Heterogeneity and the Role of Commodity Price Shocks *

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Abstract

Commodity prices are widely viewed as a major source of business-cycle fluctuations in emerging-market economies (EMEs). This view is largely based on representative agent models, where agents behave according to the permanent income hypothesis (PIH). However, recent empirical evidence points to large deviations from PIH (Bracco et al., 2021). Do these deviations from PIH behavior affect the importance of commodity price shocks for EME's business cycles? To answer this question I first show analytically that deviations from PIH can matter via two channels. On the one hand, hand-to-mouth agents (i.e. those who violate PIH) amplify the income effect of commodity price shocks in the short-run and dampen it in the long-run. On the other hand, they dampen the indirect interest-rate effect of these shocks. I then estimate a structural model to quantitatively explore the effect of PIH deviations on the importance of commodity price shocks as business-cycle drivers. The model is a standard small open economy model with two agents, and is estimated to match data from Brazil, Chile, and Colombia. Using variance decompositions I show that hand-to-mouth agents increase the importance of commodity price shocks for output and consumption fluctuations. Finally, I quantify the importance of two mechanisms in generating these results. First, the indirect interest rate effect is a relevant transmission channel for commodity price shocks, but it does not appear to be dampened by hand-to-mouth agents. Second, wealth effects on labor supply account for most of the amplification of hand-to-mouth agents on income and consumption.

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1 Introduction

Emerging markets are characterized by volatile business cycles and are often heavily dependent on commodity exports. Over recent decades, international prices of commodity goods have experienced significant fluctuations. It is natural then that commodity price shocks are widely viewed as one of the most important drivers of business cycles in emerging markets. A vast literature has focused on assessing how much commodity price shocks matter for business cycle fluctuations relative to other shocks, most notably total factor productivity (TFP) and interest rate shocks. Theoretically, this has been studied through the lens of representative agent models, where agents behave according to the permanent income hypothesis (PIH) and have low marginal propensities to consume (MPCs) out of transitory income shocks. Recent micro evidence, on the other hand, points to important deviations from PIH. This is especially the case in EMEs, where a large part of the population lives hand-to-mouth (HtM, 47% compared to 23% in developed economies, according to Bracco et al., 2021) and display large MPCs out of transitory income shocks (0.632 on average in Peru compared with 0.089 in the U.S., according to Hong, 2023b).

How relevant are PIH deviations for the transmission of commodity price shocks to emerging market economies? Can they change our understanding of the role of these shocks as business cycle drivers? This paper explores these two questions from a theoretical and quantitative point of view. I first use a stylized model to show how the presence of HtM agents, those who consume their entire income each period and therefore have large MPCs, matters for the effects of commodity price shocks. Then I use a standard small open economy model (Mendoza, 1991) with a fixed fraction of HtM agents, and bring it to the data for Brazil, Chile, and Colombia to answer the question quantitatively.

Why would the presence of HtM agents matter for the transmission of commodity price shocks? With the help of a simple endowment economy model with two agents I show that including agents that violate PIH (HtM agents) affects the two channels through which shocks to commodity prices transmit to EMEs. First, there is a direct *income chan-*

nel: an increase in commodity prices represents a positive income shock for the domestic economy. This channel is *amplified* in the short-run by HtM agents because they have high MPCs out of unexpected income changes. Second, there is an indirect *interest rate channel*: if commodity prices co-move negatively with country spreads, interest rates will constitute an additional transmission mechanism. This mechanism has been incorporated in some quantitative models in the literature (Schmitt-Grohé & Uribe, 2018; Drechsel & Tenreyro, 2018; Fernández et al., 2018), to account for the empirical evidence of a negative comovement between commodity prices and country spreads (Bastourre et al., 2012; Shousa, 2016; Hamann et al., 2023). This channel is *dampened* in the short-run by HtM agents because they are unresponsive to changes in the interest rate. Since the two effects go in opposite directions, their relative strength will determine whether heterogeneity leads to dampening or amplification overall. In a numerical example I show that, while generally HtM agents amplify the impact response of consumption, output and real exchange rate, this can be reversed by a very strong (negative) effect on the interest rate.

To study the question from a quantitative point of view, I add heterogeneity to a standard small open economy model with a commodity sector (Mendoza, 1991) and estimate it using data for Brazil, Chile, and Colombia. The model features two types of agents who differ in their participation in financial markets: Ricardian agents can borrow or lend in an international bond, while the HtM cannot. I calibrate the fraction of each type using estimates from Bracco et al. (2021). The economy is subject to shocks to the international price of the commodity good that they export, which can also impact the interest rate spread. The model also features other shocks that have been proposed in the literature as the main sources of business cycles in emerging markets. I estimate some key structural parameters of the model using Bayesian methods.

I then use the estimated model to compare it to its representative agent counterpart in two aspects: the dynamic response to commodity price shocks (through impulse response analysis) and their role as business cycle drivers (through variance decompositions). Results suggest a larger role for commodity price shocks in models that include PIH deviations, although the difference is moderate. Finally, I explore two mechanisms that drive these results. First, the indirect interest rate effect is a relevant transmission channel for commodity price shocks, but it does not appear to be dampened by HtM agents. Second, wealth effects on labor supply account for most of the amplification of HtM agents on income and consumption.

Related Literature. This paper relates to the literature on commodity prices (or more generally terms of trade) and EME's business cycles. Mendoza (1995) and Kose (2002) study the importance of terms-of-trade disturbances for explaining business cycle variability in EMEs through the lens of calibrated business cycle models. More recently, the literature has resorted to stochastic and dynamic general equilibrium models estimated with Bayesian methods to study the role of terms-of-trade (Schmitt-Grohé & Uribe, 2018) and commodity price shocks (Drechsel & Tenreyro, 2018; Fernández, Schmitt-Grohé, & Uribe, 2017). The models used in these papers feature a representative agent, who behaves according to PIH. This paper contributes by adding deviations from PIH in the form of an empirically realistic fraction of HtM consumers, to analyze if it changes our understanding of the importance of commodity price shocks in EMEs.

Extensive empirical research has studied the impact of commodity-price and terms-of-trade shocks on business cycles. Numerous papers have used variance decompositions within estimated SVAR models to explore this question (Fernández, Schmitt-Grohé, & Uribe, 2017; Di Pace, Juvenal, & Petrella, 2024; Schmitt-Grohé & Uribe, 2018). In this study, I perform a similar estimation exercise for commodity price shocks within the local projection framework. More recently, Juvenal & Petrella (2024) examine the impact of commodity price changes on EME's business cycles, focusing on distinguishing between their role as a source of shock and as a channel of transmission of global shocks.

The paper is also related to an emerging literature that argues that heterogeneity matters for the transmission of shocks in small open economies. Sudden stops are studied with the help of Heterogeneous-Agent New Keynesian (HANK) models with a full distribution of agents (De Ferra, Mitman, & Romei, 2020) or with limited heterogeneity (Cugat, 2019). HANK models have also been used to study external monetary shocks (Zhou, 2021; Auclert, Rognlie, Souchier, & Straub, 2021; Guo, Ottonello, & Perez, 2023; Oskolkov, 2023; Ferrante & Gornemann, 2022) and shocks to foreign demand (Guo, Ottonello, & Perez, 2023; Druedahl, Ravn, Sunder-Plassmann, Sundram, & Waldstrom, 2022). This paper adds to this literature by focusing on shocks to terms of trade, which have been given a central role in the analysis of EME's business cycles. Finally, this paper shares an interest in explaining business cycle properties of EMEs with Hong (2023a), who relates excess consumption volatility in EMEs to high MPCs (using micro data for Peru). My focus instead is on the impact of high MPCs for the importance of terms-of-trade shocks as business cycle drivers.

Layout. The rest of the paper is organized as follows. Section 2 features the analysis with the stylized model. The quantitative model is set-up in Section 3 and the calibration and estimation strategy are described in Section 4, along with the model performance. The main results are explained in section 5 . Finally, section 6 concludes.

2 Stylized Model

2.1 Set-up

There are two types of agents in the economy: a fraction χ of "Hand to mouth" agents and $1-\chi$ of "Ricardian" agents. Both have preferences represented by the utility function

$$U(C^i_{Ht}, C^i_{Ft}) = \sum_{t=0}^{\infty} \beta^t \left(\alpha \ln C^i_{Ht} + (1-\alpha) \ln C^i_{Ft} \right) \tag{2.1}$$

where C^i_{Ht} and C^i_{Ft} are consumption of a home and a foreign good by an agent of type $i = R, H$. The two types differ in their budget constraints. Ricardian agents maximize subject to

$$P_{Ht}C^R_{Ht} + C^R_{Ft} + D^*_t = P_{Ht}\bar{Y}_H + Y_{Ft} + R^*_{t-1}D^*_{t-1} \tag{2.2}$$

while the HtM face a simpler budget constraint:

$$P_{Ht}C_{Ht}^{H} + C_{Ft}^{H} = P_{Ht}\bar{Y}_{H} + Y_{Ft} \tag{2.3}$$

The difference is that Ricardian agents are allowed to save or borrow in an international bond while HtM agents are not. Let D_t^* denote the stock of debt owned by a representative Ricardian agent ($(1-\chi)D_t^*$ is then the total stock of debt in the economy). The bond pays R_t^* units of the foreign good at $t+1$ per unit of the good at t. Both agents are endowed with $\bar{Y}_H$ units of the home good (fixed for simplicity) and Y_{Ft} units of the foreign good. The home good has price P_{Ht} while that of the foreign good is normalized to 1 ($P_{Ft} = 1$).

The domestic economy faces an external demand for the home good given by

$$C_{Ht}^{*} = P_{Ht}^{-1}C_t^{*} \tag{2.4}$$

where C_t^* represents global demand and is taken as given by the small open economy.

We are going to look at shocks to the endowment of the foreign good, which in this very simple set-up can be analogous to shocks to commodity prices. The endowment of the foreign good follows

$$Y_{Ft} = \bar{Y}_F + \epsilon_t \tag{2.5}$$

where $\bar{Y}_F$ is the long-run level of the endowment and ϵ_t is the shock. Additionally, I allow the shock to affect the interest rate faced by the domestic economy, R_t^*. The domestic interest rate is the sum of the international interest rate $\bar{R}^*$, assumed to be constant, and a country premium that is affected by the shock ϵ_t and the debt position D_{t+1}^*:

$$R_t^* = \bar{R}^* + \gamma_R\epsilon_t + \psi\left[exp((1-\chi)D_{t+1}^* - (1-\chi)\bar{D}^*) - 1\right] \tag{2.6}$$

The parameter γ_R controls the size of the effect of the shock on the spread. The last term makes the spread debt-elastic: when debt increases above its steady state value, $\bar{D}^*$, the economy faces a higher interest rate. Debt-elastic interest rate spreads were introduced by Schmitt-Grohé & Uribe (2003) as a way to induce stationarity in small open economy models. The parameter ψ is usually given a low value (0.000742 in Schmitt-Grohé & Uribe, 2003) and plays no role in the model other than inducing stationarity.

The competitive equilibrium in this economy is determined by the first order conditions of both types of agents (in appendix A.1) and the market clearing condition for the home good:

$$(1-\chi)C_{Ht}^R + \chi C_{Ht}^H + C_{Ht}^* = \bar{Y}_H \tag{2.7}$$

The competitive equilibrium can be summarized by the following, as shown in Appendix section A.2,

$$P_{Ht}\bar{Y}_H = \frac{\alpha}{1-\alpha\chi}\left(\chi Y_{Ft} + \frac{1-\chi}{1-\alpha}C_{Ft}^R\right) + \frac{1}{1-\alpha\chi}C_t^* \tag{2.8}$$

$$\frac{1}{C_{Ft}^R} = \beta R_t^* \frac{1}{C_{Ft+1}^R} \tag{2.9}$$

$$\sum_{t=0}^{\infty}\left(\prod_{s=0}^{t-1} R_s^*\right)^{-1}\left(C_{Ft}^R - Y_{Ft} - C_t^*\right) = (1-\alpha\chi)\, D_{-1}^* \tag{2.10}$$

2.2 Some analytical results

The purpose of this section is to analyze how the dynamic responses of variables in the model depend on the fraction of HtM agents in the economy (χ). I focus on the price of the home good (inverse of the real exchange rate) and the trade balance, defined as:

$$TB_t = P_{Ht}\bar{Y}_H + Y_{Ft} - (1-\chi)\left(P_{Ht}C_{Ht}^R + C_{Ft}^R\right) - \chi\left(P_{Ht}C_{Ht}^H + C_{Ft}^H\right) \tag{2.11}$$

Consider a positive one-time shock to the endowment Y_F at time 0 ($\epsilon_0 > 0$) and no shocks for $t \geq 1$ (meaning that $Y_{F0} = \bar{Y}_F + \epsilon_0$ and $Y_{Ft} = \bar{Y}_F\ \forall t \geq 1$). The price of the home good and the trade balance react according to:

$$\Delta P_{Ht} = \frac{1}{\bar{Y}_H}\frac{\alpha}{1-\alpha\chi}\left[\chi\Delta Y_{Ft} + \frac{1-\chi}{1-\alpha}\Delta C^R_{Ft}\right] \tag{2.12}$$

$$\Delta TB_t = \frac{1-\chi}{1-\alpha\chi}\left[\Delta Y_{Ft} - \Delta C^R_{Ft}\right] \tag{2.13}$$

See appendix section A.3 for proofs. Price movements will go in the same direction as the shock, whereas the sign of the change in the trade balance depends on the response of consumption of foreign goods by Ricardian agents. If $\Delta Y_{Ft} > \Delta C^R_{Ft}$, the trade balance improves after a positive shock.

How do these changes depend on the fraction of HtM agents (χ)? Assuming that $\bar{D}^*_{-1} = 0$, it follows from equation 2.10 that C^R_{Ft} is independent of χ. Then, taking derivatives with respect to χ we find that:

$$\frac{\partial \Delta P_{Ht}}{\partial \chi} = \frac{\frac{\alpha}{\bar{Y}_H}}{(1-\alpha\chi)^2}(\Delta Y_{Ft} - \Delta C^R_{Ft}) \tag{2.14}$$

$$\frac{\partial \Delta TB_t}{\partial \chi} = \frac{-(1-\alpha)}{(1-\alpha\chi)^2}(\Delta Y_{Ft} - \Delta C^R_{Ft}) \tag{2.15}$$

If $\Delta Y_{Ft} > \Delta C^R_{Ft}$ the first derivative is positive, so HtM agents amplify price movements. When this condition is met the second derivative is negative, but the condition also affects the sign of ΔTB_t. Therefore HtM agents always dampen the response of the trade balance, independently on the size of the consumption response. If $\Delta C^R_{Ft} < \Delta Y_{Ft}$, the trade balance increases and the increase is lower the higher the fraction of HtM agents is. If $\Delta C^R_{Ft} > \Delta Y_{Ft}$ the trade balance deteriorates, but the fall is lower the larger is χ. Intuitively, the response of the trade balance is always dampened by HtM agents because they cannot borrow or lend, so they consume all their disposable income. In the extreme case of $\chi = 1$ (all agents are HtM) the trade balance must always be zero.

When does the condition $\Delta C^R_{Ft} < \Delta Y_{Ft}$ hold? It depends on how foreign consumption of Ricardian agents reacts to the shock (ΔC^R_{Ft}), which depends on whether the shock also affects the interest rate. To analyze the different mechanisms, consider two cases: (1) the shock only affects the endowment ($\gamma_R = 0$); and (2) the shock also affects the interest rate ($\gamma_R \neq 0$).

First, we focus on the response on impact to derive some analytical results. When the shock only affects the endowment of the foreign good ($\gamma_R = 0$), the condition $\Delta C^R_{F0} < \Delta Y_{F0}$ always holds. Assuming $\bar{R}^* = \beta^{-1}$ and $\bar{D}^*_{-1} = 0$, we get that Ricardian agents increase their consumption only by a fraction of the increase in the endowment:

$$\Delta C^R_{F0} = (1-\beta)\Delta Y_{F0} \tag{2.16}$$

This is clearly smaller than ΔY_{F0}, so HtM agents always amplify the real appreciation and dampen the improvement in the trade balance.

In the second case, when the interest rate is also affected by the shock ($\gamma_R \neq 0$), consumption reacts on impact according to (see A.3):

$$\Delta C^R_{F0} = (1-\beta)\Delta Y_{F0} + \frac{-\beta\gamma_R \Delta Y_{F0}}{\beta^{-1} + \gamma_R \Delta Y_{F0}}(\bar{Y}_F + \bar{C}^*) \tag{2.17}$$

There is a new intertemporal substitution effect: if the interest rate falls (if $\gamma_R < 0$), consumption increases beyond the direct effect of the shock. If this effect is very large, it could be the case that $\Delta C^R_{F0} > \Delta Y_{F0}$, violating the condition above. When does this happen?

$$\Delta C^R_{F0} > \Delta Y_{F0} \iff \gamma_R < \underline{\gamma} \equiv \frac{-\beta^{-1}}{\bar{Y}_F + \bar{C}^* + \epsilon_0} \tag{2.18}$$

If the indirect effect on the interest rate spread is negative and large enough in absolute value (below $\underline{\gamma}$), HtM agents dampen the real exchange rate appreciation. This is because HtM agents do not react to changes in the interest rate, so the aggregate consumption response is attenuated. In this case the trade balance deteriorates because consumption increases considerably.

Finally, we can look at the dynamics for $t \geq 1$. Since we are analyzing a one-time shock, we will have that at $t = 1$ variables go back to their previous values (in the case of Y_F and R^*) or jump to new steady state values (in the case of C_F^R, TB, and P_H). After $t = 1$ there are no more changes. Then, for $t = 1$ we have:

$$\Delta Y_{F1} = -\epsilon_0 \tag{2.19}$$

$$\Delta C_{F1}^R = \beta \gamma_R \epsilon_0 C_{F0}^R \tag{2.20}$$

$$\Delta P_{H1} = \frac{1}{\bar{Y}_H} \frac{\alpha}{1 - \alpha\chi} \left[-\chi\epsilon_0 + \frac{1-\chi}{1-\alpha} \beta\gamma_R \epsilon_0 C_{F0}^R \right] \tag{2.21}$$

$$\Delta TB_t = \frac{1-\chi}{1-\alpha\chi} \left[-\epsilon_0 - \beta\gamma_R\epsilon_0 C_{F0}^R \right] \tag{2.22}$$

The condition $\Delta Y_{F1} > \Delta C_{F1}^R$ reduces to $\gamma_R < \frac{-1}{\beta C_{F0}^R}$. We expect this condition to be violated (if γ_R is not extremely large in absolute value), in which case the trade balance falls and the response of the price is dampened by HtM agents. The price of the home good will fall if $C_{F0}^R > \frac{\chi}{1-\chi} \frac{(1-\alpha)\epsilon_0}{\beta\gamma_R\epsilon_0}$. The right hand side of the inequality is negative as long as γ_R is negative, so this condition will always hold.

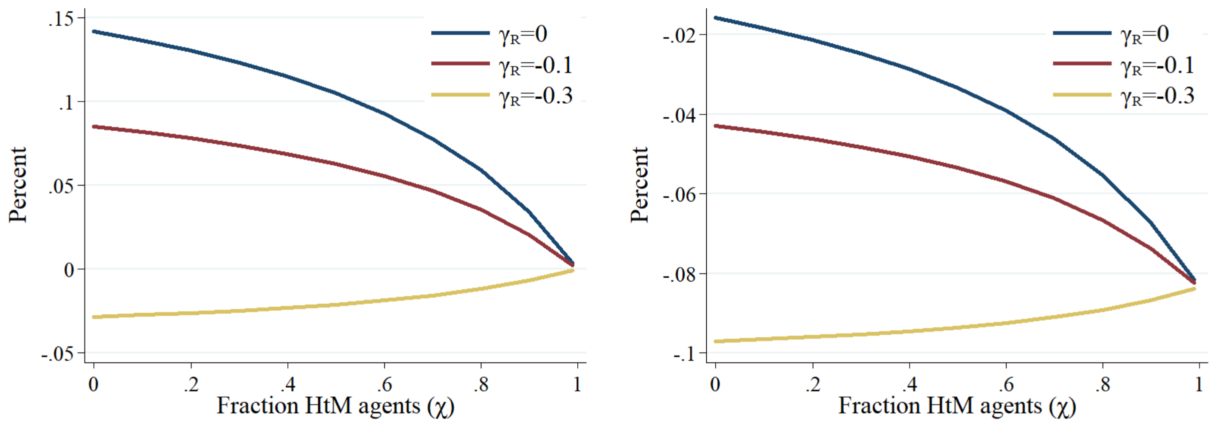
To summarize, the stylized model tells us that, under some reasonable conditions, HtM agents amplify the response on impact of prices, while in the "long-run" they dampen it. On the other hand, they always dampen the response of the trade balance.

2.3 Numerical Example

Next I briefly illustrate these analytical results using a numerical example (see Table A.1 for the parameterization). The structure of the model is the same as above, except for the

Figure 1: Impact Response to Endowment Shock

(a) Trade Balance **(b)** Real Exchange Rate



Notes: Figure 1 plots the impact response of the trade balance and the real exchange rate to a shock to the endowment of the foreign good, for different fractions of HtM agents and different assumptions about the effect of the shock on the interest rate.

process for the endowment and the interest rate, to which I incorporate some persistence:

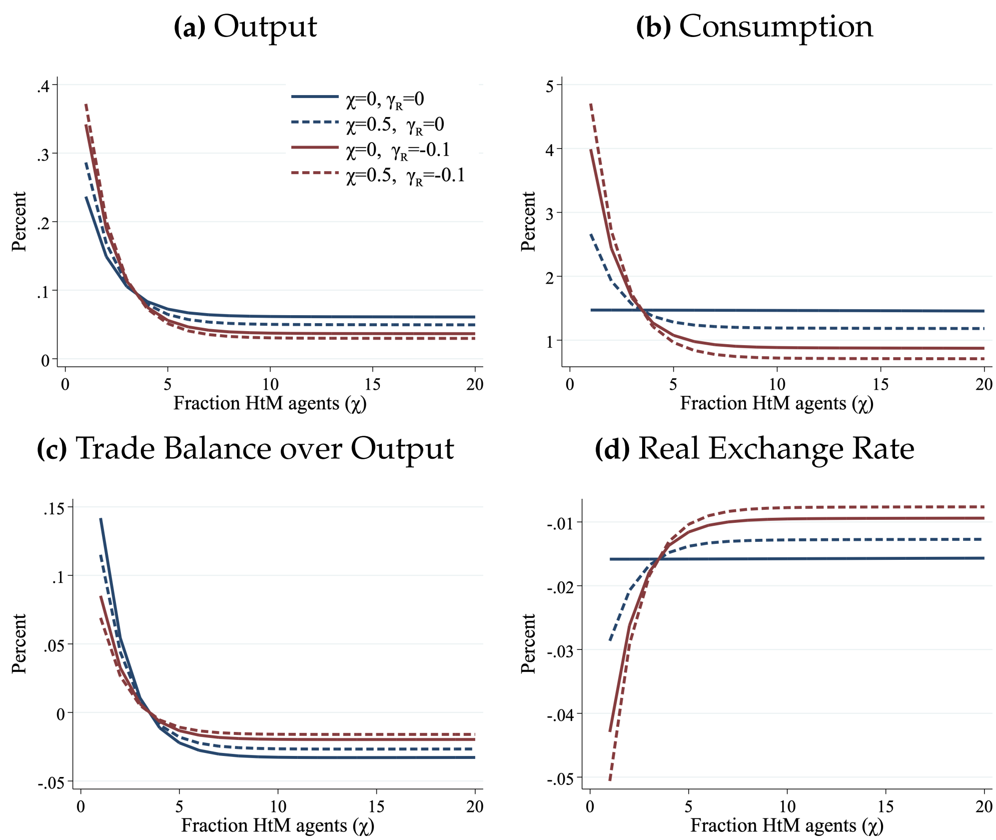
$$ln\ Y_{Ft} = (1-\rho_Y) ln\ \bar{Y}_F + \rho_Y\ ln\ Y_{Ft-1} + \epsilon_t, \qquad \epsilon_t \sim N(0, \sigma_Y^2) \tag{2.23}$$

$$ln\ r_t^* = (1-\rho_r) ln\ \bar{r}^* + \rho_r\ ln\ r_{t-1}^* + \gamma_R \epsilon_t, \tag{2.24}$$

where $r_t^* = R_t^* - 1$ and ϵ_t is the shock to the foreign good endowment, that can potentially impact the interest rate.

I focus first on the response on impact of the real exchange rate (inverse of P_{Ht}) and the trade balance, as I did above. Figure 1 compares the impact response of these variables for different fractions of HtM agents and different assumptions about the interest rate. We can see that, when there is no effect on the interest rate ($\gamma_R = 0$) the trade balance improves on impact and the real exchange rate appreciates. The first effect is dampened by HtM agents, whereas the second one is amplified. When we incorporate a small negative effect on the interest rate ($\gamma_R = -0.1$) the trade balance increases less and the real exchange rate appreciates more, but the slope of the curves becomes flatter. This means that the fraction of HtM agents χ matters less. Finally, we need a very strong interest rate effect ($\gamma_R = -0.3$)

Figure 2: Impulse Responses to Endowment Shock



Notes: Figure A.1 plots the impulse responses of four key variables in the model to a shock to the endowment of the foreign good, in different scenarios. Blue lines correspond to the model without an indirect effect on the interest rate ($\gamma_R = 0$) and red lines correspond to the model with a negative indirect effect ($\gamma_R = -0.1$). Solid lines correspond to a model where all agents are Ricardian ($\chi = 0$) and dashed lines to a model where half of agents are HtM ($\chi = 0.5$).

to get a trade balance decrease and dampening of the real exchange rate appreciation.

To conclude this section, I show in Figure 2 the impulse responses of four key variables to the endowment shock. I compare the responses in the model where half of agents are HtM ($\chi = 0.5$) to those in a model where all agents are Ricardian ($\chi = 0$), in both cases with and without an indirect effect on the interest rate. Without the effect on the interest rate (blue lines, $\gamma_R = 0$) we get the largest difference between the dashed and solid lines (with and without HtM agents). Hand-to-mouth agents react more strongly in the short-run, so consumption increases more in the first few periods (increasing the price more). However, as the shock fades, these agents go back to their initial steady state, whereas Ricardian agents keep a higher level of consumption forever. This explains why there is amplification in the short-run and dampening on the long-run. Finally, when we incorporate a small negative effect on the interest rate (red lines, $\gamma_R = -0.1$) the difference between the solid and dashed lines shrinks. In the short run Ricardian agents now increase their consumption more because of an intertemporal substitution effect. This is reflected in the other variables. Figure A.1 in the appendix shows the case with a stronger interest rate effect ($\gamma_R = -0.3$), where the red dashed and solid lines become almost indistinguishable.

3 A two-agent small open economy model

The stylized model above suggests that the presence of HtM agents can lead to amplification of some of the effects of commodity prices in the short-run, while they always lead to dampening in the long-run. To study these effects quantitatively, I build in this section a two-agent version of a standard small open economy model. The model builds on the small open economy model introduced by Mendoza (1991) and further analyzed by the literature (Fernández et al., 2018; Drechsel & Tenreyro, 2018; García-Cicco et al., 2010). Particularly, it follows Fernández et al. (2018) and Drechsel & Tenreyro (2018) in two key aspects: (i) adding a commodity sector that faces fluctuations in its international price, and (ii) allowing for a negative relationship between commodity prices and interest rate spreads, consistent with empirical evidence.

The key element that I add that is absent in their studies is the presence of a fixed fraction of HtM agents. Apart from the shocks to commodity prices, the model features other shocks that have been highlighted in the literature as sources of business cycle fluctuations in emerging markets (shocks to productivity, interest rate spreads, international interest rates and global demand). This is to analyze the importance of commodity shocks as business cycle drivers relative to these other shocks, and to understand how HtM agents affect these results.

3.1 Households

On the household side we have two types of agents: a fraction $1-\chi$ is Ricardian and a fraction χ is HtM. Both types consume a final consumption good (c_t^i for agent of type i) and supply labor to domestic firms (l_t^i). They maximize the same lifetime utility:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\left[c_t^i - \xi \frac{\left(l_t^i\right)^{1+\eta}}{1+\eta} z_t^i\right]^{1-\sigma} - 1}{1-\sigma} \qquad i = R, H \tag{3.1}$$

where

$$z_t^i = (c_t^i)^{\omega} (z_{t-1}^i)^{1-\omega} \tag{3.2}$$

These preferences are of the Jaimovich & Rebelo (2009) form, where the presence of X_t makes preferences non-time-separable in consumption and hours worked. This general class of preferences nest the two types of preferences mostly used in the business cycle literature. When $\omega = 0$ preferences are as in Greenwood et al. (1988), with no wealth effect on labor supply. When $\omega = 1$ preferences are as in King et al. (1988), with sizable wealth effects on labor supply. Therefore ω controls size of the wealth effect on labor supply. Consumption c_t^i is a bundle of domestic and imported goods:

$$c_t^i = \left[(1-\alpha_c)^{\frac{1}{\eta_c}} \left(c_t^{ih}\right)^{\frac{\eta_c - 1}{\eta_c}} + \alpha_c^{\frac{1}{\eta_c}} \left(c_t^{if}\right)^{\frac{\eta_c - 1}{\eta_c}}\right]^{\frac{\eta_c}{\eta_c - 1}} \tag{3.3}$$

where c_t^{ih} and c_t^{if} are consumption of home and foreign goods respectively, η_c denotes the elasticity of substitution between these goods, and α_c determines the share of imported goods in total consumption.

For Ricardian agents the budget constraint is defined as:

$$p_t^c c_t^R + p_t^x x_t + R_{t-1} d_{t-1} = w_t l_t^R + r_t^k k_{t-1} + d_t + \frac{1}{1-\chi} p_t^{Co} \bar{C}o \tag{3.4}$$

where p_t^c is the price of the consumption bundle, d_t is the stock of international debt that pays gross interest rate R_{t-1}, k_t is physical capital with return r_t^k, x_t is investment with price p_t^x, and w_t is the real wage. I assume that the country has a fixed endowment of the commodity good ($\bar{Co}$) with international price p_t^{Co}, which the country takes as given. I assume that this endowment is entirely owned by the Ricardian agents, so each Ricardian agent receives revenues $\frac{1}{1-\chi} p_t^{Co} \bar{Co}$ from the commodity sector. Capital accumulates following:

$$k_t = (1-\delta)k_{t-1} + x_t \left(1 - \phi_t \left(\frac{x_t}{x_{t-1}}\right)\right) \tag{3.5}$$

where $\phi_t(.)$ is the adjustment cost function from Christiano et al. (2010):

$$\phi_t \left(\frac{x_t}{x_{t-1}}\right) = \frac{1}{2}\left(e^{\left(\sqrt{a}\left(\frac{x_t}{x_{t-1}}-1\right)\right)} + e^{\left(-\sqrt{a}\left(\frac{x_t}{x_{t-1}}-1\right)\right)} - 2\right) \tag{3.6}$$

On the other hand, HtM agents cannot access financial markets or invest in physical capital, so their budget constraint is simply:

$$p_t^c c_t^H = w_t l_t^H \tag{3.7}$$

3.2 Firms

The home good consumed by households is produced by a representative domestic firm using capital and labor. This firm maximizes its profits, equal to:

$$p_t^H Y_t - r_t^k K_{t-1} - w_t L_t \tag{3.8}$$

where $Y_t = A_t K_{t-1}^{\alpha} L_t^{1-\alpha}$ (with A_t being the stochastic productivity level) and L_t and K_{t-1} are the total amounts of labor and capital demanded by the firm.

The investment good is produced with home and foreign inputs with constant elasticity of substitution (CES) technology:

$$X_t = \left[(1-\alpha_x)^{\frac{1}{\eta_x}} \left(X_t^h \right)^{\frac{\eta_x - 1}{\eta_x}} + \alpha_x^{\frac{1}{\eta_x}} \left(X_t^f \right)^{\frac{\eta_x - 1}{\eta_x}} \right]^{\frac{\eta_x}{\eta_x - 1}} \tag{3.9}$$

where X_t^h and X_t^f are domestic and imported inputs, η_x denotes the elasticity of substitution between these inputs, and α_x determines the share of imported goods in total investment.

3.3 Equilibrium

The market clearing condition for the home goods market is

$$Y_t = (1-\chi)c_t^{hR} + \chi c_t^{hH} + X_t^h + C_t^{h*} \tag{3.10}$$

where C_t^{h*} is external demand for home goods, that follows

$$C_t^{h*} = (p_t^h)^{-\epsilon_e} Y_t^* \tag{3.11}$$

where Y_t^* is aggregate demand in the rest of the world, assumed to be exogenous, and ϵ_e is the price elasticity of external demand for the home good.

There are two additional market clearing conditions, for the labor and investment goods markets:

$$L_t = (1-\chi)l_t^R + \chi l_t^H \tag{3.12}$$

$$K_t = (1-\chi)k_t \tag{3.13}$$

$$X_t = (1-\chi)x_t \tag{3.14}$$

The firm's labor demand is satisfied by both types of agents, while its demand for capital is only satisfied by Ricardian agents. Similarly, investment goods are demanded solely by Ricardian agents.

In addition, we define real GDP and the trade balance as

$$GDP_t = \frac{p_t^h Y_t + p_t^{Co}\bar{C}o}{p_t^c} \tag{3.15}$$

$$TB_t = p_t^{Co}\bar{C}o + p_t^h C_t^{h*} - \left[X_t^f + (1-\chi)c_t^{fR} + \chi c_t^{fH}\right] \tag{3.16}$$

The real exchange rate is defined as the inverse of the price of the consumption goods (see appendix section B.2 for details):

$$RER_t = (p_t^c)^{-1} \tag{3.17}$$

The domestic interest rate is the product of the international interest rate R_t^* and a country spread S_t

$$R_t = R_t^* S_t \tag{3.18}$$

where the spread is defined as:

$$S_t = s_t \left\{exp\left[\psi\left(D_t - \bar{D}\right)\right] - 1\right\} \tag{3.19}$$

where s_t is an exogenous stochastic spread and $D_t = (1-\chi)d_t$ is the aggregate level of debt. The second term of the right-hand-side is the debt-elastic interest rate mechanism of Schmitt-Grohé & Uribe (2003) already present in the stylized model.

There are five driving forces of business cycles in the economy. Commodity prices have an autoregressive structure of order 1 with shocks ϵ_t^{Co}:

$$ln\ p_t^{Co} = (1-\rho_{Co})ln\ \bar{p}^{Co} + \rho_{Co} ln\ p_{t-1}^{Co} + \epsilon_t^{Co}, \quad \epsilon_t^{Co} \sim N(0, \sigma_{Co}^2) \tag{3.20}$$

Similarly, the exogenous spread follows an AR(1) process:

$$ln\ s_t = (1-\rho_s)ln\ \bar{s} + \rho_s ln\ s_{t-1} + \gamma_R ln\ \hat{p}_t^{Co} + \epsilon_t^s, \quad \epsilon_t^s \sim N(0, \sigma_s^2) \tag{3.21}$$

where I allow the spread to be affected by deviations of commodity prices from their steady state $\hat{p}_t^{Co} = ln\ p_t^{Co} - ln\ \bar{p}^{Co}$. This is to account for the empirical evidence of a negative co-movement between commodity prices and country spreads, and to analyze the strength of this channel. The parameter γ_R governs the sensitivity of the spread to $\hat{p}_t^{Co}$ and will therefore be an important object in the analysis that follows.

Another domestic source of fluctuations are shocks to firm productivity, which follows:

$$ln\ A_t = (1-\rho_A)ln\ \bar{A} + \rho_A ln\ A_{t-1} + \epsilon_t^A, \quad \epsilon_t^A \sim N(0, \sigma_A^2) \tag{3.22}$$

Finally, there are two external driving forces: the international interest rate and the world demand, both of which follow AR(1) processes with disturbances $\epsilon_t^{R^*}$ and $\epsilon_t^{Y^*}$:

$$ln\ R_t^* = (1-\rho_{R^*})ln\ \bar{R}^* + \rho_{R^*} ln\ R_{t-1}^* + \epsilon_t^{R^*}, \quad \epsilon_t^{R^*} \sim N(0, \sigma_{R^*}^2) \tag{3.23}$$

$$ln\ Y_t^* = (1-\rho_{Y^*})ln\ \bar{Y}^* + \rho_{Y^*} ln\ Y_{t-1}^* + \epsilon_t^{Y^*}, \quad \epsilon_t^{Y^*} \sim N(0, \sigma_{Y^*}^2) \tag{3.24}$$

4 Quantitative Analysis

In this section I fit the model to the data for three countries, Brazil, Chile, and Colombia, which are important commodity exporters. The process of taking the model to the data consists on two steps. First, I assign values to the parameters that only affect the steady state by taking values from the literature and targeting some steady state moments. A key parameter is the fraction of HtM agents in each country, which I take from Bracco et al. (2021). Second, I estimate the remaining parameters that affect the dynamics and business cycle properties of the model following a Bayesian full information approach.

Table 1: Calibrated parameters

Panel A: Common parameters				
σ	Relative risk aversion coefficient		2.00	
η	Inverse labor supply elasticity		0.59	
δ	Capital depreciation rate (annual)		0.02	
η_c	Elasticity of substitution H/F in consumption		0.43	
η_x	Elasticity of substitution H/F in investment		0.43	
ϵ_e	Price elasticity of foreign demand for H good		1.18	
$\bar{Y}^*$	Steady state global demand		1.00	
$\bar{A}$	Steady state productivity		1.00	
$\bar{R}^*$	Steady state international interest rate (annual)		1.01	
ψ	Interest rate elasticity to debt		0.0001	

Panel B: Country-specific parameters		Brazil	Chile	Colombia
χ	Share of HtM agents	0.54	0.57	0.63
$\bar{D}$	Steady state external debt	5.50	0.70	3.10
ξ	Scale parameter in labor supply	3.50	3.10	3.30
α_c	Import share in consumption	0.37	0.41	0.28
α_x	Import share in investment	0.12	0.52	0.65
α	Capital share in production	0.26	0.39	0.28
$\bar{Co}$	Steady state level of commodity endowment	0.33	0.90	0.58
$\bar{s}-1$	Steady state spread (annual %)	2.66	1.46	2.15
β	Discount factor	0.991	0.994	0.992

4.1 Calibration

Table 1 summarizes the calibration of the first set of parameters, which closely follows Fernández et al. (2018). Parameters in panel A are those chosen to be common across countries and are standard in the literature. The elasticity of substitution between home and foreign goods is assumed to be the same for consumption and investment ($\eta_c = \eta_x$), and set to 0.43 following Akinci (2011). The risk aversion coefficient σ is set to 2, the Frisch elasticity of labor supply, $1/\eta$, is 1.72, and the annual depreciation rate is 10%. The price elasticity of foreign demand for the home good is set to 1.18 following Adolfson et al. (2007). The steady state levels of global demand and productivity, $\bar{Y}^*$ and $\bar{A}$, are normalized to 1. The steady state level of the international interest rate, $\bar{R}^*$, is 1.01 (annualized) and the debt elasticity of the interest rate ψ is set to 0.001.

Parameters in panel B are instead country-specific. The fraction of agents that are HtM is an important parameter for my analysis, which I calibrate using estimates from Bracco et al. (2021). This paper uses survey data from the World Bank's Global Findex from 2017 to estimate the share of HtM households for 99 countries. Concretely, they use the following question in the survey:

> "Now, imagine that you have an emergency and you need to pay [1/20 of GNI per capita in local currency]. Is it possible or not possible that you could come up with [1/20 of GNI per capita in local currency] within the next month?".

Agents are classified as HtM if they reply that they are unable to come up with the required amount of money. According to this methodology, the share of HtM households is 53.9% in Brazil, 56.6% in Chile and 62.8% in Colombia. These shares are close to the average for Latin American countries (60%) and more than twice as large than the advanced economies' average (23%). While this not the standard way of measuring HtM agents in the literature, it has the advantage of being available for a large set of countries. The standard definition by Kaplan et al. (2014) requires reliable data on liquid wealth holdings so it is not easy to obtain for many emerging markets. Bracco et al. (2021) argue that their estimates align with those in the literature computed with the definition of Kaplan et al. (2014) whenever they are available. In previous work I obtained an estimate for Chile with this methodology and using the Survey of Households' Finance from the Central Bank of Chile (2014), finding a share of 61%, close to the estimate in Bracco et al. (2021).

Finally, I choose the remaining parameters in panel B to match some long-run moments from the data. D^* is set to match the long-run share of external debt over output. The scale parameter of labor supply ξ is chosen so that aggregate labor is 1/3 in the steady state. Parameters α_c and α_x are chosen to match import shares in consumption and investment, and α is chosen to match the consumption and investment ratios to GDP. Importantly, the steady state level of the commodity endowment $\bar{Co}$ is chosen to match the long-run share of commodities in exports in each country. Finally, $\bar{s}$ is set to match the long-run value of country spreads, and the discount factor β is set to the inverse of the steady state level of the domestic interest rate, $\frac{1}{R^*\bar{s}}$.

4.2 Estimation

Estimation strategy. I estimate the remaining parameters of the model using full information Bayesian methods (Smets & Wouters, 2003). I target eight domestic variables - a country-specific commodity price index, real income, consumption, investment, the trade balance, the interest rate spread (JP Morgan's Emerging Markets Bond Index), the real exchange rate and hours worked- and two international drivers - the risk free rate (3-month real US Treasury Bills rate) and global demand (US GDP). To target these ten variables I have the five shocks outlined above ($\epsilon_t^{Co}, \epsilon_t^{s}, \epsilon_t^{A}, \epsilon_t^{R^*}, \epsilon_t^{Y^*}$) and I add measurement errors in five variables that do not have a shock directly linked to them (consumption, investment, the trade balance, the real exchange rate, and hours worked). Measurement equations are then

$$ln(GDP_t^{obs}) = ln(GDP_t) - ln(\bar{GDP}) \tag{4.1}$$

$$ln(C_t^{obs}) = ln(C_t) - ln(\bar{C}) \tag{4.2}$$

$$ln(X_t^{obs}) = ln(X_t) - ln(\bar{X}) \tag{4.3}$$

$$ln(TB_t^{obs}) = TB_t/GDP_t - \bar{TB}/\bar{GDP} \tag{4.4}$$

$$ln(s_t^{obs}) = ln(s_t) - ln(\bar{s}) \tag{4.5}$$

$$ln(RER_t^{obs}) = ln(RER_t) - ln(\bar{RER}) \tag{4.6}$$

$$ln(L_t^{obs}) = ln(L_t) - ln(\bar{L}) \tag{4.7}$$

$$ln(R_t^{*obs}) = ln(R_t^*) - ln(\bar{R}^*) \tag{4.8}$$

$$ln(Y_t^{*obs}) = ln(Y_t^*) - ln(\bar{Y}^*) \tag{4.9}$$

where C_t is aggregate consumption: $C_t = (1-\chi)c_t^R + \chi c_t^H$ and $\bar{C} = (1-\chi)\bar{c}^R + \chi\bar{c}^H$.

The commodity index is constructed using the International Monetary Fund's Primary Commodity Price Database (based on Fernández et al., 2018), the EMBI+ spread comes from Bloomberg, hours worked are computed with data from LABLAC (CEDLAS and World Bank) and the rest of variables are from the IMF's International Financial Statistics.

Table 2: Estimated parameters

	Prior			Posterior mean		
	Distribution	Mean	Var	Brazil	Chile	Colombia
a	Gamma	0.5	0.0625	0.554	1.795	1.215
γ_r	Beta	0	0.0002	-0.006	-0.003	-0.004
ω	Gamma	0.05	0.0009	0.024	0.054	0.043
ρ_{Y^*}	Beta	0.5	0.0225	0.807	0.808	0.754
ρ_{R^*}	Beta	0.5	0.0225	0.727	0.812	0.579
ρ_s	Beta	0.5	0.0225	0.917	0.54	0.544
ρ_{Co}	Beta	0.5	0.0225	0.822	0.921	0.807
ρ_A	Beta	0.5	0.0225	0.628	0.361	0.441
σ_{Y^*}	Inv. Gamma	0.007	∞	0.005	0.005	0.005
σ_{R^*}	Inv. Gamma	0.007	∞	0.001	0.001	0.001
σ_s	Inv. Gamma	0.007	∞	0.001	0.001	0.001
σ_{Co}	Inv. Gamma	0.007	∞	0.059	0.101	0.096
σ_A	Inv. Gamma	0.007	∞	0.01	0.036	0.013

I follow Fernández et al. (2018) in focusing on real income -nominal GDP divided by the consumer price index- rather than real GDP -nominal GDP divided by the GDP price deflator-, because previous studies have shown that real GDP underestimates the effect of terms-of-trade shocks on domestic income (Kohli, 2004). Hours worked are computed as the product of quarterly hours worked per worker and the share of adults employed. The time period covered is 2005.Q1-2019.Q4 for Brazil and Chile, and 2008.Q1-2019.Q4 for Colombia. More details on the data can be found in Appendix section B.3.

The estimated parameters are the adjustment cost of capital (a), the sensitivity of the spread to commodity price deviations from steady state (γ_R), the parameter that governs the size of the wealth effect on labor supply (ω), the persistence and standard deviation of the exogenous disturbances defined in equations (3.20)-(3.24), and the standard deviation of measurement errors in C_t, I_t, TB_t, RER_t, and L_t. I define standard priors for the parameters, which are displayed in table 2[1]. Particularly, I define the same prior distributions for all the different shocks to give them equal opportunity in explaining fluctuations.

Estimation results. I run a Monte Carlo Markov Chain algorithm to draw from the marginal posterior distribution of the parameters. Table 2 reports the mean of these pos-

[1]Those for measurement error parameters are relegated to the appendix for brevity, they can be found in table A.3.

Table 3: Moments: Model vs. Data

(a) Long-run ratios (%)

	Brazil		Chile		Colombia	
	Data	Model	Data	Model	Data	Model
Consumption/GDP	81.4	81.3	73	74.2	81.1	80.2
Investment/GDP	18.1	18.1	22.7	25.8	21.9	19.4
Exports/GDP	12.7	11.9	35	33.8	16.8	18
Imports/GDP	12.8	11.3	31.2	33.7	20.5	17.7
Share imported consumption	13	13.2	30.4	31.1	12	12.3
Share imported investment	3.6	3.4	40	41.3	40	40.2
External debt/GDP	68.7	66.9	13.5	13.3	42.5	42.8
Commodity exports/exports	34.4	33.6	49.5	50.8	46.2	44.4

(b) Standard deviations (%)

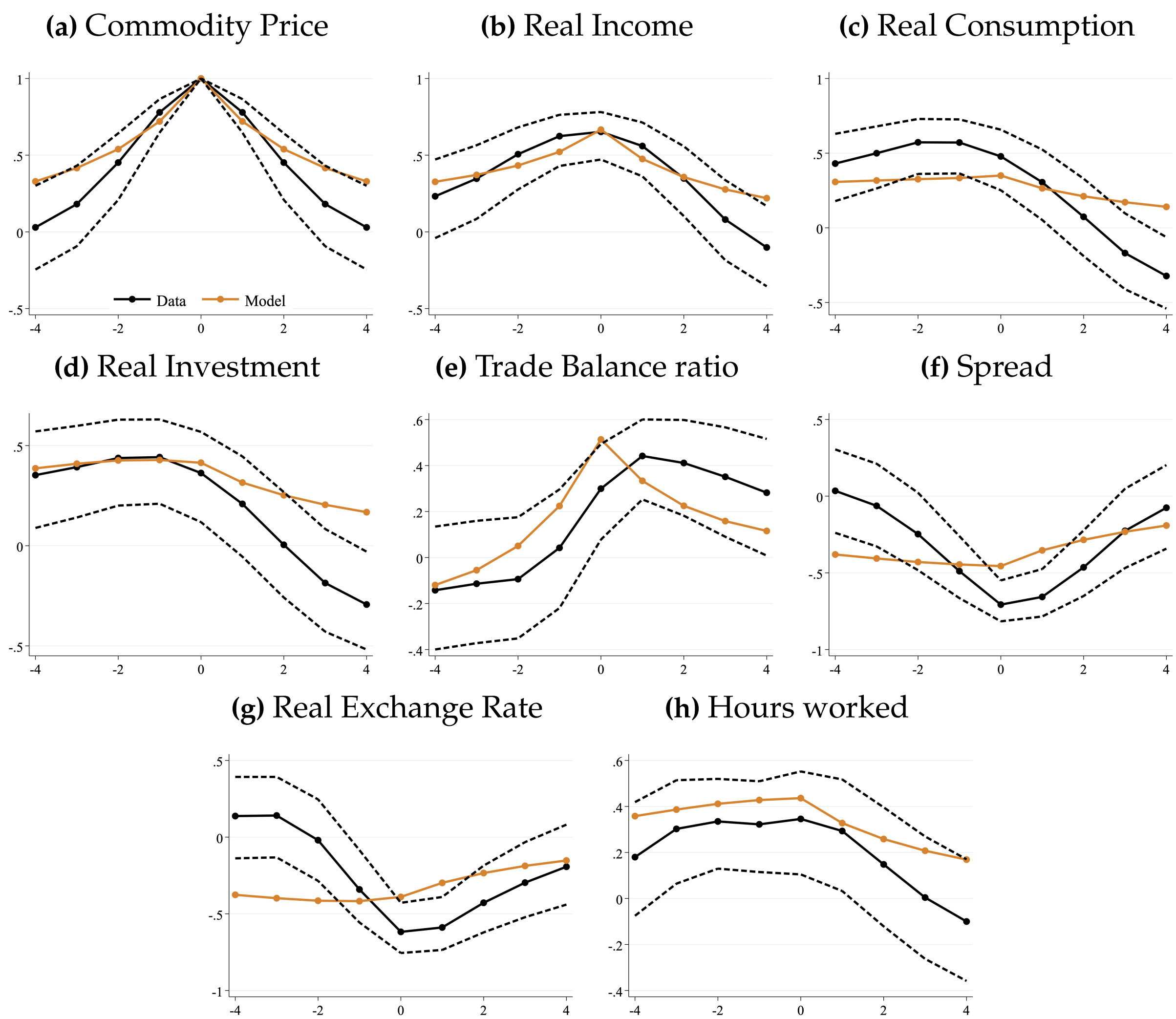
	Brazil		Chile		Colombia	
	Data	Model	Data	Model	Data	Model
p^{Co}	9.7	10.7	15.4	12.4	15.9	16.8
GDP/CPI	2.4	2.5	4	3.6	2	2.3
Real Consumption	1.8	2	2.2	2	1.1	1.6
Real Investment	5.9	6.3	6	7.3	3.1	4.6
TB/GDP	0.9	0.5	3.5	2.1	1.4	1.1
Real Exchange Rate	7.3	7.5	4.1	3.9	6.3	4.1
Spread	0.2	0.6	0.1	0.2	0.2	0.2
Hours	1	1.1	1.8	0.8	0.8	0.5

terior distribution for each country. Table A.3 in the appendix also reports the 10th and 90th percentiles of the distributions and Figure A.2 plots the prior and posterior densities together for each parameter. The posterior densities are generally quite different from the priors, indicating that the data is informative about the estimated parameters.

The posterior mean of γ_R is negative for all three countries, in line with the empirical evidence of a negative relationship between spreads and commodity prices. The estimates of the parameter ω point to a small but significant wealth effect on labor supply. Finally, regarding the estimated standard deviation of the different shocks, we can see that commodity price shocks stand out in terms of volatility (the estimated standard deviation is 5.9% for Brazil and 10.1% for Chile and 9.6% for Colombia), followed in second place by productivity shocks. External factors are estimated to be less volatile.

Model performance. I now focus on the performance of the estimated model in terms

Figure 3: Serial correlation with Commodity Prices - Average across countries



of accounting for different features of the data. Table 3 compares some model-implied moments with the corresponding moments in the data. Panel (a) displays the long-run value of some variables used to discipline the calibration. The model matches well the shares of consumption, investment, exports, and imports over GDP, the shares of imports in the consumption and investment baskets, the share of external debt over GDP and the share of commodities in total exports. Panel (b) shows the model fit in terms of matching the standard deviation of the observable variables. Generally the model captures well the volatility of the main endogenous variables of the model.

Figure 3 plots the serial correlation of different variables with commodity prices. I plot here the average across countries as they are roughly similar, but analogous figures for the three countries can be found in Figures A.6 to A.8 of the Appendix. We can see that the model does fairly well in accounting for the pro-cyclicality of commodity prices with respect to output, consumption, investment, the trade balance, and hours worked. The model also matches well the counter-cyclicality with respect to the real exchange rate.

5 Heterogeneity and Commodity Price Shocks

In this section I will first analyze the importance of commodity price shocks as business cycle drivers within the estimated model, to then explore the effect of PIH deviations on the role of these shocks.

5.1 How Important are Commodity Price Shocks?

First, to describe the dynamic response of emerging market economies to commodity-price shocks I show in Figure 4 the model-implied impulse responses to a one standard deviation shock to commodity prices. An increase in commodity prices is associated with an expansion in real income that is accompanied by increases in consumption, investment and the ratio of the trade balance surplus over output. The positive shock is also associated with a drop in the interest rate spread, consistent with the empirical evidence discussed above, and a real exchange rate appreciation. The income expansion is largest in Chile, however the increase in consumption is almost equally large for Brazil, while Colombia displays more modest responses. This could be because Colombia's main commodity export is oil (see table A.2), so a price increase also represents an increase in production costs, not captured in the model. Figure A.3 in the appendix shows empirical impulse responses estimated using an SVAR model for the three countries[2]. We can see that the responses are qualitatively similar to those implied by the theoretical model.

[2]Figure A.4 compares these estimates with impulse responses computed with local projections

Figure 4: Impulse responses to a Commodity Price shock

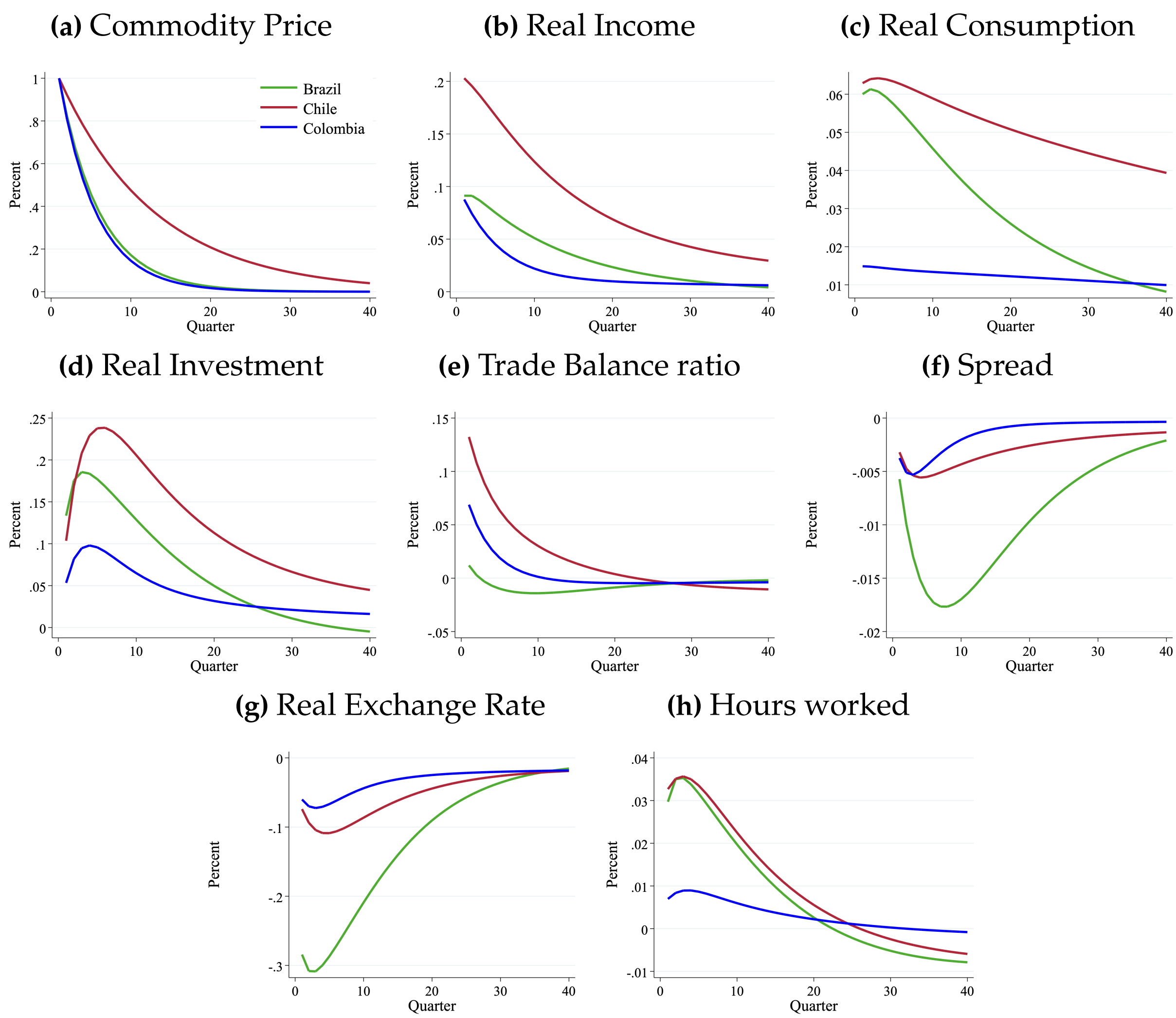
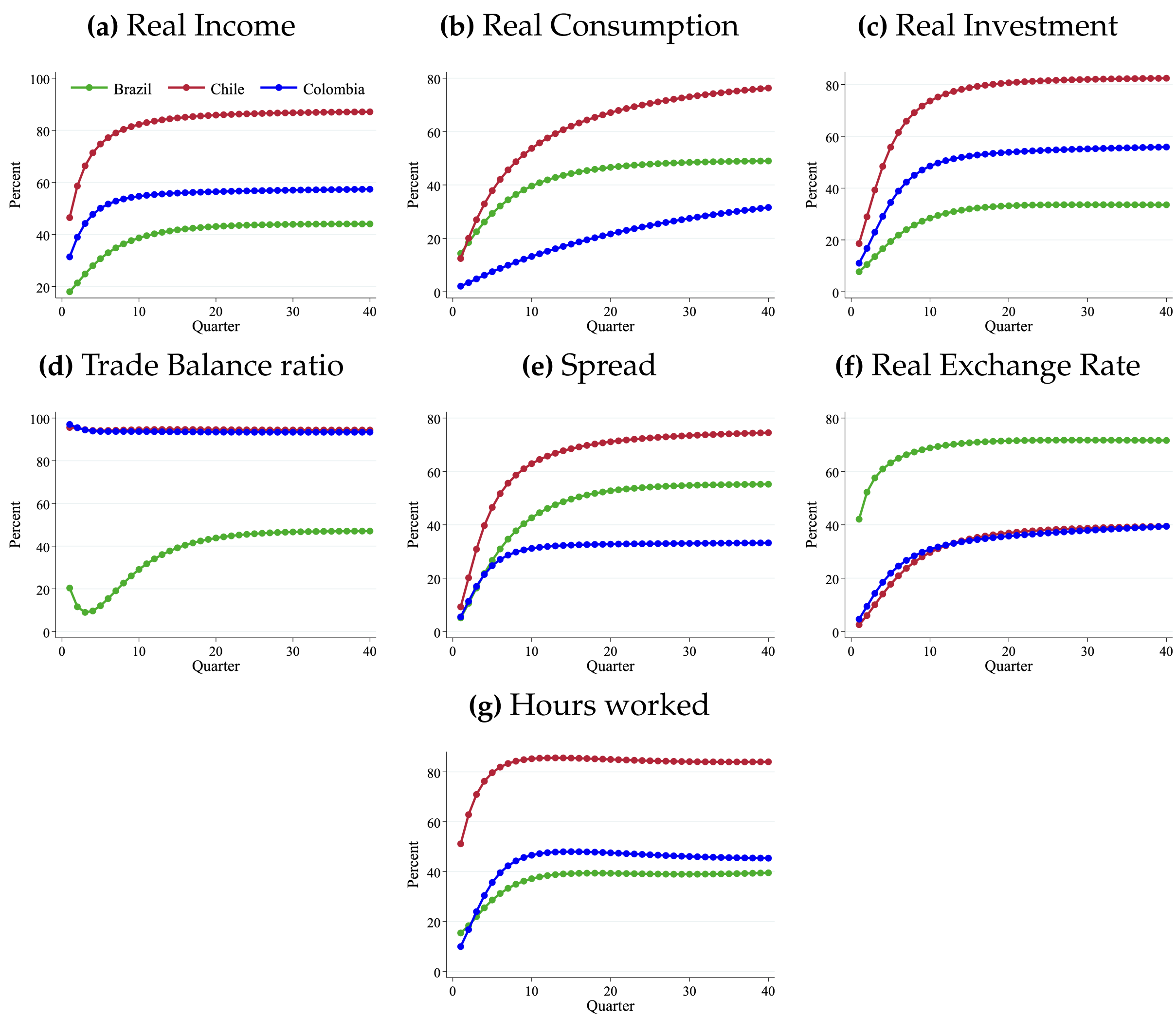


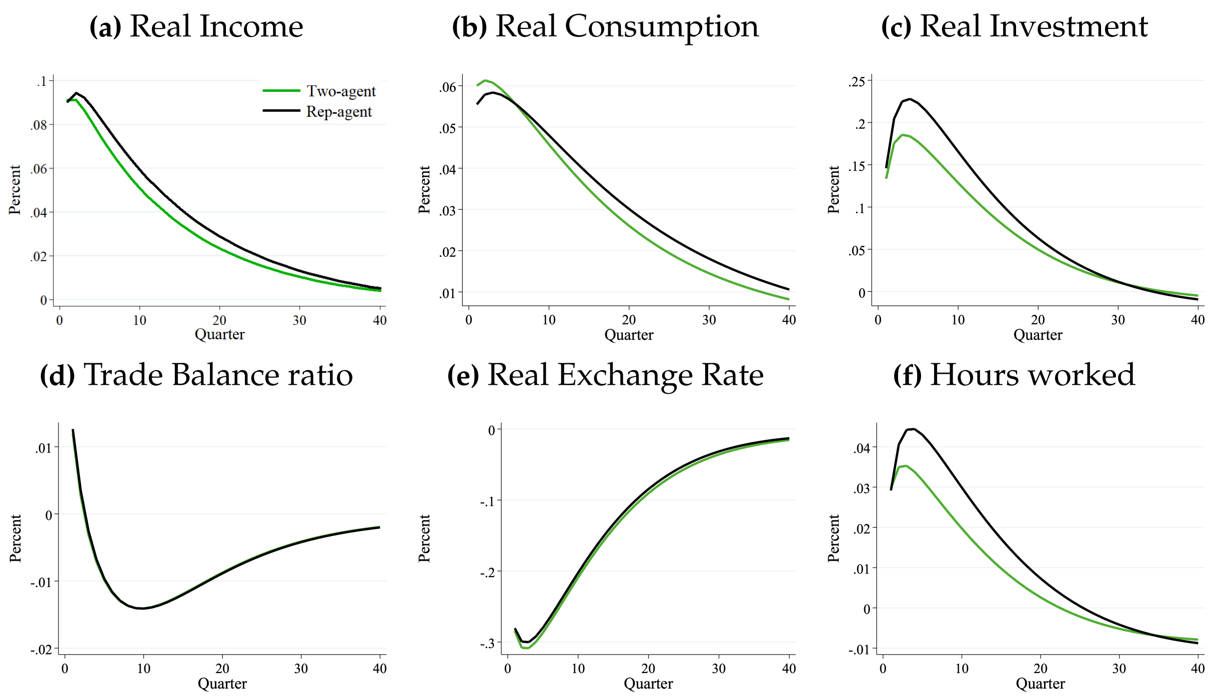
Figure 5 plots the fraction of the variance of the main macro variables explained by commodity price shocks, obtained from the variance decompositions in the model. We can see here that these shocks explain a large part of the fluctuations of real income: 15% (44%) in the short-run (long-run) for Brazil, 46% (87%) for Chile, and 31% (57%). These values are not very far from those obtained by Fernández et al. (2018) for these same three countries, or by Drechsel & Tenreyro (2018) for a model calibrated to Argentina. Commodity price shocks are also important to explain fluctuations in consumption, more so in the long-run (between 30% and 75%) than in the short-run (below 20%). They explain almost all movements in the trade balance for the case of Chile and Colombia, and still a large

Figure 5: Fraction of variance explained by Commodity Price shocks



fraction for Brazil. Finally, they also account for a large fraction of variation in investment, the interest rate spread and the real exchange rate. Figure A.5 in the appendix plots the variance decompositions estimated empirically within the local projection framework (Gorodnichenko & Lee, 2020). The empirical estimates are in line with the theoretical model in terms of the importance of commodity price shocks for the variability of income, consumption, investment and hours worked. However, they point to a more modest role than in the theoretical model in the case of the trade balance, the interest rate spread and the real exchange rate.

Figure 6: Impulse responses to a Commodity Price shock - Brazil



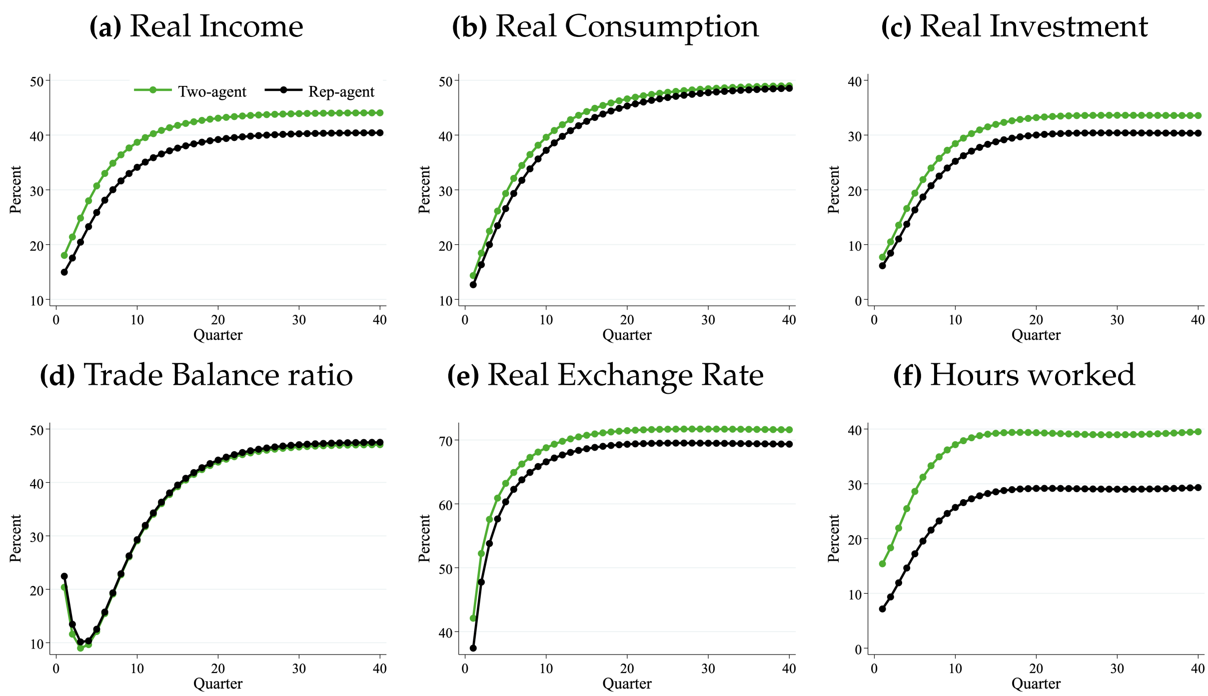
5.2 Heterogeneity

This section explores the effect of PIH deviations on the role of commodity price shocks as business cycle drivers. I compare the results obtained for the estimated model above with a counterfactual scenario in which all agents are Ricardian ($\chi = 0$). This would correspond to the representative agent version of the model, where there are no deviations from the permanent income hypothesis.

Figure 6 compares the impulse responses under the baseline two-agent model (green lines) with the representative-agent counterpart (black lines) for Brazil (similar plots for Chile and Colombia can be found in Figures A.9 and A.10 in the Appendix). Absent HtM agents consumption increases less in the short-run but more in the long-run, consistent with the results of the stylized model in section 2. There is also amplification on the response of the real exchange rate, but dampening on real income, the trade balance, investment and hours worked.

Figure 7 compares the variance decompositions in these two cases. Despite the small

Figure 7: Fraction of variance explained by Commodity Price shocks - Brazil

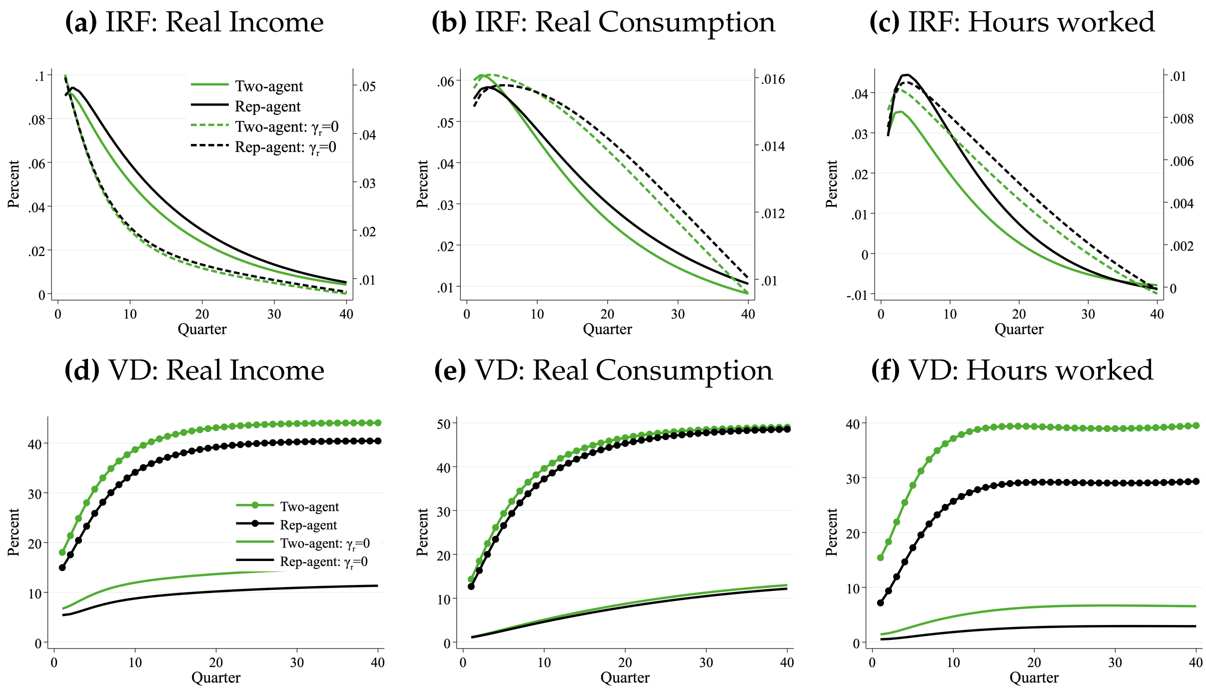


dampening seen in the impulse responses, we can see that the presence of HtM agents amplifies the importance of commodity price shocks for income variations. Commodity price shocks also explain a larger fraction of variations in consumption, investment, the real exchange rate and hours worked in the basline relative to the representative agent model. Results are similar for Chile and Colombia, as can be seen in figures A.11 and A.12, with similar results for Colombia but a bit less amplification for Chile.

5.3 Mechanisms

I now quantify the importance of different mechanisms both for the importance of commodity price shocks and for the differences between the models with and without HtM agents. I focus on two mechanisms. The first is the indirect effect of the shock through changes in interest rate spreads. The stylized model of section 2 suggested that this channel can amplify the effect of commodity price shocks but could reduce the amplification power of HtM agents. Second, I quantify the importance of the wealth effect on labor

Figure 8: Mechanisms: Spread effect - Brazil



Note: In panels (a) to (c) the secondary axis is used for dashed lines.

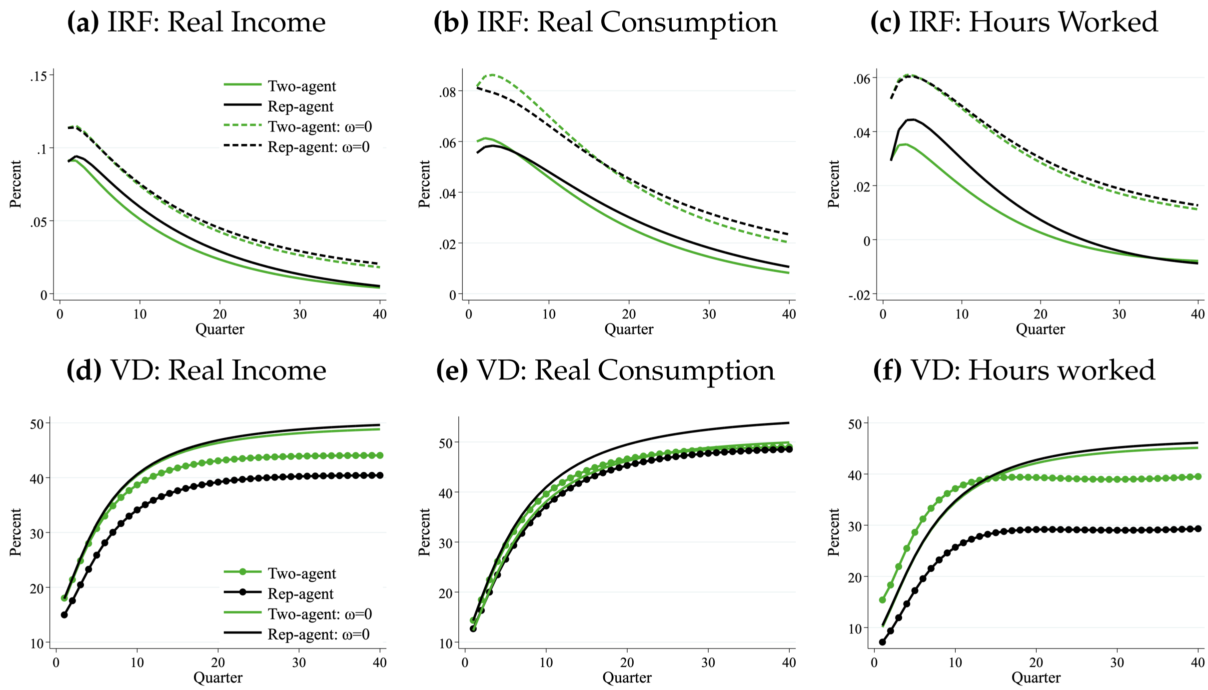
supply, which was not present in the stylized model.

To shut down the interest rate spread effect I set the parameter γ_R, which captures the sensitivity of the spread to deviations of commodity prices with respect to the steady state, to zero. Figure 8 shows how some of the results above change in the absence of the indirect interest rate effect in the case on Brazil. Looking first at the impulse responses in panels (a) to (c), we see that when we shut down the interest rate channel (dashed lines, secondary axis) the dynamic effect and the importance of commodity price shocks is significantly reduced. The effect almost halves for real income, while its reduced further for consumption and hours worked[3]. This channel appears to be an important transmission mechanism of commodity price shocks, as was highlighted in the literature before.

In terms of the amplification or dampening power of HtM agents, we see little difference for consumption and hours worked: the curves shift down but the difference between

[3]Impulse responses and variance decompositions for all variables are in the appendix for completeness.

Figure 9: Mechanisms: Wealth effect on labor supply - Brazil



the two-agent and the representative-agent models is quite similar with and without the effect on the spread. However, for income, the interest rate channel accounted for most of the dampening on output. Panels (d) to (f) compare the variance decompositions, where the interest rate effect seems to have little effect on the amplification/dampening of HtM agents.

Finally, I shut down the wealth effect on labor supply to quantify its importance by setting the parameter ω to almost zero (0.0001). Figure 9 illustrates this exercise for the case of Brazil. Absent the wealth effect on labor supply, now real income, consumption and hours worked react more strongly to the commodity price shock (this can be seen in the impulse responses of panels (a) to (c)). Without the wealth effect, there is less dampening on income and hours worked but more amplification on consumption in the short-run. The pattern is similar in Chile and Colombia, where without the wealth effect, there is a small degree of dampening on consumption on impact but then amplification lasts more periods than in the model with the wealth effect.

Analyzing the variance decompositions in panels (d) to (f), we can see that the baseline and the representative agent model "react" differently to the wealth effect in terms of the importance of the shock for fluctuations. In the baseline, the wealth effect makes the shock more important in the short-run and less so in the long run (most noticeably for hours but also for real income and consumption). On the other hand, in the representative agent version of the model the shock is less important at all horizons when there are wealth effects. This means that, without the wealth effect on labor supply, the inclusion of HtM agents dampens the importance of commodity price shocks for business cycle fluctuations at all horizons.

6 Conclusions

Recent empirical evidence points to large deviations from PIH behavior in EMEs (Bracco et al., 2021; Hong, 2023b), a main ingredient in the models used so far to study the effects of commodity price shocks, or more generally, shocks to countries' terms of trade. This paper explores the implications of this new empirical finding in two ways. I first use a stylized endowment economy model with two-agents to show analytically how HtM agents can generate amplification and dampening of different transmission mechanisms of terms-of-trade shocks. They react more strongly to their direct effect (an income channel) but do not react to indirect effects through interest rate spreads (an interest rate channel). The overall effect depends on the relative strength of the different channels, and is therefore a quantitative question.

I then explore this question quantitatively by embedding a two-agent structure to a standard small open economy model (Mendoza, 1995). I fit the model to data from Brazil, Chile, and Colombia, where between 54% and 65% of the population lives HtM (according to Bracco et al., 2021). Results suggest a larger role for commodity price shocks in models that include PIH deviations, although the difference is moderate. Finally, I explore two mechanisms that drive these results. First, the indirect interest rate effect is a relevant transmission channel for commodity price shocks, but it does not appear to be dampened by HtM agents. Second, wealth effects on labor supply account for most of the amplification of HtM agents on income and consumption.

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Appendix

A Details on Stylized Model

A.1 First Order Conditions

The FOCs of households are:

$$\frac{\alpha}{C_{Ht}^{i}} = \lambda_t^i P_{Ht} \qquad i = R, H \tag{A.1}$$
$$\frac{1-\alpha}{C_{Ft}^{i}} = \lambda_t^i \qquad i = R, H \tag{A.2}$$
$$\lambda_t^R = \beta R_t^* \lambda_{t+1}^R. \tag{A.3}$$

where $\beta^t \lambda_t^i$ is the Lagrange multiplier of agent i's maximization problem.

A.2 Proof of Equilibrium Conditions

Combining (A.1) and (A.2) we have:

$$C_{Ht}^{i} = \frac{\alpha}{1-\alpha} P_{Ht}^{-1} C_{Ft}^{i} \tag{A.4}$$

Replacing this expression in the market clearing condition for the home good (2.7) we get:

$$\frac{\alpha}{1-\alpha}\left[(1-\chi)C_{Ft}^{R} + \chi C_{Ft}^{H}\right] + C_t^* = P_{Ht}\bar{Y}_H \tag{A.5}$$

where we can substitute for C_{Ht}^{H} in terms of the endowments since we have that:

$$P_{Ht}C_{Ht}^{H} + C_{Ft}^{H} = P_{Ht}\bar{Y}_H + \bar{Y}_F \tag{A.6}$$
$$\frac{\alpha}{1-\alpha}C_{Ft}^{H} + C_{Ft}^{H} = P_{Ht}\bar{Y}_H + \bar{Y}_F \tag{A.7}$$
$$C_{Ft}^{H} = (1-\alpha)(P_{Ht}\bar{Y}_H + \bar{Y}_F) \tag{A.8}$$

Then we obtain:

$$\frac{\alpha}{1-\alpha}\left[(1-\chi)C^R_{Ft}+\chi(1-\alpha)(P_{Ht}\bar{Y}_H+\bar{Y}_F)\right]+C^*=P_{Ht}\bar{Y}_H \tag{A.9}$$

which simplifies to equation (2.8).

Combining equations (A.2) and (A.3), we obtain equation (2.9).

Finally, to obtain (2.10) we have to iterate forward on Ricardian agents' budget constraint:

$$\sum_{t=0}^{\infty}\left(\prod_{s=0}^{t-1}R^*_s\right)^{-1}\left(P_{Ht}C^R_{Ht}+C^R_{Ft}-P_{Ht}\bar{Y}_H-Y_{Ft}\right)=-R^*_{-1}D^*_{-1} \tag{A.10}$$

Using (2.8) and (A.4) we get:

$$\sum_{t=0}^{\infty}\left(\prod_{s=0}^{t-1}R^*_s\right)^{-1}\left(\frac{1}{1-\alpha}C^R_{Ft}-\frac{\alpha}{1-\alpha\chi}\left(\chi\bar{Y}_F+\frac{1-\chi}{1-\alpha}C^R_{Ft}\right)-\frac{1}{1-\alpha\chi}C^*_t-Y_{Ft}\right)=-R^*_{-1}D^*_{-1} \tag{A.11}$$

which simplifies to equation (2.10).

A.3 Proof of equations (2.12), (2.13) and (2.17)

Equation (2.12) is directly obtained by taking the first difference of equation (2.8).

To get equation (2.13), use equations (2.3), (2.8), and (A.1) to get the following expression for the trade balance

$$\begin{aligned}
TB_t &= P_{Ht}\bar{Y}_H+Y_{Ft}-(1-\chi)\left(P_{Ht}C^R_{Ht}+C^R_{Ft}\right)-\chi\left(P_{Ht}C^H_{Ht}+C^H_{Ft}\right)\\
&= P_{Ht}\bar{Y}_H+Y_{Ft}-\frac{1-\chi}{1-\alpha}C^R_{F,t}-\chi[P_{H,t}\bar{Y}_H+Y_{Ft}]\\
&= (1-\chi)(P_{H,t}\bar{Y}_H+Y_{Ft})-\frac{1-\chi}{1-\alpha}C^R_{F,t}\\
&= \frac{(1-\chi)\alpha}{1-\alpha\chi}[\chi Y_{Ft}+\frac{1-\chi}{1-\alpha}C^R_{Ft}]+\frac{1-\chi}{1-\alpha\chi}C^*_t+(1-\chi)Y_{Ft}-\frac{1-\chi}{1-\alpha}C^R_{Ft}\\
&= \frac{1-\chi}{1-\alpha\chi}\left[Y_{Ft}+C^*_t-C^R_{Ft}\right]
\end{aligned}$$

Then the change at $t=0$ is given by:

$$\Delta TB_0=\frac{1-\chi}{1-\alpha\chi}\left[\Delta Y_{F0}-\Delta C^R_{F0}\right]$$

As for the change in consumption, in the first case ($\gamma_R = 0$), from equation (2.9) and assuming $\bar{R}^* = \beta^{-1}$, we have that Ricardian consumption of foreign goods is constant ($C^R_{Ft} = \bar{C}^R_F \ \forall t$). The level can be obtained from equation (2.10), assuming $D^*_{-1} = 0$ for simplicity:

$$\bar{C}^R_F = \bar{C}^* + \frac{1-\beta}{\beta} \sum_{t=0}^{\infty} \beta^{t+1} Y_{Ft} \tag{A.12}$$

Before the shock, constant consumption was $\bar{C}^R_{F,-1} = \bar{Y}_F + \bar{C}^*$ and after the shock (at $t = 0$), it jumps to a higher constant level $\bar{C}^R_{F,0} = \bar{Y}_F + \bar{C}^* + (1-\beta)\Delta Y_{F0}$. Then, the change at $t = 0$ is $\Delta C^R_{F0} = (1-\beta)\Delta Y_{F0}$, which is equation (2.16).

Finally, in the second case ($\gamma_R \neq 0$), consumption at $t = 0$ is higher than at $t = 1$ (from Euler equation A.3):

$$\frac{1}{C^R_{F0}} = \beta R^*_0 \frac{1}{C^R_{F1}} = \beta(\underbrace{\bar{R}^* + \gamma_R \epsilon_0}_{<\bar{R}^*}) \frac{1}{C^R_{F1}} \tag{A.13}$$

After $t = 1$, the interest rate stays constant, and so does consumption ($C^R_{Ft} = \bar{C}^R_{F1} \ \forall t \geq 1$). To find this new level we can use equation (2.10):

$$\sum_{t=0}^{\infty} \left(\prod_{s=0}^{t} R^*_{s-1} \right)^{-1} \left[\bar{Y}_F + C^*_t - C^R_{Ft} \right] = 0$$

$$\beta \left[Y_{F0} + \bar{C}^* - C^R_{F0} \right] + \beta(R^*_0)^{-1} \left[Y_{F1} + \bar{C}^* - C^R_{F1} \right] + \beta(R^*_0)^{-1}\beta \left[Y_{F2} + \bar{C}^* - C^R_{F2} \right] + ... = 0$$

$$\beta \left[\bar{Y}_F + \epsilon_0 + \bar{C}^* - \frac{\bar{C}^R_{F1}}{\beta R^*_0} \right] + \beta(R^*_0)^{-1} \left[\bar{Y}_F + \bar{C}^* - \bar{C}^R_{F1} \right] + \beta(R^*_0)^{-1}\beta \left[\bar{Y}_F + \bar{C}^* - \bar{C}^R_{F1} \right] + ... = 0$$

$$\not{\beta} \left[\bar{Y}_F + \epsilon_0 + \bar{C}^* - \frac{\bar{C}^R_{F1}}{\beta R^*_0} \right] + (R^*_0)^{-1} \underbrace{\sum_{t=1}^{\infty} \beta^t (\bar{Y}_F + \bar{C}^* - \bar{C}^R_{F1})}_{\frac{\not{\beta}}{1-\beta}(\bar{Y}_F + \bar{C}^* - \bar{C}^R_{F1})} = 0$$

$$\underbrace{\left[\frac{1}{\beta R^*_0} + \frac{1}{R^*_0(1-\beta)} \right]}_{\frac{1}{\beta(1-\beta)R^*_0}} \bar{C}^R_{F1} = \bar{Y}_F + \epsilon_0 + \bar{C}^* + \frac{1}{R^*_0(1-\beta)} (\bar{Y}_F + \bar{C}^*)$$

$$\bar{C}^R_{F1} = \beta(1-\beta)R^*_0(\bar{Y}_F + \epsilon_0 + \bar{C}^*) + \beta(\bar{Y}_F + \bar{C}^*)$$

Then we can get $C^R_{F0} = \frac{\bar{C}^R_{F1}}{\beta R^*_0} = (1-\beta)(\bar{Y}_F + \epsilon_0 + \bar{C}^*) + \frac{\bar{Y}_F + \bar{C}^*}{R^*_0}$. The change in consumption is then

$$\Delta C^R_{F0} = C^R_{F0} - (\bar{Y}_F + \bar{C}^*) = (\frac{1}{R^*_0} - \beta)(\bar{Y}_F + \bar{C}^*) + (1-\beta)\epsilon_0$$

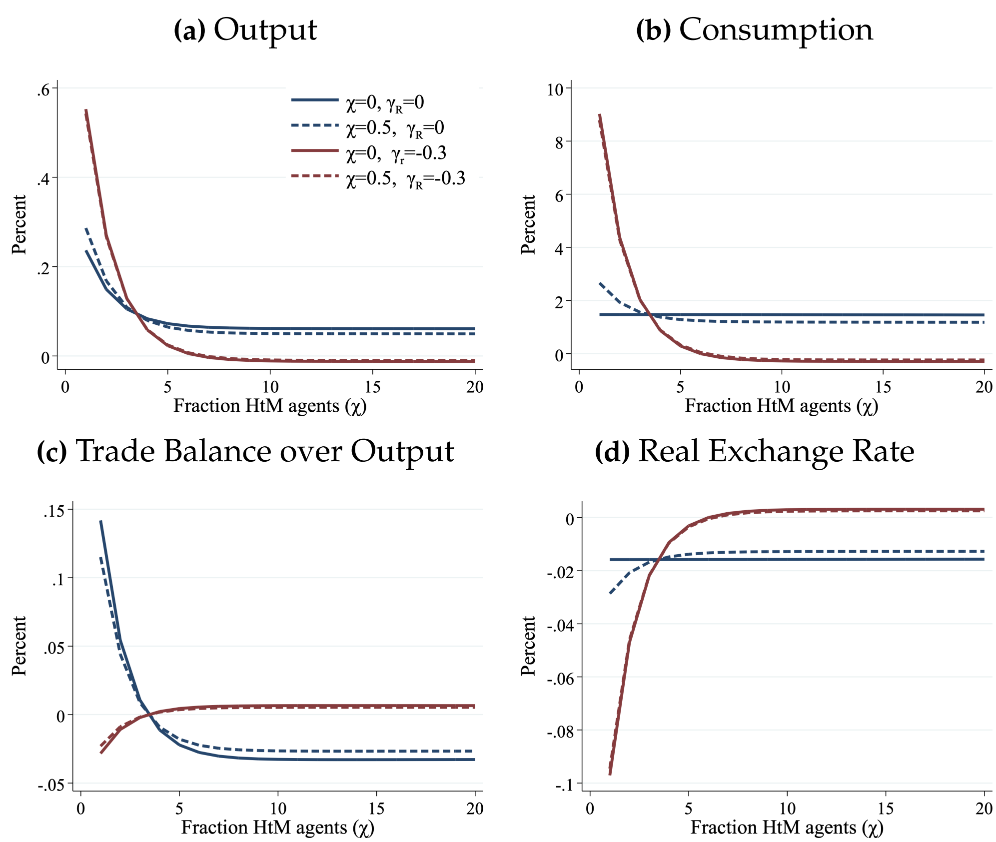
$$\Delta C^R_{F0} = \frac{-\beta\gamma_R\epsilon_0}{\beta^{-1} + \gamma_R\epsilon_0}(\bar{Y}_F + \bar{C}^*) + (1-\beta)\epsilon_0$$

A.4 Numerical Example

Table A.1: Calibration for Numerical Example

Parameter	Description	Value
β	Discount rate	0.8958
α	Home bias in consumption	0.65
$\bar{R}^*$	Steady state interest rate	0.11
$\bar{D}^*$	Steady state level of debt	0
$\bar{Y}_F = \bar{Y}_H$	Steady state endowments	1
$\bar{C}^*$	Steady state external demand	1
ρ_{Y_F}	Persistence of endowment process	0.5
σ_Y	St. dev. of shock	0.01
ρ_r	Persistence of interest rate process	0.5
ψ	Debt-elasticity of interest rate	0.0001

Figure A.1: Impulse Responses to Endowment Shock



Notes: Figure A.1 plots the impulse responses of four key variables in the model to a shock to the endowment of the foreign good, in different scenarios. Blue lines correspond to the model without an indirect effect on the interest rate ($\gamma_R = 0$) and red lines correspond to the model with a negative indirect effect ($\gamma_R = -0.3$). Solid lines correspond to a model where all agents are Ricardian ($\chi = 0$) and dashed lines to a model where half of agents are HtM ($\chi = 0.5$).

B Details on Quantitative Model

B.1 First order conditions of households

$$\left[c_t^i - \xi \frac{\left(l_t^i\right)^{1+\eta}}{1+\eta} z_t^i\right]^{-\sigma} + \mu_t^i \omega (c_t^i)^{\omega-1} (z_{t-1}^i)^{1-\omega} = \lambda_t^i p_t^c$$

$$\left[c_t^i - \xi \frac{\left(l_t^i\right)^{1+\eta}}{1+\eta} z_t^i\right]^{-\sigma} \xi (l_t^i)^{\eta} z_t^i = \lambda_t^i w_t$$

$$\left[c_t^i - \xi \frac{\left(l_t^i\right)^{1+\eta}}{1+\eta} z_t^i\right]^{-\sigma} \xi \frac{\left(l_t^i\right)^{1+\eta}}{1+\eta} + \mu_t^i = \beta \mathbb{E}\left[\mu_{t+1}^i (1-\omega) (\frac{c_{t+1}^i}{z_t^i})^{\omega}\right]$$

$$\lambda_t^R = R_t \beta E_t \lambda_{t+1}^R$$

$$Q_t^X = \beta E_t \left\{ \frac{\lambda_{t+1}^R}{\lambda_t^R} \left(r_{t+1}^k + Q_{t+1}^X (1-\delta) \right) \right\}$$

$$p_t^x = Q_t^X \left\{ \begin{array}{c} \left[1 - \frac{1}{2}\left(e^{\left(\sqrt{a}\left(\frac{X_t}{X_{t-1}}-1\right)\right)} + e^{\left(-\sqrt{a}\left(\frac{X_t}{X_{t-1}}-1\right)\right)} - 2\right)\right] \\ +X_t \left[-\frac{1}{2}\left(\left(\frac{\sqrt{a}}{X_{t-1}}\right) e^{\left(\sqrt{a}\left(\frac{X_t}{X_{t-1}}-1\right)\right)} + \left(\frac{-\sqrt{a}}{X_{t-1}}\right) e^{\left(-\sqrt{a}\left(\frac{X_t}{X_{t-1}}-1\right)\right)}\right)\right] \end{array} \right\}$$
$$- E_t Q_{t+1}^X \frac{\lambda_{t+1}^R}{\lambda_t^R} \beta \left\{ X_{t+1} \frac{1}{2} \left(\begin{array}{c} \left(-\sqrt{a}\frac{X_{t+1}}{X_t^2}\right) e^{\left(\sqrt{a}\left(\frac{X_{t+1}}{X_t}-1\right)\right)} \\ + \left(\sqrt{a}\frac{X_{t+1}}{X_t^2}\right) e^{\left(-\sqrt{a}\left(\frac{X_{t+1}}{X_t}-1\right)\right)} \end{array} \right) \right\}$$

B.2 Real exchange rate

We assume that (i) the law of one price holds between foreign goods in the EME and the rest of the world's domestic goods ($NER_t P_t^{h*} = P_t^f$), (ii) the law of one price does not hold between P_t^{f*} and P_t^h ($NER_t P_t^{f*} \neq P_t^h$). Arguably, while the rest of the world does indeed consume home goods of the domestic economy, these are just a marginal fraction from the perspective of that economy. We then have that

$$P_t^{c*} = \phi\left(P_t^{h*}, P_t^{f*}\right) \simeq \tilde{\phi}\left(P_t^{h*}\right) \tag{A.1}$$

where $\tilde{\phi}\left(P_t^{h*}\right)$ is linear in P_t^{h*} and $\tilde{\phi}\left(1\right) = 1$.

This means that $NER_t P_t^{c*} = \tilde{\phi}\left(NER_t P_t^{h*}\right) = \tilde{\phi}\left(P_t^f\right)$. And then the real exchange rate will be

$$RER_t = \frac{NER_t P_t^{c*}}{P_t^c} = \frac{\tilde{\phi}\left(P_t^f\right)/P_t^f}{P_t^c/P_t^f} = \frac{1}{p_t^c} \tag{A.2}$$

B.3 Description of data

The following variables come from the IMF's International Financial Statistics:

1. Real Output: *Gross Domestic Product, Nominal, Seasonally Adjusted, Domestic Currency* divided by *Prices, Consumer Price Index, All items, Index*.
2. Private Consumption: *Private Sector Final Consumption Expenditure, Real, Seasonally Adjusted, Domestic Currency*
3. Investment: *Gross Fixed Capital Formation, Real, Seasonally Adjusted, Domestic Currency*
4. Trade Balance:
    - *Exports of goods and services, Nominal, non-seasonally adjusted*
    - *Imports of goods and services, Nominal, non-seasonally adjusted*
5. Real Exchange Rate: *Exchange Rates, Real Effective Exchange Rate based on Consumer Price Index, Index*.
6. Foreign Demand: *Gross Domestic Product, Real, Seasonally Adjusted, Domestic Currency* for the U.S.

For the Interest Rate Spread I use *JP Morgan's Emerging Markets Bond Index Global* from Bloomberg.

I compute the international risk free rate using the *3-month T-Bill* from the U.S. Department of the Treasury deflated by the *Implicit Price Deflator of GDP* (Quarterly, Seasonally Adjusted) from FRED.

Hours worked are computed as the product of quarterly hours worked per worker (computed from *Weekly hours in all jobs*) and the *Share of adults employed*, both from the Labor Database for Latin America and The Caribbean – LABLAC (CEDLAS and The World Bank).

The construction of the country specific commodity price index follows from Fernández et al. (2018) and is a weighted average of price indexes of individual commodity goods:

$$P^{Co}_{i,t} = \sum_{j=1}^{44} \theta_{j,i} P^{Co}_{t,j} \tag{A.3}$$

$P^{Co}_{t,j}$ is the real dollar spot price of commodity j at time t in world markets. This is obtained by deflating monthly commodity prices indices from IMF's Primary Commodity Price Database with US consumer price index[4]. $\theta_{j,i}$ is the export share of commodity good j in total commodity exports by country i. I take these weights directly from Fernández et al. (2018), who compute them by averaging the shares between 1999 and 2004, using UN Comtrade data[5].

[4]Deflating is done to be consistent with the model, where foreign price is the nummeraire.

[5]Weights are constant to be consistent with model, where commodity is an endowment.

B.4 Additional tables and figures

Table A.2: Export share of selected commodities in total commodity exports (in %)

	Brazil	**Chile**	**Colombia**
Beef	3.3	0.0	0.1
Pork	1.4	0.8	0.0
Chicken	5.9	0.3	0.0
Fish	0.3	12.4	0.8
Corn (Maize)	1.0	0.7	0.0
Bananas	0.1	0.0	6.6
Sugar	9.0	0.0	3.0
Coffee	8.5	0.1	15.0
Soybean Meal	9.3	0.0	0.1
Fish Meal	0.0	3.1	0.0
Hides	4.3	0.3	1.4
Soybeans	12.5	0.0	0.0
Hard Sawn	1.9	0.2	0.0
Soft Sawn	1.2	5.4	0.0
Iron	16.5	1.4	0.0
Copper	0.6	69.6	0.1
Aluminum	7.6	0.1	0.5
Coal	0.0	0.0	15.4
Soy Oil	3.2	0.0	0.0
Gold	1.7	2.7	2.1
Shrimp	0.6	0.0	1.1
Crude Oil	8.6	2.1	52.8

Notes: I show here the most important of the 44 commodity goods used to compute the index (export share above 1% for at lease one of the three countries).

Figure A.2: Prior-posterior plots

(a) Brazil

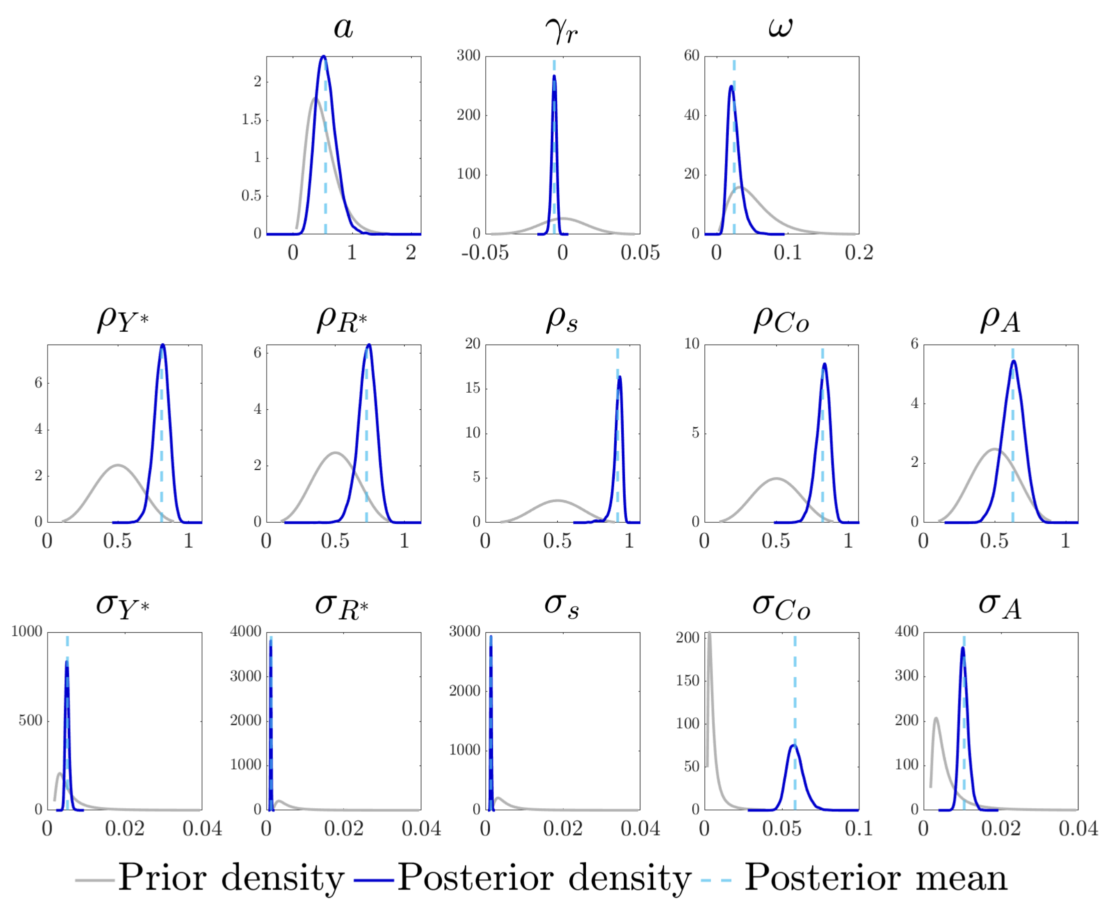


Figure A.2: Prior-posterior plots

(b) Chile

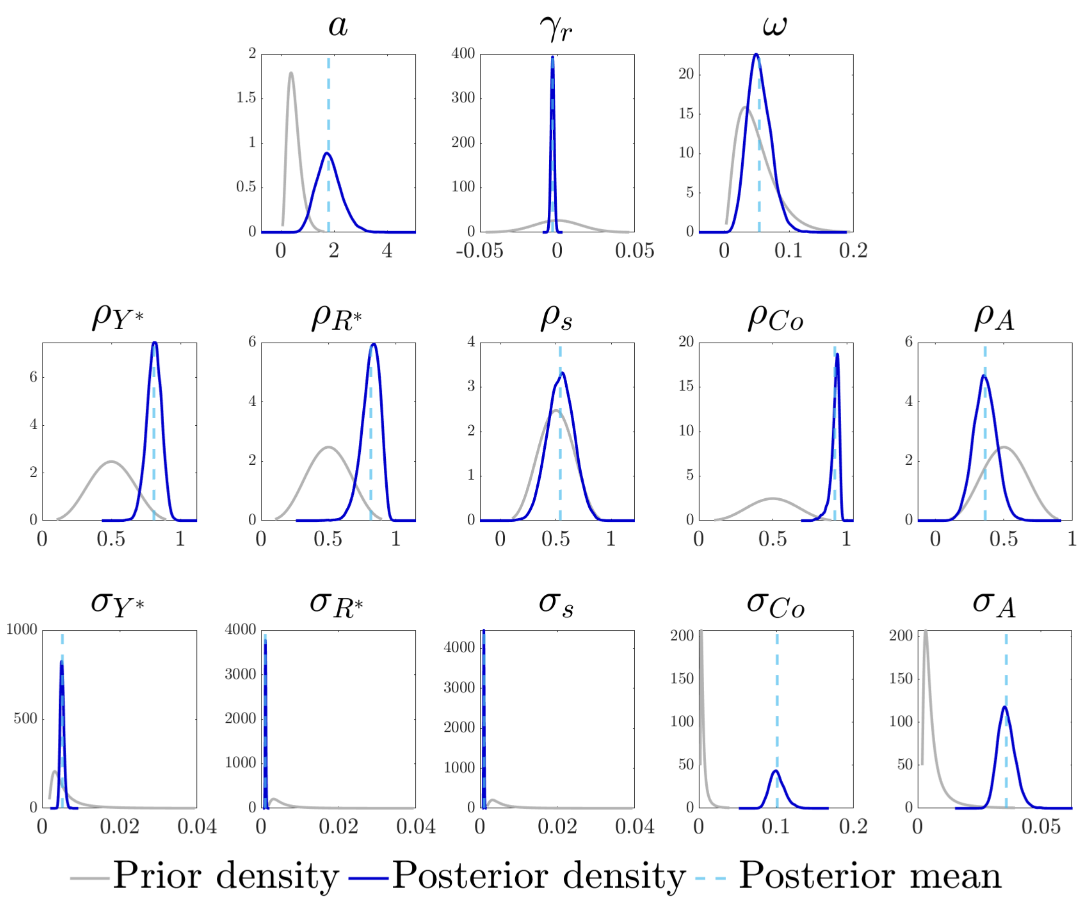


Figure A.2: Prior-posterior plots

(c) Colombia

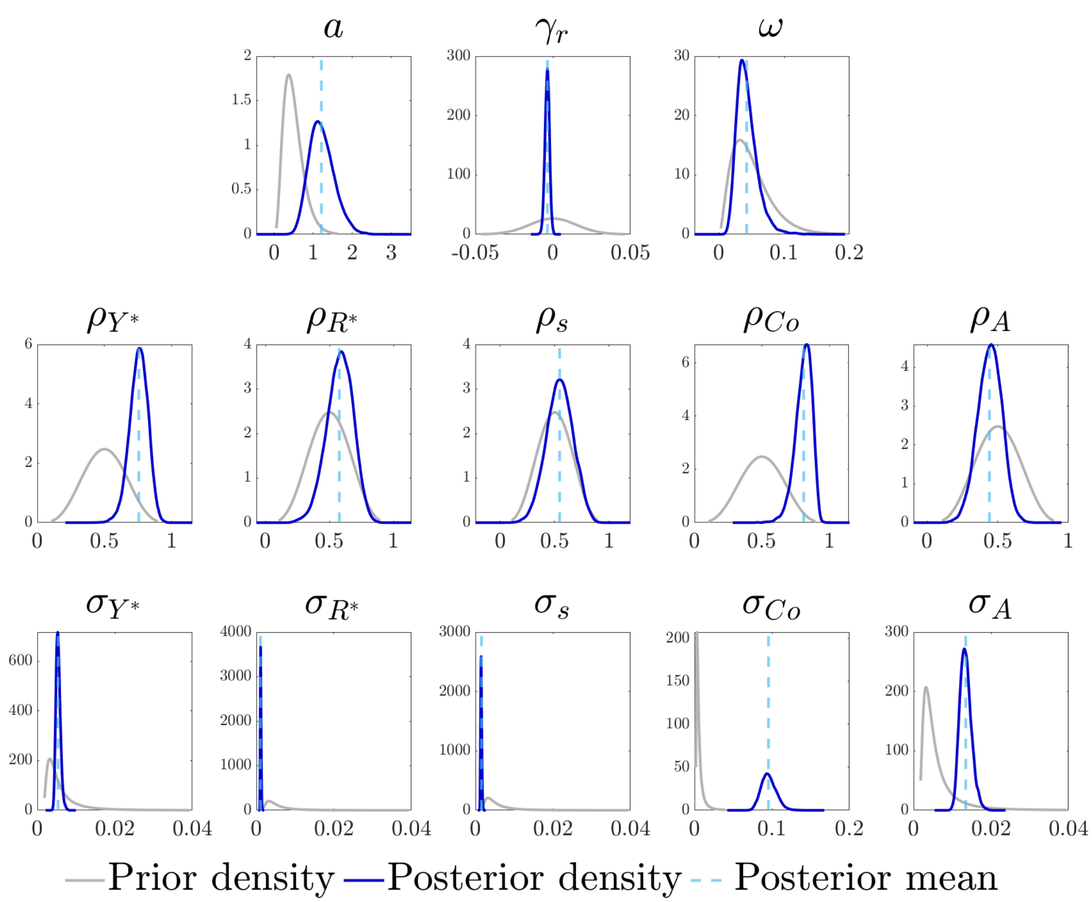


Table A.3: Prior and posterior distributions

(a) Brazil

	Prior			Posterior		
	Distribution	Mean	Var	Mean	10%	90%
a	Gamma	0.5	0.0625	0.554	0.347	0.782
γ_r	Beta	0	0.000225	-0.006	-0.008	-0.004
ω	Gamma	0.05	0.0009	0.024	0.014	0.036
ρ_{Y^*}	Beta	0.5	0.0225	0.807	0.739	0.871
ρ_{R^*}	Beta	0.5	0.0225	0.727	0.644	0.806
ρ_s	Beta	0.5	0.0225	0.917	0.881	0.948
ρ_{Co}	Beta	0.5	0.0225	0.822	0.759	0.879
ρ_A	Beta	0.5	0.0225	0.628	0.531	0.723
σ_{Y^*}	Inv. Gamma	0.007	∞	0.005	0.005	0.006
σ_{R^*}	Inv. Gamma	0.007	∞	0.001	0.001	0.001
σ_s	Inv. Gamma	0.007	∞	0.001	0.001	0.002
σ_{Co}	Inv. Gamma	0.007	∞	0.059	0.052	0.066
σ_A	Inv. Gamma	0.007	∞	0.01	0.009	0.012

(b) Chile

	Prior			Posterior		
	Distribution	Mean	Var	Mean	10%	90%
a	Gamma	0.5	0.0625	1.795	1.218	2.404
γ_r	Beta	0	0.000225	-0.003	-0.004	-0.002
ω	Gamma	0.05	0.0009	0.054	0.032	0.077
ρ_{Y^*}	Beta	0.5	0.0225	0.808	0.739	0.874
ρ_{R^*}	Beta	0.5	0.0225	0.812	0.722	0.892
ρ_s	Beta	0.5	0.0225	0.54	0.387	0.692
ρ_{Co}	Beta	0.5	0.0225	0.921	0.884	0.95
ρ_A	Beta	0.5	0.0225	0.361	0.257	0.466
σ_{Y^*}	Inv. Gamma	0.007	∞	0.005	0.005	0.006
σ_{R^*}	Inv. Gamma	0.007	∞	0.001	0.001	0.001
σ_s	Inv. Gamma	0.007	∞	0.001	0.001	0.001
σ_{Co}	Inv. Gamma	0.007	∞	0.101	0.09	0.114
σ_A	Inv. Gamma	0.007	∞	0.036	0.032	0.04

(c) Colombia

	Prior			Posterior		
	Distribution	Mean	Var	Mean	10%	90%
a	Gamma	0.5	0.0625	1.215	0.828	1.64
γ_r	Beta	0	0.000225	-0.004	-0.006	-0.002
ω	Gamma	0.05	0.0009	0.043	0.025	0.063
ρ_{Y^*}	Beta	0.5	0.0225	0.754	0.667	0.837
ρ_{R^*}	Beta	0.5	0.0225	0.579	0.445	0.707
ρ_s	Beta	0.5	0.0225	0.544	0.386	0.703
ρ_{Co}	Beta	0.5	0.0225	0.807	0.726	0.879
ρ_A	Beta	0.5	0.0225	0.441	0.332	0.547
σ_{Y^*}	Inv. Gamma	0.007	∞	0.005	0.005	0.006
σ_{R^*}	Inv. Gamma	0.007	∞	0.001	0.001	0.001
σ_s	Inv. Gamma	0.007	∞	0.001	0.001	0.002
σ_{Co}	Inv. Gamma	0.007	∞	0.096	0.084	0.108
σ_A	Inv. Gamma	0.007	∞	0.013	0.012	0.015

C Empirical results

C.1 Empirical forecast error variance decompositions

Gorodnichenko & Lee (2020) proposed a method to estimate forecast error variance decompositions (FEVD) within the local projection framework. The estimator is based on the coefficient of determination (R^2), and is downward biased so it provides lower bound.

Let y_t be the endogenous variable of interest and $\{z_t\}$ the identified shock. We have that variation in y_t due to $\{z_t\}$ is $\Psi_z(L)z_t = \sum_{i=0}^{\infty} \Psi_{z,i} z_{t-i}$. Then the forecast error for the h-period ahead value of y_t is

$$f_{t+h|t-1} \equiv (y_{t+h} - y_{t-1}) - P(y_{t+h} - y_{t-1}|\Omega_{t-1}) \tag{A.1}$$

where $\Omega_{t-1} = \{\Delta y_{t-1}, z_{t-1}, \Delta y_{t-2}, z_{t-2}, ...\}$. This can be decomposed into

$$f_{t+h|t-1} = \Gamma_{z,0} z_{t+h} + ... + \Gamma_{z,h} z_t + v_{t+h|t-1}$$

where $v_{t+h|t-1}$ are other sources of variation (orthogonal to z, Ω). Following Sims (1980) we define the share of the variance explained by contemporaneous and future innovations in z_t as:

$$s_h = \frac{Var(\Gamma_{z,0} z_{t+h} + ... + \Gamma_{z,h} z_t)}{Var(f_{t+h|t-1})} \tag{A.2}$$

We can rewrite this as:

$$s_h = \frac{Cov(f_{t+h|t-1}, Z_t^h)[Var(Z_t^h)]^{-1} Cov(f_{t+h|t-1}, Z_t^h)}{Var(f_{t+h|t-1})}$$

which can be seen as the R^2 of the projection of $f_{t+h|t-1}$ on $Z_t^h = (z_{t+h}, ..., z_t)'$. The R^2 method consists on two steps. First, we compute the forecast errors for each horizon as the residual of:

$$y_{t+h} - y_{t-1} = c_h + \sum_{i=1}^{L_y} \gamma_i^h \Delta y_{t-i} + \sum_{i=1}^{L_z} \beta_i^h z_{t-i} + f_{t+h|t-1} \tag{A.3}$$

Second, we regress residuals $\widehat{f}_{t+h|t-1}$ on shocks that happen between t and t+h:

$$\widehat{f}_{t+h|t-1} = \alpha_{z,0} z_{t+h} + \cdots + \alpha_{z,h} z_t + \widetilde{v}_{t+h|t-1} \tag{A.4}$$

Finally, the R^2 of this regression is the estimate of s_h that we use.

C.2 Additional figures

Figure A.3: Impulse response to Commodity Price shock (SVAR model)

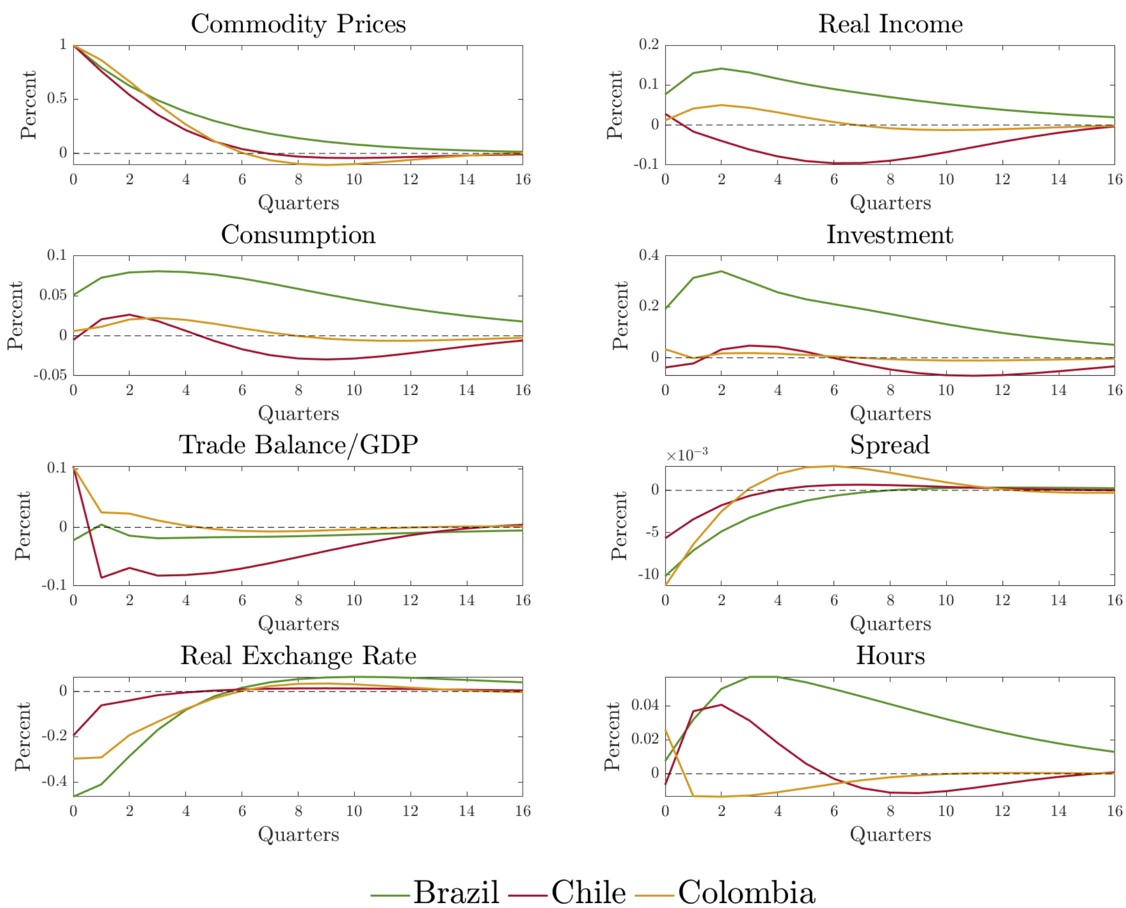


Figure A.4: Impulse response to Commodity Price shock

(a) Brazil

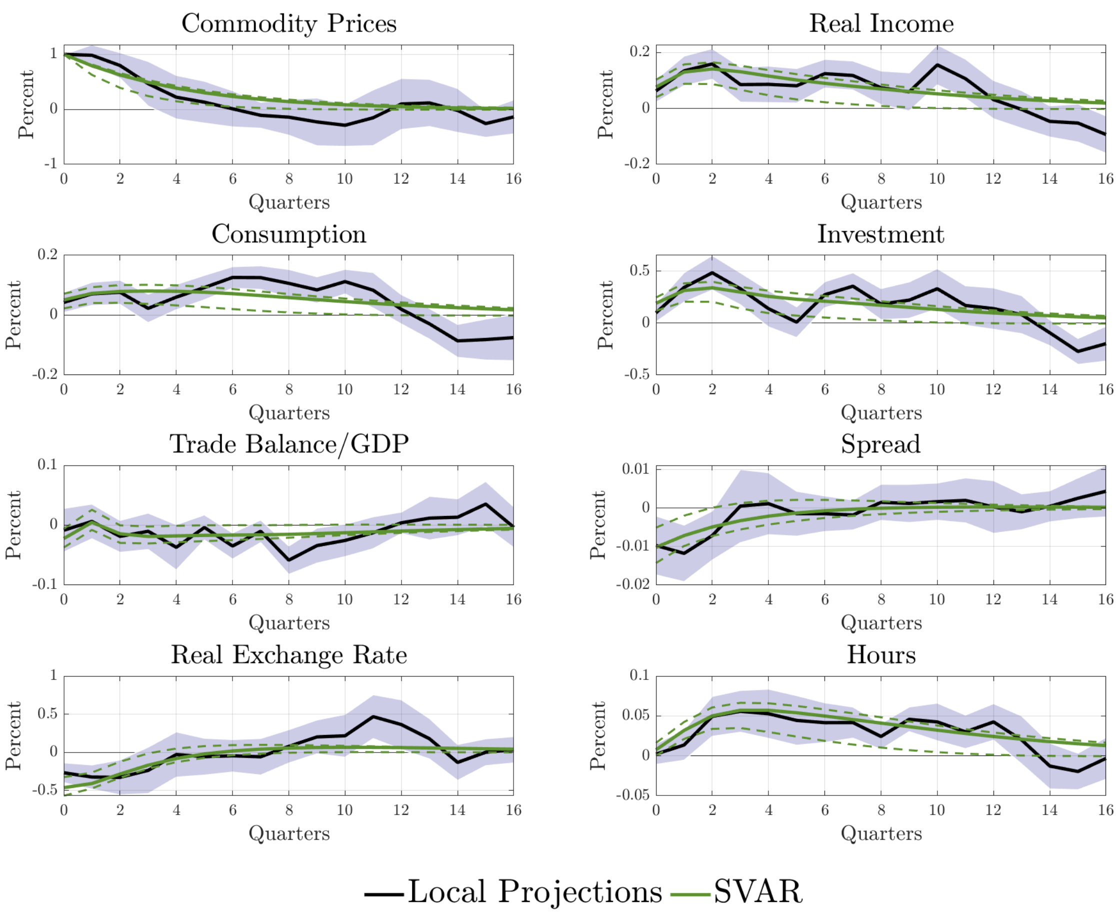


Figure A.4: Impulse response to Commodity Price shock

(b) Chile

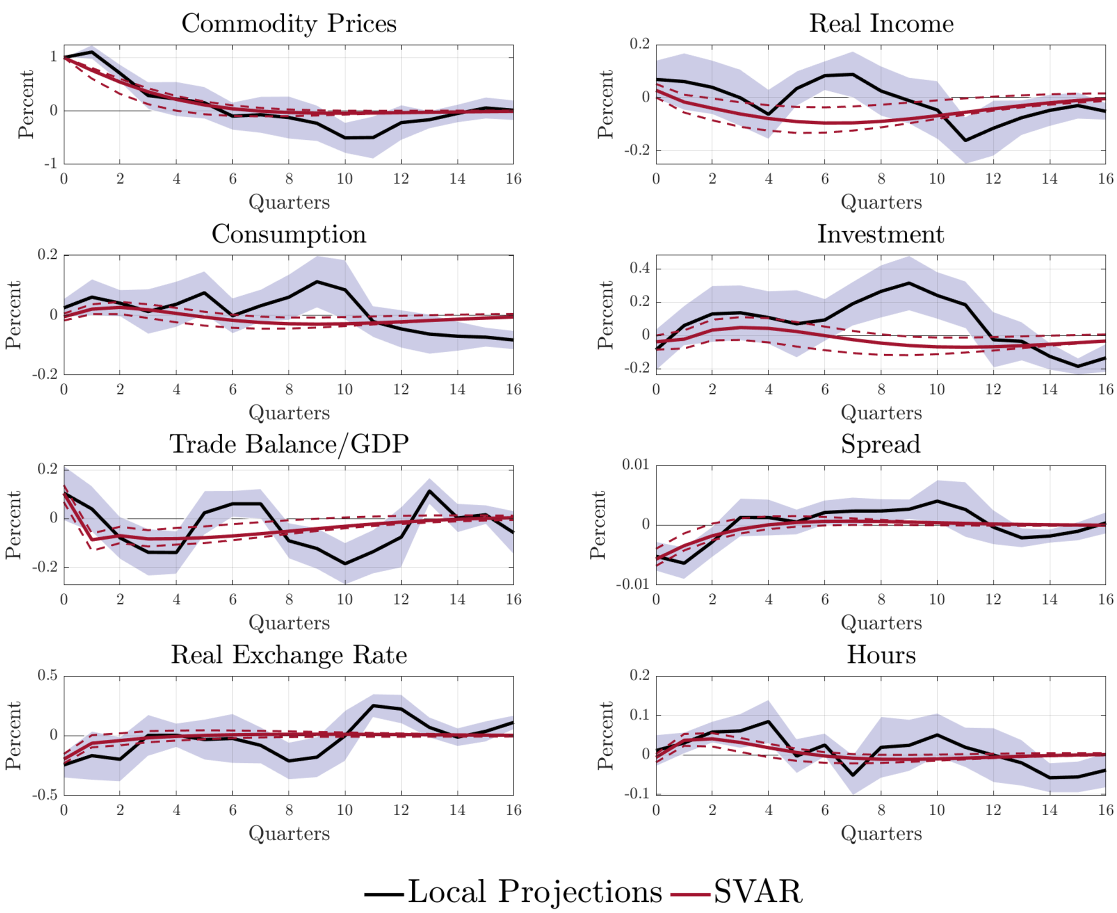


Figure A.4: Impulse response to Commodity Price shock

(c) Colombia

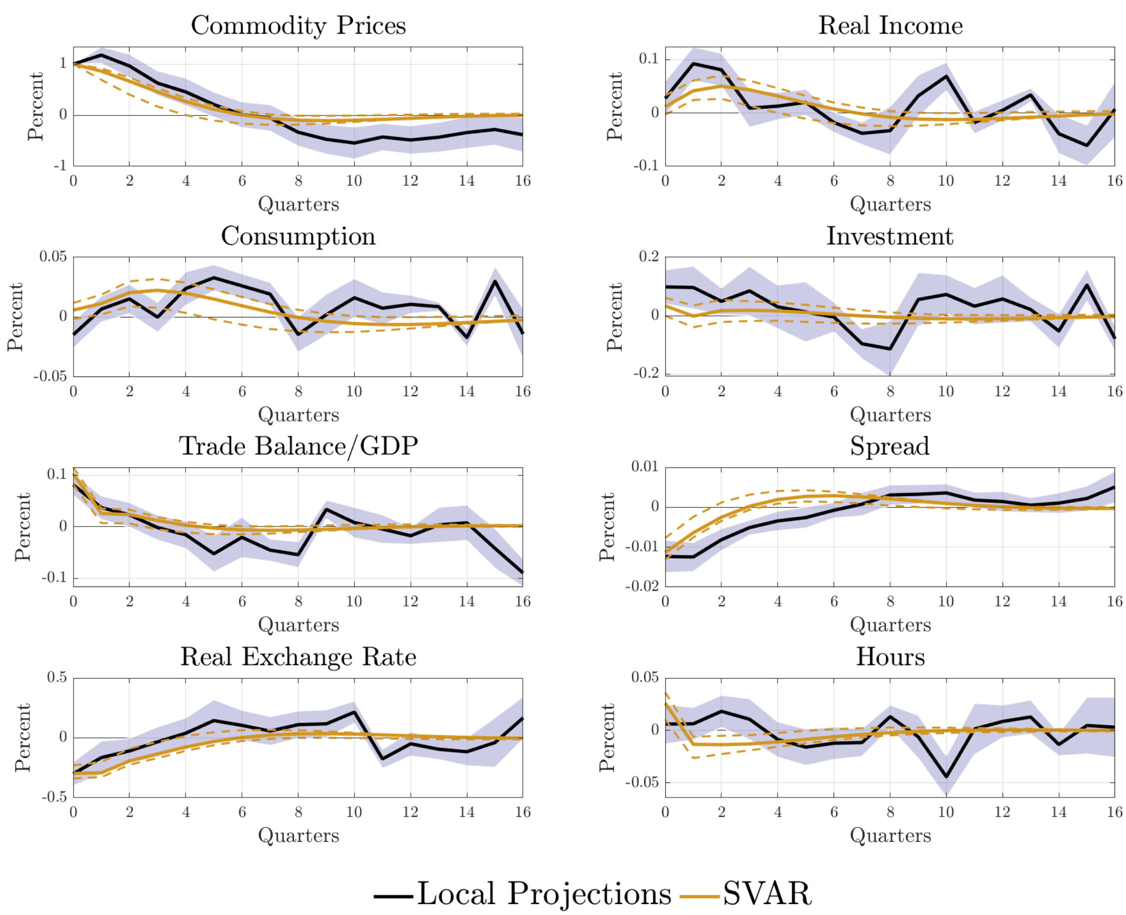
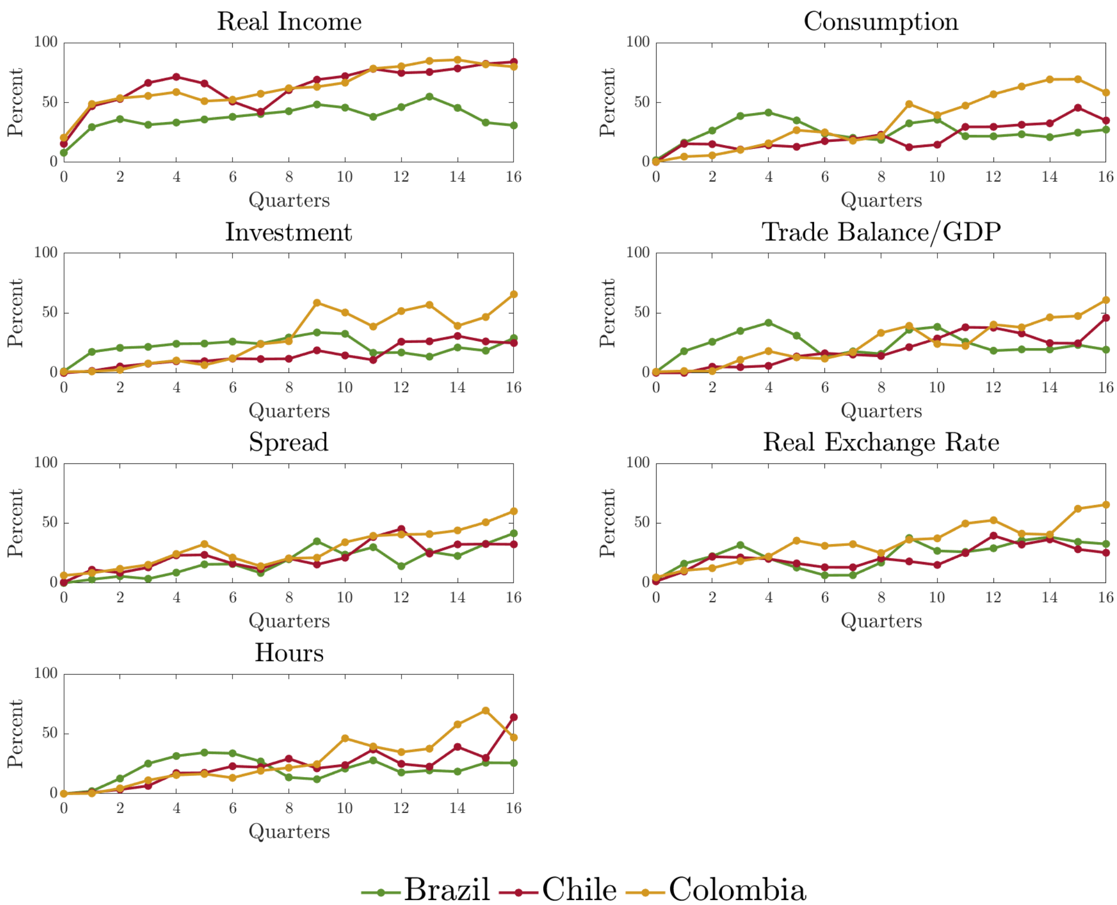


Figure A.5: Fraction of variance explained by Commodity Price shocks



D Additional results

D.1 Serial correlations

Figure A.6: Serial correlation with Commodity Prices - Brazil

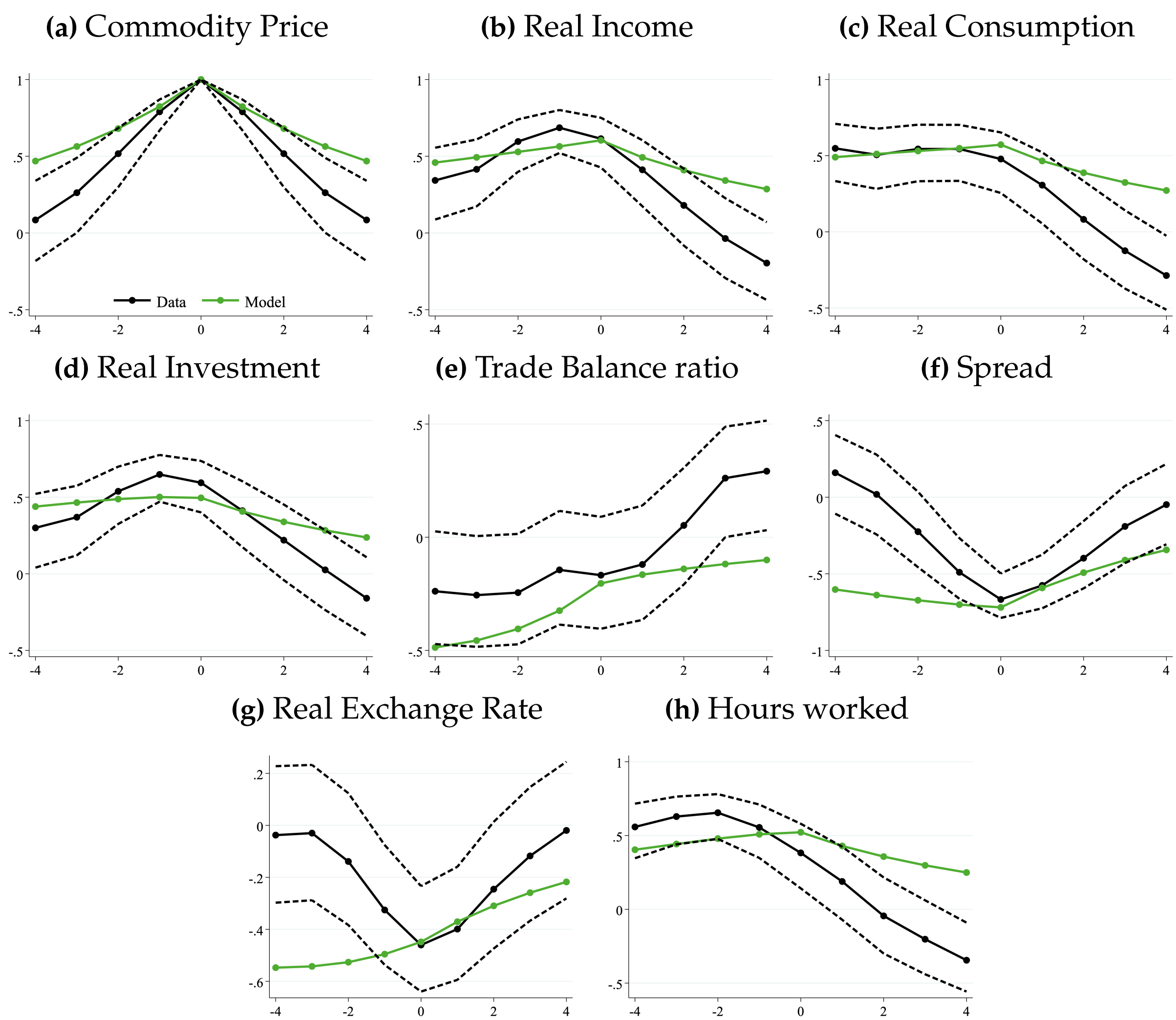


Figure A.7: Serial correlation with Commodity Prices - Chile

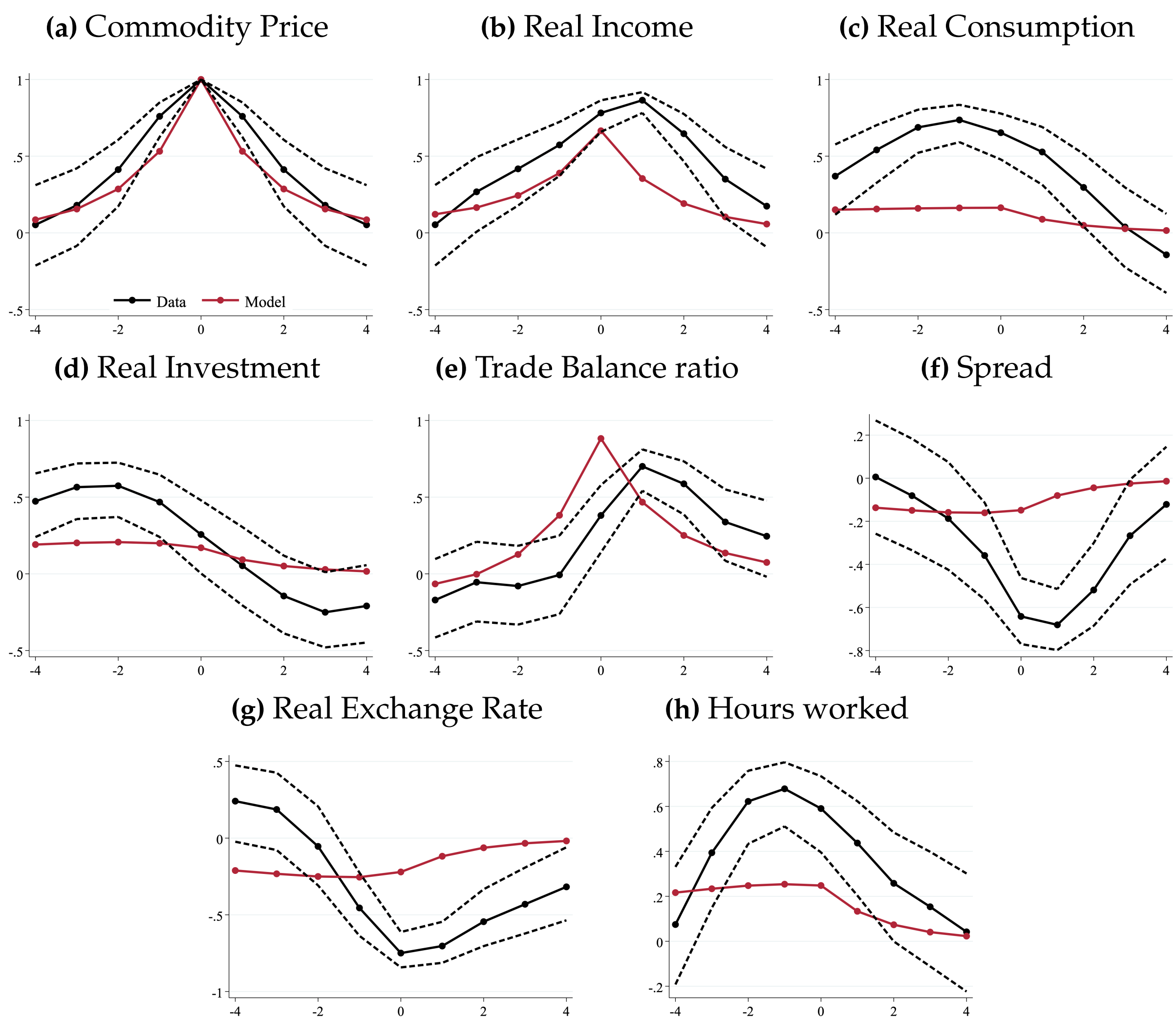
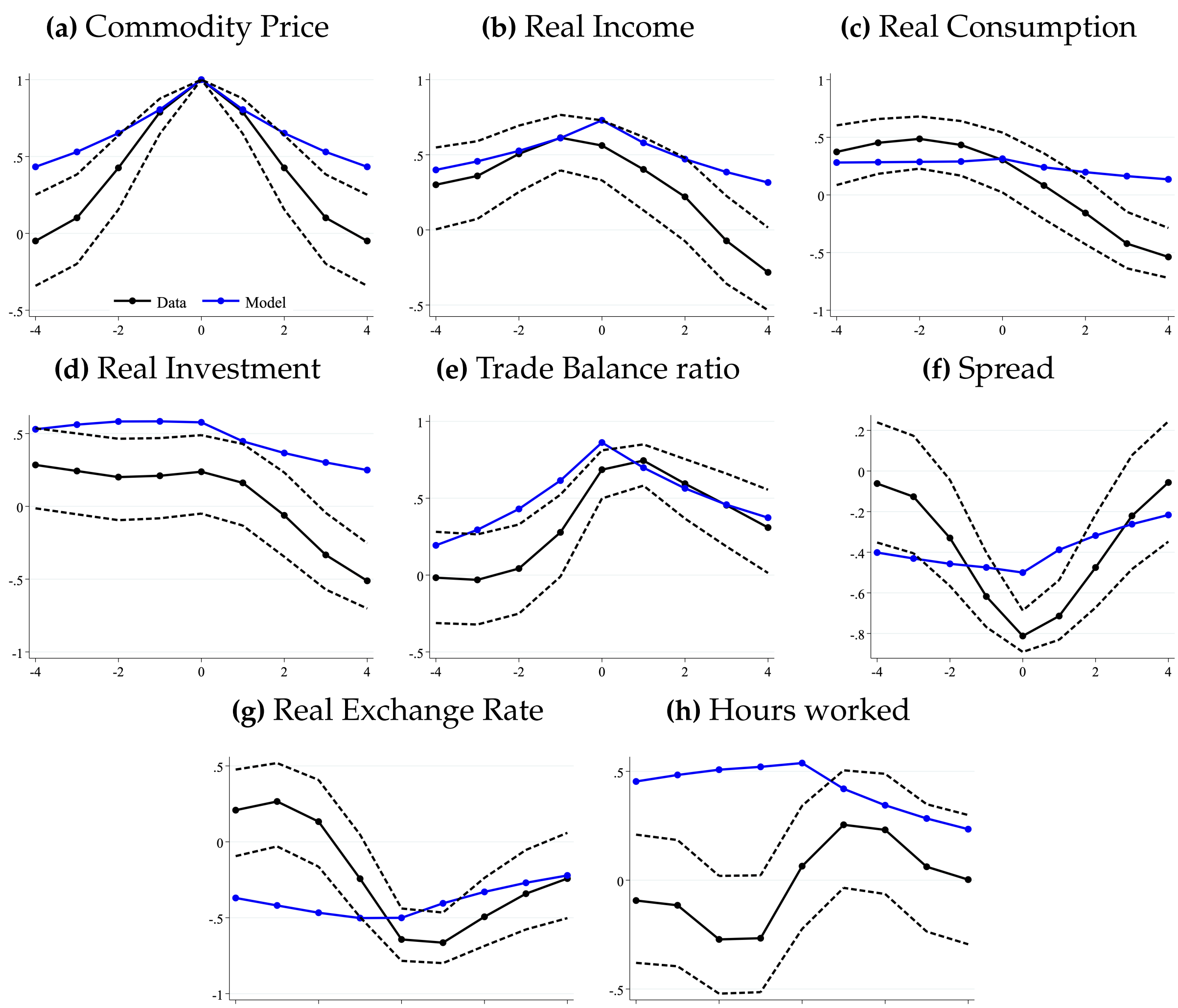


Figure A.8: Serial correlation with Commodity Prices - Colombia



D.2 Comparing two-agent with representative-agent model

Figure A.9: Impulse responses to a Commodity Price shock - Chile

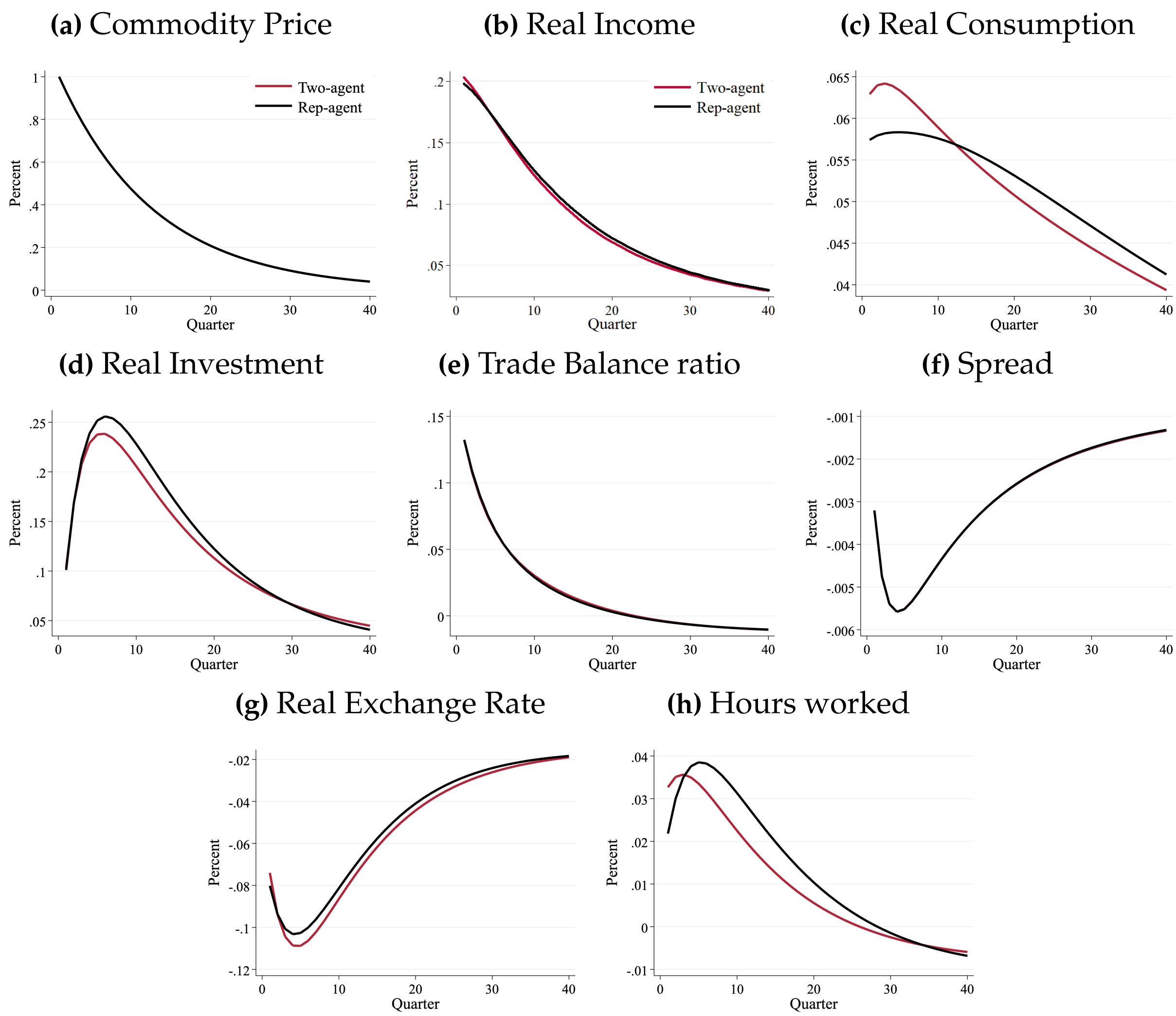
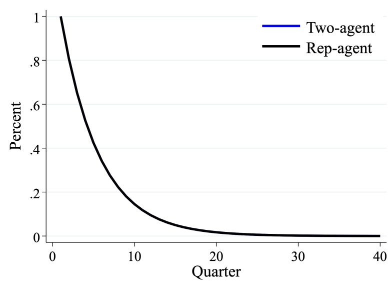
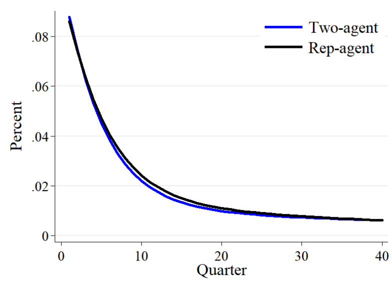


Figure A.10: Impulse responses to a Commodity Price shock - Colombia

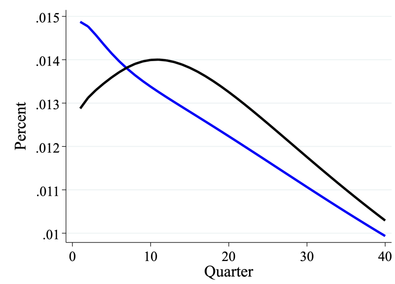
(a) Commodity Price



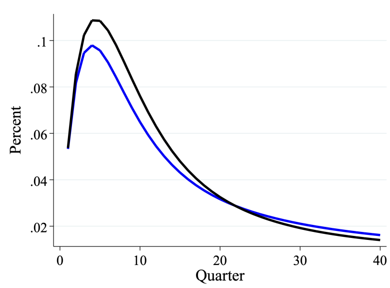
(b) Real Income



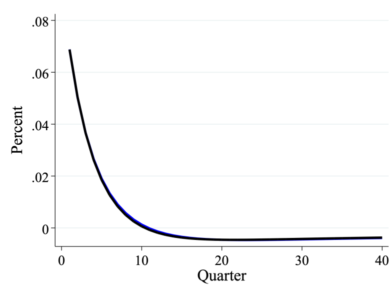
(c) Real Consumption



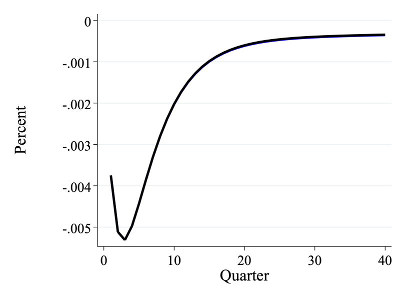
(d) Real Investment



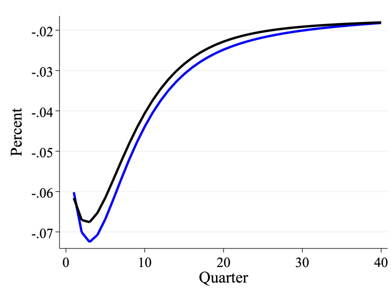
(e) Trade Balance ratio



(f) Spread



(g) Real Exchange Rate



(h) Hours worked

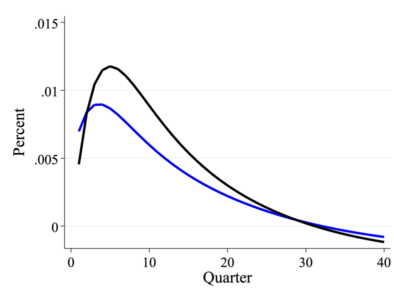
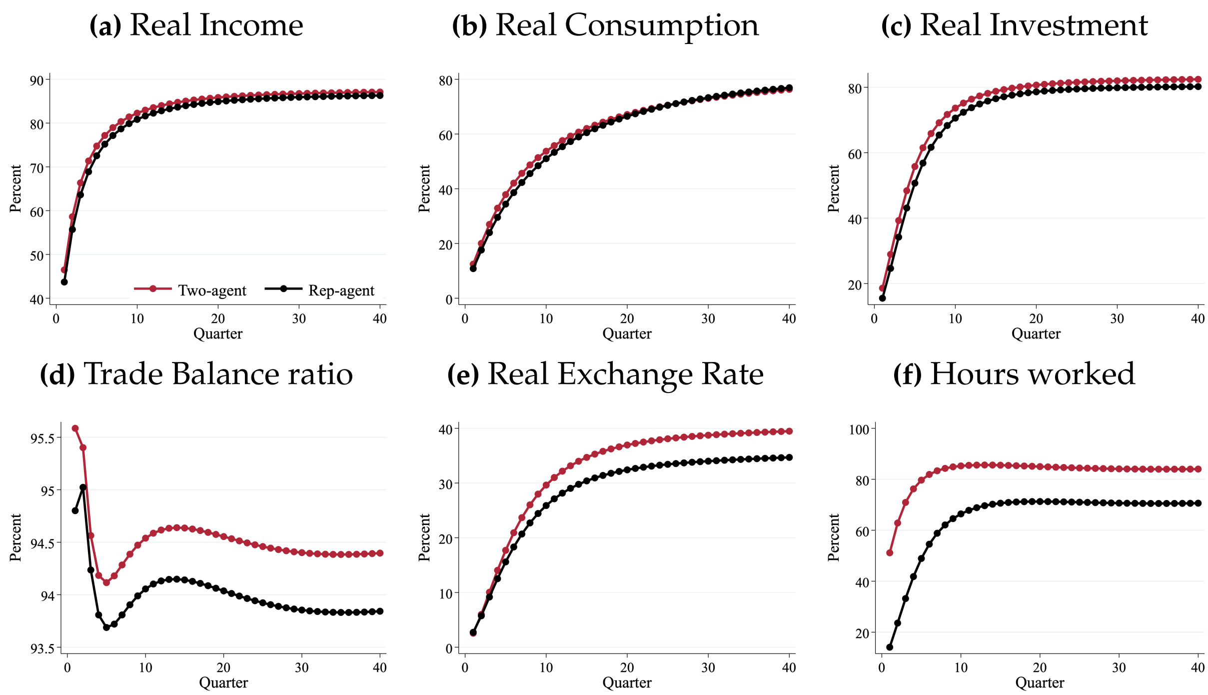
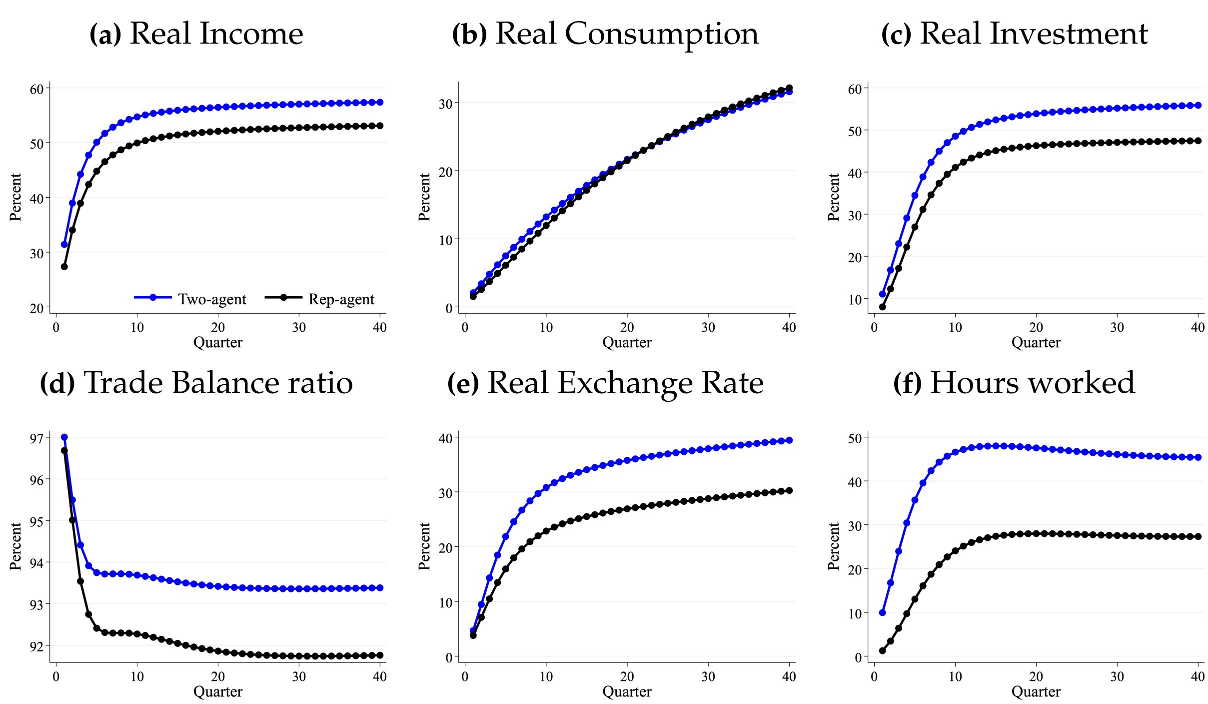


Figure A.11: Fraction of variance explained by Commodity Price shocks - Chile



(a) Real Income **(b)** Real Consumption **(c)** Real Investment **(d)** Trade Balance ratio **(e)** Real Exchange Rate **(f)** Hours worked

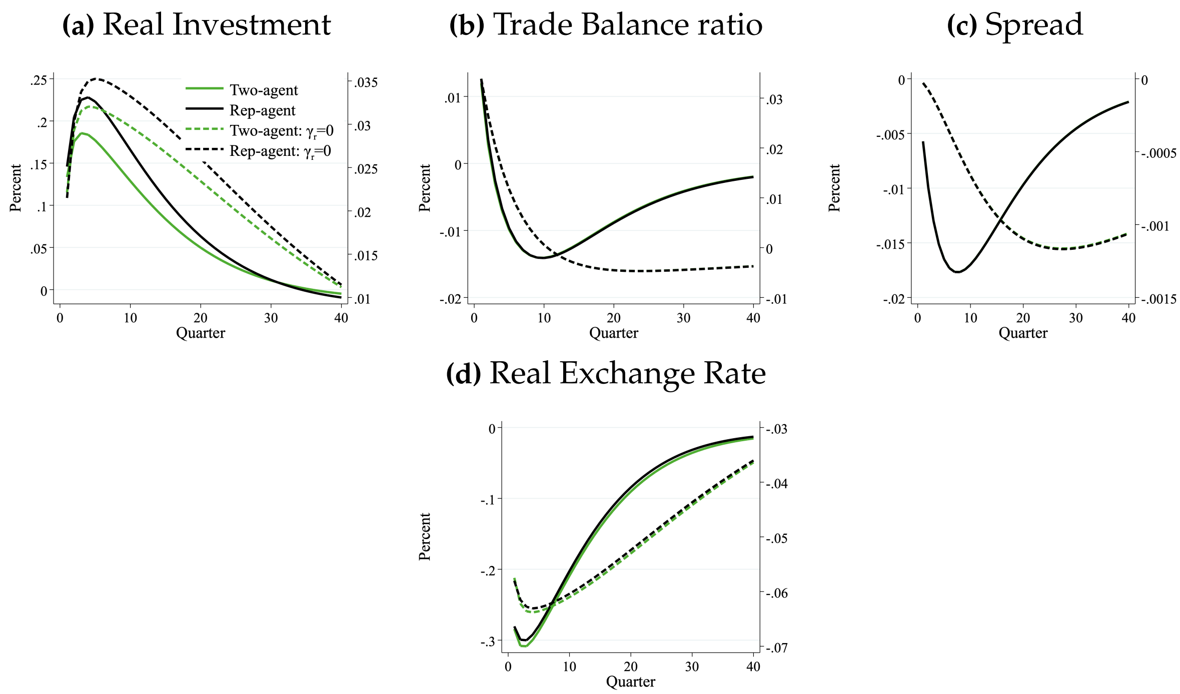
Figure A.12: Fraction of variance explained by Commodity Price shocks - Colombia



(a) Real Income **(b)** Real Consumption **(c)** Real Investment **(d)** Trade Balance ratio **(e)** Real Exchange Rate **(f)** Hours worked

D.3 Mechanisms: Spread effect

Figure A.13: Mechanisms: Spread effect - Brazil



(a) Real Investment **(b)** Trade Balance ratio **(c)** Spread **(d)** Real Exchange Rate

Figure A.14: Mechanisms: Spread effect - Chile

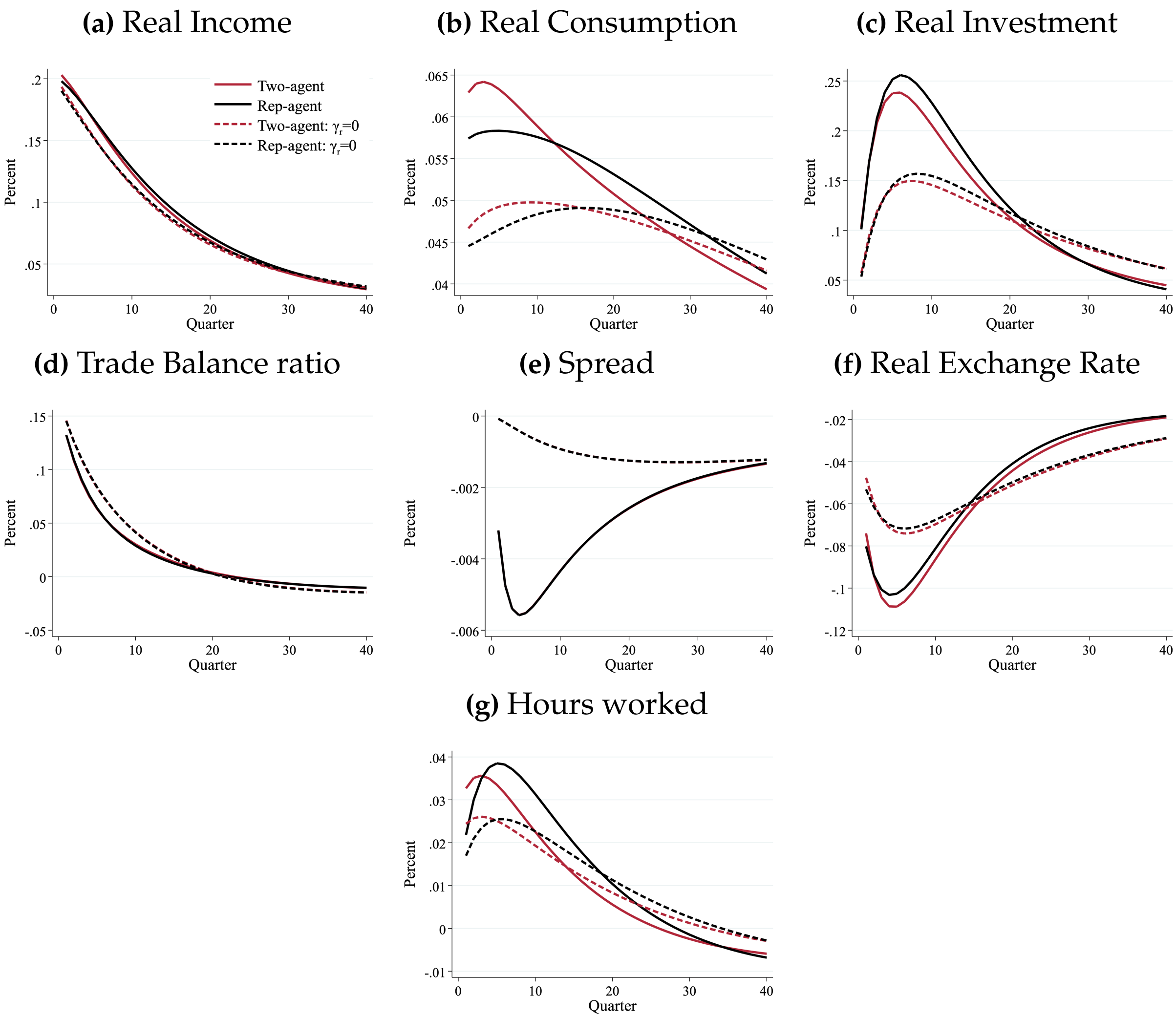


Figure A.15: Mechanisms: Spread effect - Colombia

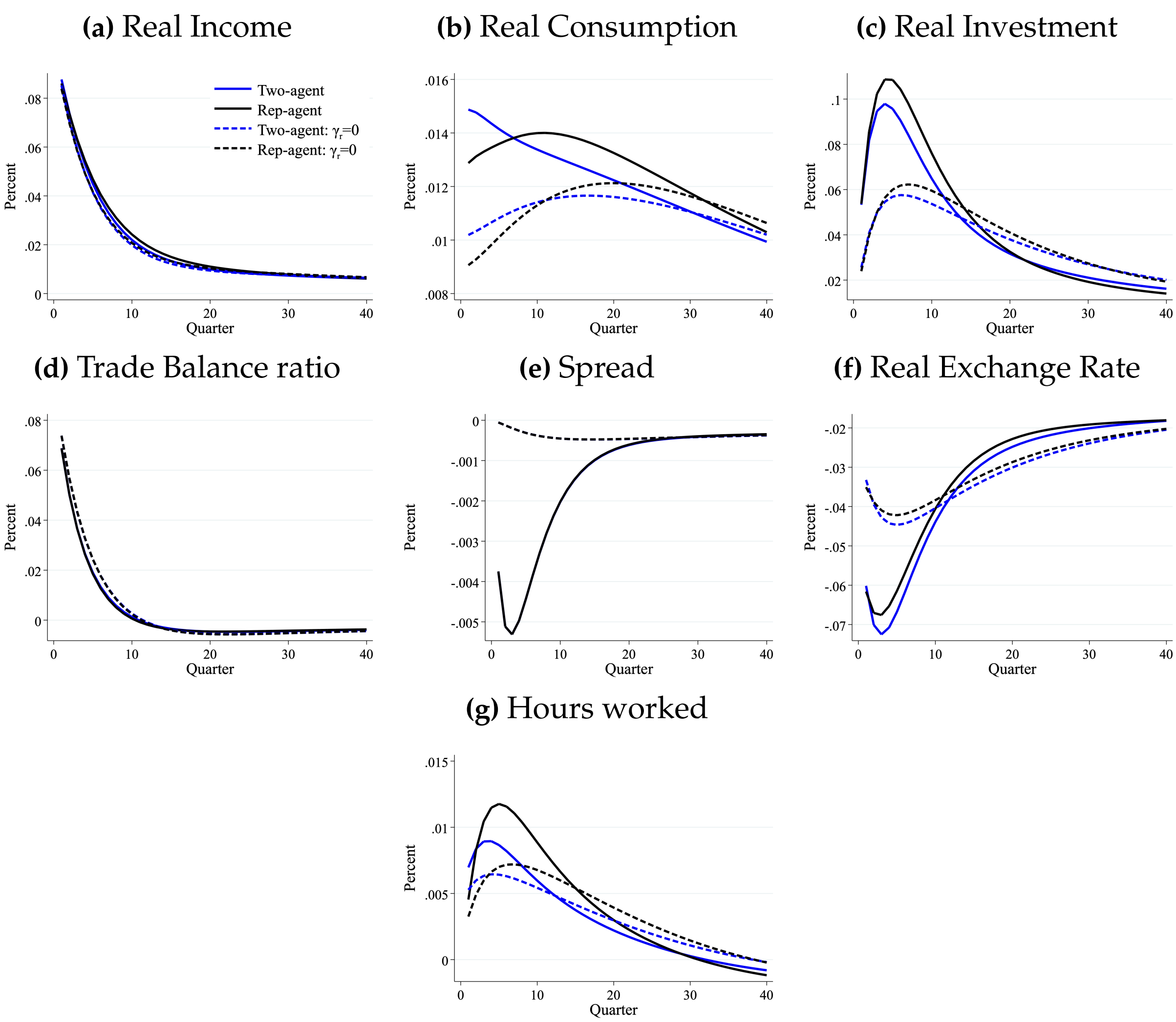


Figure A.16: Mechanisms: Spread effect - Brazil

(a) Real Investment **(b)** Trade Balance ratio **(c)** Spread **(d)** Real Exchange Rate

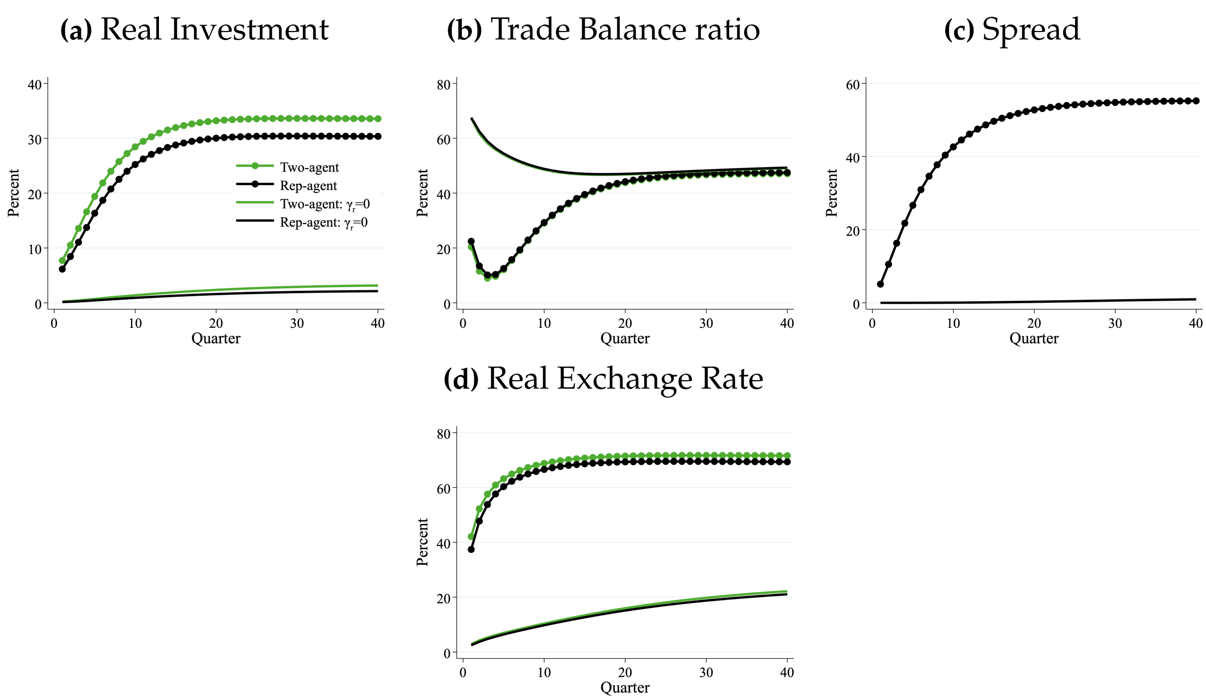


Figure A.17: Mechanisms: Spread effect - Chile

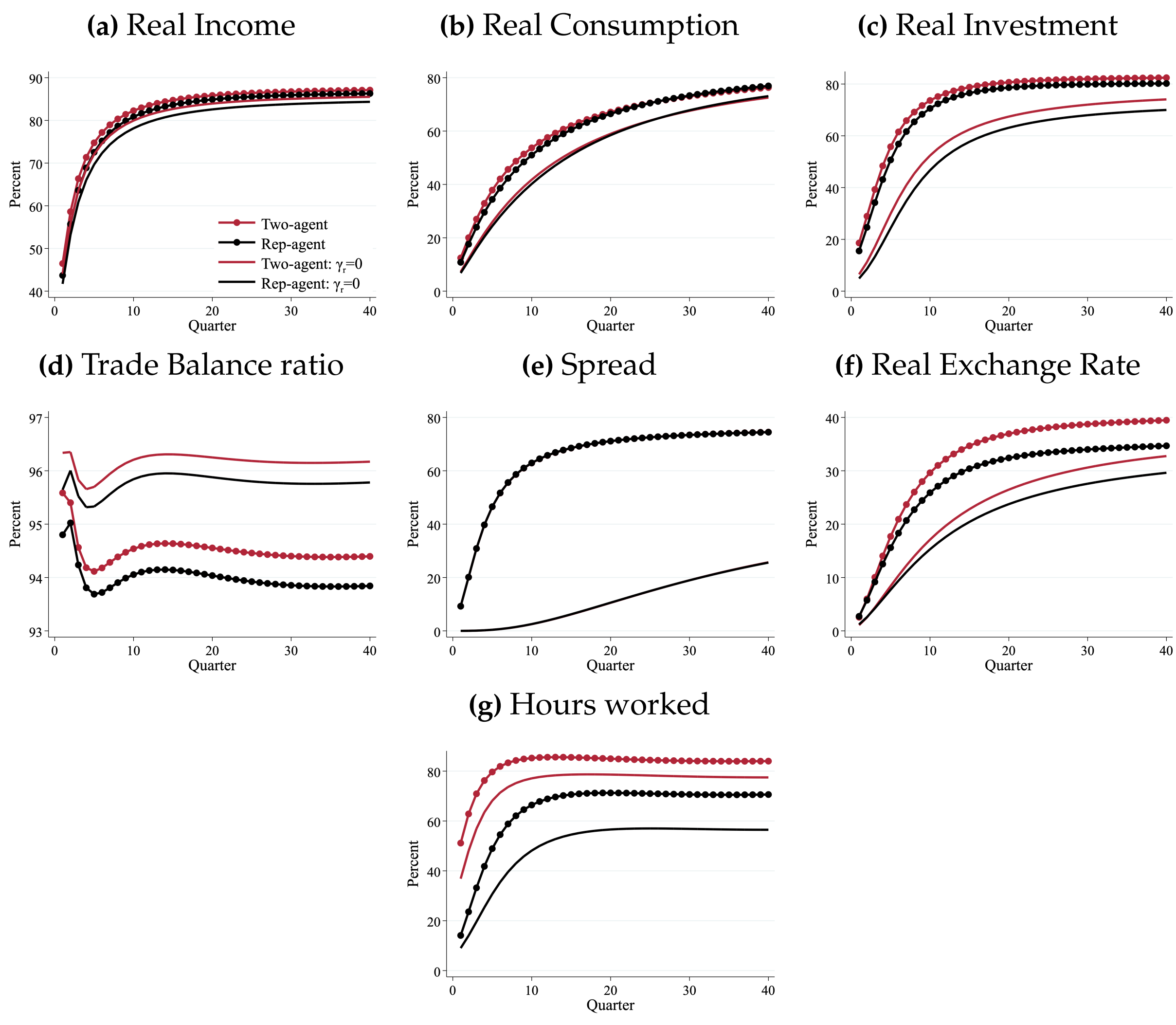
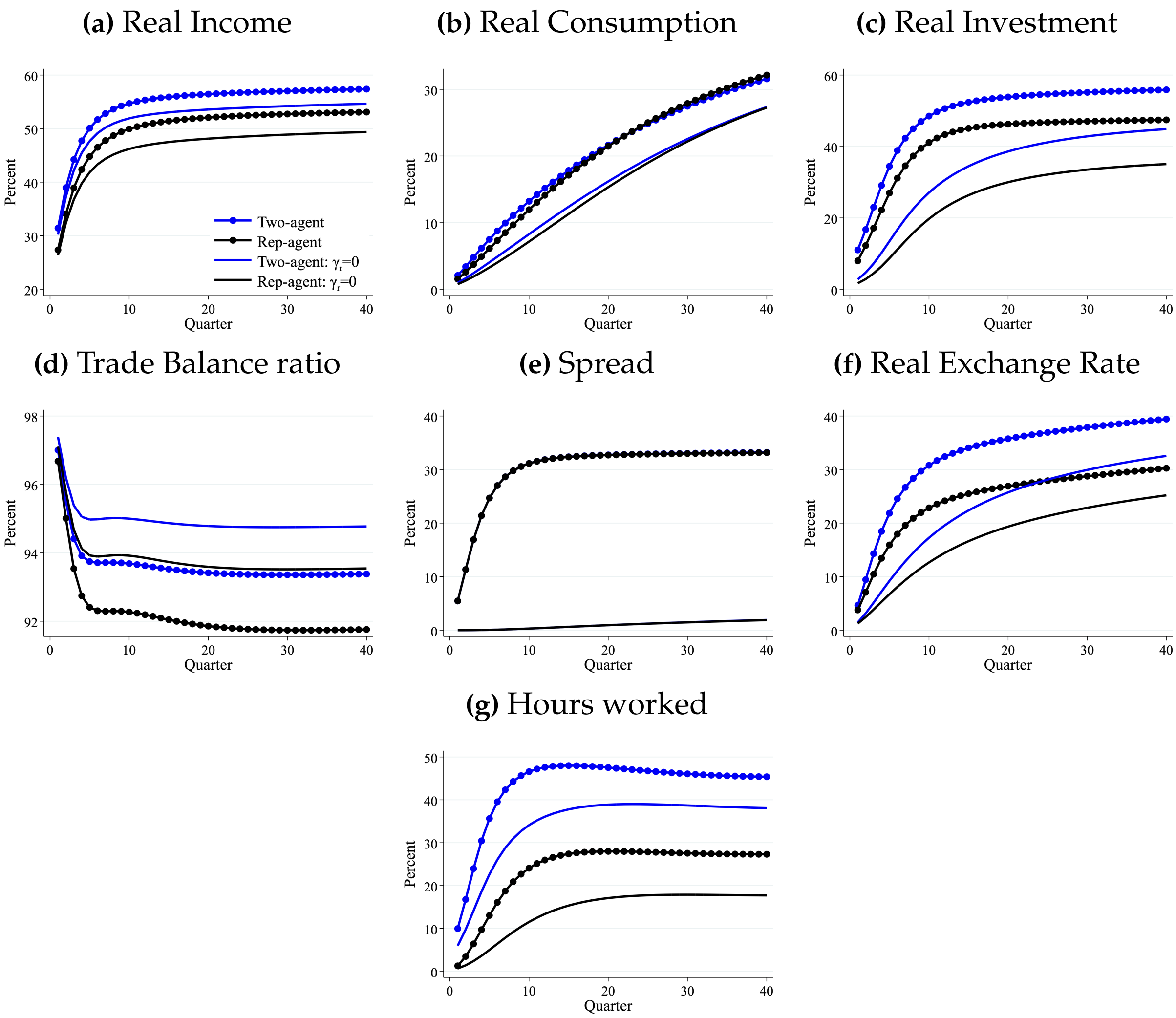


Figure A.18: Mechanisms: Spread effect - Colombia



D.4 Mechanisms: Wealth effect on labor supply

Figure A.19: Mechanisms: Wealth effect on labor supply - Brazil

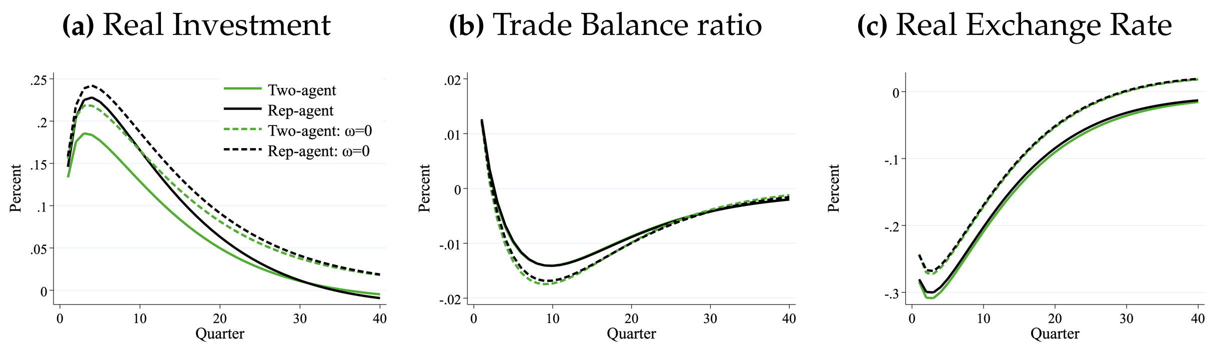


Figure A.20: Mechanisms: Wealth effect on labor supply - Chile

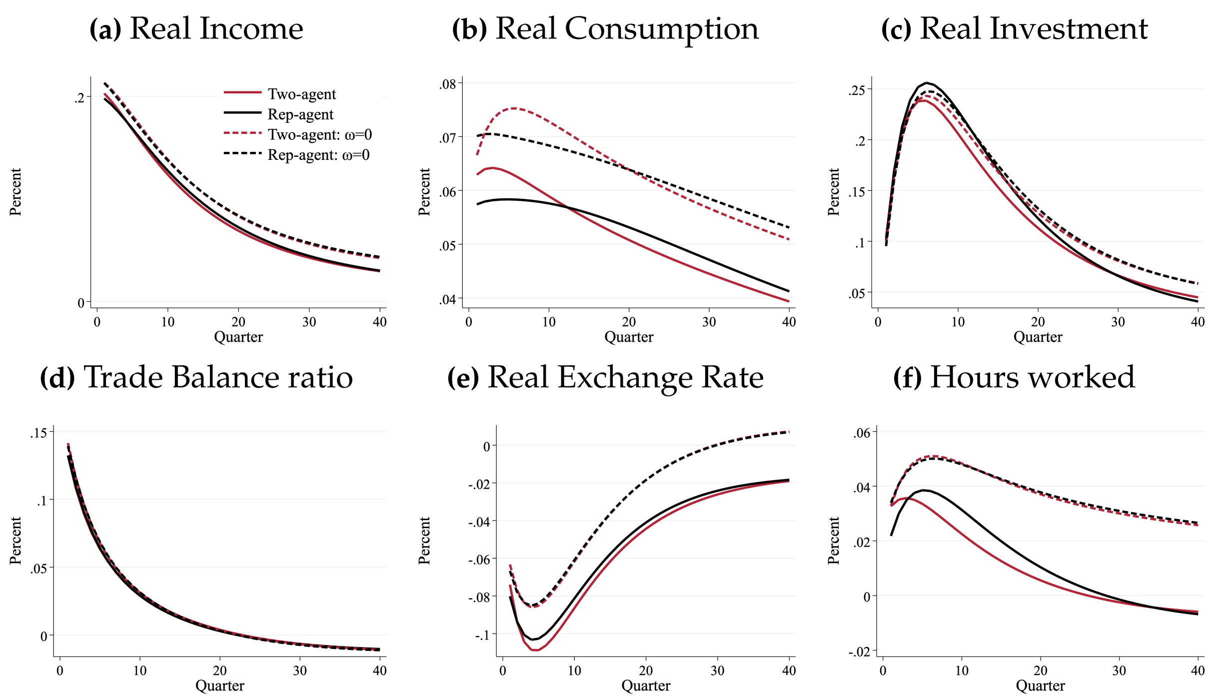


Figure A.21: Mechanisms: Wealth effect on labor supply - Colombia

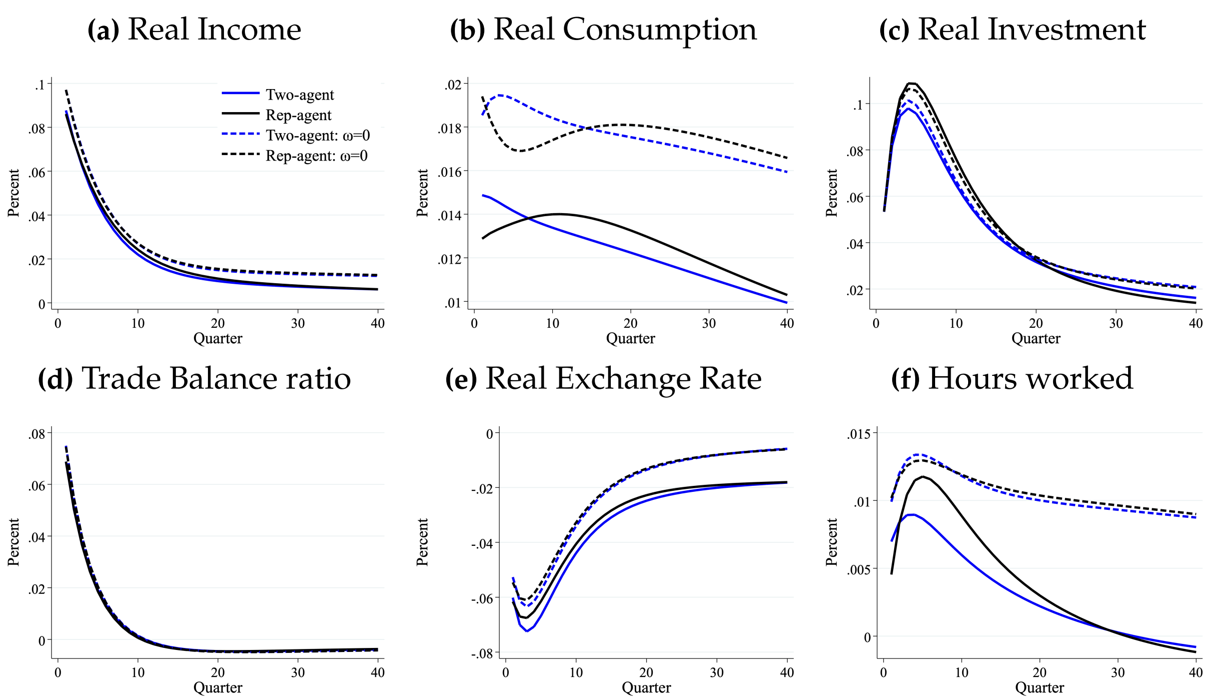


Figure A.22: Mechanisms: Wealth effect on labor supply - Brazil

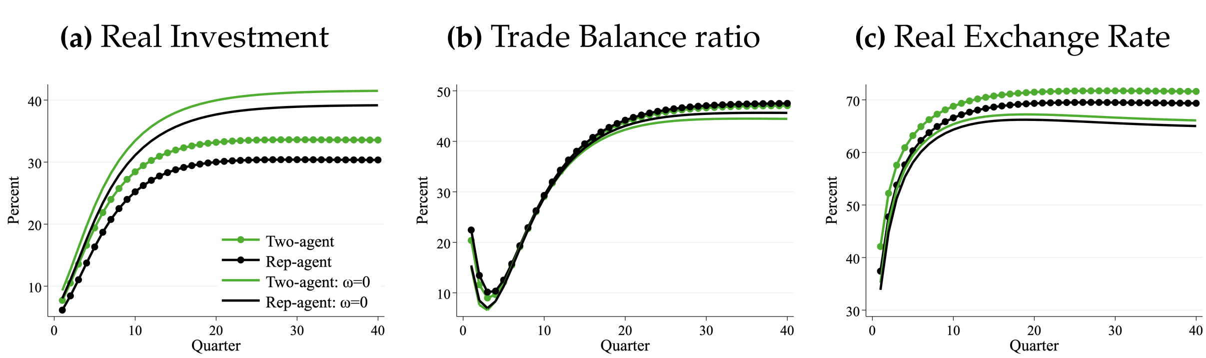


Figure A.23: Mechanisms: Wealth effect on labor supply - Chile

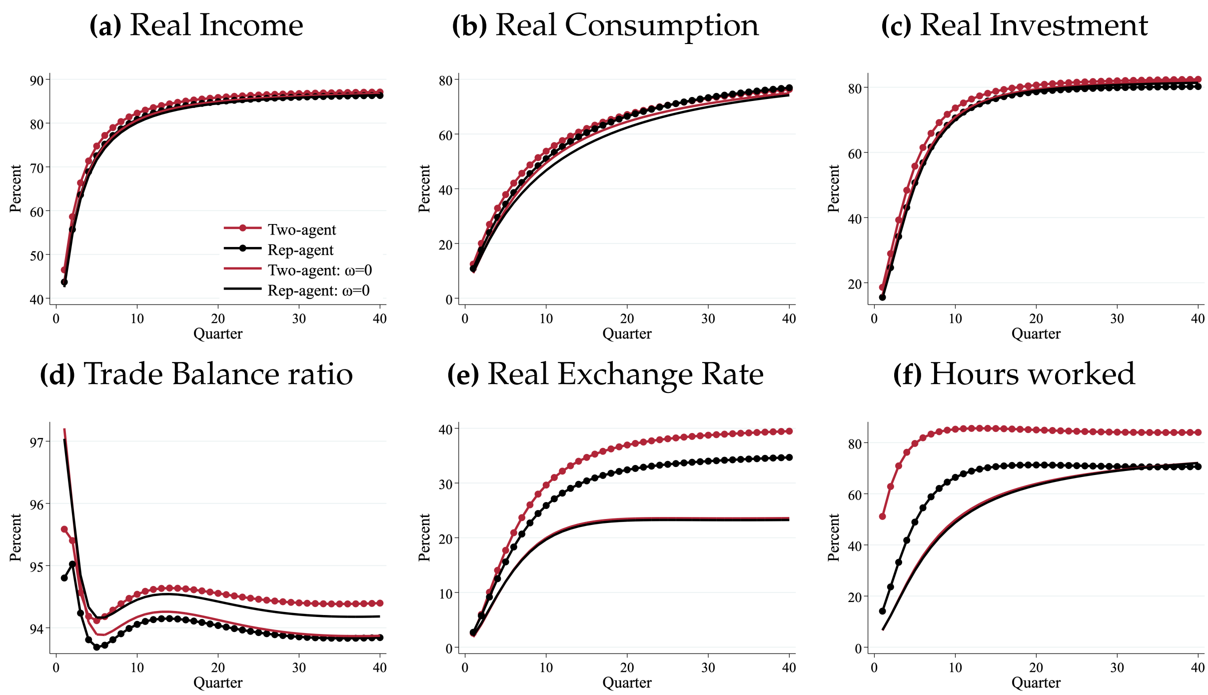


Figure A.24: Mechanisms: Wealth effect on labor supply - Colombia