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Dealing with the Dutch disease: Fiscal rules and macro-prudential policies☆

Javier García-Cicco [a, b, *], Enrique Kawamura [c, 1]

[a] Pontificia Universidad Católica Argentina, A.M. de Justo 1500, Ciudad Autónoma de Buenos Aires, Argentina
[b] Banco Central de Chile, Agustinas 1180, Santiago, Chile
[c] Universidad de San Andrés, Vito Dumas 284, Victoria, Buenos Aires, Argentina

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ABSTRACT

We evaluate from a welfare perspective three policy alternatives frequently proposed to deal with Dutch-disease problems originated from cyclical movements in commodity prices. Namely, fiscal rules for government expenditures, capital controls, and taxes to domestic lending. To this end, we develop a DSGE model of a small open economy with a sectoral decomposition that features three distinctive characteristics: financial frictions, a learning-by-doing externality in the industrial sector, and a fraction of households being non-Ricardian (credit constrained). The first two features induce inefficient relocations after commodity shocks, while the later is relevant to study the role of fiscal rules. We calibrate the model using Chilean data, applying an impulse-response-matching approach. For each of the policy tools, we analyze optimal simple rules from a welfare (Ramsey) perspective, describing how different households rank the several policy alternatives, and studying how each of the models features shape the optimal policy design. A general conclusion of the analysis is that the included Dutch-disease inefficiencies are of limited quantitative relevance in analyzing the desirability of these policies from a welfare perspective.

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* Corresponding author. Pontificia Universidad Católica Argentina, A.M. de Justo 1500, Ciudad Autónoma de Buenos Aires, Argentina. Tel.: +54 11 4349 0200.

E-mail addresses: javier_garcia@uca.edu.ar, jgarcia-cicco@bcentral.cl (J. García-Cicco), kawa@udesa.edu.ar (E. Kawamura).

[1] Tel.: +54 11 4725 7077.

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1. Introduction

The Dutch disease problem generally refers to a contraction in the industrial or manufacturing tradable sector originated from an increase in the income generated by the export of some commodity. The basic mechanism is quite simple: The wealth effect generated from commodity income rises desired consumption for all types goods, in particular non-traded goods. The later generates a rise in production and in the relative price in this sector, as that market has to clear domestically. As a result, productive resources moves to the non-traded sector, leading to a contraction in other tradable sectors like manufacturing. From a welfare perspective, however, this relocation is non desirable (i.e. the "disease" is actually a disease) only if there are inefficiencies associated from expanding one sector relative to the other.

In this paper we analyze three policy alternatives that are frequently discussed, both in academic and in policy circles, to deal with Dutch-Disease problems generated by *cyclical* movements in commodity prices. First, we consider the role of the cyclicality of government expenditures. A widely documented fact for emerging countries is that fiscal policy is pro-cyclical. For example, Frankel et al. (2013) find a positive correlation between cyclical components of real government expenditures with real GDP between 1960 and 1999. One possible consequence of this behavior is that pro-cyclical fiscal expenditures may intensify the problem of Dutch disease in many commodity producers.[2] The idea is that, when commodity prices go up, a government with weak institutional background would easily face political pressures or temptation to increase spending (specially in non-tradables), given the rise in available funds obtained from the surge in international prices. But such increase would exacerbate (instead of compensate for) the higher demand for non-tradables coming from the private sector. Given certain conditions, this may induce to real exchange appreciations and sectoral relocation of resources that are not Pareto efficient. In practice, a number of countries have implemented, or are evaluating, either sovereign funds or even fiscal rules that prevents the government to spend the cyclical part of income generated from commodities; notably the structural-balance rule in place in Chile since 2001.

A second policy tool that we evaluate is capital controls. Such a tool may help to cope with the symptoms of the Dutch disease if they move in a prudential fashion to compensate for improvements in international financial conditions. The idea is that a surge in commodities prices tend to ameliorate financing constraints with the rest of the world, which further exacerbates the desired to rise domestic absorption. Thus, a tax on international capital flows that raises when external financial conditions soften may help to reduce the adverse Dutch-disease-style effects.

The third policy alternative is a tax on domestic lending, which can be viewed as a reduced-form representation of financial controls such as reserve requirements or capital buffers for the banking sector. One of the channels that propagate a positive shock to commodity income is that domestic lending to finance investment will likely increase, as part of the extra wealth generated will be saved. In the presence of financial frictions, this additional lending will tend to exacerbate any sectoral relocations, as the financing conditions for the sectors that improve after the shock (non-tradables) will be relaxed, while the sector that is negatively affected (other tradables like manufacturing) will face tighter financing conditions. In this context, a policy that limits the increase in lending may help to cope with those inefficient movements.

We contribute to the evaluation of these policy alternatives by developing a dynamic and stochastic general equilibrium model (DSGE) featuring a learning-by-doing externalities in the manufacturing sector and financial frictions, and that also includes a non-Ricardian fiscal framework (with a fraction of households being credit-constrained). The first two characteristics allow for inefficient sectoral reallocation (i.e. the "disease" is indeed a disease). The later (non-Ricardian households) is of interest because it gives a non-trivial role for government debt, while also introducing household heterogeneity that will allow welfare evaluation from the perspective of different types of households. We take Chile as our case study, and calibrate the key parameters of the model by matching the impulse

[2] See, for instance, Frankel (2011), and Baunsgaard et al. (2012), among other authors.

responses generated by a typical cyclical shock to commodities terms of trade, obtained from a VAR model.

After analyzing equilibrium features of the model, we perform different policy exercises. First, we study the optimal degree of pro-cyclicality of government expenditures using a simple rule. Second, we analyze the virtues of both capital controls and taxes to domestic credit as previously described. For both exercises, the approach to characterize optimal policy is to study a constrained Ramsey problem, where the cyclical behavior of these instruments is set according to simple rules. In the optimal Ramsey approach there are generally two features that may affect the results. First, as households are assumed to be risk averse, optimal policy will assign some weight to the reduction in uncertainty in variables relevant for welfare (i.e. consumption and hours worked). Second, the optimal policy design will also consider how the particular policy can tackle the inefficiencies in the model, making the equilibrium as close as possible to a frictionless model. If the tool evaluated can, at the same time, reduce aggregate volatility and limit the impact of the inefficiencies present in the model then choice of the optimal policy will be straight forward. However, it might be the case the policy evaluated generates a trade off: if it is able to reduce aggregate volatility at the expense of exacerbating the inefficiencies, or vice-versa. In such a case, the optimal policy will depend on the specificities of the model and on parameter values. As we will see, for some of the policies that we evaluate such a trade-off is actually present, and we will try to characterize what are the relevant channels leading to these results.

Our main findings are as follows. In terms of fiscal pro-cyclicality, we evaluate a structural balance rule (similar to that implemented in Chile) in which a parameter governs how the difference between actual and structural (long-run) revenues determine government expenditures. We analyze the optimal value for that parameter, from the perspective of both types of households. We find that Ricardian agents would rather have a pro-cyclical rule. This is the case because such a rule will help to smooth their consumption, and therefore its variance, despite the fact that a pro-cyclical policy exacerbates any inefficiencies coming from either financial frictions or LBD externalities. In other words, the reduction in the variance of consumption outweighs the benefits of compensating for the inefficiencies present in the model.

From the perspective of non-Ricardians, however, their optimal degree of fiscal pro-cyclicality depends on the characteristics of the model. For instance, under LBD externalities, they would rather have a counter-cyclical expenditure, as the inefficient path of real wages generated by the combination of the externality and a pro-cyclical policy have a negative impact on their expected consumption. On the contrary, in the presence of financial frictions the reduction in volatility they experience with a pro-cyclical rule compensates for the inefficient movement in real wages, making them choose a pro-cyclical policy.

In addition, the welfare gains for Ricardians from setting their preferred degree of pro-cyclicality are larger than the benefits that non-Ricardians experience if they were to choose it. Therefore, it is likely that a maximization of a combined welfare function that assigns a non-trivial weight to Ricardians will likely display pro-cyclical pattern. We also find that these policy choices are also obtained in models were the inefficiencies associated with the Dutch-disease problem are not present. Therefore, the benefits of using this policy tool optimally cannot be attributed to Dutch-disease-related inefficiencies.

In terms of capital controls, we consider a rule in which a tax on foreign borrowing reacts to changes in international financing conditions (the country premium). When this alternative is available we also find a discrepancy between both types of agents. Ricardians prefer a prudential rule, whereby capital controls are tighter as external financial conditions soften. The opposite is preferred by Non-Ricardians. Such a policy will smooth out part of the responses generated by movements in international prices of commodities, reducing the variance in consumption for both types of agents. However, for Non-Ricardians a prudential capital control reduces its expected level of consumption. For the chosen parametrization, this trade-off is solved in favor of average consumption, explaining why these agents prefer a pro-cyclical capital control. In any case, welfare gains associated with this tool are relatively small.

The other policy tool that we evaluate is a tax on domestic credit that increases as lending to finance capital accumulation rises. We find that both types of households also disagree on how these taxes should move with the credit cycle. In particular, Ricardians would rather not have this tax at all, while non-Ricardians would prefer a tax that fully compensate any change in credit. However, the welfare gains or loses they experience for different degrees of reaction of this tax rate to total credit are quite small, particularly compared with the benefits of the other alternatives we have analyzed.

Finally, we also evaluate the possibility of combining the alternative policy instruments. The results, however, are mainly driven by the fact that welfare gains from fiscal pro-cyclicality are the largest. Thus, whenever this tool is available, different choices for the other tools generate only minor changes in welfare.

Before beginning the analysis we should mention that, while we focus on the effects of *cyclical* movements in commodity-related income, there is an alternative perspective to analyze the Dutch-disease problem. Namely, how long-term changes in commodity-related income affect the economy. These could be generated by changes in prices (e.g. by a structural break in the unconditional mean of the price generated, for instance, by a permanent increase in the world demand for the commodity), or in quantities (for instance, due to the increase in the endowment of a natural resource, like the discovery of a new oil field). However, a study of this alternative perspective would be significantly different than the one we present here, for it would require to analyze how the economy transitions form one steady state to the other, and how policy should be implemented during this transition. Moreover, for such a study to be relevant, one should explicitly model the interaction between commodity income and long-term growth. While this is of course a relevant issue to analyze, in this paper we focus instead on cyclical movements and therefore we will abstract from long-term considerations. Still, our analysis should be of relevance for countries that need to deal with the cyclical volatility of commodity prices.

The rest of the paper is organized as follows. Section 2 reviews the literatures related to the analysis intended here. Section 3 presents the model and its parametrization. Section 4 analyzes the dynamics and the role of different modeling features under an a-cyclical fiscal-expenditures rule. Section 5 analyzes the optimal degree of cyclicality for government expenditures, Section 6 studies capital controls, Section 7 evaluates the role of taxes to domestic lending, and Section 8 studies the combination of these alternative tools. Finally, section 8 concludes.

2. Related literature

Our paper links two brands of literature. The first one is the literature on fiscal pro-cyclicality. Part of the literature has shown that, in small open economy models with Ricardian households and incomplete assets markets, optimal fiscal policy is generally pro-cyclical (e.g. Gavin et al., 1996; Gavin and Perotti, 1997; Riascos and Vegh, 2003; Caballero and Krishnamurthy, 2004; Cuadra et al., 2010); in-line with the evidence collected for most emerging countries. A second strand studies fiscal rules in economies with non-Ricardian households, embedded in the more general literature that contrasts procyclical versus anticyclical fiscal policies. The seminal paper of this brand of literature is Gali et al. (2007), based on the modeling device by Gali et al. (2004). That paper surveys a set of empirical findings suggesting that private consumption increases after a rise in public spending. To explain such a fact that paper builds a New Keynesian DSGE model with a particular type of consumers, called *non-Ricardian*.[3] The latter are individuals who cannot smooth consumption neither over time nor across future contingencies; the only choices left to them are the intra-periodic ones. This paper gave room for a number of extensions, especially to small open economies. Among them, Garcia and Restrepo (2007a, 2007b) and García Cicco et al. (2010, 2011) build models along the lines of Gali et al. (2007) for small open economies to study the effect of distortionary taxation (2007a), the role of countercyclical policies (2007b) and the role of a commodity sector (2010). Of particular interest is García et al. (2011), since the latter consider the welfare consequences of fiscal rules in this type of models (including a commodity producing sector). Their main result is that fiscal rules that reduce public spending volatility benefit non-Ricardian households but may hurt other households with access to financial markets.[4] More recently, Céspedes et al. (2013) present a model based on the Gali et al. (2007) framework calibrated

[3] Gali et al. (2007) call them "rule-of-thumb" consumers. Others refer to them as "hand-to-mouth" or "credit-constrained" households.

[4] A similar analysis but in a much more complex model is carried by Kumhof and Laxton (2009, 2010).

and estimated to Chilean data, which includes a fiscal rule sufficiently flexible to include a balanced-budget rule and another one similar to that implemented in that country. Their main result is that, under a balanced-budget-fiscal rule, positive shocks to public transfers to the private sector have positive effects in consumption, but not the positive shocks to public spending (although the latter do increase output).[5] Finally, González et al. (2013) also find that, for a model whose parameters were calibrated to the Colombian economy, a fiscal rule similar to that in Chile would yield higher benefits than a balanced budget rule or countercyclical ones.

The second literature related to this paper is the one dealing with the generation of the so-called Dutch disease and the types of policies to deal with it. The literature on Dutch disease has been developed for several decades (see, for example, Magud and Sosa, 2013, for a surveys). The early contributions on the theoretical side stress the importance of several sources inefficiencies (such as labor market imperfections or learning-by-doing externalities in the tradables sector) to ensure that positive shocks to capital inflows would not only imply real appreciation but also an inefficiency (i.e., that the Dutch disease is really a disease). However, only recently there have been some development of papers dealing with policy responses to such inflows, particularly those generated by commodity price shocks. Caballero and Lorenzoni (2009) develop a two-sector model (one tradable, the other non-tradable) with financially constrained exporters. They consider preference shocks as a reduced-form modeling device for more explicit international price shocks. They analyze tax policies on the consumption of each good that can be applied ex-ante or ex-post. The Pareto-optimality of applying an ex-ante versus ex-post tax change depends on how financially constrained exporters are. Lama and Medina (2012) construct a DSGE model with an explicit commodity exporting sector and learning-by-doing in the non-commodity export sectors to analyze the macroeconomic and welfare effects of explicit exchange-rate stabilization policies, suggesting that the latter are dominated by others allowing for real exchange appreciations after a positive commodity shock. More recently, Schmitt-Grohe and Uribe (2012) also construct a two-sector model with labor market imperfections and pegged exchange rate regimes to study the optimal level of capital controls. Given their calibration they find that it is optimal to tax capital inflows in good times and subsidize external borrowing in bad times, not only in terms of welfare but also in terms of unemployment drop.[6] Benigno et al. (2013) construct a two-sector model with financial frictions, where the latter come under the form of a collateralized borrowing constraint similar to those in the pecuniary externality literature.[7] That paper considers three policy interventions: capital controls (tax-subsidies on foreign net asset accumulation), taxes on non-tradable consumption and taxes on tradables consumption. Their main result is that either of these two taxes can always implement the first-best allocation, while capital controls cannot. Although the last paper was originally designed to study problems of sudden stops rather than Dutch disease, the design may also suggest the same results for positive tradable income shocks. However, none of those papers put any role on fiscal spending in increasing welfare when Dutch disease is a real threat for the economy.

Perhaps, the closest reference to this proposed model is Hevia et al. (2013). That paper assumes a New Keynesian DSGE model with a commodity sector and a government consuming the same varieties of goods as households. They consider both exchange rates (monetary) policies as well as tax policies. Taxes are imposed on labor income, capital flows, and also subsidies in the non-commodity exporters demand for labor and on profits. They obtain results about the optimal mix of tax and monetary policies. However, in their model there is no condition that makes public spending relevant to smooth consumption against Dutch disease, since all consumers have access to complete financial markets. They do not consider explicit fiscal rules where the dynamics of public spending is a key ingredient of the discussion.[8] Thus, the proposed model can be seen more as a complement of Hevia et al. (2013)

[5] Another application for the Chilean economy focusing on Copper prices is Medina and Soto (2011).

[6] A complementary study is that of Farhi and Werning (2012), who analytically (in a simplified framework) characterize optimal capital controls under other rigidities.

[7] For this literature see Bianchi (2011) and a survey by Korinek (2011).

[8] Incidentally, as it will be clear below, our proposed model assumes incomplete financial markets, unlike Hevia et al. (2013) who concentrate in the complete markets case.

since their emphasis is in variables that complementary to those considered in this paper in the first place.

3. The model

We present a multi-sector model of a small open economy in the lines of the seminal work by Mendoza (1995) and, more recently for instance, by Medina and Naudon (2011) and García Cicco et al. (2013). The backbone of the model is as follows. There are four types of goods: an exportable (X), an importable (M), a non-tradable (N) and a commodity (Co). Since our economy is small and open, exportable, importable and commodity goods are internationally traded and their prices are taken as exogenous (we choose M to be the numeraire). The production of commodities is an endowment that is completely exported abroad. Households consume exportables, importables and non-tradables. Regarding production location, we assume that the importable good is produced abroad only, while the other three goods are locally produced. Exportable and non-tradable goods are produced using capital and labor. In each of these two sectors, there is a representative firm that rents capital and hire workers. In addition, another set of firms produce investment goods combining importable and non-tradable goods, and capital accumulation in both sectors is subject to adjustment costs. All sectors are assumed to be competitive. The only driving force that we consider is the commodities terms of trade.

The ingredients of the model that are of special interest for our goals are the following. First, we consider two types of households: a Ricardian group that have access to non-state contingent international bonds, and a non-Ricardian group that can only consume its after-tax labor income in each period. Second, we assume that the production of exportables (X) is subject to a learning-by-doing externality. Third, there are two sets of entrepreneurs (on in each sector X and N) that are the managers of capital and decide how much of it to accumulate over time. They need to borrow to finance capital accumulation and they are subject to a costly-state-verification problem similar to that of Bernanke et al. (1999). These last two features open the door to inefficient outcomes in response to real-exchange-rate movements. Finally, there is a fiscal authority that levies income taxes, consume non-traded goods, decide on its international asset holdings, and it may use additional fiscal instruments.

3.1. Households

3.1.1. Ricardian

There is a continuum of infinitely-lived Ricardian households whose mass is $1-\kappa$. Each of them has a lifetime utility given by,

$$E_0\left\{\sum_{t=0}^{\infty}\beta^t U\left(c_t^R, h_t^R\right)\right\},$$

where β is the intertemporal discount factor, h^R represents total hours worked and c^R is consumption of final goods.

Each of these households can work in either the exportable sector or the non-tradable sector and they are indifferent between the two options, i.e.

$$h_t^R = h_t^{R,X} + h_t^{R,N},$$

where $h_t^{R,X}$ and $h_t^{R,N}$ are hours worked in the exportable sector and the non tradable sector respectively. Notice that this implies that labor is perfectly mobile between sectors.

Individually, each Ricardian household's faces in period t the following resource constraint,

$$\begin{aligned}p_t c_t^R + d_{t-1}^{R*}\left(1+r_{t-1}^*\right) - d_t^{R*} &= (1-\tau)\left[w_t h_t^R + p_t l_{t-1}^R\left(1+r_{t-1}^L\right) - p_t l_t^R + \Omega_t^R\right]\\ &\quad + \left(1-\tau^{Co}\right)p_t^{Co} y_t^{Co}\frac{s^{Co,R}}{(1-\kappa)},\end{aligned}$$

where p_t is the price of the final consumption bundle,[9] d_t^{R*} is the stock of international debt, l_t^R are loans to entrepreneurs (denominated in domestic-consumption units), w_t denotes real wages, r_t^* is the world interest rate, r_t^L is the interest rates on loans, and Ω_t^R are profits coming from the ownership of different firms. Additionally, we assume that there is an exogenous stochastic endowment of commodities y_t^{Co} which is fully exported at an international relative price of p_t^{Co}. The fraction $s^{Co,R}$ denotes the share of commodity production that is owned by Ricardian households. Finally, these households pay two types of taxes: a tax τ proportional to all the domestic non-commodity sources of income, and a proportional tax to the revenue generated by commodities τ^{Co}.

The world interest rate is assumed to be equal to

$$r_t^* = r_t^w + \exp\left\{\phi_d\left(\frac{d_t^* - \overline{d}^*}{\overline{d}^*}\right)\right\} - 1, \tag{1}$$

where d_t^* is the economy-wide foreign debt position, $\overline{d}^*$ and ϕ_d are positive parameters, and r_t^w is an exogenous process. This country's premium ($cp_t \equiv r_t^* - r_t^w$) serves as a closing device as in Schmitt-Grohe and Uribe (2003).

3.1.2. Non-Ricardian

There is also a continuum of non-Ricardian households, with mass κ. Their lifetime utility is the same as that of Ricardian households, i.e.

$$E_0\left\{\sum_{t=0}^{\infty}\beta^t U\left(c_t^{NR}, h_t^{NR}\right)\right\},$$

with $h_t^{NR} = h_t^{NR,X} + h_t^{NR,N}$. However, these households do not have access to any type of financial market, nor they receive income from profits. Thus, every period each of them face the constraint,

$$p_t c_t^{NR} = (1-\tau) w_t h_t^{NR},$$

where τ denotes a proportional income tax. As a consequence of the constraints they face, these households just solve an intra-temporal allocation problem.

3.2. Production

3.2.1. Aggregate consumption

The aggregate consumption good is produced by combining tradables, c_t^T, and non-tradables, c_t^N,

$$c_t = \left[\varphi^{1/\varepsilon}\left(c_t^N\right)^{1-1/\varepsilon} + (1-\varphi)^{1/\varepsilon}\left(c_t^T\right)^{1-1/\varepsilon}\right]^{\frac{\varepsilon}{\varepsilon-1}},$$

where ε is the elasticity of substitution and $0<\phi<1$ is a parameter governing the share of non-tradables in aggregate consumption. Tradable consumption is in turn a Cobb–Douglas aggregation of exportable, c_t^X, and importable, c_t^M, goods:

$$c_t^T = \left(\frac{c_t^X}{\chi}\right)^{\chi}\left(\frac{c_t^M}{1-\chi}\right)^{1-\chi},$$

with χ determining the share of exportables in total tradables' expenditure. The relative prices of tradables, exportables and non-tradables are denoted by, respectively, p_t^T, p_t^X and p_t^N.

3.2.2. Exportables

The technology for exportables goods presents a learning-by-doing feature. Borrowing from Lama and Medina (2012), producing y_t^T units of tradable goods involve using the following production function,

[9] Notice that $1/p_t$ is the real exchange rate in this model.

$$y_t^X = a_t^X (z_t)^{\psi} \left(h_t^X\right)^{\alpha_X} \left(k_{t-1}^X\right)^{1-\alpha_X-\psi}$$

where z_t denotes "organizational capital" following the law of motion,

$$z_t = (z_{t-1})^{\mu} \left(\overline{y}_{t-1}^X\right)^{1-\mu}.$$

a_t^X is an exogenous productivity shock and $\overline{y}_t^X$ is the aggregate production of exportables (i.e. in equilibrium, $\overline{y}_t^X = y_t^X$). This type of technological externality is one of the most traditional channels generating inefficient Dutch disease effects, as stressed in Magud and Sosa (2013) among others. Finally, the rental rate of capital in this sector is u_t^X.

3.2.3. Non-tradables

The technology for non-tradable goods is given by

$$y_t^N = a_t^N \left(h_t^N\right)^{\alpha_N} \left(k_{t-1}^N\right)^{1-\alpha_N}$$

In particular, notice that we assume that there is no learning-by-doing technology in this sector.[10] The rental rate of capital in this sector is u_t^N.

3.2.4. Entrepreneurs

For each sector $j = X, N$ there are two groups of entrepreneurs who are the managers of the stock of capital. The start every period with a stock of capital k_{t-1}^j and outstanding loans l_{t-1}^j. They rent the stock of capital to the firms in each sector (at a rate u_t^j) and, after depreciation (whose rate is denoted by δ), they sell the remaining stock to capital producers (described below) at a price q_t^j, and repay the loans. Afterwards, they buy new capital from these capital-goods producers at price q_t^j.

We assume that in order to finance the purchase of new capital, entrepreneurs use both loans from households and their own net worth (n_t^j). That is,

$$q_t^j k_t^j = n_t^j + p_t l_t^j.$$

for $j = X, N$.

We include a financial friction in the spirit of Bernanke et al. (1999). In their setup, there is a costly-state-verification problem that limits the entrepreneur's ability to freely borrow from households. As a result, the optimal (incentive-compatible) debt contract specifies that there is a wedge between the expected return on purchasing one new unit of capital and the rate at which households are willing to lend (i.e. their opportunity cost, r_t^L). Moreover, as shown by Bernanke et al. (1999), this wedge (known as the external finance premium) will be an increasing function of entrepreneurs' leverage (given by $q_t^j k_t^j / n_t^j$).

We borrow these insights from Bernanke et al. (1999) and specify the following relationship between r_t^L and the expected return on purchasing one new unit of capital,

$$E_t \left\{ \frac{u_{t+1}^j + (1-\delta) q_{t+1}^j}{q_t^j} \right\} = \left(1 + r_t^L\right) rp_t^j \tag{2}$$

where

$$rp_t^j \equiv rp \left(\frac{q_t^j k_t^j}{n_t^j} \frac{1}{lev} \right)^{\xi_j},$$

[10] For instance, Begnino and Fornaro (2013) describe evidence supporting this assumption.

for $j = X, N$. The parameter lev is the steady state leverage, while rp is the steady-state risk premium, both assumed to be equal across sectors.[11] Thus, $\xi_j > 0$ captures the elasticity of the premium with respect to leverage in each sector.

Finally, net worth evolves as following. After repaying loans, a fraction $1-\vartheta$ of entrepreneurs exit the market and transfer the remaining profits to Ricardian households. The same fraction enters the market every period, each of them receiving a startup capital injection from Ricardian households given by $\iota^j/1-\vartheta$. Thus, the law of motion of aggregate net worth in each sector is given by,

$$n_t^j = \vartheta\left\{\left[u_t^j + (1-\delta)q_t^j\right]k_{t-1}^j - p_t l_{t-1}^j\left(1+r_{t-1}^L\right)\right\} + \iota^j.$$

3.2.5. Capital and investment goods

In each sector, there is a group of firms that buy old capital and combine it with investment goods to produce new capital using the technology

$$k_t^j = (1-\delta)k_{t-1}^j + \left[1 - S_j\left(\frac{i_t^j}{i_{t-1}^j}\right)\right]i_t^j.$$

for $j = X, N$. The function $S_j(\cdot)$ captures convex adjustment costs in investments. In turn, investment goods are produced by another set of firms operating a technology that combines imported and non-traded goods to produce. In particular, we assume,

$$i_t = \left(\frac{x_t^N}{\gamma}\right)^{\gamma}\left(\frac{x_t^M}{1-\gamma}\right)^{1-\gamma},$$

where $i_t = i_t^N + i_t^X$. The relative price of investment goods is given by p_t^i.

3.3. Fiscal policy

In the baseline setup, we assume that fiscal policy levies the taxes previously described, has access to international debt markets (d_t^{g*}),[12] and purchases non-traded goods (g_t). Its resource constraint is given by

$$p_t^n g_t + d_{t-1}^{g*}\left(1+r_{t-1}^*\right) = rev_t + d_t^{g*}.$$

where rev_t denotes total revenues, which is equal to the sum of tax collection and revenues from ownership of commodity production. In particular, it can be shown that in equilibrium the collection of proportional taxes equals

$$rev_t = \tau\left(p_t^X y_t^X + p_t^N y_t^N\right) + p_t^{Co} y_t^{Co}\left[\tau^{Co}\left(s^{Co,R} + s^{Co,*}\right) + s^{Co,g}\right]$$

where $s^{Co,*}$ and $s^{Co,g}$ are the shares of commodity production owned by, respectively, foreigners and the government (with $s^{Co,R} + s^{Co,*} + s^{Co,g} = 1$).

Given τ and τ^{Co}, there are two other policy variables to be decided (g_t and d_t^{g*}) but only one of them can be chosen by the government, as the other will be determined by its resource constraint. We specify a rule for expenditures in the spirit of the structural-balance rule in place in Chile:

$$p_t^n g_t + d_{t-1}^{g*}\left(r_{t-1}^* + \eta_r\right) = \eta_0 + rev + \eta_{rev}(rev_t - rev), \tag{3}$$

[11] Unfortunately, we do not have data that allow us to discriminated these averages across sectors.
[12] To simplify the analysis, we do not consider the case of domestic government debt.

where rev is the long-run (steady-state) level of revenues.[13] The rule is characterized by three parameters: $\eta_{rev} \in [-1, 1]$ governs the degree of pro-cyclicality, η_0 determines the cyclically-adjusted structural deficit, and $\eta_r \in (0, r^W)$ is an adjustment factor. The latter is required for a technical reason: without it, government debt d_t^{g*} may display a unit root.[14] Finally, notice that η_0 is linked to the long run level of government debt: in steady state $d^{g*} = \eta_0/\eta_r$.

Our calibration strategy for the fiscal side of the model is as follows. First, we calibrate g in steady state to match the average share of government expenditures over GDP observed in the data. Second, we impose $d^{g*} = 0$. We make this choice because we want to focus on the cyclical properties of different policy alternatives.[15] We also set the adjustment factor η_{rev} to a small value, and calibrate $\eta_0 = d^{g*}\eta_r$. Finally we calibrate τ^{Co} and $s^{Co,g}$ according to the data and let τ to be determined endogenously in steady state to satisfy the government budget constraint.[16]

3.4. Aggregation and market clearing

The following are market clearing conditions in different markets:

$$\begin{aligned}
&\text{Labor}: \quad (1-\kappa)h_t^R + \kappa h_t^{NR} = h_t^X + h_t^N.\\
&\text{Consumption}: \quad (1-\kappa)c_t^R + \kappa c_t^{NR} = c_t.\\
&\text{Foreign debt}: \quad (1-\kappa)d_t^{R*} + d_t^{g*} = d_t^*.\\
&\text{Loans}: \quad (1-\kappa)l_t^R = l_t^X + l_t^N.\\
&\text{Investment}: \quad i_t = i_t^N + i_t^M.\\
&\text{Non-tradables}: \quad y_t^N = c_t^N + x_t^N + g_t.
\end{aligned}$$

In addition, we define the trade balance as follows:

$$imp_t \equiv c_t^M + x_t^M.$$

$$exp_t \equiv p_t^X\left(y_t^X - c_t^X\right) + p_t^{Co} y_t^{Co}.$$

$$tb_t \equiv exp_t - imp_t.$$

With this, the net-foreign lending position evolves as follows,[17]

$$d_{t-1}^*\left(1 + r_{t-1}^*\right) = d_t^* + tb_t - p_t^{Co} y_t^{Co} s^{Co,*}\left(1 - \tau^{Co}\right).$$

Finally, we define GDP in consumption units as,

$$p_t gdp_t \equiv p_t^X y_t^X + p_t^N y_t^N + p_t^{Co} y_t^{Co}.$$

[13] Throughout, we use the notational convention that variables without time subscript denote their respective steady-state values.

[14] To see this, combine the fiscal rule with the government resource constraint to obtain $d_{t-1}^{g*}(1-\eta_r) = -\eta_0 + (1-\eta_{rev})(rev_t - rev) + d_t^{g*}$. Thus, if rev_t is a stationary $\eta_r = 0$ will imply that d_t^{g*} contains a unit root. Thus $\eta_r \in (0, r^W)$ is a necessary condition that ensures the existence of stationary equilibrium. This is however not a sufficient condition for equilibrium existence, as the rule can interact in a non-trivial way with other features of the model that may generate a non-existence result.

[15] This and some others assumptions we have already described allow us to isolate the issues regarding the optimal cyclical properties of fiscal policy, without entering in the discussion about the optimal long-run setup for fiscal policy. These other issues are of course relevant as well, but we want to narrow the scope of this paper to the cyclical analysis.

[16] In the calibration for Chile, we obtain $\tau = 0.054$.

[17] This can be derived by combining the households and the government resource constraints with several market clearing conditions.

In equilibrium, the definition of GDP can also be expressed in terms of expenditures as $p_t gdp_t = p_t c_t + p_t^i i_t + p_t^N g_t + tb_t$.

3.5. Driving forces and functional forms

While the model may be set to include a number of exogenous driving forces, we focus the attention on the dynamics originated by commodities terms of trade (p_t^{Co}). Accordingly, for all other driving forces ($a_t^X, a_t^N, y_t^{Co}, r_t^W$ and p_t^X) we assume they remain fixed at a constant value, while we assume that the logarithm of p_t^{Co} follows an AR(1) processes with Gaussian innovations.

We specify the following functional form for the instantaneous utility,

$$\frac{\left[c_t^i - \zeta \frac{\left(h_t^i\right)^{1+\upsilon}}{1+\upsilon}\right]^{1-\theta} - 1}{1-\theta}, \quad \text{for } i = R, NR.$$

This GHH specification is widely used in the literature analyzing business cycles fluctuations in emerging countries. In particular, in our model it implies that the supply of labor of both types of agents will be the same in equilibrium. Finally, for investment adjustment costs we assume,

$$\frac{\phi_I}{2}\left(\frac{i_t^j}{i_{t-1}^j} - 1\right)^2, \quad \text{for } j = X, N.$$

This completes the description of the model. The on-line Technical Appendix contains the set of equilibrium conditions, as well as the computation of the steady state.

3.6. Parametrization

We now describe how we choose the different parameter values. First, we draw from the related literature to calibrate some preference (θ, ω, χ), technology (α_X, α_N, δ), and commodity-related shares parameters (τ^{Co}, $s^{Co,g}$, $s^{Co,*}$) as shown in Table 1. The parameters β, $\overline{d}^*$, y^{Co}, g, ζ, a^X, φ are set in steady state to match the following averages form Chilean data: the shares of trade balance, mining production, government expenditures, and non-trade production to GDP; hours worked, the relative price of non-tradables and the world interest rate. We also pick a small value for the elasticity of the country premium ϕ_d. The share of non-Ricardian households is set to 0.5, following the evidence presented in Céspedes et al. (2013).

In addition, we calibrate the average leverage of entrepreneurs to be 2.05, in line with the average leverage for non-financial firms in Chile from 1999 to 2014, and we set a risk premium in steady state equal to 1.23% (quarterly), which is the average lending-deposit spread for 90-days commercial loans from 1996 to 2014. We also set the survival rate of entrepreneurs to 0.97, a usual value in the related literature. These determine the values for ι^X, ι^N in steady state.

The other parameters in the model are ε (the elasticity of substitution between c^N and c^T), ϕ_I (the capital adjustment cost), ψ (the share of organizational capital z in y^X), μ (the persistence of the learning by doing technology), ξ_X and ξ_N (the elasticities of the external finance premium), $\rho_{p^{Co}}$ and $\sigma_{p^{Co}}$ (the persistence and standard error variance for commodities terms of trade). To calibrate these, we follow an impulse response matching approach, similar to that proposed by Christiano et al. (2010). In particular, we first estimate a VAR model for the following variables using Chilean quarterly data from 1996.Q1 to 2014.Q2: mining terms of trade (p^{Co}), the shares of tradable and non-trades production in non-commodity output (respectively, $s_t^X \equiv p_t^X y_t^X / p_t^X y_t^X + p_t^N y_t^N$ and $s_t^N \equiv p_t^N y_t^N / p_t^X y_t^X + p_t^N y_t^N$),[18] the real exchange rate ($rer_t = 1/p_t^c$), the ratio of consumption to non-commodity GDP ($s_t^C \equiv p_t^C c_t / p_t^X y_t^X + p_t^N y_t^N$),

[18] The X sector corresponds to manufacturing GDP, while the N sector includes Construction, Retail, restaurants and hotels, Transportation, Communication, Financial Services, Home services, Personal services, and Public administration.

Table 1
Calibration.

Parameter	Description	Value	Source
Structural parameters			
θ	Risk aversion	2	García Cicco et al. (2010)
ω	Frisch elasticity	1.6	García Cicco et al. (2010)
χ	Share of c^X in c^T	0.5145	Medina and Naudon (2011)
α_X	Share of h^X in y^X	0.36	Medina and Naudon (2011)
α_N	Share of h^N in y^N	0.65	Medina and Naudon (2011)
δ	Depreciation rate	0.015	Medina and Soto (2011)
γ	Share of x^N in i	0.4	Medina and Naudon (2011).
ϕ_d	Elasticity of country premium	0.001	Calibrated
κ	Share of Non-Ricardian households	0.5	Céspedes et al. (2013).
τ^{Co}	Tax rate on copper income	0.35	Medina and Soto (2011)
$s^{Co,g}$	Government participation in Com. Production	0.4	Medina and Soto (2011)
$s^{Co,*}$	Foreigners participation in Com. Production	0.6	Medina and Soto (2011)
η_r	Adj. Factor in fiscal rule	0.001	Normalization
ϑ	Entrepreneurs survival rate	0.97	Bernanke et al. (1999).
Steady state targets			
s^{tb}	Share of tb in gdp	0.04	Average in Chilean data
s^{Co}	Share of y^{Co} in gdp	0.1	Average in Chilean data
s^g	Share of g in gdp	0.11	Average in Chilean data
s^N	Share of y^N in gdp	0.5	Average in Chilean data
lev	Entrepreneurs leverage	2.05	Average in Chilean data
rp	External finance premium	1.23%	Average in Chilean data
r^W	World interest rate	1.48%	Average in Chilean data
p^{Co}	Commodities T.o.T	1	Normalization
p^X	Non-Commodities T.o.T	1	Normalization
a^N	Productivity in the N sector	1	Normalization
p^N	Relative price of N goods	1	Normalization
h	Total hours worked	0.3	Normalization

Note: The parameters β, $\overline{d}^*$, y^{Co}, g, ζ, a^X, φ, ι^X, ι^N are determined endogenously in steady state to match the targeted values.

and the average risk premium across sector ($rp_t = l_t^X rp_t^X + l_t^N rp_t^N / l_t$), proxied by the lending-deposit spread.[19] We use shares of aggregate variables instead of levels or some detrended version of these because, as our model does not feature long-term growth, it will be inconsistent to use any of these alternatives to match the empirical and the theoretical model. Instead, matching the shares and assuming they are stationary it is consistent with the assumptions in the model.

In addition, there is another non-stationarity issue that we have to deal with to make the VAR model consistent the theoretical model. For the mining-terms-of-trade series in Chile (driven mainly by the price of copper) displays a structural break around 2005. Indeed using both Andrews-QLR structural-break test and the Bai-Perron methodology to detect break dates, we found a break in the unconditional mean of mining terms of trade in 2005.Q1. Given that our focus is on cyclical movements of commodity prices, it is relevant to control for this structural break. If not, the persistence of the estimated process for the p^{Co} will be highly influenced by the break, which will then have non-trivial consequences for the welfare analysis below. Thus, to be consistent with the goal of the paper, the estimated VAR model includes a dummy variable that takes a value of one after the detected break date.

The commodity-price shock is the identified by a Cholesky decomposition on the short-run relationship matrix, assuming that mining term of trade is ordered first and that it is strictly exogenous with respect to domestic variables.[20] Fig. 1 display in solid-blue lines the responses from the VAR, while

[19] All variables are in logs. The source of the data is the Central Bank of Chile.

[20] The VAR model contains only one lag, which was chosen according to both BIC and HQ information criteria. In addition, as previously discussed, the model contains also a constant and a dummy for the break period. Confidence bands were computed by bootstrap, drawing with replacement 1000 samples from the reduced form residuals. We also estimated an alternative model that controls also for the EMBI for Chile (in a sample from 1999 to 2014), but results are quite similar between both samples.

the gray areas represent 95% confidence bands for those responses. As can be seen, the typical commodity terms-of-trade shock induces Dutch-disease-stile responses. In particular, the manufacturing sector shrinks, the non-traded sector expands and the real exchange rate appreciates. The share of consumptions seems to experience a minor drop at the moment of the shock, but it increases afterwards. Finally, the average lending-deposit spread significantly falls after the shock.

Table 2 shows the combination of parameters that better match the VAR responses.[21] The value for ε is similar to previous estimated values for this parameter (see, for instance, the survey by Akinci, 2011). The parameters for the learning-by-doing technology are somehow different from those used by Lama and Medina (2012) for the case of Canada. In particular, they use $\psi = 0.25$ and $\mu = 0.63$, while in our case the model seems to require a larger fraction of organizational capital in the production of tradables. The persistence of the learning accumulation process is somehow smaller in our case.

In terms of financial frictions, the model requires a larger premium elasticity for the N sector than for the X sector. This is the case because, as we will analyze below, after a commodity shock the premium in the N sector falls relatively more than in the X sector, as the former is favored by the shock while the latter is worse off. Thus, to make the average premium fall as in the data, the model requires the premium in the N sector to be more sensitive the improvements in financial conditions.

The dynamics generated by this combination of parameters are displayed in the dashed-dotted red (in the web version) lines in Fig. 1. As can be seen, the responses of the model generally lie within the VAR error bands. The model does a good job in matching the behavior of the share of non-tradables and of the average risk premium. The negative response of s^X is somehow milder in the model than in the VAR, although it lies within the VAR confidence bands. The initial real appreciation implied by the model it is not as large as in the VAR, although it generates a persistent change in this variable as in the empirical model. Finally, the initial drop in the share of consumption cannot be replicated by the model, but the behavior of this share after the first quarters is consistent with the VAR model once uncertainty is taken into account. Overall, the model does a fairly good job in matching these responses.

4. Dynamics under an a-cyclical rule

Before presenting the normative analysis, we begin by describing the role of several of the modeling features in propagating the shock to commodity prices (p_t^{Co}), under the assumption that the fiscal rule is a-cyclical (i.e. $\eta_{rev} = 0$). This exercise will shed light on how the different model features affect the dynamics trigged by the commodity shock. To this end, we consider several alternative versions of the model. The version labeled as “Base” is the model that just features Ricardian households and that excludes both financial frictions and the learning-by-doing externality. If a model name includes “NR” it means that Non-Ricardian households are considered, if it includes “FF” the model assumes the presence of financial frictions, and if it includes “LBD” the setup features the learning-by-doing externality. In the rest of the section we show impulse-response functions obtained under different versions of the model in response to a shock to commodities terms of trade (p_t^{Co}).[22] The impulse is a shock that increases p_t^{Co} by 11% and it has a half-life of around 5 quarters.

We begin by describing the dynamics in the Base model, depicted in the solid-blue (in the web version) lines in Fig. 2. The shock induces a positive wealth effect that rises desired consumption in all goods, generating in particular a rise in the relative price of non-tradables (a real appreciation) and a relocation of resources from the X sector to the N sector. In addition, investment increases for three reasons. First, the demand for capital in the N sector rises, although it is reduced in the X sector. Second,

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[21] For this exercise, we assume an a-cyclical fiscal rule ($\eta_{rev} = 0$). The compute the impulse responses, the model is solved using a log-linear approximation around the non-stochastic steady state. The impulse-response matching procedures seeks to minimize the distance between the first 16 VAR responses for all the variables with those generated by the model. Given that there are more moments to match than parameters, we weighted each of the response by the inverse of its variance in the VAR, computed with the Bootstrap procedure previously described.

[22] For these exercises, the model is solved with a first-order perturbation approximation around the non-stochastic steady state. Impulse responses computed using s second-order of approximation yield similar results.

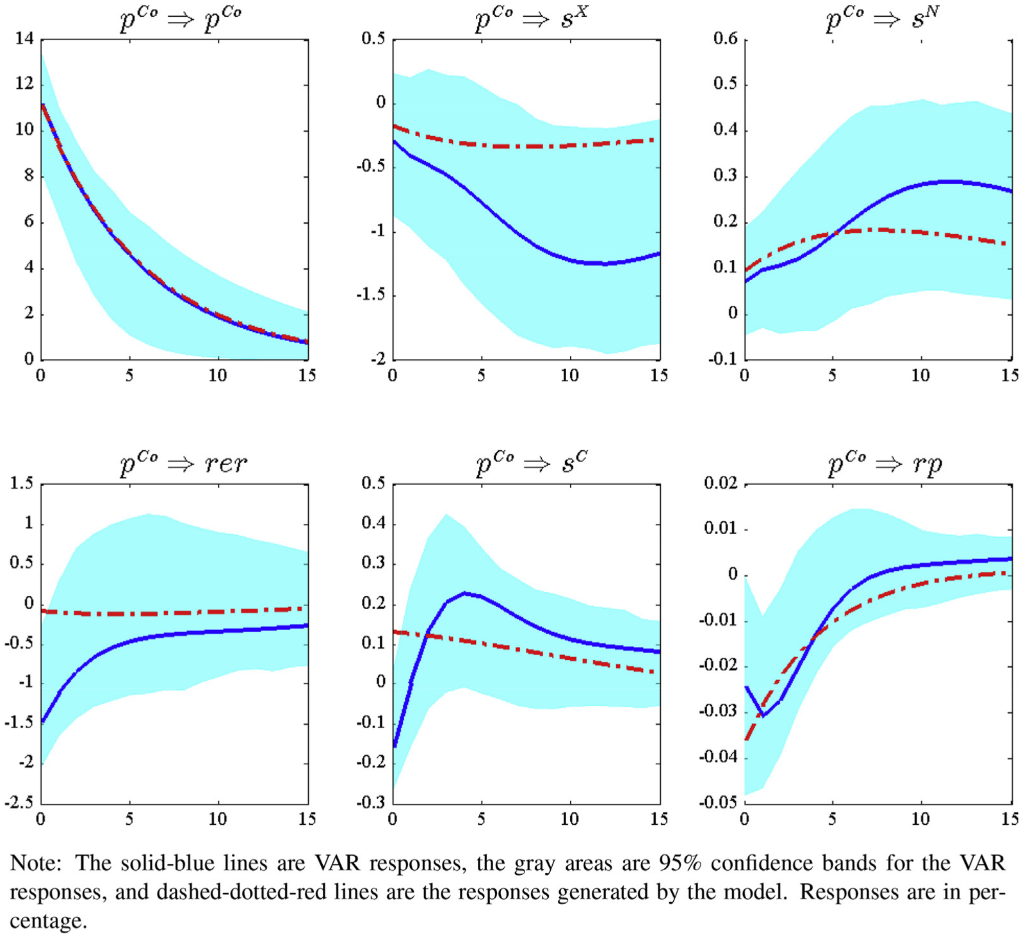


Fig. 1. VAR and model based responses to a commodity price shock.

given that a large part of investment goods are imported, the real appreciation drops the relative price of investment goods. Third, the improvement in the trade balance reduces the aggregate net-foreign-debt position, generating a drop in the country premium which lowers the domestic interest rate. Thus, in equilibrium, regardless of the contraction in production of X goods, investment in that sector rises due to the second and third effects, and therefore aggregate investment rises. In equilibrium, investment in the X sector rises as well, so the first effect that we mentioned is compensated by the other two.

Notice also that the fiscal rule under the assumption of $\eta_{rev} = 0$ implies that government expenditures decreases somehow in the first periods, while it persistently rises afterwards. The former is due to the real appreciation: in the first period, the value of government purchases in terms of the imported good has to remain fixed; thus, expenditures in non-tradable units need to drop on impact. The latter effect is due to the accumulation of foreign assets by the government that the rule generates: given the rule, the government can spend the interest income originated from asset accumulation. As the shock is quite persistent, the increase in government assets is quite large and therefore g rises for several periods.

In the same figure the responses in a model that adds the learning-by-doing externality are also displayed. We can see that this feature intensifies the drop in y^X due to the drop in productivity induced by the learning technology. At the same time, this expected drop in productivity negatively affects

Table 2
Impulse-response based calibration.

Parameter	Description	Value
ε	Elasticity of substitution between c^N and c^T	0.9813
ψ	Share of z in y^X	0.3416
μ	Persistence of learning technology	0.5921
ξ^X	Elasticity of the risk premium in the X sector	0.0169
ξ^N	Elasticity of the risk premium in the N sector	0.115
ϕ_I	Capital adj. cost	5.4315
$\rho_{p^{Co}}$	Autocorrelation of p_t^{Co}	0.8399
$\sigma_{p^{Co}}$	Standard deviation of $\varepsilon_t^{p^{Co}}$	0.1113

investment in that sector. In equilibrium, the real exchange rate appreciation is milder that in the Base model. The other relevant difference is the behavior of consumption, which increases by less in the model that includes the externality. This happens because the real wage increases by less and the return on capital is reduced in the X sector.[23]

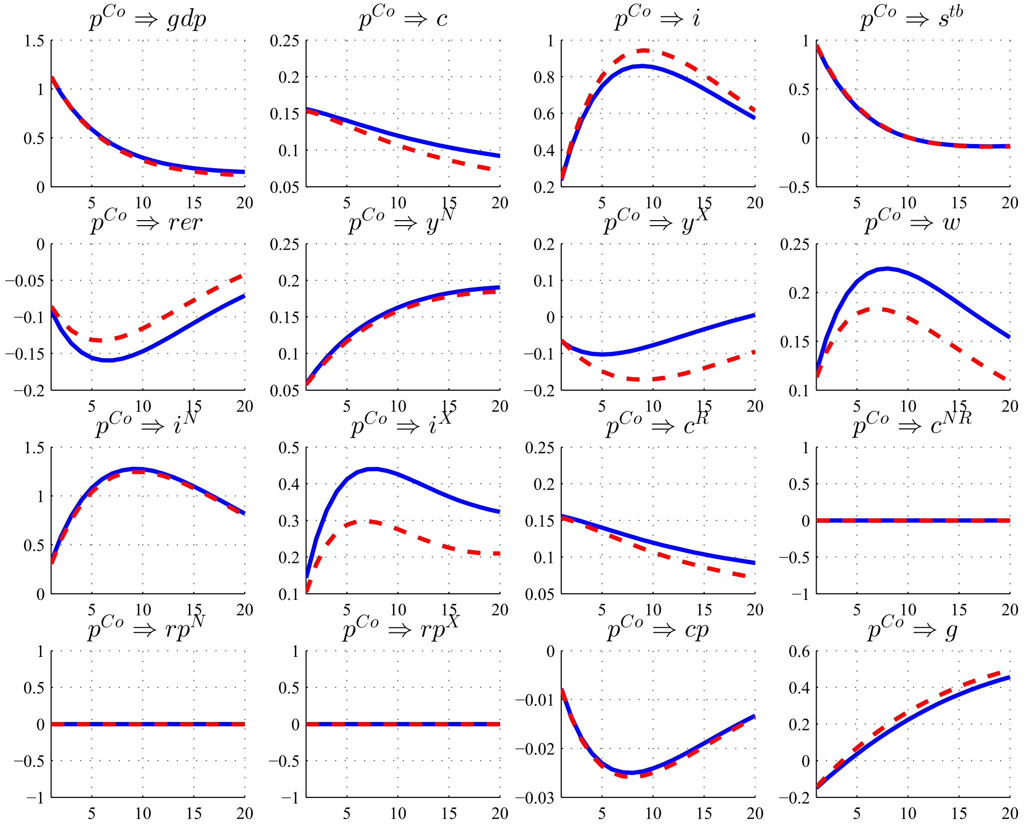
Fig. 3 compares the responses in the Base model with and specification that includes financial frictions. After this expansionary shock, and given the sectoral relocation, the increase in the value of capital and in the return from capital in the N sector induces an improvement in net worth in this sector, decreasing the leverage and reducing the external finance premium. On the contrary, the spread in the X sector drops only marginally in the short run and it increases persistently after some quarters. Indeed, the fall in the premium for this sector is much short lived than in the N sector. As a consequence, i^X increases by less in the FF model relative to the Base, while i^N increases by more than in the Base model. The real exchange rate presents a slightly larger appreciation in the first periods, while afterwards it experiences a milder appreciation relative to the Base case. In addition, we can see that the path for consumption moves upwards relative to that in the Base case. In other words, as investment is less attractive in the presence of financial friction, agents choose to devote a relatively larger fraction of the extra income generated for consumption.

Finally, Fig. 4 plots the responses of the Base model and the Base + NR alternative. As can be seen, the consumption of Non-Ricardian households increases after the shocks, lead by the increase in real wages. At the same time, the rise in consumption for Ricardian consumers is milder than in the Base model, which can be explained as follows. Ceteris paribus, the rise in consumption by Non-Ricardians is expansionary, for it increases the demand for all goods. Everything else equal, this translates in a larger increase in income for Ricardians who, instead of consuming it, increase saving. Thus the overall response of aggregate consumption can be larger or smaller than in the Base model depending on parameter values. In this case, aggregate consumption rises by less than in the Base model. In turn, this additional saving is devoted in part to invest, hence investment increases by more in the Base + NR model.

5. Fiscal pro-cyclicality

We now turn to the analysis of the optimal degree of pro-cyclicality. First, we use impulse response analysis to describe how different values for η_{rev} in the rule (3) affect the dynamics originated by a shock to commodity prices. Fig. 5 compares the responses in the full model (Base + NR + FF + LBD) for three alternative values for η_{rev}: 0, 0.5 and −0.5. When η_{rev} is positive, the path of government expenditures moves upwards relative to the case of η_{rev}. For Ricardian consumers, this ameliorates the expansion in their consumption, while for non-Ricardians consumption rises by more. Overall, as the change for Ricardians dominates, aggregate consumption increases.

[23] In the responses it seems that, although investment increase by less in the LBD model, aggregate investment increases by more. This happens because, in the steady state of the LBD share of investment in the N relative to total investment is larger than in the X sector, and therefore the weighted sum in the log linear approximation generates a larger percentage change in total investment with the Base + LBD model.



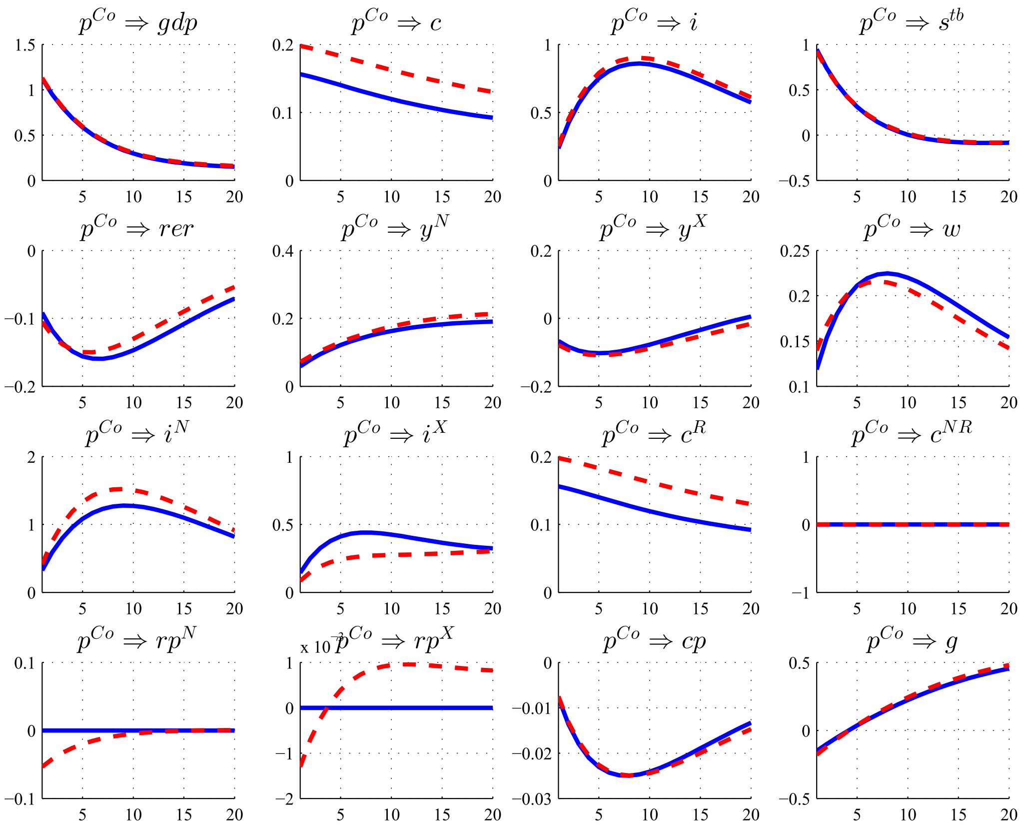
Note: The solid-blue lines are the responses from the Base model while the dashed-red lines are from the Base+LBD model. The variables depicted are GDP, consumption, investment, the trade-balance-to-gdp ratio, the real exchange rate, production of non-tradables and that of exportables, real wage, investment in non-tradables and that in exportables, consumption of Ricardian and non-Ricardian households, the external finance premium for non-tradables and for exportables, the country premium, and government expenditures. All responses are in percentage deviations with respect to the steady state, except for s^{tb} that is expressed in percentage-points deviations. The time units in the horizontal axes are quarters. The size of the shock increases p_t^{Co*} by 5.6% and it has a half-life of 90 quarters.

Fig. 2. Responses to a commodity price shock, Base vs. Base + LBD, $\eta_{rev} = 0$.

In terms of production, the rise in *G* increases the demand of *N* goods, increasing production in this sector and generating a larger appreciation. This effect is partially compensated by the relative reduction in consumption, but it is not fully offset as the consumption bundle includes both types of goods. Thus, fiscal pro-cyclicality clearly exacerbates the relocation effects. In addition, we can also see that investment is negatively affected under a pro-cyclical policy. When η_{rev} is negative, the opposite happens.

For the welfare analysis that we implement below a relevant observation is in order. While a negative value for η_{rev} allows Ricardian households to enjoy more consumption,[24] the path of consumption is more volatile in such a case. Moreover, the change in volatility of consumption for different

[24] The equilibrium path of aggregate labor (not shown) does not vary significantly with different values of η_{rev}; a result driven by the GHH preferences that we have assumed.



Note: The solid-blue lines are the responses from the Base model while the dashed-red lines are from the Base+FF model. See Figure 2 for variables and unit of measure.

Fig. 3. Responses to a commodity price shock, Base vs. Base + FF, $\eta_{rev} = 0$.

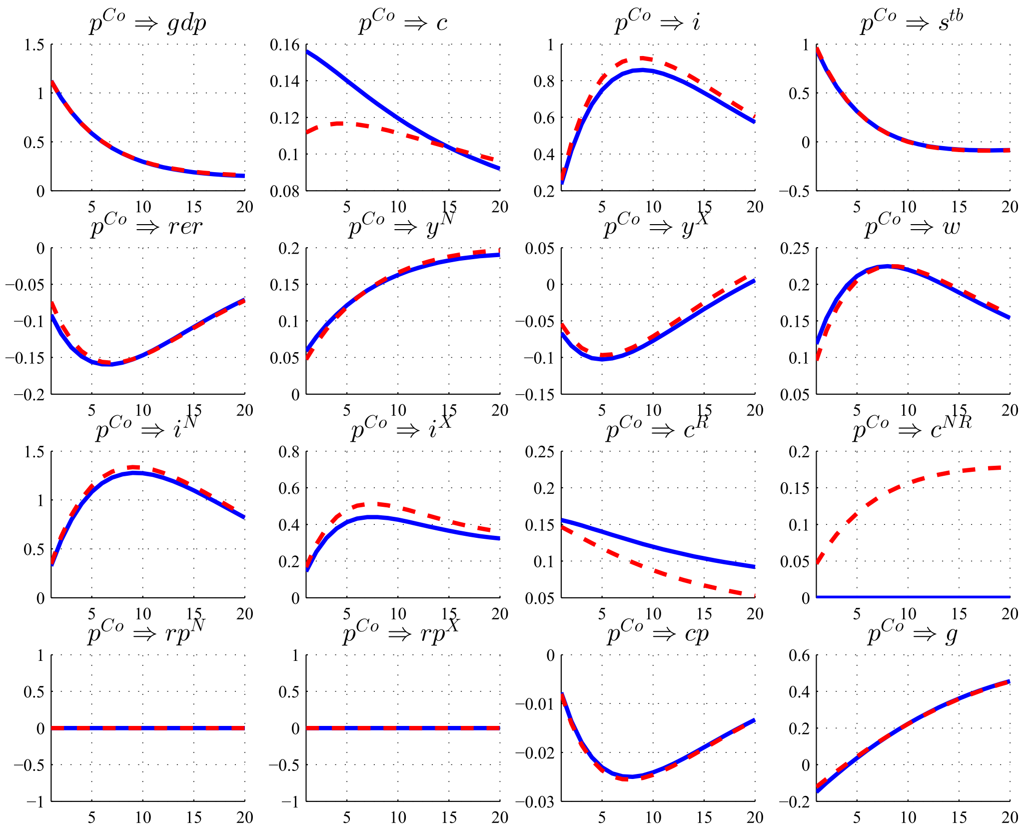
values of η_{rev} is likely to be large, given that the response of consumption is highly persistent. Thus, it is not clear what the optimal policy would recommend, as a tension between mean and variance will likely influence the welfare analyze based on a second order of approximation.[25] For non-Ricardians the responses are less clear. While it seem that either positive or negative values for η_{rev} induce a larger variance in consumption, a negative value for η_{rev} seems to increase the net present value of consumption relative to the case with $\eta_{rev} = 0$.[26]

We next turn to the welfare evaluation of the optimal value for η_{rev}. In particular we choose the value of η_{rev} the maximizes

$$E_0\left\{\sum_{t=0}^{\infty}\beta^t U\left[c_t^i(\eta_{rev}), h_t^i(\eta_{rev})\right]\right\}.$$

for agent $i = R, NR$. In addition, in some cases we also compute the policy that maximizes a weighted average of both welfare criteria. We approximate the value of this expected utility using a second-order

[25] Recall that up to second order the variance affects the unconditional mean of the endogenous variables.
[26] While in the short run C^{NR} fall with $\eta_{rev} < 0$, it later rises persistently above the response with $\eta_{rev} = 0$.



Note: The solid-blue lines are the responses from the Base model while the dashed-red lines are from the Base+NR model. See Figure 2 for variables and unit of measure.

Fig. 4. Responses to a commodity price shock, Base vs. Base + NR, $\eta_{rev} = 0$.

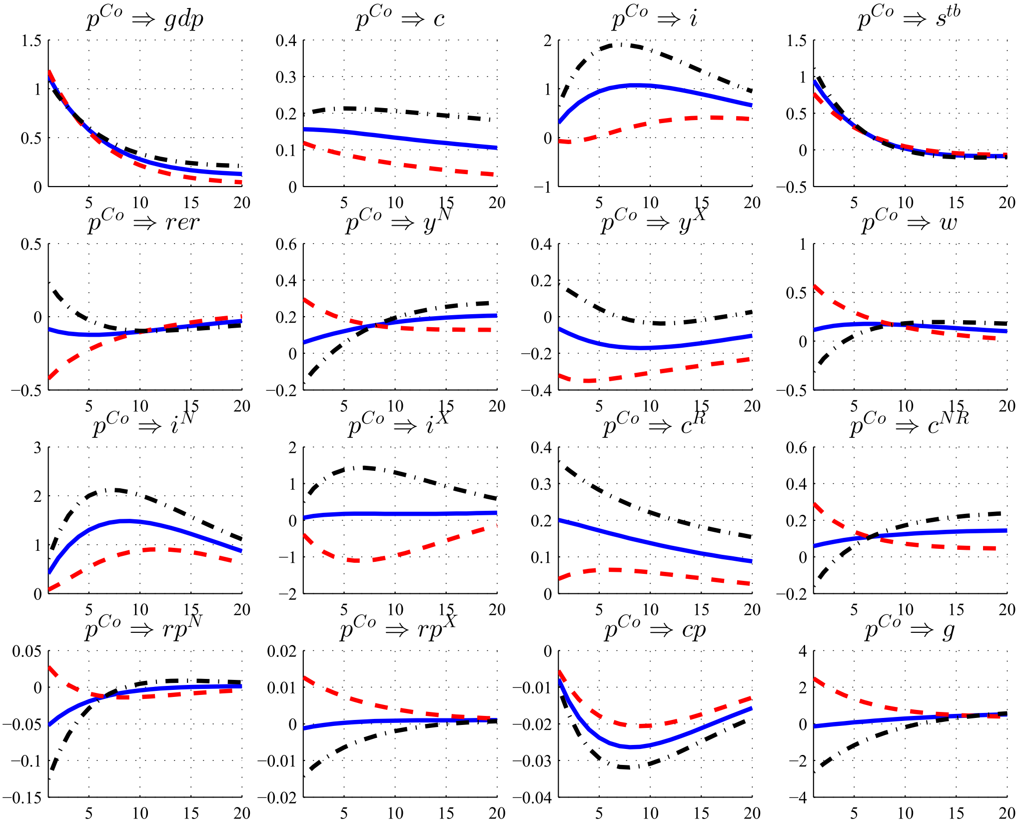
Taylor approximation around the non-stochastic steady state, following Schmitt-Grohe and Uribe (2007a,b). We also compute the consumption equivalent that would make the household indifferent between the equilibrium with the optimal η_{rev} and that obtained with the a-cyclical rule ($\eta_{rev} = 0$). In other words, we define λ^i such that,

$$E\left\{\sum_{t=0}^{\infty} U\left[c_t^i\left(\eta_{rev}^{opt}\right), h_t^i\left(\eta_{rev}^{opt}\right)\right]\right\} = E\left\{\sum_{t=0}^{\infty} U\left[\left(1-\lambda^i\right)c_t^i(\eta_{rev}=0), h_t^i(\eta_{rev}=0)\right]\right\}.$$

for agent $i = R, NR$. We compute a second order approximation to λ^i around the non-stochastic steady state.[27] We also compute the ratio of the standard deviation and of both consumption and hours worked obtained with η_{rev}^{opt} relative to the case with $\eta_{rev} = 0$, as well as the percentage increase in these two variables η_{rev}^{opt} relative to the case with $\eta_{rev} = 0$.[28] This set of statistics will be useful to understand the welfare ranking of different policy alternatives.

27 Schmitt-Grohe and Uribe (2007a,b) show how to implement this approximation for the case in which the utility function is such that $U[(1-\lambda)c_t, h_t] = (1-\lambda)U(c_t, h_t)$. However, our GHH specification does not satisfy this condition. Thus, in the on-line Technical Appendix we show how the method proposed by Schmitt-Grohe and Uribe can be extended for the general case.

28 These moments are computed using a second-order approximation to the solution.



Note: The solid-blue, the dashed-red and the dashed-dotted-black lines correspond, respectively, to the models with $\eta_{rev} = \{0, 0.5, -0.5\}$. See Figure 2 for variables and unit of measure.

Fig. 5. Responses to a commodities price shock, Base + NR + FF + LBD model, different values for η_{rev}.

The results are displayed in Table 3, were we have performed the welfare evaluation for different versions of the model. Panel A show the results when policy is chosen to maximize Ricardian welfare. We can see that in all the specifications they prefer full pro-cyclicality ($\eta_{rev}^{opt} = 1$). As we previously described, a counter-cyclical policy allows them to enjoy a larger consumption stream after a positive shock and, in the presence of inefficiencies, a counter-cyclical policy reduces the adverse effect generated by the relocation across sectors. However, the reduction in volatility in consumption and, to a less extent, in hours generates an increase in the average value of consumption up-to-second order, which is also translated in a larger value for expected utility. This is the case because, as we already mentioned, an evaluation based on a second-order-of approximation will in part depend on the impact of volatility in the endogenous variables due to precautionary savings motives. In other words, as consumption is less volatile with $\eta_{rev}^{opt} = 1$, precautionary savings drop allowing them to enjoy a larger consumption on average. Moreover, we can see that the reduction in the variance is quite large. This is not surprising because, as it was evident in the impulse-response analysis, the process for consumption is highly persistence. Thus, even a small downward shift in the path of consumption will imply a large reduction in its variance. Overall, they are willing to give up around 4% of the consumption stream obtained under an a-cyclical rule.

In panel B of Table 3 we ask Non-Ricardians which value of η_{rev} they prefer, and we can see that the answer depends on the details of the model. In models with no financial frictions (Base + NR and Base + NR + LBD), they would rather have a fully counter-cyclical policy ($\eta_{rev} = -1$). In both setups, we

Table 3
Welfare evaluation: fiscal pro-cyclicality.

Model	η_{rev}^{opt}	Comparision relative to $\eta_{rev} = 0$							
		$100\lambda^R$	Ricardians				$100\lambda^{NR}$	Non-Ricardians	
			St.Dev.		Mean			St.Dev.	Mean
			c	h	c	h		c	c
A. Maximization of Ricardian welfare									
Base + NR	1	−4.04	0.08	0.44	4.25	0.03	0.01	0.47	0.02
Base + NR + FF	1	−3.17	0.10	0.50	3.30	0.09	−0.05	0.53	0.14
Base + NR + LBD	1	−3.79	0.08	0.59	3.98	0.05	0.00	0.62	0.05
Base + NR + LBD + FF	1	−3.22	0.17	0.76	3.36	0.06	−0.01	0.78	0.08
B. Maximization of Non-Ricardian welfare									
Base + NR	−1	6.23	2.64	2.76	−5.71	0.37	−0.33	2.75	0.79
Base + NR + FF	1	−3.17	0.10	0.50	3.30	0.09	−0.05	0.53	0.14
Base + NR + LBD	−1	4.62	2.28	2.52	−4.37	0.29	−0.28	2.51	0.63
Base + NR + LBD + FF	−1	2.91	2.24	2.49	−2.72	0.07	−0.07	2.47	0.17
C. Welfare weight 50%									
Base + NR + LBD + FF	1	−3.22	0.17	0.78	3.36	0.06	0.00	0.08	0.06

Note: The second column display the welfare maximizing η_{rev}, the third to seventh columns compare the optimal relative to the case of $\eta_{rev} = 0$ in the given model. These columns display: $100*\lambda^i$ is the welfare equivalent consumption in percentage terms, "St.Dev. c" is the ratio of the standard deviation of consumption with η_{rev}^{opt} relative to the case with $\eta_{rev} = 0$, "St.Dev. h" is the analogous with hours worked, "Mean c" is the percentage increase in the mean of consumption with η_{rev}^{opt} relative to the case with $\eta_{rev} = 0$, and "Mean h" is the analogous with hours worked. All these have been computed using a second-order approximation. We do not report results for hours worked for non-Ricardians because this variable is the same for both types of agents.

can see that the counter-cyclical policy actually rises the variance of non-Ricardian consumption but at the same time it increases average consumption. For this agents the precautionary savings channel is not present, for they do not have access to financial markets. Thus, a larger variance does not necessarily imply a reduction in average consumption. Therefore, in welfare terms, a trade-off may arise for them between reducing volatility, which they would like to decrease due to risk aversion, and increasing average consumption. Given the parameters values, in these two models they prefer to have a larger average consumption, despite being exposed to a much larger variance. Still, the gains in terms of equivalent consumption are quite small.

In the model that includes financial frictions (Base + NR + FF) the result is different, for it seems that here a pro-cyclical policy can reduce the variance of consumption for non-Ricardians while it increases its average value at the same time. So in this cases there is no trade-off present. But as can be seen the welfare gain is small, even smaller that in the other two models. Thus, in the full model (Base + NR + FF + LBD), the results obtained without financial frictions seem to dominate and non-Ricardians still prefer a counter-cyclical policy.

Finally, in panel C of Table 3 we use as a welfare criteria the equally-weighted average of both agents' individual expected utility. As we can see, the preference of Ricardians dominates and the optimal policy is full pro-cyclicality. This is not surprising given that the welfare gains obtained by non-Ricardians when they chose optimally were relatively small.

Overall, the results in this section are in line with the literature previously discussed that finds that fiscal policy ought to be pro-cyclical in models with incomplete markets, particularly for Ricardian agents. Our analysis contribute to this literature by showing that the presence of inefficiencies that may generate social costs as in the Dutch disease literature, that could in principle call for a counter-cyclical fiscal policy, do not change this general result. We have also shown that for non-Ricardians this choice is less trivial, although their welfare does not seems to be significantly altered by different degrees of pro-cyclicality.

6. Capital controls

As we discussed in the introduction, another tool that is frequently proposed to cope with the Dutch disease is capital controls. We model this as a tax rate τ_t^{cc} charged to Ricardian household for every unit of foreign debt d_t^{*R}. Moreover, we assume that the government rebates in a lump-sum fashion the proceeding from this taxes to Ricardian, so the presence of capital controls do not interact with the fiscal rule. Additionally, we assume for these exercises that $\eta_{rev} = 0$. In equilibrium, the only condition that changes in the presence of such a tax is the intertemporal condition for holdings of foreign debt by Ricardian households, that now reads

$$\frac{\lambda_t}{p_t} = \beta \frac{(1 + r_t^*)}{(1 - \tau_t^{cc})} E_t \left\{ \frac{\lambda_{t+1}}{p_{t+1}} \right\},$$

In an economy with only Ricardian households and no other inefficiencies, a Ramsey planer would like to use this tax to offset inefficient movements in the country premium, which according to (1) is $r_t^* - r_t^W = \exp\{\phi_d(d_t^* - \overline{d}^* / \overline{d}^*)\} - 1$. Thus, we consider a simple rule for τ_t^{cc} of the form,[29]

$$\tau_t^{cc} = \phi_{\tau^{cc}} \left(r_t^* - r_t^W \right),$$

for $\phi_{\tau^{cc}} \in (-1, 1)$. Notice that because the country premium is proportional to foreign debt, a positive value for $\phi_{\tau^{cc}}$ implies that controls are tighter as the country receives more net capital inflows and external financial conditions are tighter. As we motivated in the introduction, the reduction in the country premium generated after a positive commodity shock exacerbates the increase in domestic absorption that triggers the relocation effects, which further motivates considering a policy tool that tackles that change in the country premium.

Fig. 6 shows the responses in the Base + NR + FF + LBD model obtained under three alternative values for $\phi_{\tau^{cc}}$: 0, 0.5 and −0.5. We can see that a negative value for $\phi_{\tau^{cc}}$ contributes to smooth the fluctuations generated by the rise in commodity prices, while the opposite happens with a positive value. In this sense, we can refer to a negative $\phi_{\tau^{cc}}$ as prudential. Moreover, the changes in the responses are not symmetrical. In particular, when $\phi_{\tau^{cc}} = 0.5$ it generates a milder absolute change in the variables (relative to $\phi_{\tau^{cc}} = 0$) that what happens when $\phi_{\tau^{cc}} = 0.5$.

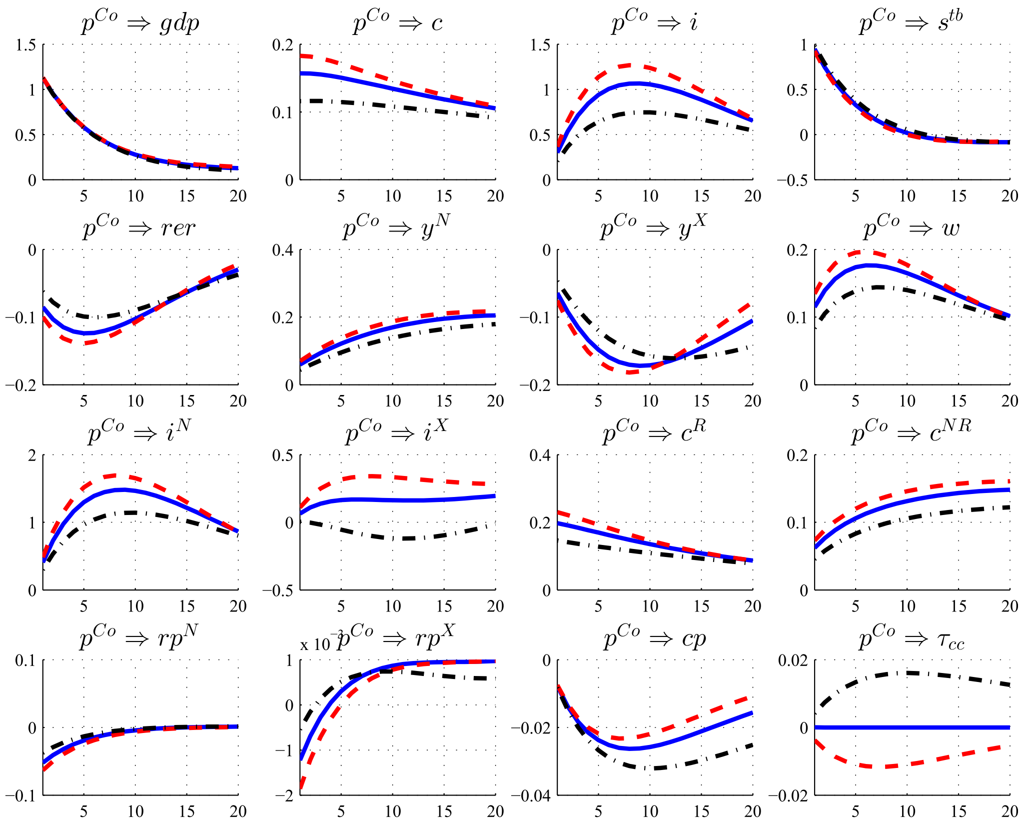
Looking at the path of consumption for both types of agents, we can see that a prudential capital control generates a downward shift in the whole consumption schedule relative to the case of $\phi_{\tau^{cc}} = 0$. Therefore, prudential capital controls will tend to reduce the variance of consumption for both types of agents.

In addition, we can see that with prudential capital controls, the relocation between sector is reduced: y^N increases by lees and the reduction in y^X is milder. This is also reflected in a smaller real appreciation.

In Table 4 the results of the welfare evaluation are displayed. In this case, Ricardian households prefer highly prudential capital controls (i.e. $\phi_{\tau^{cc}}^{opt}$ is close to −1) in all models. In line with the analysis based on impulse responses, a prudential capital control reduces the variance of consumption and hours worked for these agents, rising also the average value of consumption and reducing that of labor. It should be noticed, however, that the welfare gains of having the optimal policy instead of no capital controls are relatively small; less than one percent of the consumption obtained in a word without this policy tools.

On the contrary, non-Ricardians would rather have the positive policy: capital controls being procyclical. This result seems to reflect, as analyzed also in the previous section, that these agents value relatively more the increase in average consumption than a reduction on its variance. In any case, the welfare gains are even smaller than those computed for Ricardians so the presence of this policy tools does not seem to be that relevant for these agents. We have also computed the policy that maximizes the equally-weighted average welfare, finding that the taste of Ricardians seems to also dominate in this case.

[29] Given our calibration, the premium is zero in steady state. Thus, capital controls are also zero in steady state.



Note: The solid-blue, the dashed-red and the dashed-dotted-black lines correspond, respectively, to teh models with $\phi_{\tau^{cc}} = \{0, 0.5, -0.5\}$. See Figure 2 for variables and unit of measure.

Fig. 6. Responses to a commodities price shock, Base + NR + FF + LBD model, different values for $\phi_{\tau^{cc}}$.

Table 4
Welfare evaluation: capital controls.

Model	$\phi^{opt}_{\tau^{cc}}$	Comparision relative to $\phi_{\tau^{cc}} = 0$							
		$100\lambda^{R}$	Ricardians				$100\lambda^{NR}$	Non-Ricardians	
			St.Dev.		Mean			St.Dev.	Mean
			c	h	c	h		c	c
A. Maximization of Ricardian welfare									
Base + NR	−0.93	−0.33	0.86	0.70	0.30	−0.05	0.04	0.70	−0.10
Base + NR + FF	−0.88	−0.16	0.85	0.60	0.14	−0.01	0.00	0.60	−0.02
Base + NR + LBD	−0.92	−0.18	0.88	0.60	0.16	−0.03	0.03	0.60	−0.07
Base + NR + LBD + FF	−0.88	−0.10	0.89	0.54	0.09	−0.01	0.01	0.54	−0.02
B. Maximization of Non-Ricardian welfare									
Base + NR	1	0.13	1.01	1.01	−0.11	0.04	−0.04	1.01	0.08
Base + NR + FF	1	0.06	1.02	1.07	−0.05	0.01	−0.01	1.07	0.03
Base + NR + LBD	1	0.08	1.01	1.03	−0.07	0.03	−0.03	1.03	0.05
Base + NR + LBD + FF	1	0.04	1.02	1.10	−0.03	0.01	−0.01	1.10	0.02
C. Welfare weight 50%									
Base + NR + LBD + FF	−0.90	−0.10	0.87	0.49	0.09	−0.01	0.01	0.49	−0.02

Note: See Table 3 for a description. Recall that hours worked are the same for both types of agents.

Finally, we should notice that the desirability of prudential capital controls appears also in the versions of the model that does not include Dutch-Disease related inefficiencies.[30] In fact, examining the welfare equivalent consumption, we can see that, for Ricardians, the gains for having prudential capital controls is larger in a model that does not feature either learning-by-doing externalities or financial frictions. Therefore, the recommendation from our analysis in favor of prudential capital controls is not due in particular to the presence of Dutch-disease concerns.

7. Tax on domestic lending

The final policy tool that we analyze is a tax on domestic credit. As we argued in the introduction, given that part of the extra income from commodities will be saved, it is likely that the positive shock will increase lending to finance capital accumulation. This additional credit will be devoted relatively more to the N sector, as the return on capital in that sector will be relatively higher due to the sectoral relocation. In the absence of financial frictions, there are no inefficiencies associated with that relative distribution of credit. However, under financial frictions the relocation will be larger, as the external finance premium in th N sector will decrease while it will rise in the X sector.[31] Therefore, to prevent this inefficiency to arise, one can consider taxing domestic credit to compensate this effect.[32]

In particular, we assume that the equations characterizing the external finance premium (2) now reads,

$$E_t\left\{\frac{u^j_{t+1}+(1-\delta)q^j_{t+1}}{q^j_t}\right\}=\left(1+r^L_t\right)rp^j_t\left(1+\tau^l_t\right),$$

for $j=X,N$. A possible, reduced-form, way to interpret the tax rate τ^l_t is to think in a model with banks that are subject to reserve requirements; for they would induce a gap between the rate that households perceive from banks ($1+r^L_t$ in this case) and the opportunity cost that banks face in lending to entrepreneurs ($(1+r^L_t)(1+\tau^l_t)$ in our notation). Further, we assume (as we did with capital controls) that the government rebates in a lump-sum fashion the proceeding from this taxes to Ricardians, so the presence of capital controls do not interact with the fiscal rule. Moreover, we assume for these exercises that $\eta_{rev}=0$. Hence, these are the only equilibrium conditions that change in this case.

Given the motivation for considering this policy tool, we consider a simple rule of the form

$$\tau^l_t=\phi_{\tau^l}\left(\frac{l_t-l}{l}\right),$$

with $\phi_{\tau^l}\in[0,1]$,[33] and where l_t is the sum of the credit to both types of entrepreneurs.[34] Thus, the tax reacts to the difference (in percentage points) of credit relative to its steady state value.

Fig. 7 displays the responses in the Base + NR + FF + LBD model obtained for different values of ϕ_{τ^l} (0, 0.3 and 0.6). We can see that when ϕ_{τ^l} is greater than zero, the expansion of total credit (l) is much more limited, offsetting the effects on the premium in both sectors. In terms of aggregate activity, a positive value for ϕ_{τ^l} tend to smooth the expansion in investment. This happens because, while the premium moves in both sectors, total credit is reduced and the same will happen with investment.

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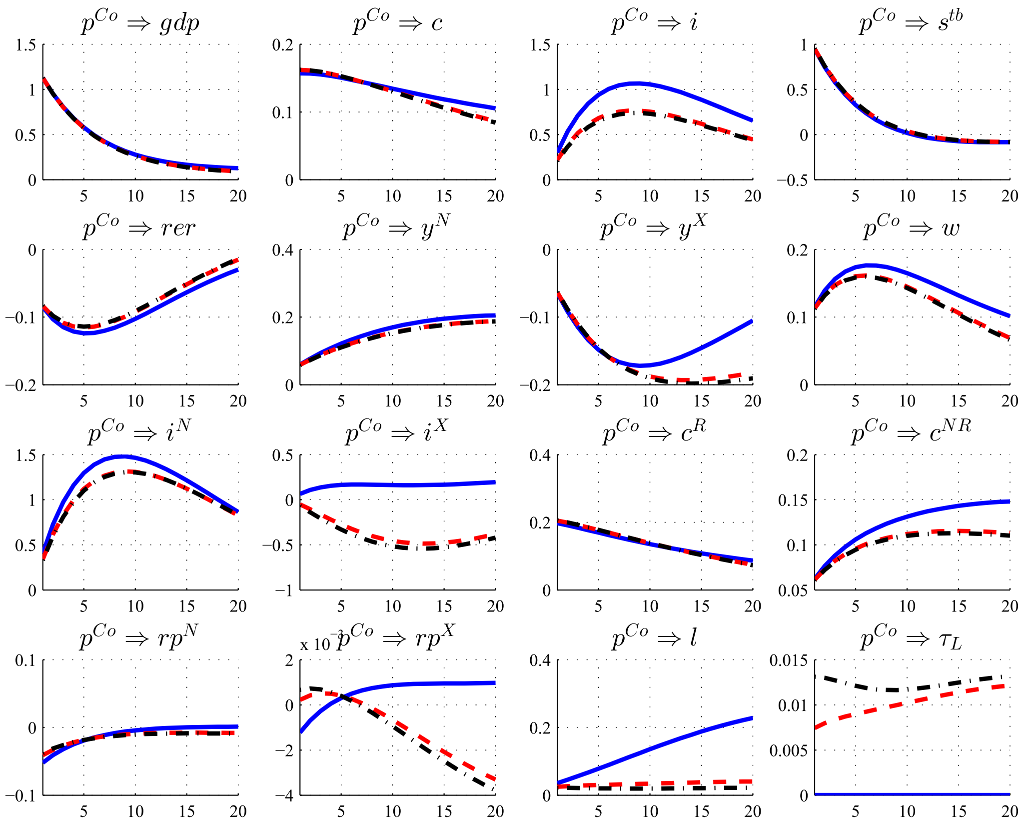
30 Actually, although not shown, the same result holds in the Base model with only Ricardian households.

31 Given the relevance of financial frictions for this argument, we will only consider the versions of the model that feature this characteristic.

32 Ideally, one would like to have a differential treatment in each sector: taxing lending to the N sector and subsidizing it for X companies. We do not evaluate that alternative because, while in the model it is simple to distinguish both sectors, it is likely that such a distinction in real life would be harder to specify. For that reason, we just consider a tax on aggregate credit.

33 A stationary equilibrium ceases to exist if $\phi_{\tau^l}<0$.

34 Notice that we are implicitly assuming that this tax is zero in steady state.



Note: The solid-blue, the dashed-red and the dashed-dotted-black lines correspond, respectively, to teh models with $\phi_{\tau^l} = \{0, 0.3, 0.6\}$. See Figure 2 for variables and unit of measure.

Fig. 7. Responses to a commodities price shock, Base + NR + FF + LBD model, different values for ϕ_{τ^l}.

In terms of consumption, the role of ϕ_{τ^l} is different for both types of households. For Ricardians the fact that credit is limited mildly increases their consumption in the first periods by more than in the case without these taxes. Non-Ricardians, on the contrary, have a path for consumption that, while in the first periods is close to the case with $\phi_{\tau^l} = 0$, it lies below after some periods when $\phi_{\tau^l} > 0$. Thus, while for Ricardians it is not obvious how the variance of consumption will be affected, for non-Ricardians the volatility of consumption will be reduced with an active rule for these taxes.

The welfare-based analysis is presented in Table 5. The preference of both agents is quite different. Ricardians would rather have no taxes on domestic credit,[35] while non-Ricardian would like a tax that completely offsets any increase in credit. And this result holds in both models. For Ricardians, as shown in the impulse responses, their consumption path is not significantly altered by a positive value of ϕ_{τ^l}. In fact, one can verify numerically that the welfare function is relatively insensitive to the value of ϕ_{τ^l}. For non-Ricardians, it seems that the reduction in the variance brought about by the positive ϕ_{τ^l} improve their welfare. But again, the welfare gains are relatively relatively small. Therefore, it seems that this policy tool is not that relevant from a welfare perspective for neither type of households.

[35] This result also holds in models without non-Ricardian households.

Table 5
Welfare evaluation: tax on domestic lending.

Model	$\phi_{\tau^L}^{opt}$	Comparision relative to $\phi_{\tau^L} = 0$							
		100λ	Ricardians				100λ	Non-Ricardians	
			St.Dev.		Mean			St.Dev.	Mean
			c	h	c	h		c	c
A. Maximization of Ricardian welfare									
Base + NR + FF	0	0.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00
Base + NR + LBD + FF	0	0.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00
B. Maximization of Non-Ricardian welfare									
Base + NR + FF	1	0.33	0.92	0.67	−0.28	0.16	−0.16	0.67	0.32
Base + NR + LBD + FF	1	0.04	0.95	0.62	−0.03	0.03	−0.03	0.62	0.05
5. Welfare weight 50%									
Base + NR + LBD + FF	1	0.04	0.95	0.62	−0.03	0.03	−0.03	0.62	0.05

Note: See Table 3 for a description. Recall that hours worked are the same for both types of agents.

8. Combining different policy tools

Finally, we explore the possibility of combining the different policy instruments. For this exercise, we continue to assume that the revenues collected for either capital controls or tax on domestic credit are rebated in a lump-sum fashion to Ricardian households. We think this is a reasonable assumption, for it is not likely that either of these two tax alternative will generate a large revenue for the government. The analysis will be presented only for the full model (Base + NR + FF + LBD). Table 6 show the results. For every possible combination of tools, we compute the optimal values of the coefficients characterizing the rules according to the three alternative welfare criteria.

When we consider having both the expenditure rule and capital controls, we can see that the optimal choice resembles what we have find for each instrument individually. In particular, Ricardians would like to have a pro-cyclical policy and a prudential capital control, while the opposite is true for non-Ricardians. A difference with the individual analysis is that Ricardians would like a smaller negative value for the elasticity of capital controls that when we analyze this tool in isolation.

A non trivial interaction appears for non-Ricardians when they can choose η_{rev} and ϕ_{τ^l} at the same time. In particular, their choice will be the opposite of what they would like with each policy in

Table 6
Welfare evaluation: combining different tools.

Welfare maximized	η_{rev}^{opt}	$\phi_{\tau^{cc}}^{opt}$	$\phi_{\tau^l}^{opt}$	Comparision relative to $\eta_{rev} = \eta_{\tau^{cc}} = \phi_{\tau^l} = 0$							
				100λ	Ricardians				100λ	Non-Ricardians	
					St.Dev.		Mean			St.Dev.	Mean
					c	h	c	h		c	c
R	1	−0.44		−3.28	0.18	0.76	3.42	0.06	−0.06	0.76	0.12
NR	−1	1		3.23	2.31	2.64	−3.00	0.10	−0.08	2.64	0.21
50%	1	−0.92		−3.27	0.21	0.80	3.41	0.07	−0.07	0.80	0.14
R	1		0	−3.27	0.16	0.75	3.41	0.06	−0.06	0.75	0.11
NR	1		0	−3.28	0.16	0.75	3.41	0.06	−0.06	0.75	0.12
50%	1		0.65	−3.27	0.15	0.75	3.40	0.05	−0.05	0.75	0.09
R		−0.88	0	−0.10	0.89	0.54	0.09	−0.01	0.01	0.54	−0.02
NR		1	0.79	0.06	0.97	0.73	−0.06	0.03	−0.03	0.73	0.06
50%		−0.87	1	−0.01	0.87	0.34	0.00	0.03	−0.03	0.34	0.05
R	1	−0.18	0	−3.28	0.17	0.75	3.42	0.06	−0.06	0.75	0.12
NR	1	0.7963	0.00	−3.28	0.16	0.75	3.41	0.06	−0.06	0.75	0.11
50%	1	1	1	−3.27	0.14	0.75	3.40	0.05	−0.05	0.75	0.10

Note: See Table 3 for a description.

isolation, for here they would like a pro-cyclical policy and a zero tax on domestic credit in these cases.

If we allow them to chose only $\phi_{\tau^{cc}}$ and $\phi_{\tau^{l}}$, both types of agents would also have opposite preferences. Ricardians prefer prudential capital controls and no taxes on domestic credit, while Non-Ricardians would rather have a pro-cyclical capital control and a high tax rate on domestic credit.

Finally, when the three instruments are available, both households would coincide in having a pro-cyclical expenditure rule and zero tax on domestic credit, but the would disagree on how capital controls should behave.

As a general conclusion for this part of the analysis, we can see that the larger effect on welfare arise by the Ricardians taste for fiscal pro-cyclicality. Non-Ricardians, on the other hand, seem to have a welfare function that is relatively flat in these policy parameters, so that minor changes in the model induce different answers in terms of the policies they would prefer. However, most of these alternative generate only minor welfare gains for them.

9. Conclusions

This paper presents a DSGE model of a small open economy with sectoral distinctions that also included non-Ricardian agents, financial frictions and a learning-by-doing externality. The inclusion of non-Ricardians agents is relevant both as a way to meaningfully analyze to role of fiscal rules, and also to have different perspectives in welfare evaluations. The last two model features generate inefficient sectoral relocations after an increase in commodity income, making the Dutch disease truly a disease. We use this model to evaluate three policy alternatives to deal with shock to commodity prices: a structural-balance rule for government expenditures, capital controls that react to changes in foreign financial conditions, and taxes to domestic credit to ameliorate expansions in lending after increases in commodity income.

In terms of the expenditure rule we find that, on the one hand, Ricardian agents would rather have a pro-cyclical rule, for such a rule will help to smooth their consumption. This is so despite the fact that a pro-cyclical expenditure exacerbates any inefficiencies coming from either financial frictions or LBD externalities (so the reduction of variance is more important for them than compensating for inefficiencies). On the other hand, non-Ricardians would not necessarily prefer the same thing, and their optimal degree of fiscal pro-cyclicality depends on the characteristics of the model. For instance, under LBD externalities, they would rather have a counter-cyclical expenditure, as the inefficient path of real wages generated by the combination of the externality and a pro-cyclical policy have a negative impact on their expected consumption. On the contrary, in the presence of financial frictions the reduction in volatility they experience with a pro-cyclical rule compensates for the inefficient movement in real wages, making them choose a pro-cyclical policy.

The analysis of capital controls also show such a discrepancy between both types of agents. Ricardian agents would choose a prudential rule for taxes on foreign borrowing, with these taxes increasing whenever external financial conditions are relaxed; while Non-Ricardians prefer the opposite. A prudential rule for capital controls will smooth out part of the responses generated by movements in international prices of commodities, but for non-Ricardians it also lowers their average consumption.

Finally, both types of households also disagree on how taxes on domestic credit should move with the credit cycle. In particular, Ricardians would rather not have this tax at all, while non-Ricardians would prefer a tax that fully compensate any change in credit. However, the welfare gains or loses they experience for different degrees of reaction of this tax rate to total credit is quite small, particularly compared with the benefits of the other alternatives we have analyzed.

Going back to the motivation of the paper (namely, if these policy tools where appropriate to deal with Dutch-disease problems originated from cyclical movements in commodity prices) we have found that most of the results can also be obtained in versions of the model not featuring any inefficient reallocation effects. Thus, whether one policy alternative is preferred to the other is not related to Dutch-disease concerns.

The analysis also highlights that welfare evaluations are not trivial in stochastic models with heterogeneous agents. In particular, in many cases we have found that non-Ricardian agents face a trade-off between higher variance of their outcomes and unconditional means. For Ricardians such a trade-off is not generally present, because for them a less volatile world increases average consumption due to the reduction in precautionary savings. However, as non-Ricardians cannot access any saving vehicle, their choice is generally more complicated.

We have also described that the largest gains in terms of welfare are produce when Ricardians can choose their preferred degree of fiscal pro-cyclicality. All the other alternatives deliver only minor improvements in terms of welfare.

To conclude, we discuss some limitations of our analysis. As we mentioned in the introduction, one could also study the appropriate way to deal with Dutch-disease situations that are not due to cyclical movements in commodity prices but rather due to persistent changes in commodity income. The latter can occurred due to a sudden increase in the endowment of natural resources, or to a permanent rise in the price of the commodity. The analysis of such a situation is not trivial, for it requires to specify how the change in commodity income will impact the long run behavior of the economy; something that a model like ours cannot account for. Moreover, in such a framework policies can have two different effects: to smooth the transition to the new steady state or to affect the long run equilibrium of the economy. And it is not clear whether a trade off will arise between these two goals, particularly in a world with uncertainty. Still, as this alternative approach is quite relevant, we consider a promising line of future research to study the welfare consequence's of permanent changes in commodity-related income in model with endogenous growth.

Finally, in this paper we have focused on analyzing only simple rules for the policy alternatives that we have consider. While we think that the analysis of simple rule is of practical relevance, one can alternatively evaluate the optimal Ramsey policy that is not constrained to a particular simple rule. In fact, as we surveyed in section 2, much of the normative literature on the Dutch disease has taken this approach. Therefore, given that many of the simple rules that we have analyzed deliver only minor welfare improvements, a study that is not based on simple rules can shed some light on how these policy instruments should be set, and what are the potential welfare gains of using those policies. We left this alternative approach for future research.

Acknowledgments

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Appendix A. Technical appendix

Appendix A.1. Equilibrium conditions

Ricardian Households (4):

$$\lambda_t = U^R_{c,t}, \tag{A.1}$$

$$-U^R_{h,t} = \frac{\lambda_t}{p_t}(1-\tau)w_t, \tag{A.2}$$

$$\frac{\lambda_t}{p_t} = \beta(1+r^*_t)E_t\left\{\frac{\lambda_{t+1}}{p_{t+1}}\right\}, \tag{A.3}$$

$$\lambda_t = \beta\left(1 + r_t^L\right)E_t\{\lambda_{t+1}\}, \tag{A.4}$$

Non-Ricardian Households (2):

$$-U_{h,t}^{NR} = \frac{U_{c,t}^{NR}}{p_t}(1-\tau)w_t, \tag{A.5}$$

$$p_t c_t^{NR} = (1-\tau)w_t h_t^{NR}, \tag{A.6}$$

Aggregate consumption (6)

$$c_t = \left[\varphi^{1/\varepsilon}\left(c_t^N\right)^{1-1/\varepsilon} + (1-\varphi)^{1/\varepsilon}\left(c_t^T\right)^{1-1/\varepsilon}\right]^{\frac{\varepsilon}{\varepsilon-1}}, \tag{A.7}$$

$$c_t^T = \left(\frac{c_t^X}{\chi}\right)^{\chi}\left(\frac{c_t^M}{1-\chi}\right)^{1-\chi}, \tag{A.8}$$

$$c_t^N = \varphi\left(\frac{p_t}{p_t^N}\right)^{\varepsilon} c_t, \tag{A.9}$$

$$c_t^T = (1-\varphi)\left(\frac{p_t}{p_t^T}\right)^{\varepsilon} c_t, \tag{A.10}$$

$$c_t^X = \chi\left(\frac{p_t^T}{p_t^X}\right)c_t^T, \tag{A.11}$$

$$c_t^M = (1-\chi)\left(p_t^T\right)c_t^T. \tag{A.12}$$

Production of tradables (4):

$$y_t^X = a_t^X (z_t)^{\psi}\left(h_t^X\right)^{\alpha_X}\left(k_{t-1}^X\right)^{1-\alpha_X-\psi}, \tag{A.13}$$

$$z_t = z_{t-1}^{\mu}\left(y_{t-1}^X\right)^{1-\mu}, \tag{A.14}$$

$$w_t = p_t^X \alpha_X \frac{y_t^X}{h_t^X}, \tag{A.15}$$

$$u_t^X = p_t^X (1 - \alpha_X - \psi) \frac{y_t^X}{k_{t-1}^X}, \tag{A.16}$$

Production of non-tradables (3):

$$y_t^N = a_t^N \left(h_t^N\right)^{\alpha_N} \left(k_{t-1}^N\right)^{1-\alpha_N}, \tag{A.17}$$

$$w_t = p_t^N \alpha_N \frac{y_t^N}{h_t^N}, \tag{A.18}$$

$$u_t^N = p_t^N (1 - \alpha_N) \frac{y_t^N}{k_{t-1}^N}, \tag{A.19}$$

Entrepreneurs (6):

$$q_t^X k_t^X = n_t^X + p_t l_t^X, \tag{A.20}$$

$$E_t \left\{ \frac{u_{t+1}^X + (1-\delta) q_{t+1}^X}{q_t^X} \right\} = \left(1 + r_t^L\right) rp \left(\frac{q_t^X k_t^X}{n_t^X lev} \right)^{\xi_X}, \tag{A.21}$$

$$n_t^X = \vartheta \left\{ \left[u_t^X + (1-\delta) q_t^X \right] k_{t-1}^X - p_t l_{t-1}^X \left(1 + r_{t-1}^L\right) \right\} + \iota^X, \tag{A.22}$$

$$q_t^N k_t^N = n_t^N + p_t l_t^N, \tag{A.23}$$

$$E_t \left\{ \frac{u_{t+1}^N + (1-\delta) q_{t+1}^N}{q_t^N} \right\} = \left(1 + r_t^L\right) rp \left(\frac{q_t^N k_t^N}{n_t^N lev} \right)^{\xi_N}, \tag{A.24}$$

$$n_t^N = \vartheta \left\{ \left[u_t^N + (1-\delta) q_t^N \right] k_{t-1}^N - p_t l_{t-1}^N \left(1 + r_{t-1}^L\right) \right\} + \iota^N, \tag{A.25}$$

Capital and Investment (7):

$$k_t^X = (1-\delta) k_{t-1}^X + \left[1 - S_X \left(\frac{i_t^X}{i_{t-1}^X} \right) \right] i_t^X, \tag{A.26}$$

$$p_t^I = q_t^X \left[1 - S_X \left(\frac{i_t^X}{i_{t-1}^X} \right) - S_X' \left(\frac{i_t^X}{i_{t-1}^X} \right) \frac{i_t^X}{i_{t-1}^X} \right] + E_t \left\{ \beta \frac{\lambda_{t+1}}{\lambda_t} q_{t+1}^X S_X' \left(\frac{i_{t+1}^X}{i_t^X} \right) \left(\frac{i_{t+1}^X}{i_t^X} \right)^2 \right\}, \tag{A.27}$$

$$k_t^N = (1-\delta)k_{t-1}^N + \left[1 - S_N\left(\frac{i_t^N}{i_{t-1}^N}\right)\right] i_t^N, \tag{A.28}$$

$$p_t^I = q_t^N \left[1 - S_N\left(\frac{i_t^N}{i_{t-1}^N}\right) - S_N'\left(\frac{i_t^N}{i_{t-1}^N}\right) \frac{i_t^N}{i_{t-1}^N}\right] + E_t\left\{\beta \frac{\lambda_{t+1}}{\lambda_t} q_{t+1}^N S_N'\left(\frac{i_{t+1}^N}{i_t^N}\right)\left(\frac{i_{t+1}^N}{i_t^N}\right)^2\right\}, \tag{A.29}$$

$$i_t = \left(\frac{x_t^N}{\gamma}\right)^{\gamma}\left(\frac{x_t^M}{1-\gamma}\right)^{1-\gamma}, \tag{A.30}$$

$$x_t^N = \gamma\left(\frac{p_t^I}{p_t^N}\right) i_t, \tag{A.31}$$

$$x_t^M = (1-\gamma)\left(p_t^I\right) i_t, \tag{A.32}$$

Fiscal Policy (3):

$$p_t^n g_t + d_{t-1}^{g*}\left(1 + r_{t-1}^*\right) = rev_t + d_t^{g*}, \tag{A.33}$$

$$rev_t = \tau\left(p_t^X y_t^X + p_t^N y_t^N\right) + p_t^{Co} y_t^{Co}\left[\tau^{Co}\left(s^{Co,R} + s^{Co,*}\right) + s^{Co,g}\right], \tag{A.34}$$

$$p_t^n g_t + d_{t-1}^{g*}\left(r_{t-1}^* + \eta_r\right) = \eta_0 + rev + \eta_{rev}(rev_t - rev), \tag{A.35}$$

Aggregation and market clearing (12):

$$(1-\kappa)h_t^R + \kappa h_t^{NR} = h_t^X + h_t^N, \tag{A.36}$$

$$(1-\kappa)c_t^R + \kappa c_t^{NR} = c_t, \tag{A.37}$$

$$(1-\kappa)d_t^{R*} + d_t^{g*} = d_t^*, \tag{A.38}$$

$$(1-\kappa)l_t^R = l_t^X + l_t^N, \tag{A.39}$$

$$i_t = i_t^N + i_t^M, \tag{A.40}$$

$$y_t^N = c_t^N + x_t^N + g_t, \tag{A.41}$$

$$imp_t = c_t^M + x_t^M, \tag{A.42}$$

$$exp_t = p_t^X \left(y_t^X - c_t^X \right) + p_t^{Co} y_t^{Co}, \tag{A.43}$$

$$tb_t = exp_t - imp_t, \tag{A.44}$$

$$p_t gdp_t = p_t^X y_t^X + p_t^N y_t^N + p_t^{Co} y_t^{Co}, \tag{A.45}$$

$$rer_t = 1/p_t, \tag{A.46}$$

$$d_{t-1}^* \left(1 + r_{t-1}^*\right) = d_t^* + tb_t - p_t^{Co} y_t^{Co} s^{Co,*} \left(1 - \tau^{Co}\right), \tag{A.47}$$

$$r_t^* = r_t^w + \exp\left\{ \phi_d \left(\frac{d_t^* - d^*}{d^*} \right) \right\} - 1, \tag{A.48}$$

$$gdp_t^m = p_t gdp_t. \tag{A.49}$$

Endogenous variables (49):

$$\begin{array}{cccccccccc}
\lambda_t & c_t^R & c_t^{NR} & h_t^R & h_t^{NR} & w_t & p_t & r_t^L & c_t & c_t^N \\
c_t^T & c_t^X & c_t^M & p_t^N & p_t^T & y_t^X & z_t & h_t^X & k_t^X & y_t^N \\
h_t^N & k_t^N & u_t^X & u_t^N & q_t^X & q_t^N & n_t^X & n_t^N & l_t^X & l_t^N \\
i_t^X & i_t^N & p_t^I & i_t & x_t^N & x_t^M & g_t & d_t^{g*} & rev_t & d_t^{R*} \\
d_t^* & l_t^R & imp_t & exp_t & tb_t & gdp_t & rer_t & r_t^* & gdp_t^m &
\end{array}$$

Exogenous variables (6):

$$a_t^X \; a_t^N \; y_t^{Co} \; r_t^W \; p_t^{Co} \; p_t^X$$

Appendix A.2. Steady state

We show how to compute the steady state for given values of all parameters and steady state values of exogenous variables, except for $\overline{d}, y^{Co}, \beta, \zeta, \phi, a^X$ that are determined endogenously to match the following steady state values: $s^{tb} = tb/gdp^m$, $s^{Co} = p^{Co}y^{Co}/gdp^m$, r^W, h^X, h^N, and p^N. Also, as the fiscal rule does not pin down the steady state level of g, we also calibrate $s^g = p^N g/gdp^m$.

From (A.3), (A.4) and (A.48),

$$\beta = \left(1 + r^W\right)^{-1}, r^* = r^W, r^L = r^*.$$

From (A.30)–(A.32), (A.10)–(A.12), (A.27) and (A.29),

$$p^I = \left(p^N\right)^{\gamma}, p^T = \left(p^X\right)^{\chi}, q^X = p^I, q^N = p^I.$$

From (A.21) and (A.23),

$$u^X = q^X\left[\left(1+r^L\right)rp - 1 + \delta\right], u^N = q^N\left[\left(1+r^L\right)rp - 1 + \delta\right].$$

From (A.17)–(A.19),

$$k^N = \left[\frac{u^N}{p^N(1-\alpha_N)a^N}\right]^{-\frac{1}{\alpha_N}} h^N, y^N = a^N\left(h^N\right)^{\alpha_N}\left(k^N\right)^{1-\alpha_N}, w = p^N\alpha_N\frac{y^N}{h^N}.$$

From (A.13)–(A.16),

$$k^X = \left[\frac{w(1-\alpha_X-\psi)}{u^X\alpha_X}\right]h^X, a^X = \left(\frac{w}{p^X\alpha_X}\right)^{1-\psi}\left(\frac{h^X}{k^X}\right)^{1-\alpha_X},$$

$$y^X = \left(a^X\right)^{\frac{1}{1-\psi}}\left(h^X\right)^{\frac{\alpha_X}{1-\psi}}\left(k^X\right)^{1-\frac{\alpha_X}{1-\psi}}, z = y^X.$$

From (A.26), (A.28), (A.31), (A.32) and (A.40),

$$i^X = \delta k^X, i^N = \delta k^N, i = i^X + i^N, x^N = \gamma\left(\frac{p^I}{p^N}\right)i, x^M = (1-\gamma)\left(p^I\right)i.$$

From (A.45) and (A.49), and shares' definitions

$$gdp^m = \frac{p^X y^X + p^N y^N}{1-s^{Co}}, g = s^g gdp^m, y^{Co} = \frac{s^{Co} gdp^m}{p^{Co}}, tb = s^{tb} gdp^m.$$

From (A.41),

$$c^N = y^N - x^N - g.$$

From (A.42)–(A.44), (A.8) and (A.11)–(A.12),

$$c^M = (1-\chi)\left(p^X y^X + p^{Co}y^{Co} - x^M - tb\right), c^X = \frac{\chi}{(1-\chi)}\frac{c^M}{p^X}, c^T = \left(\frac{c^X}{\chi}\right)^{\chi}\left(\frac{c^M}{1-\chi}\right)^{1-\chi},$$

$$imp = c^M + x^M, exp = p^X\left(y^X - c^X\right) + p^{Co}y^{Co}.$$

From (A.7) and (A.9)–(A.10),

$$\varphi = \left[1 + \left(\frac{p^T}{p^N}\right)^{\varepsilon}\frac{c^T}{c^N}\right]^{-1}, c = \left[\varphi^{1/\varepsilon}\left(c^N\right)^{1-1/\varepsilon} + (1-\varphi)^{1/\varepsilon}\left(c^T\right)^{1-1/\varepsilon}\right]^{\frac{\varepsilon}{\varepsilon-1}}, p = p^N\left(\frac{c^N}{\varphi c}\right)^{\frac{1}{\varepsilon}}.$$

From (A.46)–(A.49),

$$gdp = \frac{gdp^m}{p}, rer = 1/p, d^* = \frac{tb - p^{Co}y^{Co}s^{Co,*}(1-\tau^{Co})}{r^*}, \bar{d} = \frac{d^*}{gdp^m}.$$

From (A.20)–(A.25),

$$n^X = \frac{q^X k^X}{lev}, n^N = \frac{q^N k^N}{lev}, l^X = \frac{q^X k^X - n^X}{p}, l^N = \frac{q^N k^N - n^N}{p},$$

$$\iota^X = n^X - \vartheta\left\{\left[u^X + (1-\delta)q^X\right]k^X - pl^X\left(1+r^L\right)\right\},$$

$$\iota^N = n^N - \vartheta\left\{\left[u^N + (1-\delta)q^N\right]k^N - pl^N\left(1+r^L\right)\right\}.$$

Finally, from (A.1)–(A.2), (A.5), (A.33)–(A.35), (A.36)–(A.37) we can obtain $\lambda, c^R, c^{NR}, h^R, h^{NR}, \zeta, rev\eta_0$ and d^{g*}.

Appendix A.3. Welfare measure

Consider two possible equilibria: r (reference) and a (alternative). The goal is to compute which percentage of the consumption sequence of equilibrium r is the household willing to sacrifice to be indifferent between the r and the a equilibria, denoted by λ, where indifference is measured in terms of unconditional expected utility. Thus, λ is implicitly defined as,

$$E\left\{\sum_{t=0}^{\infty} U\left(c_t^a, h_t^a\right)\right\} = E\left\{\sum_{t=0}^{\infty} U\left((1-\lambda)c_t^r, h_t^r\right)\right\}. \quad \text{(A.50)}$$

In some cases, the utility function is such that we can solve for λ explicitly,[36] but in general this may not be the case. We will the show how to approximate λ using a second order Taylor-expansion around the steady state in the general case.

Let σ denote the perturbation parameter that scales the variance of all the shocks in the model. It can be shown that, up to second order, the unconditional expectation of a generic variable X_t is approximated by

$$E\{X_t\} = X^{ss} + X_{\sigma^2}\frac{\sigma^2}{2},$$

where X_{σ^2} reflects how the unconditional expectation depends on σ^2.[37] Thus, we redefine the left-hand side of (A.50) as $V^a(\sigma^2)$ to reflect the fact that it will depend on the perturbation parameter, and its approximation is then $V^a(\sigma^2) \approx V^{a,ss} + V^a_{\sigma^2}\sigma^2/2$, which can be easily computed with most computational packages such as Dynare. Similarly, for a given value of λ, the right-hand side of (A.50), defined as $V^r(\lambda, \sigma^2)$, can also be approximated only as a function of σ^2 (i.e. $V^r(\lambda, \sigma^2) \approx V^{r,ss}(\lambda) + V^r_{\sigma^2}(\lambda)\sigma^2/2$ for all λ).

36 For instance, in Schmitt-Grohe and Uribe (2007a).
37 For instance, see Andreasen et al. (2013).

Therefore, given that λ is implicitly defined as $V^a(\sigma^2) = V^r(\lambda, \sigma^2)$, it is then clear that it will be a function of σ^2 that can be approximated up to second order as $\lambda(\sigma^2) \approx \lambda^{ss} + \lambda_{\sigma^2}\sigma^2/2$. To compute λ^{ss}, notice the because in steady state $\sigma = 0$, (A.50) yields

$$V^a(0) = V^r(\lambda^{ss}, 0).$$

In many cases λ^{ss} can be solved for algebraically from that equation, and if not it can be found with a numerical solver.

To obtain λ_{σ^2}, differentiate $V^a(\sigma^2) = V^r(\lambda, \sigma^2)$ with respect to σ^2 and evaluate at the steady state, which yields

$$\lambda_{\sigma^2} = \frac{V^a_{\sigma^2} - V^r_{\sigma^2}(\lambda^{ss})}{V^r_{\lambda}(\lambda^{ss})}$$

where $V^r_{\lambda}(\lambda^{ss})$ denotes the second-order approximation of the derivative of $V^r(\lambda, \sigma^2)$ with respect to λ evaluated at the steady state λ^{ss}. This is the second-order approximation of $-E\{\sum_{t=0}^{\infty} U_c((1-\lambda^{ss})c^r_t, h^r_t)c^r_t\}$, which can also be computed using Dynare or similar.

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