The Spending Cap and Monetary Policy Effectiveness

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Abstract

What is the impact on the transmission of monetary policy in Brazil under the fiscal ceiling implemented in 2016? We find empirical evidence of the response of fiscal variables to monetary policy shocks by estimating a dynamic model factor. Then,we analyze whether the imposition of an expenditure ceiling affected monetary policy effectiveness in Brazil. We propose a heterogeneous-agents new keynesian model (HANK) to the Brazilian economy with spending cap and find that the expenditure ceiling adopted by Brazil might have "muted" a fiscal transmission channel for monetary policy, reducing its impact on the output gap.

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1 Introduction

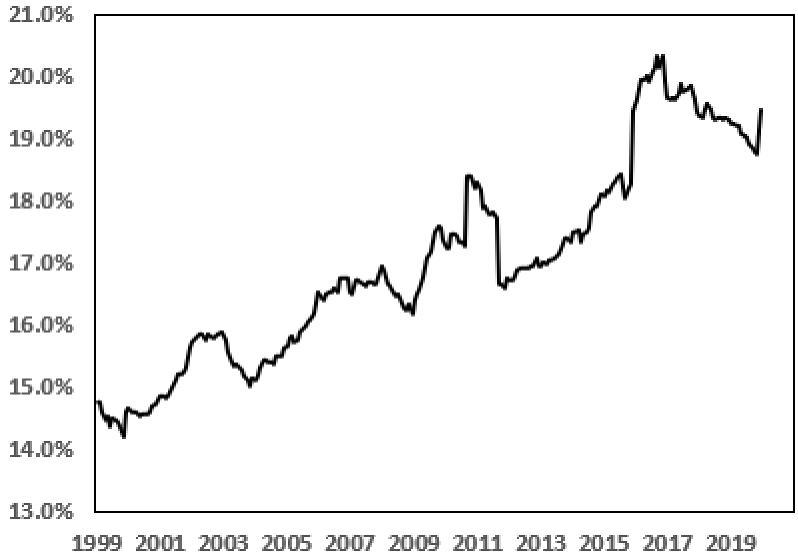
After years of loose fiscal policy, the adoption of an expenditure ceiling in 2016 marked a significant departure towards a more sustainable fiscal regime (Spilimbergo and Srinivasan (2019), p.34), which was strengthened by the approval of a pension reform in 2018 (Spilimbergo and Srinivasan (2019), p.203), gaining time to deal with other aspects of the fiscal sustainability that were not addressed.

The rule put in place a "ceiling" based on the federal government's 2016 primary expenditure level, and, after that, expenditures were only allowed to grow in line with inflation as measured by the 12 month inflation rate up to June of the prior year. This marked an important departure of decades of expenditures growing in real terms. From 1999 to 2016, expenditures grew, on average, 6.2% in real terms. From 2017 to 2019, the growth of spending in real terms came down to 1.0%. As a share of GDP, there is a marked downward trend that began with the adoption of the ceiling[1], as can be seen in Figure 1.

There is evidence that new fiscal regime has impacts on the real neutral interest rate (see for example Schymura (2018), Fonseca and Muinhos (2019) and Muinhos et al. (2020)). Considerations regarding the fall in risk premium coming from the institution of the expenditure ceiling are part of this literature. What is not clear, though, is what is its the impact on the transmission of monetary policy. The aim of this the paper is to shed some

[1] There is a downward trend of expenditures as a share of GDP even as they grew in real terms. This is explained by the fact expenditures are deflated by the IPCA, the Brazilian official inflation measure, which was below the GDP deflator in the period.

Figure 1: Federal government's expenditure (as % of GDP)



Source: Brazilian National Treasury. Produced by the author.

light on the matter.

As recent models with heterogeneous agents show that fiscal policy is an important transmission channel for the monetary policy (Kaplan et al. (2018)), we analyze whether monetary policy is not as effective to stimulate demand since the imposition of the expenditure ceiling in Brazil. If that is the case, the necessary monetary stimulus to offset a given shock might be higher than originally thought.

In order to investigate this matter, we first present empirical evidence that fiscal policy reacts to monetary shocks in Brazil. Then, by calibrating a Heterogeneous Agents New Keynesian (henceforth HANK) model to the Brazilian economy, we explore the mechanisms behind the impact of a "muted" fiscal channel to monetary policy comparing a baseline scenario without an expenditure cap to an alternative scenario where the government expenditures follow a rule similar to the adopted expenditure ceiling.

Rich macroeconomic models that take into account heterogeneity between agents are not new (see for example Aiyagari (1994) and Huggett (1993)). Such framework has not gained much traction until recently, while the use of a representative agent prevailed. This is due to the computational complexity of models that take into account heterogeneity (Ahn et al., 2017; Kaplan and Violante, 2018) and the fact that such complexities seemed not to be very useful in adding relevant information when compared to the use of a representative agent (Krusell and Smith, 1998).

Recent works made possible by computational developments are once again incorporating heterogeneity between agents into dynamic general equilibrium models. Different authors have found that such rich models do have contributions that are important when analyzing macroeconomic aggregates and their dynamics. Shocks that involve private-borrowing seem to be amplified (Auclert et al., 2018), monetary policies seem to have important redistributional effects (Gornemann et al., 2012), and also the very transmission channels of such policies seem to be different when taking into account inequality (Kaplan et al., 2018), to name a few.

Simultaneously, much research have been done regarding the interplay of fiscal and monetary policies (Sargent (1981), Granville (2013), Leeper and Leith (2016)). More recently, the resurgence of models with heterogeneous agents brought forward important discussions about the transmission channels of monetary policy and the role of the fiscal policy in such regard, which is also discussed in Kaplan et al. (2018).

The use of such models seems to have much to contribute in understanding the use of (and the interplay between) different economic policies. We find empirical evidence that fiscal variables respond to monetary policy shocks. Under an heterogeneous-agents framework, we calibrate a model to the Brazilian economy and find that the potency of interest rates changes to affect the economy activity is lower under a fiscal rule similar to the one in Brazil.

The rest of this paper is organized as follows. In the next section, we review literature literature related to this paper. Section 3 presents empirical evidence that fiscal policy reacts to monetary shocks. In Section 4, we simulate a HANK model calibrated to the Brazilian economy in order to account for the impacts of the expenditure ceiling in the transmission of monetary policy, showing that the findings in the data presented in the previous section are also accounted by this class of model. Finally, section 5 presents the main results, and section 6 concludes by highlighting the contributions of the present paper to the exiting literature.

2 Related Literature

The first relevant concept in understanding how macroeconomic aggregates react to a monetary policy shock comes from the so called permanent income hypothesis (PIH) described by Friedman (1957), which states that permanent income is responsible for the major part of variation in consumption. Such idea was later formalized by Hall (1978), which paved the way for a style of research called "Euler equation approach" (Campbell and Mankiw, 1989), where consumers obey the first-order conditions for a optimal path of consumption given rational expectations. As such, consumption should be sensible to interest rate movements, with households substituting consumption inter-temporally after a monetary policy shock. Nevertheless, Campbell and Mankiw (1989) tested that theory for the United States and refuted it. They found only a small effect of changes in the interest rate to consumption, after controlling for income. Several studies were conducted in order to test the validity of the PIH to the Brazilian economy.

Costa and Gutierrez (2015) shows that a portion of consumers in Brazil consumes their current income, which invalidates the PIH. Utilizing a dataset from a credit card company, Lucinda and de Freitas Oliveira Favaro (2018) show that not only the PIH is rejected in Brazil, but also that the degree of heterogeneity found in consumption is much higher than the results found in developed countries, concluding that credit constraints in the country are an important aspect to explain consumption behaviour.

The second relevant concept is that, in the standard literature on New Keynesian models, there is an infinitely-lived representative household. As such, they are called Representative Agent New Keynesian models, henceforward RANK, for short. This simplification in building such models might not be of much concern if and only if (i) the information being omitted by this simplification is not that much relevant for the question being asked, and (ii) if the limitations imposed by the simplification are well understood.

On the other hand, since late 1980s some authors started to utilize the distribution of income and wealth of economic agents (Huggett (1993), Aiyagari (1994), Krusell and Smith (1998) and others) on macroeconomic models. HANK models more recently started to share as a common assumption the existence of idiosyncratic shocks to labor productivity and households' income[2]. Recent models also try to incorporate (i) the existence of more than one type of assets that can be traded and (i) an exogenous borrowing limit that may or may not be binding to different fractions of households at different points in time, as in Kaplan et al. (2018).

The main building block of HANK models is the so-called income fluctuation problem. Households are subject to non insurable productivity shocks (and, as a consequence, to income shocks). Thus, different shocks to different individuals in each point of time give rise to a wealth distribution. Aiyagari (1994) presents a version of the neoclassical growth model with idiosyncratic, non-insurable shocks, and was one of the pioneers in applying numerical solutions to the challenge presented in such models. Similarly, Huggett (1993) constructed a model with agents that face uninsurable idiosyncratic endowment shocks to show that such framework could explain differences on estimated real risk-free interest rates when compared to the use of RANK models.

In general, the effect of any shock on macroeconomic aggregates will depend on the way that the distribution of income and wealth across individuals is affected by the initial shock (Galí (2018)). Thus, the shock might be amplified or dampened. Auclert (2017) and Kaplan et al. (2018) analyze how monetary policy transmission channels are affected by heterogeneity.

The transmission channels analyzed are: (i) the intertemporal substitution channel, in response of a change in real interest rates; (ii) the income

[2]Oh and Reis (2011), Guerrieri and Lorenzoni (2011) and Debortoli and Galí (2017) are examples of contributions to this literature.

channel, (iii) the channel that arises from heterogeneity in earnings, where some individuals see their income increase in relative terms, (iv) a Fisher channel, by which unexpected inflation revalues nominal balance sheets, resulting in nominal creditors losing, while nominal debtors are left better off; (v) an unhedged interest rate exposure channel, given possible heterogeneities between agents regarding the mismatch between assets and liabilities' durations they hold.

While the first two channels are also present in RANK models, the last three arise directly by taking into account heterogeneity. Auclert (2017) shows that monetary policy has a redistribution effect on income and wealth. Given that different households will have different marginal propensities to consume (MPC), and those who gain from a loose monetary policy have higher MPC, the redistribution channel amplifies monetary policy shocks.

By contrast, McKay et al. (2015) uses a standard New Keynesian model with a pro-cyclical uninsurable income risk and borrowing constraints that results in a dampened effect of monetary policy shocks when compared to RANK models. Given the pro-cyclicality of earnings risk, such dampening effect arises, and is presented by the authors as an explanation for the lesser effect of forward guidance relative to RANK models.

Another model can be found in Kaplan et al. (2018), where the authors introduce the coexistence of two types of assets, a liquid and an illiquid one, with transactional costs between them. An important implication of such assumptions is the existence of wealthy individuals that, because much of their wealth is held in illiquid assets, consume as hand-to-mouth individuals. These individuals amplify the fraction of households that are highly sensitive to income shocks.

One of the main contributions from Kaplan et al. (2018) is that such framework makes indirect effects arising from changes in interest rates much more prominent than direct effects (the intertemporal substitution channel), mainly coming from variations in households' income. Moreover, the authors show that the fiscal response after the monetary shock, and its redistribution channel, also contributes to shape the overall effect of monetary policy on aggregate demand. This opens the way for fiscal policy to become an important transmission channel of monetary policy.

Auclert et al. (2020), on the other hand, show that the fiscal policy relevance on the transmission of monetary policy depends mainly on a simplification made by Kaplan et al. (2018), which is that fiscal policy response happens instantaneously after the interest rate shock. The authors propose a model that matches both the jumps that are observed in consumption after a transitory income shock and the humps that are characteristic of the response of output after a monetary policy shock. The fiscal policy in this model has two distinct characteristics: the existence of long-term debt and a delayed fiscal adjustment, which leads to a lesser role of fiscal policy in transmitting an interest rate shock to aggregate demand, as opposed by the findings of Kaplan et al. (2018). One important caveat here is that the duration of debt matters, and, as such, countries that have lower debt duration may observe a bigger fiscal role as a transmission channel.

In Brazil, important institutional reforms after the creation of the Real in the mid 90s were fundamental in stabilizing its economy. Afonso et al. (2016) offers a good summary in the evolution of fiscal and monetary institutions in Brazil and their role in taming inflation. The authors also show that, contrary to prior crisis, the Brazilian response after the Great Financial Crisis of 2008 (GFC) broke with its tradition of implementing institutional reforms in difficult times. After promoting a fiscal expansion to exit the crisis, the country continued to maintain an expansionary fiscal stance to accelerate growth, leading to a fiscal and political crisis that emerged in a recession that began in 2014. Finally, in 2016 an expenditure ceiling was approved by Congress and put into the Brazilian Constitution.

3 Do fiscal variables respond to monetary shocks?

Following Forni and Gambetti (2008) and Benedeti (2020), we estimate a dynamic factor model to investigate the relationship between fiscal and monetary policies in Brazil, with data between 2007 and 2019. 145 quarterly time series were used, encompassing data regarding (i) inflation, (ii) economic activity, (iii) employment, (iv) credit market, (v) fiscal variables, (vi) external accounts and (vii) domestic and international financial data. More information about the time series and transformations used are available on Appendix A.

On this class of model, and different from a structural VAR, for example, it is possible to model a large number of variables without requiring a large number of restrictions being imposed on the identification strategy[3]. Each variable $x_{i,t}$ is taken as the sum of two non-observable and mutually orthogonal components, the common component $\chi_{i,t}$ and the idiosyncratic

[3]More information on the use of this class of models to investigate the propagation of monetary policy can be found in Forni and Gambetti (2008).

component $\xi_{i,t}$, as in:

$$x_{i,t} = \chi_{i,t} + \xi_{i,t}, \tag{1}$$

where $t = 1, ..., T$ and $i = 1, ..., N$, representing the macroeconomic time series used in the estimation.

The idiosyncratic components are not "macroeconomic shocks" as they are poorly correlated in the cross-sectional dimension. The common components, in turn, are the ones responsible for the main bulk of the co-movements between the variables. They can be seen as linear combinations of a small number r of factors:

$$\chi_{i,t} = a_{1,i} f_{i,t} + ... + a_{r,i} f_{r,t} = a_i f_t, \tag{2}$$

The vector f_t of common factors follows a VAR relationship as in:

$$f_t = D_1 f_{t-1} + \ldots + D_p f_{t-p} + \varepsilon_t, \tag{3}$$

where $\varepsilon_t = Ru_t$ with q dynamic factors u_t. It can be seen that $x_{i,t}$ can be written in the following dynamic form:

$$x_{it} = b_i(L) u_t + \xi_{it}, \tag{4}$$

where:

$$b_i(L) = a_i \left(I - D_1 L - \cdots - D_p L^p\right)^{-1} R. \tag{5}$$

As discussed in Forni and Gambetti (2008), the dynamic factors u_t are assumed to be macroeconomic structural shocks, while $B_i(L)$ are the impulse response functions.

The estimation process used here closely follows the one found in Forni and Gambetti (2008) and in Benedeti (2020), but using quarterly data as opposed to monthly data. The number of static and dynamic factors used ($\hat{r}$ and $\hat{q}$, respectively) were chosen by the method proposed in Bai and Ng (2002), resulting in $\hat{r} = 4$ and $\hat{q} = 4$. $\hat{r}$ are estimated by the first 4 principal components of the macroeconomic time series. If $\hat{A}_n = (\hat{a}'_1 \hat{a}'_2 \dots \hat{a}'_n)'$ is the estimated loading matrix, containing the normalized eigenvectors. As such, the common factors are $f_t = \widehat{A'}_n \, (x_{1t} x_{2t} \dots x_{nt})'$.

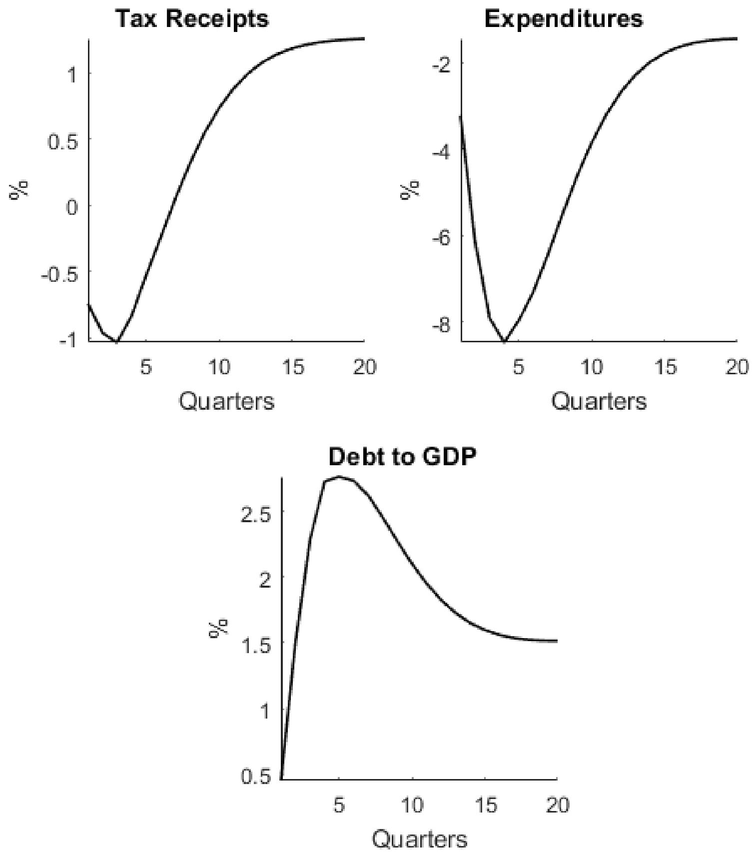
The static factors are estimated by using the $\hat{r}$ first principal components of the macroeconomic time series. Being $\hat{A}_n = (\hat{a}'_1 \hat{a}'_2 \dots \hat{a}'_n)'$ the loading matrix with the normalized eigenvectors as its columns, the estimated factors are $f_t = \widehat{A'}_n \, (x_{1t} x_{2t} \dots x_{nt})'$.

A VAR(p) is then run with f_t, producing estimates of $D(L)$ and of the residuals ε_t, $\hat{D}(L)$ and $\hat{\varepsilon}_t$, respectively, and the non-structural representation of the common components is obtained by a spectral decomposition of the sample variance-covariance matrix of $\hat{\varepsilon}_t$.

For the identification strategy, it is assumed that the industrial production and prices are not contemporaneously affected by a monetary policy shock. In addition, the exchange rate is assumed not to affect contemporaneously the Selic interest rate. As such, the following ordering was used: industrial production, IPCA, the Selic rate and the exchange rate.

As we are mainly interested in the interlink between monetary and fiscal policies, the impulse response functions regarding a selection of fiscal indicators are reported in Figure 2.

Figure 2: Impulse-response functions to a contractionary monetary policy shock



Notes: Percentage deviations after a shock of one percentage point on the nominal interest rate estimated by the dynamic factor model.

There is evidence of a fiscal policy response to a monetary policy shock. Not only because of a fall in tax receipts, given the contractionary impact on activity, but also on expenditures. This result is in line with Kaplan et al. (2018). The next section presents the simulation exercise of a model with heterogeneous households.

4 Theoretical Model

We follow Kaplan et al. (2018) and calibrate a HANK model to the Brazilian economy.

Households. Agents have an utility function $u(.)$ that takes into account consumption (c) and labor supply (l), represented as hours worked as a fraction of a time endowment that is normalized to 1. Preferences are conditional on surviving (with a probability given by $1-\zeta$, with ζ being the quarterly death rate), and the future is discounted at rate ρ:

$$E_0 \int_0^\infty e^{-(\rho+\zeta)t} u\left(c_t, \ell_t\right) dt. \tag{6}$$

There are illiquid assets a that are associated with a deposit or withdrawal cost, and there are liquid assets b that households can borrow from up to a exogenous limit given by $\underline{b}$ at the real interest rate $r_t^{b-} = r_t^b + \kappa$, with $\kappa > 0$ being an exogenous wedge between borrowing and lending rates.

Let d_t denote a household's deposit rate, with negative values denoting withdrawals. $\chi\left(d_t, a_t\right)$ is the cost of depositing at such a rate. The consequence of the existence of a transaction cost is that, in equilibrium, the illiquid asset pays a real return higher than the liquid asset.

The evolution of a household's asset holdings is as follows: household's income stream net of (i) deposits or withdrawals from the illiquid account d_t, (ii) transaction costs $\chi\left(d_t, a_t\right)$ and (iii) consumption expenditures c_t are saved in liquid assets b_t. Illiquid assets a_t evolves equal to interest payments plus net deposits. The equations that describe these relashionships are as follows:

$$b_t = (1 - \tau_t)\, w_t z_t \ell_t + r_t^b\,(b_t)\, b_t + T_t - d_t - \chi\,(d_t, a_t) - c_t. \tag{7}$$

$$\dot{a}_t = r_t^a a_t + d_t. \tag{8}$$

$$b_t \geq -\underline{b}, \quad a_t \geq 0. \tag{9}$$

The transaction cost has two components. The first one is a linear component that generates an inaction region in household's optimal deposit policies. The second one is a convex component that ensures that deposit rates are finite. Its functional form is as follows:

$$\chi(d, a) = \chi_0 |d| + \chi_1 \left| \frac{d}{a} \right|^{x_2} a. \tag{10}$$

Households maximize (6) subject to (7)-(10). The recursive solution to this problem consists of a series of decision rules: for consumption $c(a, b, z; \Gamma)$, for deposits $d(a, b, z; \Gamma)$ and for labor supply $\ell(a, b, z; \Gamma)$, with $\Gamma := \left(r^b, r^a, w, \tau, T\right)$. In its Appendix B.1, Kaplan et al. (2018) describes the problem's Hamilton-Jacobi-Bellman equation, as well as the Kolmogorov forward equation that characterizes the distribution of liquid and illiquid assets and labor income $\mu(da, db, dz; \Gamma)$.

Firms. There is a competitive representative final-good producer that aggregates a continuum of intermediate inputs, where ε ¿ 0 is the elasticity of substitution across goods:

$$Y_t = \left(\int_0^1 y_{j,t}^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}}. \tag{11}$$

The demand for each intermediate good j is given by:

$$y_{j,t} \left(p_{j,t} \right) = \left(\frac{p_{j,t}}{P_t} \right)^{-\varepsilon} Y_t, \tag{12}$$

where $P_t = \left(\int_0^1 p_{j,t}^{1-\varepsilon} dj \right)^{\frac{1}{1-\varepsilon}}$.

Each intermediate good j is produced by a monopolistically competitive producer using $k_{j,t}$ units of capital rented at a rate r_t^k in a competitive capital market and $n_{j,t}$ units of labor hired at wage w_t in a competitive labor market, according to the following production function:

$$y_{j,t} = k_{j,t}^{\alpha} n_{j,t}^{1-\alpha}. \tag{13}$$

The marginal cost across all producers is given by:

$$m_t = \left(\frac{r_l^k}{\alpha} \right)^{\alpha} \left(\frac{w_t}{1-\alpha} \right)^{1-\alpha}. \tag{14}$$

There are price adjustment costs as in Rotemberg (1982), which are expressed as a fraction of aggregate output and are quadratic in the rate of price changes:

$$\Theta_t \left(\frac{p_t}{p_t} \right) = \frac{\theta}{2} \left(\frac{p_t}{p_t} \right)^2 Y. \tag{15}$$

From the solution of the pricing problem, a New Keynesian Phillips curve is derived:

$$\left(r^a_t - \frac{\dot{Y}_t}{Y_t}\right)\pi_t = \frac{\varepsilon}{\theta}\left(m_t - m^*\right) + \pi_t, \tag{16}$$

where $m^* = \frac{\varepsilon-1}{\varepsilon}$.

Assets. Illiquid savings can be invested in (i) capital and in (ii) equity shares of the aggregate portfolio of intermediate firms, denoted by s_t. This represents a claim on the future stream of profits net of price adjustment costs, $\Pi_t := \tilde{\Pi}_t - \frac{\theta}{2}\pi_t^2 Y_t$. As such, a household's illiquid assets can be expressed as $a_t = k_t + q_t s_t$. As it follows, the dynamics of capital and equity must satisfy:

$$k_t + q_t s_t = \left(r^k_t - \delta\right) k_t + \Pi_t s_t + d_t, \tag{17}$$

where $\Psi'(\cdot)$ is a cost function associated to investment.

There is also a no-arbitrage condition that must hold between capital and shares:

$$\frac{\Pi_t + q_t}{q_t} = r^k_t - \delta =: r^a_t. \tag{18}$$

The monetary authority follows a monetary policy rule, setting the nominal interest rate i_t on liquid assets:

$$i_t = \bar{r}^b + \phi\pi_t + \epsilon_t. \tag{19}$$

where the coefficient ϕ regarding inflation is greater than one.

Government. The government issues bonds of infinitesimal maturity, with negative values denoting government debt. Its intertemporal budget constraint is as follows:

$$B_t^g + G_t + T_t = \tau_t \int w_t z \ell_l(a,b,z) d\mu_t + r_t^b B_t^g, \tag{20}$$

where T_t is a lump-sum transfer, τ_t is a proportional tax rate and G_t are the government expenditures.

The equilibrium in steady-state is defined by the paths of decisions taken by households and firms $\{a_t, b_t, c_t, d_t, \ell_t, n_t, k_t\}_{t\geq 0}$, input prices and returns on liquid and illiquid assets $\left\{w_t, r_t^k\right\}_{t\geq 0}$ and $\left\{r_t^b, r_t^a\right\}_{t\geq 0}$, share prices $\{q_t\}_{t\geq 0}$, the inflation rate $\{\pi_t\}_{t\geq 0}$, fiscal variables $\{\tau_t, T_t, G_t, B_t\}_{t\geq 0}$ and aggregate quantities such that households and firms both maximize their objectives, aggregate consistency conditions are met, the government budget constraint holds and all markets clear.

There are four market clearing conditions, one for the liquid asset market, the illiquid asset market, the labor market and the goods market, respectively, as follows:

$$B_t^h + B_t^g = 0, \tag{21}$$

$$K_t + q_t = A_t, \tag{22}$$

$$N_t = \int z \ell_t(a,b,z) d\mu_t, \tag{23}$$

$$Y_t = C_t + I_t + G_t + \Theta_t + \chi_t + \kappa \int \max\{-b, 0\} d\mu_t, \tag{24}$$

where $B_t^h = \int b d\mu_t$ are the household's holdings of liquid bonds, $A_t = \int a d\mu_t$ household's holdings of illiquid assets, Y_t the aggregate output, C_t the total consumption expenditures, I_t the investment that adds to the capital stock K_t and Θ_t the total price adjustment costs.

Let's assume that the economy is initially in steady-state. At time $t = 0$, there is a monetary shock with a deterministic decay back to zero. In order to assess the mechanisms of transmission, the total effect of the monetary shock is decomposed into direct/partial equilibrium and indirect/general equilibrium effects, as per Kaplan et al. (2018). First, the aggregate consumption is written as a function of the sequence of equilibrium prices, taxes and transfers $\{\Gamma_t\}_{t\geq 0}$ after the monetary policy shock:

$$C_t\left(\{\Gamma_t\}_{t\geq 0}\right) = \int c_t\left(a, b, z; \{\Gamma_t\}_{t\geq 0}\right) d\mu_t, \tag{25}$$

where $\Gamma_t = \left\{r_t^b, r_t^a, w_t, \tau_t, T_t\right\}$. Besides, $c_l\left(a, b, z; \{\Gamma_t\}_{t\geq 0}\right)$ is the consumption policy function and μ_t is the joint distribution of liquid and illiquid assets, as well as the idiosyncratic income. The decomposition of the consumption response arises after equation 25 is differentiated as:

$$dC_0 = \underbrace{\int_0^\infty \frac{\partial C_0}{\partial r_t^b} dr_t^b dt}_{\text{direct effect}} + \underbrace{\int_0^\infty \left(\frac{\partial C_0}{\partial w_t} dw_t + \frac{\partial C_0}{\partial r_t^a} dr_t^a + \frac{\partial C_0}{\partial \tau_t} d\tau_t + \frac{\partial C_0}{\partial T_t} dT_t\right) dt}_{\text{indirect effects}}. \tag{26}$$

The direct effects are related to a change in the path of the liquid return, since it enters the budget constraint of households. This encompasses both the inter-temporal substitution and income effects. The indirect effects are related to changes in wages, the illiquid return and the government budget constraint that arise in general equilibrium and are threefold.

First, non-hand-to-mouth households increase consumption in response to the fall on liquid return by the inter-temporal substitution channel. Intermediate firms increase their demand for labor in order to meet this additional demand for goods, and wages rise. An increase in labor income then leads to a further increase in consumption expenditures.

Second, after a change in the liquid return, the illiquid return also changes. Consumption then is also affected by households that choose to rebalance their asset portfolio with deposits or withdrawals from their illiquid account, which prompts a fall or a rise in consumption, respectively.

Third, there is the fiscal channel, the one directly related to the analysis here presented. A fall in the liquid return reduces the government's interest payments on its debt, while also results in higher tax receipts because of the rise in labor income. Both loosen the government inter-temporal budget constraint. In the next section, we present a simulation of this model calibrated to the Brazilian economy, analyzing both the baseline scenario, where government expenditures adjust after a monetary policy shock, and the alternate scenario, where expenditures follow a ceiling rule.

5 Quantitative Analysis

In Section 3 we documented the empirical evidence of fiscal response to monetary policy shocks in Brazil. In this section, we use the model presented in Section 4 to answer the main research question of this paper: what is the impact on the transmission of monetary policy under a fiscal rule that resembles the fiscal ceiling in Brazil?

In order to that, we present two scenarios. First, the baseline scenario in which the impact of a monetary policy shock is simulated without the expenditure ceiling, i.e. government's expenditures can be adjusted more freely after a monetary shock. Second, an alternative scenario in which government expenditures only grow in nominal terms following the inflation rate of the previous period, an approximation of the Brazilian expenditure ceiling.

5.1 Calibration

The model is calibrated to the Brazilian economy, and the choices for the relevant parameters are shown in Table 1.

The borrowing limit is set to 1 times quarterly average labor income. As in Kaplan et al. (2018), high frequency earnings dynamics are inferred from moments of annual earnings. As such, we use the variance of annual earnings and the variance and kurtosis of the 1 year change and 5 year change of earnings from the PNADc survey from IBGE. It is important to note, though, that the existence of heterogeneous agents brings the main results of Kaplan et al. (2018), but different distributions of wealth and earnings do not have a meaningful impact on the results here presented, as discussed by Wieland et al. (2016).

Table 1: Calibrated parameters used in the HANK model

Parameter	Description	Value	Target / Source
Preferences			
ζ	Death rate	1/180	Avg. Lifespan of 45y
$1/\gamma$	Intertemporal elasticity of subs.	1.3	
$1/\nu$	Frisch easticity of labor supply	1	Castro et al. (2015)
φ	Disutility of labor	2	
ρ	Discount rate factor	0.989	
Production			
ε	Elasticity of substitution	10	10% profit share (Kaplan et al. (2018)
θ	Price adjustment cost	100	Slope of Phillips curve, $\varepsilon/\theta = 0.1$ (Kaplan et al. (2018)
α	Capital share	0.448	Castro et al. (2015)
δ	Depreciation rate	6	
Government			
τ	Proportional labor tax	0.3	
Monetary Policy			
ϕ	Taylor rule coefficient	1.5	
$\bar{r}^b$	Liquid asset return factor	1.0314	Castro et al. (2015)
Adjustment cost function			
$\chi 0$	Linear component	0.0438	
$\chi 1$	Convex component	0.956	Kaplan et al. (2018)
$\chi 2$	Convex component	1.402	
a	Min a in denominator	1,000	

Source: produced by the author

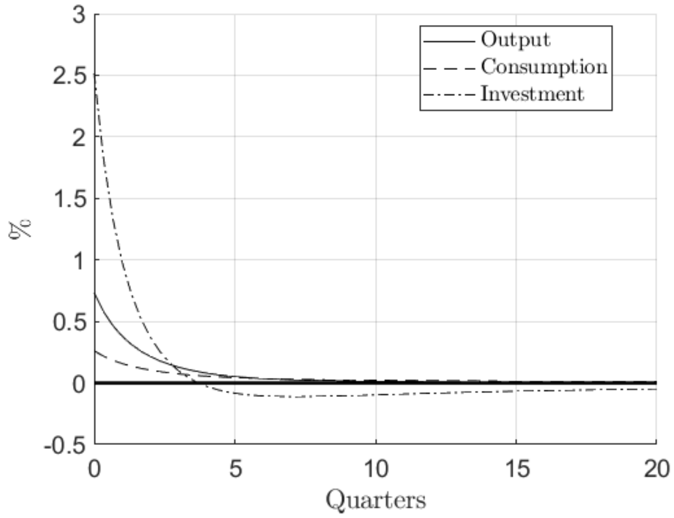
5.2 Monetary Policy Under a Fiscal Ceiling

We simulate the response of the economy to a one-time unexpected monetary shock (with the Selic rate being reduced in 1 percentage point), its decomposition into direct and indirect effects and the differences of the responses on consumption and output after the shock from the baseline and the alternate, "expenditure ceiling" scenarios. At $t = 0$, there is a 1 percentage point innovation to the Taylor rule that mean reverts at a rate that corresponds to a quarterly autocorrelation of $e^{\eta} = 0.61$.

First, the results from the baseline scenario, where expenditures adjust after the monetary policy shock.

Figure 3 displays the impulse responses for aggregate quantities after the

Figure 3: Impulse response to a monetary policy shock in the baseline scenario



Source: produced by the author.

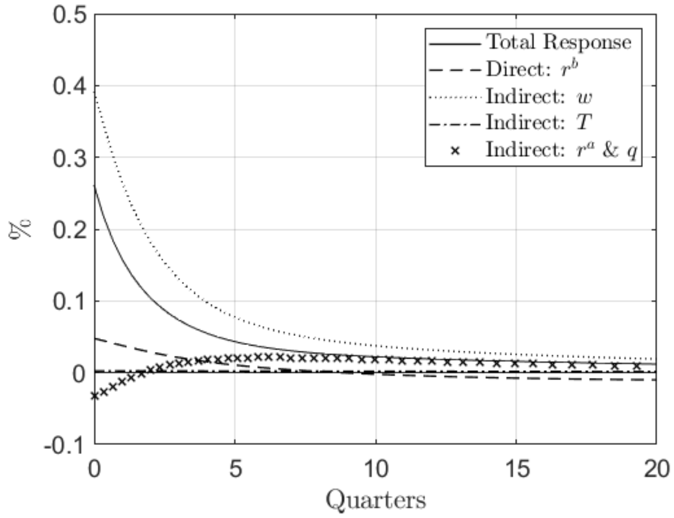
monetary shock. In response to the shock, consumption and investment are stimulated, leading to an increase in output. Qualitatively, consumption rises less than output, while investment rises more. Quantitatively, the impact on output and on consumption are close to the ones reported in the recent literature (see for example Kanczuk (2015), Castro et al. (2015) and the box of BCB (2020b) entitled "New small-scale aggregate model with Bayesian estimation").

The decomposition of the effects of the monetary shock on consumption is shown in Figure 4. The effect on wages is the most relevant one, followed by the direct effect on the liquid rate r^b. As such, just like in Kaplan et al. (2018), indirect effects prevail.

The results from the alternate scenario, with expenditures following a ceiling rule similar to the one adopted in Brazil, are shown in Figure 5.

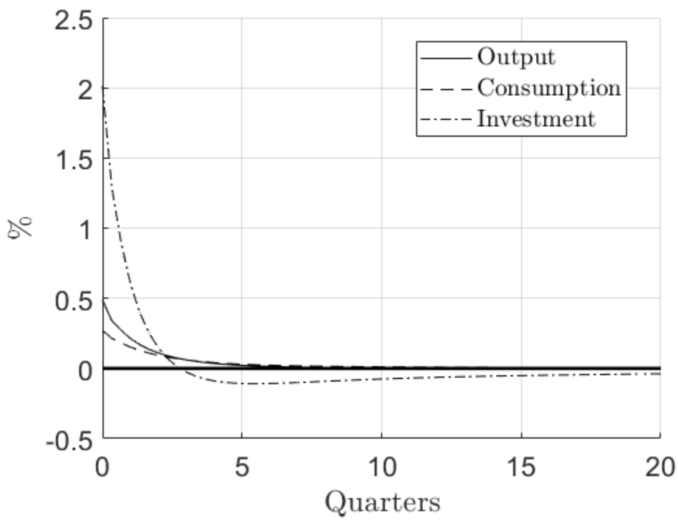
The effect on investment is less pronounced in this scenario. Consumption

Figure 4: Decomposition of the effects on consumption in the baseline scenario



Source: produced by the author.

Figure 5: Impulse response to a monetary policy shock in the alternate, expenditure ceiling scenario

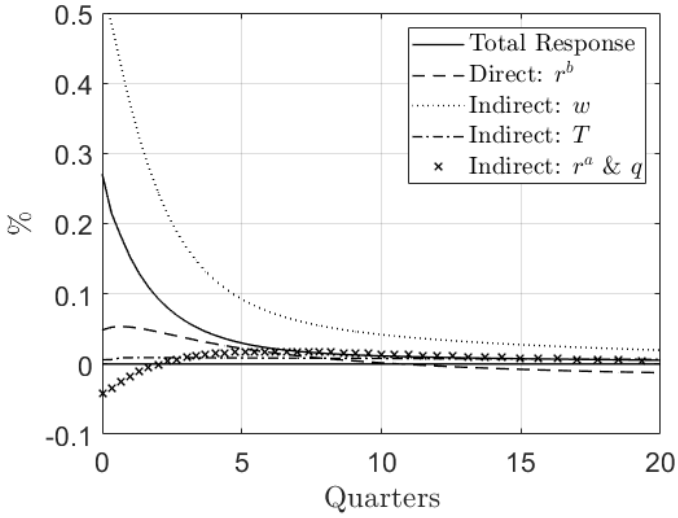


Source: produced by the author.

is virtually unaffected, but, as shown in Figure 6, with a different share of direct and indirect effects. There is, then, a smaller response from output.

The direct effect on the liquid rate r^b is slightly more pronounced. Indirect

Figure 6: Decomposition of the effects on consumption in the alternate, expenditure ceiling scenario



Source: produced by the author.

effects have a different composition, with a greater impact coming from the effect on wages, while the other indirect channels are slightly less pronounced. The overall effect on consumption is essentially the same as in the baseline scenario.

As can be seen, the way expenditures react to a monetary policy shock dictates not only the overall effect on output, but also the composition of the response, with different relative sizes of direct and indirect effects. When expenditures are constrained by a rule and, as such, are not allowed to react freely to changes in interest rates, the effect on aggregate demand is smaller. The fiscal side of the monetary policy transmission is, then, "muted".

6 Final Remarks

In this article, the interplay of monetary and fiscal policies is reviewed under a HANK framework. After the implementation of an expenditure cap beginning in 2017, the proposed hypothesis was that an important channel of transmission of monetary policy might have been ”muted”. To investigate this, a two-step approach was used: first, a dynamic factor model was estimated in order to look for evidence of a fiscal response to a monetary shock. After such evidence was found in the data, a state of the art model was calibrated in order to formalize the channels by which a monetary shock propagates to the economy, taken into consideration an heterogeneous agents framework, given rise for the fiscal response channel.

The results found corroborate the initial hypothesis, and there is evidence that the fiscal response channel is relevant for the transmission of a monetary shock, both in the data and in the theoretical model shown. Calculations provided here indicate that, if such channel is unable to adjust after the shock, which is the case after the spending rule enacted, the effect of the monetary shock on output is subdued.

Nevertheless, fiscal policy is not the only relevant variable relevant to this discussion. Other important structural changes also took place in the Brazilian economy. For example, in the second half of the last decade, the BCB worked to strengthen its credibility after years of persistent above target inflation (Val et al. (2017); Issler and Soares (2019)). At the same time, important changes in credit markets (for example the reduction in earmarked credit and changes in interest rates that are charged by the Brazilian development bank, BNDES) might also have affected monetary policy effects on the real economy. Such points are made by BCB (2020a) on a box that studied the power of monetary policy in Brazil. Yet, as shown here, it is an important factor to take into account when calibrating monetary policy.

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A Variables and Transformations - Empirical Exercise

Variable				Transformation		Source
1	Economic Activity	Industrial Production	Industrial Production	2	6	PIM - IBGE
2			Extractive	2	6	PIM - IBGE
3			Manufacturing	2	6	PIM - IBGE
4			Capital Goods	2	6	PIM - IBGE
5			Intermediary Goods	2	6	PIM - IBGE
6			Consumption Goods	2	6	PIM - IBGE
7			Durable Goods	2	6	PIM - IBGE
8			Non Durable Goods	2	6	PIM - IBGE
9			Construction	2	6	PIM - IBGE
10		Retail Sales	Retail Sales - Core	2	6	PMC - IBGE
11			Fuel	2	6	PMC - IBGE
12			Food and Beverages	2	6	PMC - IBGE
13			Supermarkets	2	6	PMC - IBGE
14			Fabrics and clothing	2	6	PMC - IBGE
15			Furnitures and appliances	2	6	PMC - IBGE
16			Pharmaceutical, medical, orthopedic, perfumery and cosmetic	2	6	PMC - IBGE
17			Books and Newspapers	2	6	PMC - IBGE
18			Equip. and office supplies. informatics and communication	2	6	PMC - IBGE
19			Other articles for personal and domestic use	2	6	PMC - IBGE
20			Vehicles	2	6	PMC - IBGE
21			Construction	2	6	PMC - IBGE
22			Retail Sales	2	6	PMC - IBGE
23		IBC-Br	Brazil	2	6	BCB
24		Manufacturing Confidnce	Manufacturing Confidence Index	2	4	Ibre - FGV
25			Current Situation	2	4	Ibre - FGV
26			Expectations	2	4	Ibre - FGV
27			Total Demand	2	4	Ibre - FGV
28			Inventory	2	4	Ibre - FGV
29			Estimated Total Demand	2	4	Ibre - FGV
30			Estimated Production	2	4	Ibre - FGV
31			Estimated Employment	2	4	Ibre - FGV
32			Business Trend Indicator	2	4	Ibre - FGV
33			Installed Capital Utilization Level	2	4	Ibre - FGV
34		Energy Consumption	Brazil	2	6	EPE
35			Residential	2	6	EPE
36			Industrial	2	6	EPE
37			Retail	2	6	EPE
38			Others	2	6	EPE

Continues...

	Variable				Transformation		Source
39	Labor Market	PnadC	Unemployment Rate		2	4	IBGE
40			Participation Rate		2	5	IBGE
41			Employment Level		2	6	IBGE
42			Real Wages		3	6	IBGE
43		Caged	Hiring	Total	2	6	Caged
44				Extractive	2	6	Caged
45				Manufacturing	2	6	Caged
46				Public Services	2	6	Caged
47				Construction	2	6	Caged
48				Retail	2	6	Caged
49				Services	2	6	Caged
50				Public Administration	2	6	Caged
51				Agriculture	2	6	Caged
52			Layoffs	Total	2	6	Caged
53				Extractive	2	6	Caged
54				Manufacturing	2	6	Caged
55				Public Services	2	6	Caged
56				Construction	2	6	Caged
57				Retail	2	6	Caged
58				Services	2	6	Caged
59				Public Administration	2	6	Caged
60				Agriculture	2	6	Caged
61			Avg hiring wages		3	6	Caged
62			Avg layoff wages		3	6	Caged

Continues...

	Variable				Transformation		Source
94	Inflation	IPCA	Total		2	4	IBGE
95			Administered Prices		2	4	IBGE
96			Free Prices		2	4	IBGE
97			BCB Criteria	Food	2	4	IBGE
98				Services	2	4	IBGE
99				Goods	2	4	IBGE
100			Underlying	Underlying Food	2	4	IBGE
101				Underlying Services	2	4	IBGE
102				Underlying Goods	2	4	IBGE
103			Core	IPCA-DP	2	4	IBGE
104				IPCA-MS	2	4	IBGE
105				IPCA-MA	2	4	IBGE
106				IPCA-EX0	2	4	IBGE
107				IPCA-EX1	2	4	IBGE
108				IPCA-EX2	2	4	IBGE
109				IPCA-EX3	2	4	IBGE
110				Average of Core Measures	2	4	IBGE
111		IGP-DI	Total		2	4	FGV
112			IPA-DI		2	4	FGV
113			INCC-DI		2	4	FGV
114	External Accounts	Balance of Payments	Current Account		1	6	BCB
115			Foreign Direct Investment		1	6	BCB
116			Fixed Income		1	6	BCB
117			Equities		1	6	BCB
118		Trade Balance	Exports		2	6	Funcex
119			Capital Goods		2	6	Funcex
120			Intermediary Goods		2	6	Funcex
121			Durable Goods		2	6	Funcex
122			Non Durable Goods		2	6	Funcex
123			Fuel		2	6	Funcex
124			Imports		2	6	Funcex
125			Capital Goods		2	6	Funcex
126			Intermediary Goods		2	6	Funcex
127			Durable Goods		2	6	Funcex
128			Non Durable Goods		2	6	Funcex
129			Fuel		2	6	Funcex

Continues...

#	Variable				Transformation		Source
94	Inflation	IPCA	Total		2	4	IBGE
95			Administered Prices		2	4	IBGE
96			Free Prices		2	4	IBGE
97			BCB Criteria	Food	2	4	IBGE
98				Services	2	4	IBGE
99				Goods	2	4	IBGE
100			Underlying	Underlying Food	2	4	IBGE
101				Underlying Services	2	4	IBGE
102				Underlying Goods	2	4	IBGE
103			Core	IPCA-DP	2	4	IBGE
104				IPCA-MS	2	4	IBGE
105				IPCA-MA	2	4	IBGE
106				IPCA-EX0	2	4	IBGE
107				IPCA-EX1	2	4	IBGE
108				IPCA-EX2	2	4	IBGE
109				IPCA-EX3	2	4	IBGE
110				Average of Core Measures	2	4	IBGE
111		IGP-DI	Total		2	4	FGV
112			IPA-DI		2	4	FGV
113			INCC-DI		2	4	FGV
114	External Accounts	Balance of Payments	Current Account		1	6	BCB
115			Foreign Direct Investment		1	6	BCB
116			Fixed Income		1	6	BCB
117			Equities		1	6	BCB
118		Trade Balance	Exports		2	6	Funcex
119			Capital Goods		2	6	Funcex
120			Intermediary Goods		2	6	Funcex
121			Durable Goods		2	6	Funcex
122			Non Durable Goods		2	6	Funcex
123			Fuel		2	6	Funcex
124			Imports		2	6	Funcex
125			Capital Goods		2	6	Funcex
126			Intermediary Goods		2	6	Funcex
127			Durable Goods		2	6	Funcex
128			Non Durable Goods		2	6	Funcex
129			Fuel		2	6	Funcex

Transformations used: 1 = original series, 2 = seasonally adjusted series, 3 = seasonally adjusted and deflated series, 4 = level, 5 = log, 6 = first log difference, 7 = second log difference. Source: Benedeti (2020)