ought to be an even deeper need of coordination between fiscal and monetary policy in emerging market economies. The effect of public spending on aggregate output depends on three idiosyncratic elements: first, the responsiveness of risk premia to changes in public indebtedness; second, the length of time during which monetary policy is expected to be constrained if fiscal policy is active; and finally, the sensitivity of tax revenue to economic activity (Corsetti et al. 2013). As a matter of fact, the sensibility of risk premium to variations of debt is shown to be higher in emerging market economies exporting commodities, and so is the sensitivity of tax revenue to economic activity due to the volatility of oil prices. Countries with large fiscal imbalances present the feature that fiscal policy may affect exchange rates through the risk premium channel (Giorgianni 1997). Indeed, without fiscal discipline in a context of high public debt with a short-average maturity, the concerns about sovereign debt sustainability significantly increase the risk premium, if the latter is assumed to reflect the performance of fiscal policy (Bi 2012).

Additionally, the conduct of monetary policy may radically worsen the public finance stance. Several studies, including Blanchard (2004) and Favero & Giavazzi (2004), show the role of debt dynamics on the performance of inflation targeting. These studies imply that, after a sovereign risk-premium shock, the risk-premium channel could actually further modify the price level in the economy when the central bank follows a tight monetary policy depending on the fiscal response (Bi 2012, Corsetti et al. 2013). On one hand, without any credible fiscal contraction, a tighter monetary policy associated with higher real interest rates would increase the debt service burden and could actually lead to capital outflows due to a flight to quality, and eventually to a depreciation of the domestic currency by increasing the sovereign risk premium, assuming for risk averse investors (Aktas et al. 2010). On the other hand, in the presence of a credible fiscal contraction, the risk-premium channel manifests itself by a lower risk carried by home-currency denominated assets, which increase their demand and finally could appreciate domestic currency (Giorgianni 1997). A higher sovereign risk premium that leads to a credible fiscal contraction in an economy with a large stock of public debt may produce two consequences. First, the fiscal contraction reduces the amount of public debt being held by domestic and foreign investors. Second, it lowers uncertainty about future taxation, making the economy less sensitive to external shocks. According to Corsetti et al. (2011, 2013), the risk-premium channel reduces the fiscal multiplier because it dampens aggregate demand through the fiscal tightening in the absence of any credible fiscal response.

3 A Look at the Recent Evolution of Fiscal and Monetary Policy in Mexico

3.1 The Fiscal Policy

Since the GFC, and more recently, through the Covid-19 crisis, the Mexican economy has been negatively affected by a number of simultaneous shocks. These shocks have impacted public finance in Mexico. In this section, we describe the current fiscal stance in Mexico as it holds some country-specific arrangements.

During the GFC, the Mexican economy was affected by a contraction in output and consequently, a fall in public revenue. Additionally, since 2014, the international prices of oil registered a considerable drop combined with a downward trend in PEMEX's oil production, which has led to a sharp reduction in oil-based public revenues. Given these elements, the fiscal authority was allowed to temporally widen the public deficit, under the clauses of the Fiscal Responsibility Law in 2014. In the following years, the fiscal consolidation process was postponed, causing greater public deficits and, therefore, a higher total debt-to-GDP ratio. Negative oil-price shocks gradually led to a deterioration in the terms of trade as oil-price shocks corresponds to demand shocks in the Mexican economy, since negative oil price shocks lower government's revenue, which implies a negative government spending shock (Stevens 2015).

The decline in terms of trade contributed to a domestic currency depreciation since the end of 2014. This currency depreciation has been essentially caused by the oil-prices drop since the end of "the commodity super-cycle". In this context, the current account deficit in terms of GDP deepened due to a reduction in oil exports. To sum up, in addition to a sharp domestic currency depreciation, the evolution of public spending and income has led a significant increase in the stock of public debt, from 32.9% to 44.9% GDP between 2008 and 2018. In April 2019 the government reoriented PEMEX's objectives to help the company face structural challenges such as oil prices volatility and re-orientating production goals.[3] In particular, the current PEMEX Business Plan entails changes for the fiscal policy in the short term. The Business Plan in 2019 forecasts that direct taxes paid by the firm eventually show an upward trajectory given an increase in production. On the other hand, despite the tax reform implemented in 2014, tax-to-GDP revenues have decreased, while also decreasing its share in total revenues. Indeed,

[3]For a detailed description, see the "PEMEX Business Plan" Box in the April - June 2019 Banco de Mexico Quarterly Report, pp. 42-45.

oil revenue between 2015 to 2019 represents around 4% GDP, whereas between 2005 and 2014 oil revenues represented around 7.5% GDP. As a consequence of the slowdown in tax revenues, the government has tapped resources from the Budgetary Income Stabilization Fund (BISF). The BISF is a fiscal buffer in Mexico, that operates as a counter-cyclical mechanism allowing fiscal compensation when public revenues are lower in order to reach the fiscal objective given by the Law of Federal Revenue.[4]

In addition, there has been an increase in the Mexican sovereign risk premium, measured by the EMBI-G which includes PEMEX's debt. This can lead to a negative effect on activity and a depreciation of the exchange rate.

Yet, since 2016, the Ministry of Finance has carried out fiscal consolidation process. In 2017 the government obtained a primary surplus of 0.4% of GDP for the first time since 2008. In 2018, the government reached its deficit target of 2.5% of GDP, being measured by PSBR.

However, in 2019, the fiscal target was not reached, if one excludes the use of the BISF. The IMF warned of a slight deviation from that target in 2019, due to a weaker income. Although, the IMF already points out the need to take additional measures to increase income or reduce spending, in order to avoid generating additional fiscal gaps for 2020. Thus, in late 2019, the foreseen deficit was 0.5% to 1.5% of GDP for 2020-2024.[5] Furthermore, in the medium term, the deficit should reach a debt of 55% GDP.

A foreign interest rate shock, added to a negative both oil prices and a tax shock result in generating more volatility and therefore high uncertainty for the Mexican economy and public finance outlook for 2020. These numerous shocks pose the challenges for the fiscal policy to attain a reasonable deficit and level of public debt, and raise the question of which monetary policy should be conducted to minimize the impact of those shocks on the exchange rate, inflation and activity, while fiscal policy aims at maintaining sustainability of debt.

Indeed, if the primary deficit deteriorates, the PSBR increases. The latter raises the sovereign risk, and consequently yields a depreciation of the exchange rate. In particular, an increase in the interest rate accommodates the higher inflation derived from the initial expansion of activity and the depreciation of the exchange rate.

3.2 Monetary Policy

The Mexican economy has experienced a period of increasing inflation rates from the 1970's to the early 1990's, generated by the implementation of excessively expansionary policies, as well as the obligation imposed on the central bank to extend credit to finance

[4]The Budgetary Revenue Stabilization Fund is not explicitly included in the model in this paper but can be introduced in the form of a positive shock to public spending. This tool was originally created in 2001 for compensating losses in public revenues from oil activity, due to the volatility of oil prices.

[5]See Article IV-Consultation Report for Mexico, IMF (2019).

the fiscal deficit. Indeed, if we consider the 1990-2017 period, the average annual inflation rate was around 10.1%, but if we consider the period 2001-2017, the average annual inflation rate falls to 4.3% (López Hernández 2018). This period of high inflation provoked the modification of the legal nature of the central bank, Banco de México, in 1993 making it an autonomous state body and with the unique mandate of ensuring price stability with a long-term commitment.[6] The independent status of the central bank was in line with the international trend that aimed at modifying the legal relations between the government and the central bank, as well as giving it greater credibility and transparency.

In this regard, the central bank's autonomy is defined by three fundamental pillars: exclusive capacity to determine its own credit (very strict limit to grant a credit to the government if the central bank decided so), independence from the government (the Board of Governors is appointed by the president but approved by the Senate, with mandates that are disconnected from the political cycle of the presidency) and the autonomy of its administration. Furthermore, two purposes related to the fulfillment of its mandate were added: i) promoting the development of the financial system and, ii) to promote the proper functioning of payment systems.

Later on, in 2001, Banco de México formally adopted a flexible inflation targeting regime as a framework for conducting monetary policy and fully complying with its constitutional mandate. Consequently, it was established that, as of 2003, the permanent inflation target would be a percentage change of the National Index of Consumer Prices (INPC) of 3% with a variability interval of plus-minus 1%. Thereafter, inflation began to register a decreasing trend towards the target of 3%. The conduct of monetary policy according to its target has led to a less persistent inflation and a lower pass-through of the exchange rate to inflation. Consequently, different severe external shocks affected less the exchange rate, the inflation and consequently the economic activity in Mexico.

Furthermore, the Mexican economy operates under a flexible exchange rate regime since 1995. This has allowed the exchange rate to act as a shock absorber for the economy as the value of the currency is priced mainly by its economic fundamentals, and leaving to the market the determination of the real equilibrium rate. However, mechanisms for intervention in the foreign exchange market have been punctually used, to manage the level of international reserves or to propel orderly market operating conditions, through the decisions of the Foreign Exchange Commission (FX Commission). Due to the liquidity of the Mexican peso, interventions have relied on preannounced rules-based tools to lower volatility and to establish clear operating mechanisms for the general public.[7] These include the daily US dollar auctions (both with and without a minimum bid price), the USD-denominated credit lines offered to banks (also allocated through auctions), as

[6]The 1993 amendment to Article 28 of the Constitution, which came into force in 1994, granted Banco de México full autonomy.

[7]The Mexican peso is the 15th currency most traded in the world, and the second most traded among emerging market economies (Triennial Central Bank Survey from the BIS, 2019).

well as interventions through derivatives. Notwithstanding, extraordinary measures to provide FX market with liquidity and restore its smooth functioning have been used when necessary. It is important to stress that these actions have been taken without setting a particular target for the exchange rate and are very punctual. As a result, historical interventions have been executed in consistently with the flexible exchange rate regime. Finally, it is worth mentioning that the monetary policy rate is not determined by the level of the exchange rate. While the level of the exchange rate is closely monitored by the central bank, it is only important as long as it affects the observed or the expected path of inflation.

3.3 Data and Descriptive Statistics

We use 23 quarterly time series data for the period 2001:Q1 to 2020:Q4. Six of them were used for the building of fiscal account identities. The other 17 variables cover the main model structure. All fiscal variables were expressed in terms of GDP. Risk premium is proxied by EMBI-G. For the international price of oil, we use WTI expressed in U.S. dollars.

Tables (1) and (2) show the variables used in the model as well as a general description of them for the period 2008:Q1 to 2020:Q4.[8] All variables were obtained from official sources or from financial platforms as indicated in the tables. For estimation purposes, all series are demeaned in order to be consistent with the gap model.

Table 1: Descriptive statistics for the fiscal block

Descriptive Statistics (2008-2020)					
Symbol	**Description**	**Notes**	**Mean**	**Stdv**	**Source**
τ_t	Public revenue	Quarterly data (% GDP)	5.44	0.515	SHCP
τ_t^{tax}	Income tax revenue	Quarterly data (% GDP)	2.56	0.55	SHCP
τ_t^{oil}	Oil revenue	Quarterly data (% GDP)	1.59	0.54	SHCP
wti_t	WTI	U.S. dollars per barrel	62.59	25.61	Bloomberg
x_t^{oil}	Oil Domestic production platform	Thousands of barrels per day	2650	537.34	SIH/PEMEX
b_t^d	Debt denominated in domestic currency	Quarterly data (% GDP)	35.64	5.90	SHCP
b_t^f	Debt denominated in foreign currency	Quarterly data (% GDP)	11.40	2.80	SHCP
$psbr_t$	Public Sector Borrowing Requirements	Quarterly data (% GDP)	-0.73	0.68	SHCP
CF_t	Debt Service	Quarterly data (% GDP)	0.56	0.20	SHCP
g_t	Public spending	Quarterly data (% GDP)	5.24	0.86	SHCP
Υ_t	Risk premium proxied by EMBI Global Spread.	Quarterly data (p.p.)	235	78.5	Bloomberg

Notes: The sources used for this classification are Secretaría de Hacienda y Crédito Público (SHCP), Petróleos Mexicanos (PEMEX) and Bloomberg.

[8]The period 2008:Q1 to 2020:Q4 was selected given that there is no publicly-available data for the Public Sector Borrowing Requirements before that period.

Table 2: Descriptive statistics for the monetary block

Descriptive Statistics (2008-2020)					
Symbol	**Description**	**Notes**	**Mean**	**Stdv**	**Source**
x_t	Output gap	Quarterly data (% Potential GDP)	-0.10	1.82	BANXICO
π_t	Overall inflation	CPI index (QoQ)	1.03	0.71	INEGI
s_t	Real exchange rate	U.S. Bilateral real exchange rate	0.66	0.09	BANXICO
i_t^{US}	Federal funds rate	Quarterly data (overnight rate in p.p.)	1.30	1.95	FRED
i_t	Nominal interest rate	Quaterly data (overnight rate in p.p.)	6.29	2.40	BANXICO

Notes: The sources used for this classification are Banco de México (BANXICO), Instituto Nacional de Estadística y Geografía (INEGI) and Federal Reserve Economic Data (FRED).

4 Monetary and Fiscal Macroeconomic Model

The model is based upon Aguilar & Ramírez-Bulos' work (2014, 2018). It is constructed upon two blocks, the fiscal block (subsection 4.1) and the monetary block (subsection 4.2). In this model, the fiscalblock is solved first independently, we then insert the output into the monetary block, and obtain the monetary policy response to fiscal decisions. This strategy corresponds to the fact that the central bank is goal-independent in the model (Debelle & Fischer (1994), among others) and that the fiscal policy is passive.[9]

4.1 Fiscal Block

The fiscal block has been built upon the public finances framework in Mexico and Aguilar & Ramírez-Bulos (2014, 2018). That is, the public revenue mostly depends on income tax, oil tax, corporate tax and others types of tax. This fiscal block follows a VAR structure for most of its equations. Each VAR equation has been calibrated, and using quarterly data from 2001 to 2019. One strong assumption, that conditions the return to steady state, is that the fiscal budget must be balanced. In the fiscal block, US and international markets are ruled by a law of motion following an AR(1) process.[10]

[9]Banco de Mexico is independent since April 1994 after enforcement of the 1993 amendment to Article 28 of the Constitution. The CB independence can be decomposed into two components, *i.e.*, the goal independence and the instrument independence. The guarantee of being goal-independent is given by a CB that is free from political pressures when defining its policy objectives and preferences. Goal independence can be designed by meeting several criteria such as the mandate period for the governor and the board superior to five years, the fact that the governor or/and the board are not appointed by the government, the non-approval of the government for monetary policy formulation (Balls et al. 2018). The instrument independence can be observed by the way the central bank freely adjusts its policy tools while targeting its goals.

[10]The international variables do not follow a VAR since all variables are depending only on its past value and a white noise shock.

We decided for a matter of simplicity to then express all variables as deflated ratios of the GDP, following this general expression:

$$a_t = \hat{a}_t/(p_t x_t)\,, \tag{1}$$

where the matrix of variables a_t that are in the fiscal block are deflated using the consumer price index measure (p_t) through the INPC, and expressed as a ratio to the GDP (x_t). Hence, all the following equations are expressed in terms of real GDP, in contrast with Aguilar & Ramírez-Bulos' analysis (2018), where variables are transformed into percentage points of potential GDP.

The public revenue τ_t is constituted by the sum of main taxes in México:

$$\tau_t = \tau_t^{tax} + \tau_t^{oil} + \tau_t^{ab} + \tau_t^{others}, \tag{2}$$

where τ_t^{tax} is the revenue from income tax, τ_t^{oil} the revenue from oil-sector taxes and royalties, τ_t^{ab} the revenue generated by government agencies and private firms, and τ_t^{others} is composed of other types of revenue.[11] τ_t^{ab} and τ_t^{others} follow AR (1) processes for simplicity.

The income tax τ_t^{tax} is a fixed proportion of the output gap x_t:

$$\tau_t^{tax} = \upsilon_1 x_t + \varepsilon_t^{tax}, \tag{3}$$

with υ_1 representing the average share of income collected by the government, and ε_t^{tax} an exogenous shock to the income tax.[12]

According to the literature (among others Pieschacón (2012) and Bergholt (2014)), empirical analysis of the oil-prices effects is complex since many oil exporting countries have market power in the oil market. However, given its proven oil reserves, Mexico is considered as an invited member of the OPEC, explaining why Mexico is considered here as a price taker. Thus, we need to take into account the impact of the price of US oil WTI barrels on the price fixation, as a standard oil price measure, as in Aguilar and Ramírez-Bulos' analysis. We henceforth consider the oil revenues as:

$$\tau_t^{oil} = \lambda_1 wti_t + \lambda_2 x_t^{oil} + \lambda_3 s_t + \varepsilon_t^{oil}, \tag{4}$$

[11] Oil revenue depends on the oil prices in US dollars p_t^{oil}, such as $\tau_t^{oil} = \left(p_t^{oil} FX_t\right) X_t^{oil}$, where the nominal exchange rate FX_t expresses the value of one unit of foreign currency (here US dollars) against domestic currency (Mexican peso here) defined by $FX_t = s_t - s_{t-1} + \left(\pi_t - \pi_t^{US}\right)$, where s_t the real exchange rate, π_t represents the domestic inflation, π_t^{US} the US inflation.

The quantity of oil extracted from the production platform x_t^{oil} follows an AR (1) process:$x_t^{oil} = \varphi x_{t-1}^{oil} + \varepsilon_t^{X^{oil}}$.

[12] All exogenous shocks are assumed to follow a normal distribution with a zero mean. The variances are different for each shock, and are obtained from GMM estimations. We consider here the possibility for the economy to face income tax shocks, extending the model of Aguilar & Ramírez-Bulos (2014, 2018).

where wti_t represents the price of US oil WTI barrels (in US dollars), x_t^{oil} the domestic oil production, and s_t the real exchange rate. An increase in s_t corresponds to a currency depreciation, and conversely, negative values of s_t imply the domestic currency appreciation. Finally, ε_t^{oil} is an exogenous shock to the oil revenue. Parameters in (4) implicitly capture the complex tax structure through which PEMEX contributes to public revenue.[13]

Since we analyze a small open emerging-market economy, we take into account the fact that the government debt b_t is constituted by the contemporaneous sum of domestic debt b_t^d and foreign debt b_t^f, according to their legal definition[14] and to its description in Aguilar & Ramírez-Bulos (2014). The debt, denominated in the same currency, is divided into those two elements following Aguilar & Ramírez-Bulos (2018):

$$b_t = b_t^d + b_t^f, \tag{5}$$

where the domestic debt corresponds to

$$b_t^d = \kappa_1 b_{t-1}^d + \kappa_2 psbr_t + \varepsilon_t^{B^d}, \tag{6}$$

with $psbr_t$ representing the PSBR, κ_1 the persistence degree of the domestic debt, and κ_2 the proportion of the PSBR financed with domestic debt. The shock $\varepsilon_t^{B^d}$is exogenous. An increase in PSBR implies a deterioration of the expanded public balance.
The foreign debt is converted to mexican pesos from dollars, explaining why we need to take into account the real exchange rate s_t in the following expression (see the methodology used by Secretaría de Hacienda y Crédito Público, 2019):

$$b_t^f = \mu_1 b_{t-1}^f + \mu_2 s_t + \mu_3 psbr_t + \varepsilon_t^{B^f}, \tag{7}$$

where μ_1 is the the lag coefficient for the foreign debt, μ_2 measures the sensitivity of the foreign debt to real exchange rate, μ_3 accounts for the sensitivity of foreign debt to Public Sector Borrowing Requirements, and $\varepsilon_t^{B^f}$ represents exogenous shocks to foreign debt.

Thus, considering the definitions of domestic and foreign debt, public debt, b_t, can be expressed as:

$$b_t = \kappa_1 b_{t-1}^d + \mu_1 b_{t-1}^f + (\mu_3 + \kappa_2) psbr_t + \mu_2 s_t + \varepsilon_t^{B^d} + \varepsilon_t^{B^f}. \tag{8}$$

The PSBR is the widest measure of the public deficit and embody the primary deficit d_t and the public sector financial cost FC_t defined below in (13), the latter being also called debt service.

[13]Note that Mexico has been a net oil-importer since 2014; for instance, in 2019, Mexico has a deficit of 21 000 millions of dollars in oil (see the INEGI-Press Release 23/20 from January 2020).

[14]Public Sector Borrowing Requirements (PSBR) is the widest measure for the historical stock of debt.

$$psbr_t = d_t + FC_t + \varepsilon_t^{PSBR}. \tag{9}$$

The primary deficit can be defined as the difference between primary public spending g_t and public revenue from tax collection τ_t given by (2):

$$d_t = g_t - \tau_t, \tag{10}$$

where the primary public spending g_t depends on:

$$g_t = \psi_1 g_{t-1} - (1 - \psi_1)\,\psi_2 psbr_t + \varepsilon_t^g, \tag{11}$$

where ε_t^g represents an exogenous shock to primary spending. This primary public spending equation includes its own lagged component and the PSBR constraint. Therefore, equation (11) is based on the definition of the deficit rule, as in Aguilar & Ramírez-Bulos (2018).

Following their work, we study a unique fiscal rule: the fiscal rule works through the primary spending (g_t). The fiscal rule aims to stabilize the PSBR at their equilibrium level. In turn, it is assumed that the government seeks to smooth changes in its public spending, as adjustments are costly, given the regulations surrounding the Federal Expenditure Budget. Thus, the government will gradually stabilize its accounts. For instance, an exogenous shock that affects government revenue has three main effects: an increase in debt, a fiscal adjustment that impacts aggregate demand, and a financial impact that affects exchange rate through the risk premium, the latter connecting the fiscal and monetary blocks. Thereby, the exogenous change in the fiscal position of the country provokes an immediate reaction from the government that adjusts spending, aiming to stabilize PSBR and to satisfy the fiscal rule. Furthermore, the variation of risk premium through the change in the PSBR impacts the real exchange rate and, thus, inflation (see further explanations in the Section 5). As a consequence of the latter, the central bank sets the policy interest rate. Furthermore, we assume that only a fraction of the spending is exercised productively g_t^p, where the productive public spending is defined as:

$$g_t^p = \omega_1 g_t. \tag{12}$$

This productive spending is then reflected into the monetary block in the IS equation (15). This novel assumption in the model structure extendes the analysis performed in Aguilar & Ramírez-Bulos (2014, 2018) who consider g_t. The productive public spending is constituted by investment public spending, in opposition to consumption public spending. Following Chu et al. (2018), we assume that public spending is 90% productive, the last 10% of public spending being dedicated to public consumption, an assumption that is made for emerging market economies.[15] Such a spending introduces the idea that there exists a positive feedback between the tax rate, the productive capacity of the economy and tax revenue, a concept pioneered by Baxter & King (1993), then further developed by Kamiguchi & Tamai (2011, 2012), among others.

An exogenous increase in tax revenues reduces the primary deficit, which allows reducing the PSBR. Higher public revenues yield a higher public spending, which stimulates economic activity, but ultimately translates into inflationary pressures. Meanwhile, lower PSBR reduces the country risk, which appreciates the exchange rate.

In contrast to Aguilar & Ramírez-Bulos (2014, 2018), we consider the contemporaneous relation between the debt service and the domestic and foreign real interest rates following the literature (Flood & Jeanne (2005); Eusepi & Preston (2011); among others), as well as the contemporaneous relation between debt service and risk premium. The debt service, measured by public sector financing costs, FC_t, depends on the primary deficit d_t, the domestic and foreign real interest rates respectively ($r_t = i_t - \pi_t$ and $r_t^{US} = i_t^{US} - \pi_t^{US}$), and the risk premium (Υ_t) defined below in (14):

$$FC_t = \phi_1 FC_{t-1} + (1-\phi_1)\left(\phi_2 i_t - \phi_3 \pi_t + \phi_4 i_t^{US} - \phi_5 \pi_t^{US} + \phi_6 d_t + \phi_7 \Upsilon_t\right) + \varepsilon_t^{FC}. \quad (13)$$

We extend the analysis of Aguilar & Ramírez-Bulos (2018), but differ from them, since they define the risk premium depending on the contemporaneous global risk, that represents the financial markets risk aversion (measured by the volatility VXO index), and public debt. As an index of risk premium, following the literature, we use the EMBI-G built by JP Morgan that is assumed to represent fiscal performance. The EMBI-G tracks total returns for traded external debt instruments in the emerging markets, and is a wider measure of sovereign risk by including, for instance, PEMEX's debt variation. Our approach also entails caveats. Indeed, other factors can also explain EMBI-G spreads movements. For instance, Calvo (2003) shows that domestic factors could be irrelevant in explaining the EMBI-G spreads, since the main determinant of this spread is the foreign investors appetite for risk. Additionally, the evolution of EMBI-G is highly sensitive to political news. Moreover, the bonds that form the EMBI-G spread typically have long maturities that do not necessarily reflect the government's fiscal flow position. Consequently, EMBI-G spreads reflect not only the fiscal performance but also external factors and political news. Therefore, the changes in the EMBI-G spreads cannot be

[15]The productive government spending constitutes the sum of expenditure on education, health, defense, housing, economic affairs and general public services expenditure, while non-productive expenditure consists of expenditure on public order and safety, recreation and social protection. We performed simulations for other levels of productive public spending in Appendix A. In this exercise, we adopt a level of productive government public spending that is lower (75%), which would be the case for advanced economies, and a second one slightly higher than the model level (95%). We find that modifying this level does not change qualitatively any impact of the shocks on the model variables.

viewed as being derived solely from fiscal fundamentals. Finally, EMBI-G spreads are weighted averages that are not based on a structural model (Aktas et al. 2010). From the proxy we use as being the risk premium, the most accurate way to describe the evolution of EMBI-G for Mexico given the variables we use is taking into account that the risk premium depends on its own lag (Υ_{t-1}), given its strong persistence, its expected value and the level of the deficit ($psbr_t$), which depends on the public revenues issued from oil production:

$$\Upsilon_t = \xi_1 \Upsilon_{t-1} + \xi_2 \mathbb{E}\left(\Upsilon_{t+1}\right) + \xi_3 psbr_t + \varepsilon_t^{\Upsilon}. \tag{14}$$

The risk premium is directly connected to the PSBR representing the historical stock of debt, and as such has a strong impact on the debt service in Mexico. The risk premium has an indirect impact on the evolution of the foreign debt and domestic debt, through its feedback effect into the debt service (see equation 13), whose latter has a countable relation with the PSBR when taking into account the primary deficit from equation (10). Therefore, when the risk premium increases, both foreign and domestic debt increase through the PSBR. Furthermore, there is an additional indirect channel where the risk premium raises the foreign debt through the real exchange rate (see below the UIP equation 17 and 7).

The fiscal block works as follows, given a negative oil price shock (for a positive oil price shock, we obtain a symmetric negative result). A decrease in oil revenues yields lower total revenues of the public sector, which increases the primary deficit and the PSBR. Lower revenues reduce public spending and, therefore, decrease economic activity, which translates into a deflationary trend. Simultaneously, the PSBR increase raises the country risk, which depreciates the exchange rate. To adjust for deflationary trend generated by a lower economic activity (despite the depreciation of the exchange rate), the interest rate decreases. Public spending increases little by little as the effect of this oil-price shock dissipates. Of course, this example is conditioned on the set-up of the monetary block, which we address in the following subsection (4.2).

One caveat of our approach in the fiscal block is to consider that oil-price shocks have symmetric effects whether they are positive or negative. In the literature, there is no consensus about the necessity of introducing asymmetric effects of oil-price shocks.

Another caveat is that an increase in tax will have, in the end, a positive effect on aggregate activity through a mechanical increase in public spending. This tax increase could also discourage workers from working more hours or paying their taxes, and encourage them to leave the formal sector, a key feature present in emerging economies, especially in LATAM.[16]

[16] The labor market including formal and informal sectors is not here modeled but constitutes a possible extension for this fiscal block.

4.2 Monetary Block

The monetary block follows a DSGE-VAR structure (Del Negro & Schorfheide 2006, Aguilar & Ramírez-Bulos 2014, 2018) being based on the IS equation, Phillips curve, and the Uncovered Interest Rate Parity (UIP) condition.

We explicitly define the IS curve, extending the model of Aguilar & Ramírez-Bulos (2018), by taking into account the public productive spending, instead of the total public spending, and the global effect of total taxes, instead of the income tax effect.

$$x_t = \alpha_1 x_{t-1} + \alpha_2 \mathbb{E}_t(x_{t+1}) - \alpha_3 r_t + \alpha_4 s_t + \alpha_5 g_t^p - \alpha_6 \tau_t - \alpha_7 \Upsilon_t + \alpha_8 x_t^{US} + \varepsilon_t^x. \tag{15}$$

The output gap x_t evolves according to its own lagged value x_{t-1} and forward-looking component x_{t+1}. It also depends on the real exchange rate s_t, the US output gap x_t^{US}, and fiscal block's variables such as primary spending that is productively used g_t^p, government revenue τ_t, and the risk premium Υ_t. Finally, demand shocks hit the economy under the form of an exogenous shock ε_t^x.

The variables g_t^p, τ_t and Υ_t connect the fiscal block to the monetary block. The parameters α_5 and α_6 measure the direct impact of fiscal policy on the activity, as such α_5 may be interpreted as the positive public spending effect on activity (Keynesian multiplier) whereas an excessively high α_6 could offset public spending's positive consequences for activity and would correspond to a Ricardian equivalence condition. An increase in the risk premium Υ_t yields negative effects for the economic activity, connecting the effect of an increase in public debt to the output gap. We therefore represent the crowding out effect of public debt on private investment that is higher for emerging market economies than advanced ones (see, for the theory, among others, Claeys et al. (2012); Teles & Mussolini (2014); and for Mexico, Castillo Ponce & Garcia Meneses (2007)).

The Phillips Curve describes the deviations of inflation from the central bank objective as:

$$\pi_t = \beta_1 \pi_{t-1} + (1 - \beta_1) \mathbb{E}_t (\pi_{t+1}) + \beta_2 x_{t-1} + \beta_3 s_t + \varepsilon_t^\pi. \tag{16}$$

Current inflation π_t is based on inflation backward looking components, due to the observation of inflation persistence as widely supported by the literature (Cogley & Sbordone (2008); Fuhrer (2010); among others). Current inflation is also strongly conditioned by inflation expectations, here the coefficient β_1 matches the degree to which the economy is backward looking. Furthermore, we represent current inflation depending on past output gap since the output gap is observed with a lag of one quarter, as Gerlach & Smets (1999) and Walsh (2003) point out among others. To improve the data fit, we follow Aguilar & Ramírez-Bulos (2014), so that current inflation also moves according to the contemporaneous real exchange rate s_t, in the sense that a depreciation of domestic currency unambiguously leads to inflationary pressures, and the exogenous shock ε_t^{π} represents cost-push shocks to the domestic economy.

The real exchange rate evolution is described by the UIP condition:

$$s_t = (1 - \gamma_1) s_{t-1} + \gamma_1 \mathbb{E}_t (s_{t+1}) - \gamma_2 r_t + \gamma_3 r_t^{US} + \gamma_4 \varUpsilon_t + \varepsilon_t^s, \tag{17}$$

where real exchange rate s_t moves with its own lagged and forward-looking s_{t+1} value weighted by γ_1, the domestic and foreign real interest rates (r_t and r_t^{US}, respectively) and an exogenous exchange-rate shock ε_t^s. Following Aguilar & Ramírez-Bulos (2018), the risk premium component $\varUpsilon_t$ is determined endogenously by equation (14). According to the data, an increase in the risk premium directly leads to the domestic currency depreciation.

To close the monetary block, the central bank determines a Taylor Rule that defines the determinants of the policy interest rate i_t:

$$i_t = \rho_\pi i_{t-1} + \delta_1 \pi_t^g + \delta_2 x_t + \varepsilon_t^i, \tag{18}$$

where the inflation gap π_t^g is given by the expected inflation gap and the current level of inflation:

$$\pi_t^g = \rho_{\pi^g} \mathbb{E}_t (\pi_{t+1}^g) + \pi_t. \tag{19}$$

The inflation gap is defined by the difference between current inflation and the central bank objective. Here the central bank sets policy rate i_t according to the past value of the policy interest rate i_{t-1}, but also to domestic inflation gap π_t^g, output gap x_t, and to a monetary policy exogenous shock ε_t^i. Given that the monetary policy is conducted with a time lag, the Taylor rule entails a forward looking component of inflation.

The adjustment for higher inflation requires an increase in the monetary policy interest rate, while the deterioration in the public balance caused by a higher interest rate, measured by the PSBR in (9) and reflected in IS curve (15), stabilizes with a contraction of public spending.

We chose in this monetary block to introduce persistence in inflation, output-gap and the exchange rate through the introduction of a lag corresponding variables in (15)-(17) to better match observed data. This simple technique is widely used in the literature. An alternative more realistic manner to reproduce persistence in the model is to take into account private agents' expectations being slightly backward looking, by using survey data for instance (Milani 2020, Ormeño & Molnár 2015, Trehan 2015). This approach could be easily implemented for advanced economies, but not necessarily for emerging market economies, because of the scarcity of this type of data.

4.3 Parameters Calibration

The model is calibrated and estimated for Mexico using quarterly data. For the fiscal block, for instance, we set $\upsilon_1 = 0.03$ to match the average quarterly income tax collection. This implies an annual collection of 12%, as reported in Secretaría de Hacienda y Crédito Público (2019). The parameters κ_2 and μ_3 are fixed to 0.68 and 0.32, respectively, given the implicit fraction of domestic and foreign currency-issued debt in the PSRB (Secretaría de Hacienda y Crédito Público 2019). The fraction of productive public spending, ω_1, is set to 0.90 following Chu et al. (2018). For the monetary block, Taylor rule parameters are set following Castillo et al. (2009), who consider standard values in the Neo-Keynesian literature. For the Phillips Curve, we set β_1, β_2, β_3 as in Sidaoui & Ramos-Francia (2008). The rest of parameters are based on a GMM estimation using data from 2001 to 2019.[17] Tables (3) and (4) present the main model parameters:

[17]Despite differences in both blocks' equations compared to Aguilar & Ramírez-Bulos (2018), after estimation, we find that the monetary block is similar to the calibration given in Aguilar and Ramírez-Bulos (2018), that use a GMM estimation as well for data from 2001 to 2017. The parameters that yields similar estimates are: ψ_1, in the public spending rule, κ_1, κ_2, in the domestic debt equation, μ_1, μ_3 in the foreign debt one (four over 22 in the fiscal block), and α_1, α_2, α_3, α_4, α_8 in the IS equation, β_1, β_2 in the Phillips equation, γ_3 in the UIP condition, ρ_π and δ_1 in the Taylor rule (10 over 18). While we estimate different λ_1,λ_2, λ_3 in the tax collection equation, μ_2 in the domestic debt equation, ψ_2 in the foreign debt one, ξ_1, ξ_2, ξ_3 in the risk premium equation, ϕ_1, ϕ_2, ϕ_3, ϕ_4, ϕ_5, ϕ_6, ϕ_7 in the debt service equation; α_5, α_6, α_7 in the IS equation, γ_1, γ_2 ,γ_4 in the UIP condition.

Table 3: Fiscal block calibration

Parameter	Description	Value	Source
Tax collection			
υ_1	Output Gap.	0.03	SHCP (2019)
λ_1	WTI.	0.01	Estimated
λ_2	Oil Production Platform.	0.001	Estimated
λ_3	Real Exchange Rate.	0.0007	Estimated
Debt denominated in domestic currency			
κ_1	Backward Looking Component.	0.88	Estimated
κ_2	PSBR.	0.68	SHCP (2019)
Debt denominated in foreign currency			
μ_1	Backward Looking Component.	0.87	Estimated
μ_2	Real Exchange Rate.	0.03	Estimated
μ_3	PSBR.	0.32	SHCP (2019)
Public spending rule			
ψ_1	Backward Looking Component.	0.76	Estimated
ψ_2	PSBR.	0.65	Estimated
ω_1	Productive Public Spending.	0.90	Chu et al. (2008)
Risk premium			
ξ_1	Backward Looking Component.	0.37	Estimated
ξ_2	Forward Looking Component.	0.07	Estimated
ξ_3	PSBR.	4.41	Estimated
Debt service			
ϕ_1	Backward Looking Component.	0.30	Estimated
ϕ_2	Domestic Nominal Interest Rate.	0.34	Estimated
ϕ_3	Domestic Inflation Rate.	0.02	Estimated
ϕ_4	Foreign Nominal Interest Rate.	0.20	Estimated
ϕ_5	Foreign Inflation Rate.	0.16	Estimated
ϕ_6	Primary Deficit.	0.60	Estimated
ϕ_7	Risk Premium.	0.09	Estimated

Table 4: Fiscal block calibration

Parameter	Description	Value	Source
IS Curve			
α_1	Backward Looking Component.	0.37	Estimated
α_2	Forward Looking Component.	0.32	Estimated
α_3	Real Interest Rate.	0.12	Estimated
α_4	Real Exchange Rate.	0.01	Estimated
α_5	Productive Public Spending.	0.81	Estimated
α_6	Overall tax collection.	0.01	Estimated
α_7	Risk Premium.	0.03	Estimated
α_8	US output gap.	0.35	Estimated
Phillips curve			
β_1	Backward Looking Component.	0.33	Sidaoui & Ramos-Francia (2008)
β_2	Output Gap.	0.02	Sidaoui & Ramos-Francia (2008)
β_3	Real Exchange Rate.	0.006	Sidaoui & Ramos-Francia (2008)
Uncovered interest rate parity (UIP)			
γ_1	Forward Looking Component.	0.51	Estimated
γ_2	Domestic Real Interest Rate.	0.21	Estimated
γ_3	Foreign Real Interest Rate.	0.70	Estimated
γ_4	Risk Premium.	0.02	Estimated
Taylor rule			
ρ_π	Persistence.	0.70	Castillo & Montoro (2009)
δ_1	Inflation deviation from target.	1.50	Castillo & Montoro (2009)
δ_2	Output Gap.	0.10	Castillo & Montoro (2009)

5 Impulse Response Functions

Emerging market economies are more exposed to episodes of global risk aversion given the importance of capital flows and commodities to either public finances or GDP, and financial stability. Given the constraints faced by emerging market economies (constrained counter-cyclical fiscal policies possibilities, existence of external debt), the responses the fiscal and monetary institutions can implement are relatively more limited, resulting in a larger increase in their risk premiums. While the ability of economic policies to mitigate supply and demand shocks are well known, it is unclear what would be the best policy response in the face of different type of shocks hitting the Mexican economy.

We therefore show what would be the impact of distinct shocks on macroeconomic variables. This section illustrates the interaction between fiscal and monetary policy, taking account each block's specificity. Therefore, in the next subsection 5.1, for simplicity, we first present the model mechanisms for independent shocks occurring one at a time. The following subsection 5.2 discusses further possible extensions of the model to strengthen the analysis robustness.

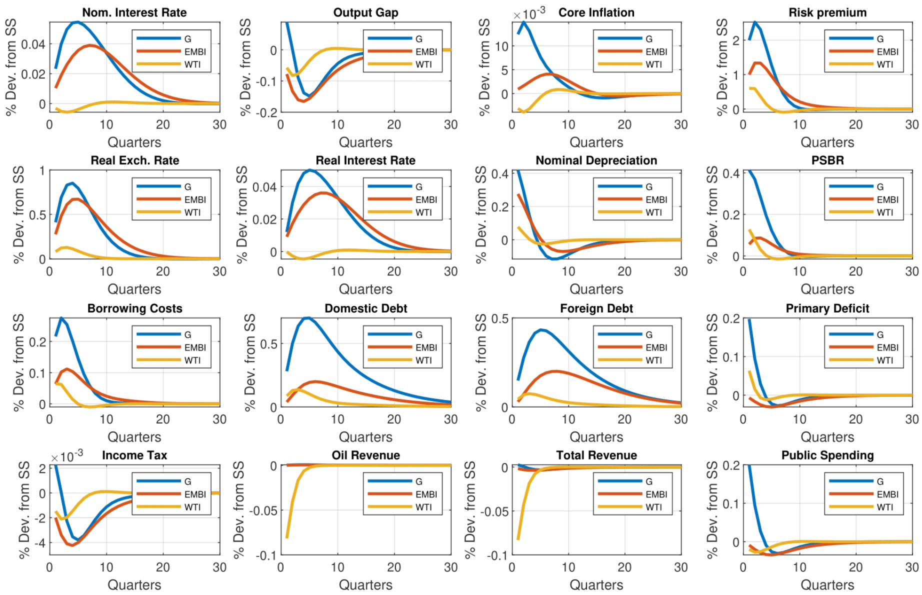
In the following section, when the same variables are exposed, we compare our results to the ones presented in Aguilar & Ramírez-Bulos (2014) when employing a similar fiscal rule (balanced budget), and Aguilar & Ramírez-Bulos (2018). They study the IRF for 20 periods whereas we do it for 30 periods. The analysis performed in this section suggests that, the propagation mechanisms and connections among the policy interest rate, the risk premium, and the government debt are different in our model. A possible explanation is that, in their model, a strong relationship seems to exist between the public deficit and the real exchange rate that may cause distinct reactions of variables after public spending, oil price and risk premium shocks, compared to the model.

5.1 Model Mechanisms

For the fiscal block shocks, corresponding to Figure (1), we choose to study the effects of a positive public spending shock, of a negative shock increasing risk premium, and a negative oil-price shock. Those shocks are defined as a temporary deviation from steady state.

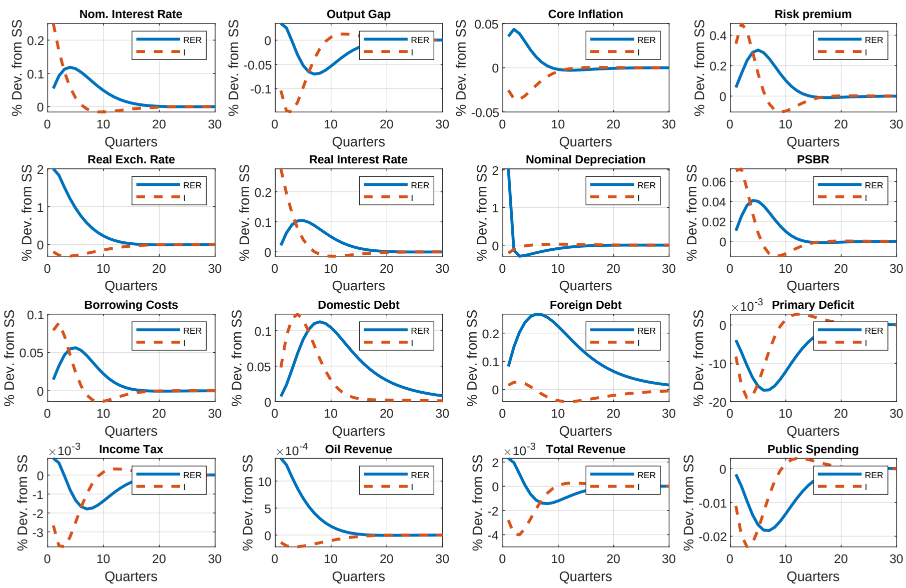
For the monetary block shocks, corresponding to Figure (2), we examine the effects of a depreciation shock of the real exchange rate and, a monetary policy shock increasing policy interest rate.

Figure 1: Fiscal block shocks: Public spending (G), risk premium (EMBI), and oil-price (WTI) shocks



Notes the impulse-response functions are plotted on a horizon of 30 quarters and the y-axis corresponds to the percentage deviation of each variable with respect to its steady state. Source: own calculations.

Figure 2: Monetary shocks: Real exchange rate depreciation (RER) and monetary policy (I) shocks.



Notes: the impulse-response functions are plotted on a horizon of 30 quarters and the y-axis corresponds to the percentage deviation of each variable with respect to its steady state. Source: own calculations.

5.1.1 Public Spending

The positive public spending shock has two direct effects on the fiscal block. First, the public spending shock positively affects output gap through its productive component from equation (12) entering into the IS equation (15).[18] The second direct effect enters through the primary deficit in (10). The indirect effects of public spending impact mostly the fiscal block through the primary deficit affected by public spending shock, that then enters into the PSBR in (9). In turn, the public spending shock indirectly moves both types of debt through the PSBR in (6)-(7).

A positive public spending shock increases demand at the cost of worsening both the primary deficit and the PSBR. The positive public spending shock impacts the monetary block via the productive public spending that enters into the IS equation (15) and the risk premium that enters into the UIP condition (17). Therefore, the higher level of debt-to-GDP ratio (from the expansion of primary deficit via public spending) increases country risk premium and, due to risk aversion, the nominal exchange rate depreciates (that is, s_t increases). Inflationary pressures are driven by the depreciation of the nominal exchange rate and the increase in the output gap, due to higher productive public spending (as public spending is higher), raising the aggregate demand. Monetary authority increases short-term nominal interest rate in order to keep inflation expectations anchored and stabilize output gap due to the Taylor rule given by (18). Even if the tax collection increases temporarily, the government faces higher debt service due to higher policy interest rate from equation (13). Thus, in order to stabilize debt, public spending should decrease inducing future primarily surpluses given the fiscal rule that we consider in equations (9) and (11).

For comparison, in Aguilar & Ramírez-Bulos (2018), the IRFs for a government spending shock are different. The output gap is positive for a longer period, the real exchange rate appreciates then rises and remains depreciated; said appreciation generates a fiscal surplus in the model. The response of exchange rate, output gap, government debt and risk premium converge in a longer horizon than 20 periods in their model, whereas in the model used in this paper the risk premium converge after 10 periods, the real exchange rate and the output gap after 16 periods, and the government debt after 30 periods, including both components. As in their work, on impact, output gap, monetary policy rate, public deficit, government debt, government expenditure and risk premium turn positive. Inflation, monetary policy rate, government income and public deficit converge in both models at most after 20 periods.

[18]In Appendix (A), we perform robustness checks concerning the impact of productive public spending on the policy-mix. We find that moving such proportion of productive public spending from 90% to 95% or from 90% to 75% in (12) does not have a qualitative impact nor a strong quantitative one on the evolution of our macroeconomic variables.

5.1.2 Risk Premium

A negative shock that increases risk premium directly translates into both the fiscal and monetary block, respectively, on the debt service and on the output gap and the real exchange rate. On one hand, the spike in the risk premium causes an increase in the debt service from equation (13). This larger debt service raises total public debt through an increase in the PSBR (10) that is reflected into domestic debt equation (6) and into the foreign debt one (7).

The rise in the risk premium causes a direct negative impact on the output gap (see the IS curve (15)), which represents the well-known crowding-out effect due to the higher level of total public debt, and discourages private investment, which in turn, weakens economic activity. On the other hand, the risk premium shock directly induces a nominal exchange rate depreciation through the UIP equation (17) and increases inflation due to higher import goods prices. To achieve the fiscal target and respect the fiscal rule of the model, public spending should decrease so that primary surplus could be reached. Finally, the central bank increases short-term nominal interest rate to keep inflation expectations anchored.

Thus, a shock to the risk premium operates mainly through demand, exchange rate, and fiscal channels. It spreads to the economy through a change in the investors perception of the economy. Consequently, the risk premium affects investment and it induces changes in the nominal exchange rate which, in turn, move inflation. The latter provokes a reaction of the central bank. Finally, the effect of such a change in borrowing costs through risk perception and the action of central bank modify public spending to achieve fiscal target.

For comparison, in Aguilar & Ramírez-Bulos (2018), after a positive global risk shock (corresponding to a rise in risk aversion in global financial markets), the debt service is lower and the policy interest rate turns negative through indirect effects of the model. In their model, the policy interest rate remains positive at impact, and afterwards, before converging to its steady state value. On impact, government expenditure is positive in their model, while we obtain a negative effect. In their model, the public deficit is negative on impact, but then turns positive into a surplus whereas in the model, on impact, the primary deficit remains negative, corresponding to a fiscal surplus, due to public spending contraction while the PSBR remain positive before converging. The output gap, the government debt, the public deficit, and the government spending converge to their steady state in a longer horizon than 20 periods. In the model used in this paper, output gap converges after 20 periods, domestic government debt after 28 periods, foreign government debt after 30 periods, and government spending after 15 periods. This is, all variables converge at most in 30 periods to their steady state value. As in Aguilar & Ramírez-Bulos (2018), on impact, output gap, inflation, real exchange rate, monetary policy rate, financial costs and government debt are positive. Inflation in both models converge after 15 periods.

5.1.3 Oil Price

As we mentioned above, given the role of PEMEX in Mexican public finances, we model an oil price shock which affects government budget constraint and thus, can be interpreted as a demand shock.[19]

A decrease in oil prices affects the Mexican economy through different channels. The first transmission channel goes through the fiscal block, since an oil-price shock directly lowers oil revenues through oil tax collection, and therefore, diminishes public revenues in equation (4) fueling into (2). Mechanically the lower public revenues increases the primary deficit in (10), and therefore affects the risk premium through equation (14). The higher primary deficit, jointly with a higher risk premium, raise the debt service from equation (13). The consequent transmission channel goes through the monetary block where the activity is negatively affected. Indeed, from the IS equation (15), lower tax collection would have a negative effect on the activity. Additionally, lower primary public spending, translated into productive public spending from equation (15), has a lower feedback effect on the activity. To sum up, the total effect of a decrease in oil prices on the output gap would be negative (see Figure 1). The lower activity has a direct impact on the policy interest rate that would react in a less aggressive way by the Taylor rule (18), due to lower feedback effect from output to inflation in (16).

Another existing interaction between the fiscal and monetary blocks goes through the relation between the risk premium and the exchange rate. From the above explanation, a decrease in oil prices raises the risk premium; consequently, from equation (14), the higher risk premium leads to a raise in s_t, which corresponds to a depreciation of the domestic currency. First, given that oil represents a wide share of commodities exports in emerging economies, the negative shock worsens terms of trade which, in turn, depreciate the real exchange rate. However, the effect of the slack of aggregate demand on inflation is stronger than the depreciation effect on inflation, which in this calibration causes a lower inflation level from its steady state when the oil shock happens. This means that in the model, the fiscal block has a very strong impact on the monetary one.

To sum up the effects of a decrease in oil prices, we observe that from the fiscal rule we apply in this model, and the IRF in Figure (1), fiscal policy reaction should be restrictive, contracting economic activity. Finally, inflation decreases, since the effect of lower public revenues, and a widen slack of aggregate demand, more than compensates the inflationary effect of the currency depreciation. Central bank reacts reducing short-term nominal interest rate to better keep inflation expectations anchored, and stabilizing

[19]See the discussion on omitting oil-prices in the model in Subsection 5.2.

output gap.

For comparison, in Aguilar & Ramírez-Bulos (2014), after a positive oil price shock (noting that this is in the opposite direction of the shock that we simulate), the real exchange rate appreciates, the output gap, inflation, policy interest rate, and government revenues increase.

In Aguilar & Ramírez-Bulos (2018), the IRFs differ from ours underlining that there are different mechanisms at work. Indeed, the output gap, the exchange rate, the risk premium, the government debt require more than 20 periods after the shock to converge. On impact and afterwards, in their model, financial costs do not respond to positive oil price shock, remaining flat, while borrowing costs in the model increase on impact for a negative shock. In their model, public deficit exhibits a different dynamic relationship with oil-price shock since, public deficit is negative on impact but then exhibits a fiscal surplus after 5 periods, while in the model used in this paper, the relation between oil-price shock and primary deficit and PSBR is always negative, before these variables converge. In Aguilar & Ramírez-Bulos (2018), on impact and taking into account the opposite direction of the shock, output gap, inflation, real exchange rate, monetary policy rate, government income and expenditure, public deficit, the government debt, and risk premium react following the same logic as in the model. In their work, inflation and government income converge after 20 periods, whereas, in the model used in this paper, they converge after 12 and 7 periods, respectively.

5.1.4 Real Exchange Rate Depreciation

The real exchange rate depreciation shock has three direct effects on both blocks, through the public debt and the oil tax collection, as well as for the monetary block, through the output.

On one hand, the public debt tends to increase when the domestic currency is depreciating due to its foreign debt component given by equation (7), which causes an increase in the PSBR in (9) and therefore the primary deficit raises from (10). Following the fiscal rule we imposed, the government should reduce its public spending in order to reach the equilibrium. Simultaneously, the oil tax collection increases (see (2) and (4)) which raises the public revenues given by equation (10). The higher public revenue does not fully compensate the higher PSBR that restricts the public spending, which pushes the government to balance its budget. Another collateral effect is that due to higher PSBR, the risk premium increases which causes a further currency depreciation.

On the other hand, real exchange rate depreciation in (17) stimulates aggregate demand through the IS curve (15) which corresponds to an increase in net exports. The depreciation translates itself through a nominal exchange rate depreciation and is not immediately fueled into the price level, given that the monetary block is characterized by price rigidities. The latter increases both inflation and inflation expectations. Monetary policy tightens to accommodate the shock. The latter increases PSBR. It is worth mentioning that even when nominal exchange rate depreciation increases oil tax collection, it also expands foreign currency issued obligations, therefore foreign public debt's service, and worsens overall PSBR and risk premium. Therefore, government spending decreases to achieve the fiscal target.

5.1.5 Monetary Policy Shock

Starting from the steady state, an exogenous rise in the short-term nominal interest rate has different transmission mechanisms. First, within the monetary block, the positive nominal interest rate shock increases the yield in domestic-currency-denominated assets, which in turn, through the uncovered interest rate parity appreciates the exchange rate. Therefore, tighter monetary conditions, with respect to the steady state, reduce both output gap and inflationary pressures.

In the fiscal block, an exogenous increase in the policy interest rate has a direct impact on the debt service, by increasing (13). This increase in the debt service then raises the PSBR in (9), which worsens the primary deficit from equation (10). From the tighter monetary conditions, indirect effect occurs through the output gap in the fiscal block. Indeed, lower activity reduces tax collection and worsens public deficit, through higher PSBR, and increase risk premium. Fiscal authority decreases public spending inducing a reduction in the deficit to accommodate this shock. Note that, if the economy is in steady state, monetary policy shocks affect fiscal policy stance, suggesting the importance of coordinated policies.

For comparison, in Aguilar & Ramírez-Bulos (2018), on impact, after an increase in the policy interest rate, in their model, the government debt decreases, while in the model the relation is positive between the policy interest rate and both domestic and foreign debt. In their model, on impact, there is a fiscal surplus for 5 periods and then this surplus turns into public deficit that however converges after 20 periods. The output gap, government debt and risk premium, however, converge to their steady state value after 20 periods after the shock whereas in the model used in this article, all variables converge, at most, after 15 periods. In this model, as in Aguilar & Ramírez-Bulos (2018), on impact, the output gap, the inflation, the real exchange rate and government expenditure turn negative and the financial costs are positive. Inflation, the real exchange rate, monetary policy rate, government income and public deficit converge in both models at most after 20 periods.

5.2 Discussion

As a robustness exercise, we could analyze the policy-mix in Mexico without taking into account the commodity prices (i.e. exclude from the model used in this paper the presence of oil and related mechanisms). Intuitively, ignoring the commodity would suppress the share of government revenues due to oil sales. However, the mechanism of the oil shock through the economy is very similar to an exogenous shock to government revenues, therefore we would not observe any difference in the IRFs in the event of other shocks. That is to say, it does not change the direction of the IRF it only changes the persistence of a shock, and very likely the size of public spending when there is a positive shock in tax collection in the absence of commodity prices. Moreover, we consider it crucial integrating oil-price shocks in the model because the value added in the oil sector is high for instance, when the world price of oil is high, or even when oil production is high and the foreign currency is strong (since oil is sold in foreign currency) (see Pieschacón (2012) and Bergholt (2014)).

A plausible extension of this model would be to perform a Bayesian estimation for the Mexican economy, in order to confirm the mechanisms observed through the IRFs, and to increase the robustness of the model when identifying the transmission mechanisms.

Moreover, it would allow us to identify the exogenous shocks that are driving the business cycle. A further step to this analysis would be to assess the performance of different monetary and fiscal policies that both aim to accommodate those shocks. Indeed, in the literature, it is standard to choose a set of control variables to maximize a social welfare function and compare their performances. However, this analysis requires an explicit formulation of the objective function and the constraints that the social planner faces. While not all models have these characteristics, such as the Real Business Cycle models (RBCs), it may be possible to use a function that allows a similar policy evaluation. In this context, loss functions represent the simplest and most commonly used way to deal with target functions (Cecchetti 2000). Such kind of functions usually contain the square of the differences between the actual and desired value of each target variable multiplied by an associated weight (Pearce 1986). But the literature on which variables and weights are best for social welfare is broad and controversial.

Finally, further research may consider a scenario in which public spending and monetary shocks are calibrated so that they minimize a loss function. It may imply a stronger counter-cyclical coordination given the tradeoffs that each institution face. We leave it for further research to perform this analysis to observe what would be the optimal behavior of both institutions for each type of shock. Further extensions of the model used in this paper could be twofold: on one hand, estimate the model via full information methods such as Bayesian techniques. On the other hand, forecasts and historical shock decomposition can be done in order to assess Mexican developments through the lens of the model.

6 Conclusion

The model presented in this article extends previous work and allows to analyze the effect of fiscal policy actions on different variables relevant to monetary policy, applied to Mexico taking into account the country's specificities.

The results show the different channels where fiscal policy and monetary policy interact: the risk premium, the debt service, the exchange rate, the aggregate demand variation from public spending, the level of public debt and inflation. A direct application of the model in this article is its ability to analyze the consequences of different adverse shocks to a small open market-economy that is exporting commodities in terms of policy mix, when both the central bank and the fiscal authority are independent, and the fiscal authority pursues a deficit target.

Starting from the steady state, monetary policy actions have implications for public finances mainly through the channels of debt service, the exchange rate, the negative relation between interest rate and aggregate demand, and thus overall tax collection, risk premium and inflation. Fiscal policy influences inflation and its expectations through the productive public spending, primary deficit and thus, public debt and risk premium. We also find a classical result of Ricardian equivalence, where an increase in primary spending has only a temporary positive effect on economic activity, since the fiscal rule is binding, and fiscal policy then adjusts its spending, yielding a decrease in economic activity.

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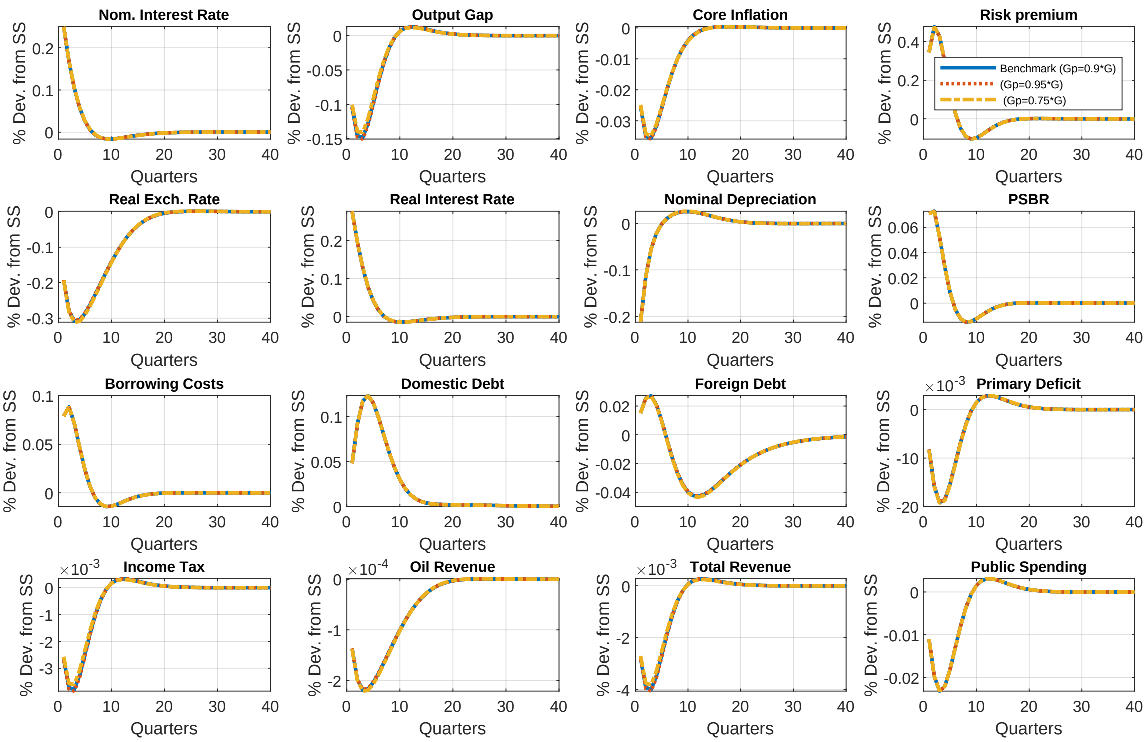
Appendix

A Robustness Check For Productive Public Spending Effects

For robustness check of our analysis, we perform two counter-scenarios where the productive public spending in the equation (12) is raised to 95% of total public spending, and where the same productive public spending is lowered to 75% of total public spending respectively. The variables that are represented in Figures (3)-(7) are simulated in function of their deviation from the steady state.

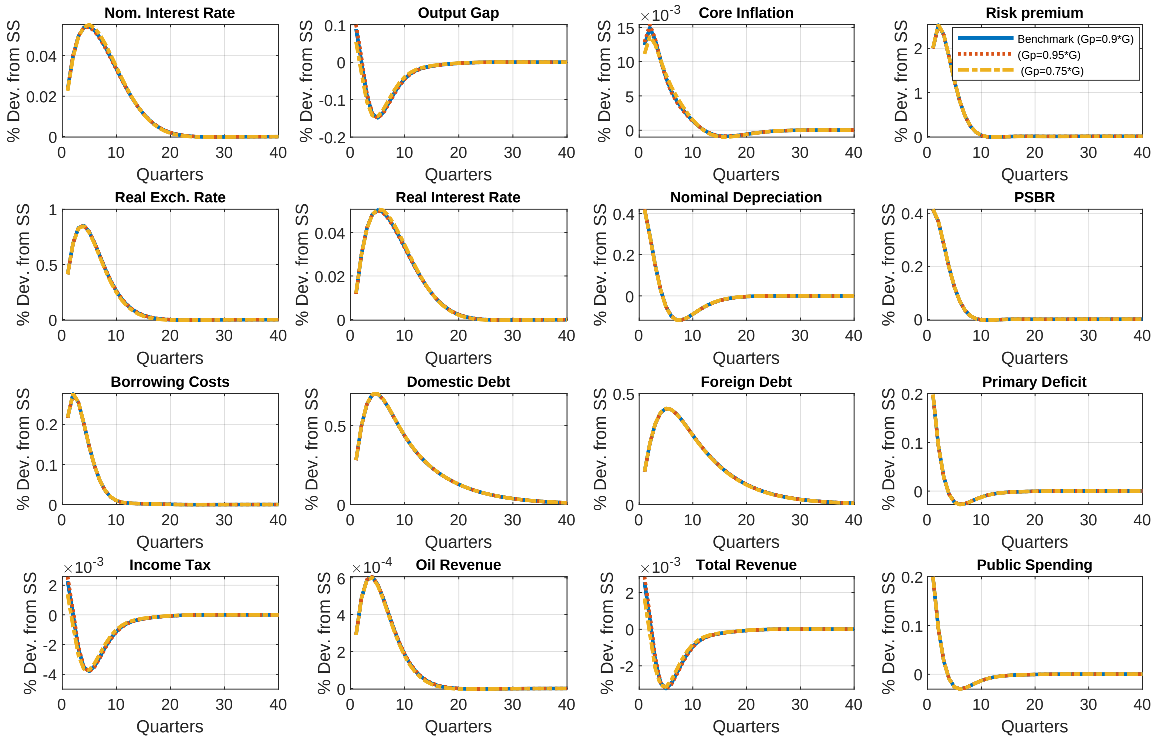
By studying the IRF for distinct shocks (monetary policy shock I, public spending G, WTI prices, risk premium EMBI, and exchange rate LTCR), we find that when productive public spending is lower or higher, all variables respond in the same direction for any shock. We remark that when the WTI prices shock occurs, core inflation, output gap and interest rate (nominal and real) do vary very slightly due to the demand channel that is activated through the oil prices above described mechanism. These four graphs show us quite robust model mechanisms when productive public spending changes.

Figure 3: Different levels of public productive spending in the event of a monetary policy shock (I)



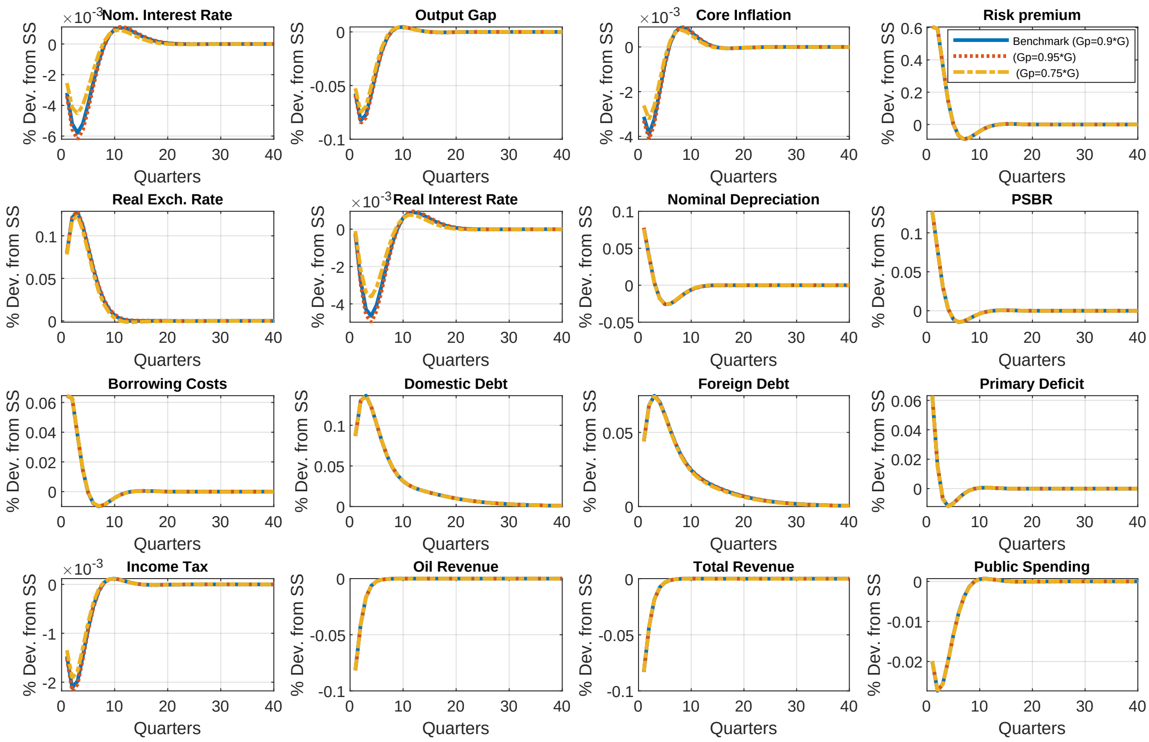
Notes: the impulse-response functions are plotted on a horizon of 30 quarters and the y-axis corresponds to the percentage deviation of each variable with respect to its steady state. Source: own calculations.

Figure 4: Different levels of public productive spending in the event of a public spending shock (G)



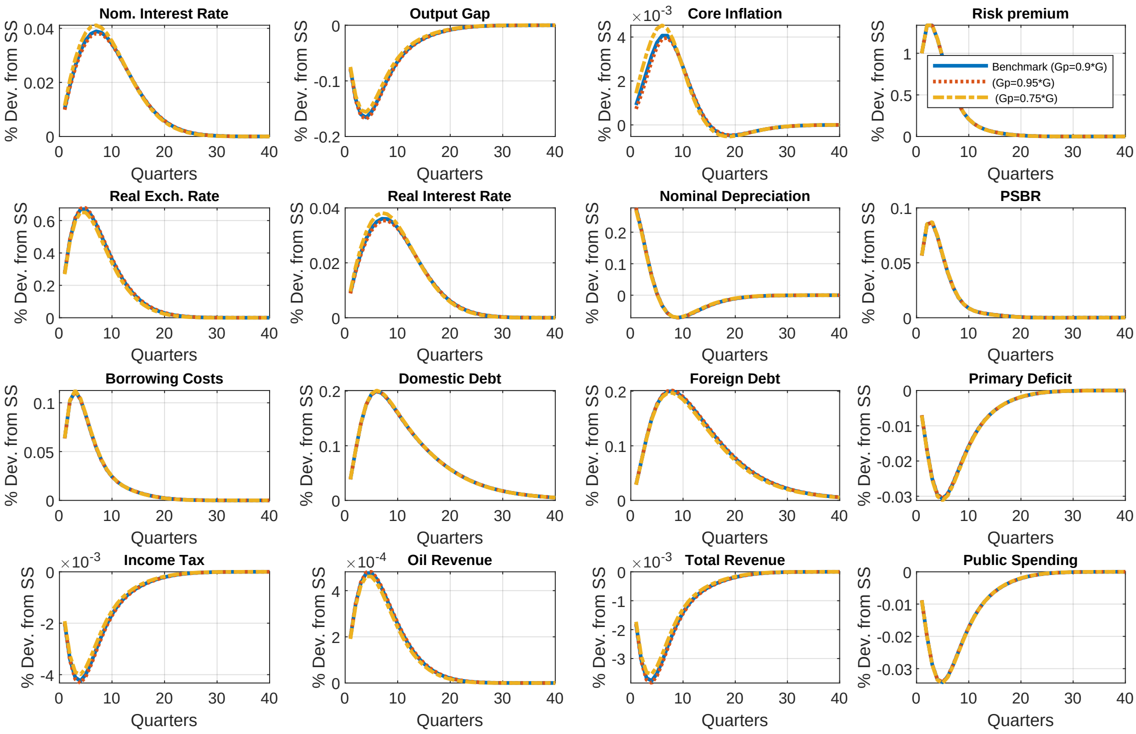
Notes: the impulse-response functions are plotted on a horizon of 30 quarters and the y-axis corresponds to the percentage deviation of each variable with respect to its steady state. Source: own calculations.

Figure 5: Different levels of public productive spending in the event of in the event of a positive international oil price shock (WTI).



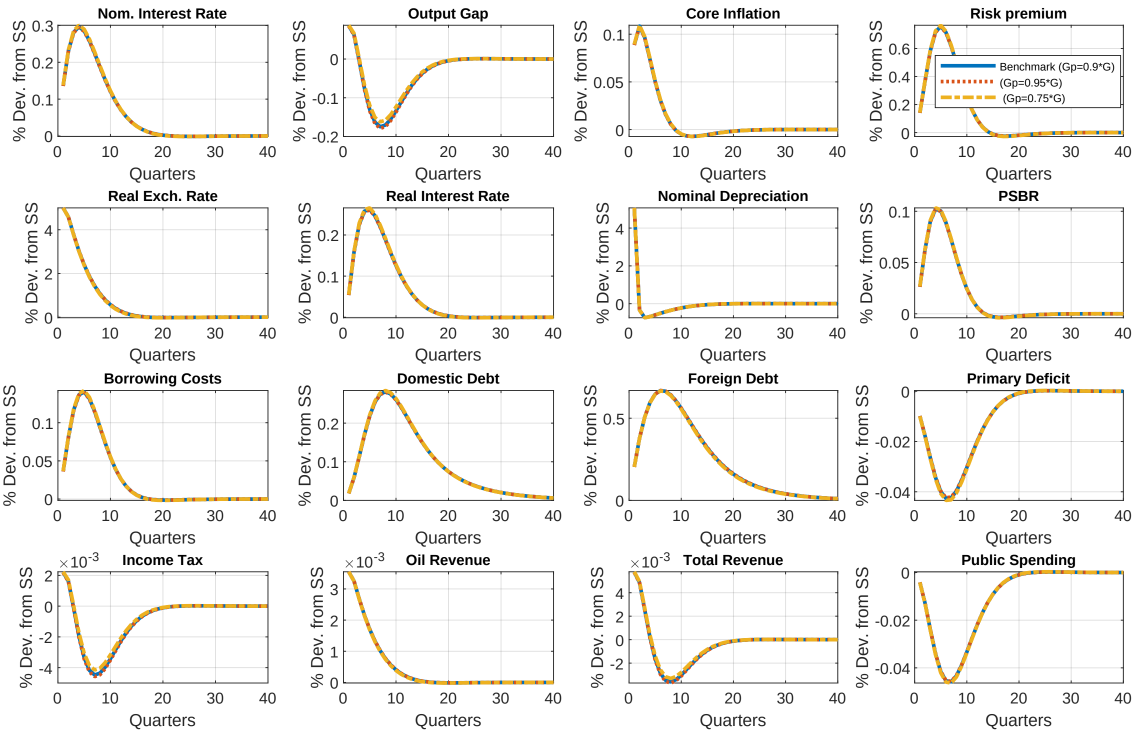
Notes: the impulse-response functions are plotted on a horizon of 30 quarters and the y-axis corresponds to the percentage deviation of each variable with respect to its steady state. Source: own calculations.

Figure 6: Different levels of public productive spending in the event of a positive risk-premium shock (EMBI)



Notes: the impulse-response functions are plotted on a horizon of 30 quarters and the y-axis corresponds to the percentage deviation of each variable with respect to its steady state. Source: own calculations.

Figure 7: Different levels of public productive spending in the event of a depreciation shock (LTCR)



Notes: the impulse-response functions are plotted on a horizon of 30 quarters and the y-axis corresponds to the percentage deviation of each variable with respect to its steady state. Source: own calculations.