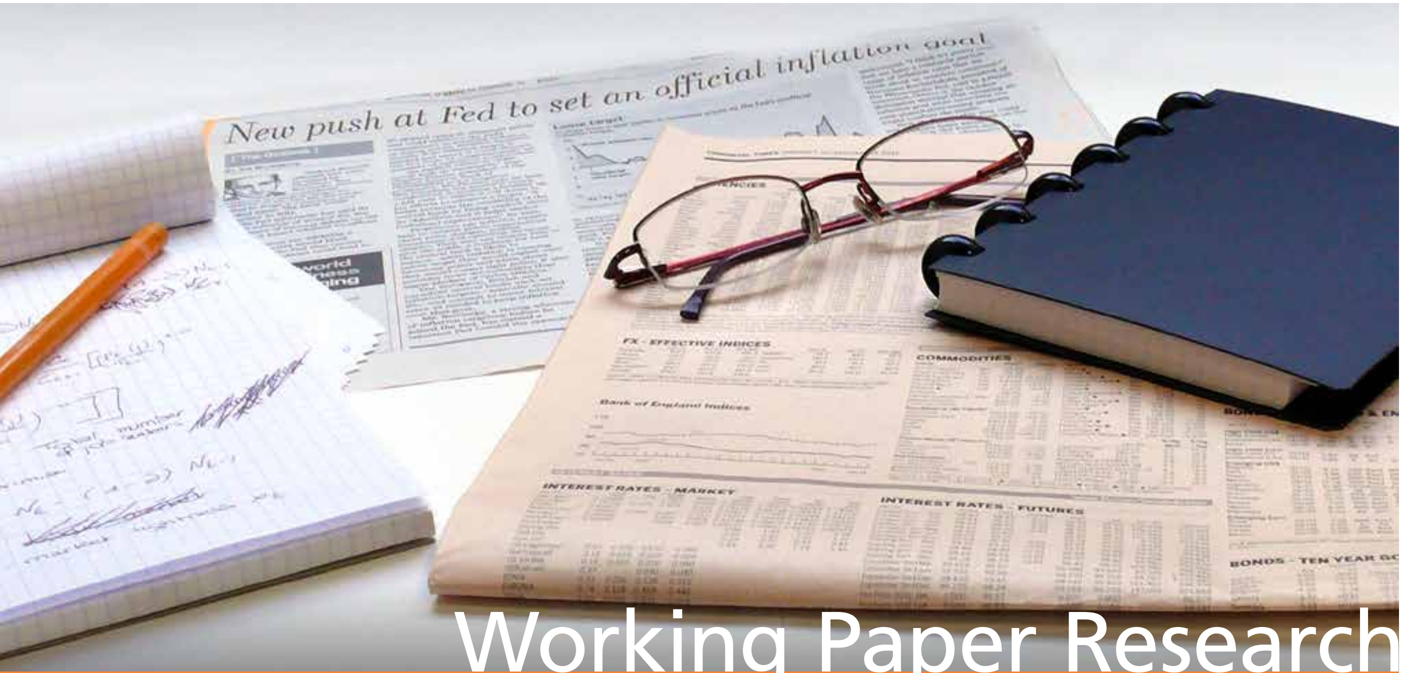
Welfare effects of business cycles and monetary policies in a small open emerging economy



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Abstract

This paper evaluates the welfare cost of business cycles and the effects of monetary policies in a DSGE model tailored to a small open emerging economy. The model generates rich business cycle fluctuations, features labor market idiosyncratic risks and accounts for imperfect financial and capital markets inclusion. In this context, households excluded from financial and capital markets experience larger costs of business cycle fluctuations due to their inability to hedge against labor market idiosyncratic risks. Different degrees of exposure to different types of risks generate divergent preferences regarding the conduct of monetary policy. While a strong response to inflation deviation from target maximizes welfare for included households, excluded households benefit the most from unemployment and wage stabilization policies.

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1 Introduction

The measure of the welfare cost of business cycles and the design of appropriate stabilization policies has received substantial attention in advanced economies. The same is not true of emerging markets. However, since works by Lucas (1987) and Imrohoruglu (1989), it has become clear that two crucial determinants of the welfare cost of business cycles are aggregate consumption volatility and the ability - or not - to hedge against idiosyncratic risks. In emerging markets, business cycle fluctuations tend to be stronger. Moreover, a large proportion of households are excluded from financial markets and own little to no wealth. They are therefore highly exposed to large aggregate and idiosyncratic income risks. It is therefore surprising that most papers measuring the welfare costs of business cycles and dealing with the design of monetary policies disregarded emerging markets.

This paper aims to fill this gap by evaluating the welfare cost of business cycles and the effects of monetary policies in a DSGE model tailored to a small open emerging economy. The model generates rich business cycle fluctuations, features labor market idiosyncratic risks and accounts for imperfect financial and capital markets inclusion. In this context, households excluded from financial and capital markets experience larger costs of business cycle fluctuations due to their inability to hedge against labor market idiosyncratic risks. Different degrees of exposure to different types of risks generate divergent preferences regarding the conduct of monetary policy. While a strong response to the CPI inflation rate deviation from target maximizes the welfare of included households, excluded households benefit the most from unemployment and wage inflation stabilization policies. As an illustration, the model is applied to South Africa.[1]

The core of the model follows the small open economy (SOE) model developed by Adolfson et al. (2007) with four main extensions that are meant to take the specificities of an emerging economy into account and to introduce idiosyncratic risks. First, firms produce two different types of goods: commodities and secondary products, which capture the empirical importance of commodity price fluctuations in many emerging economies (e.g. Mendoza, 1995, Kose, 2002 and Houssa et al., 2019). Second, I introduce search and matching frictions (hereafter SAM) with staggered wage bargaining following Gertler and Trigari (2009) and Thomas (2008). These rigidities generate idiosyncratic income risks in the labor market. Unemployment risks, sectoral wage differences (between the commodity and secondary sectors) and nominal wage rigidities generate dispersion in households' labor incomes. Third, I

[1] Data for key macroeconomic variables are available on a quarterly basis. It is therefore possible to use advanced estimation techniques to fit the business cycle. Moreover, households' surveys allow to infer the size of idiosyncratic risks faced by households in the labor market.

explicitly model unemployed households' revenues. In the baseline, unemployed households receive pro-cyclical social transfers as observed in many emerging economies.[2] In an alternative scenario, unemployment benefits are tied to past wages, which fits the South African institutional framework described in the appendix. In another alternative case, I assume that the unemployed do not receive benefits, but rather work in an informal sector. This experiment captures the importance of this sector (e.g. Fernandez and Meza, 2015) and the low unemployment benefits coverage in some low- and middle-income countries (e.g. OECD, 2011). Fourth, there are two categories of households that differ with respect to access to capital and financial markets. Households excluded from these markets own no physical capital or financial wealth and simply consume their entire labor income in every period as in Mankiw (2000). In addition, they do not trade in state-contingent asset markets and are unable to insure against idiosyncratic risks. Labor income idiosyncratic risks thus translate into consumption dispersion for this category of agents. Within this rich framework, monetary policy is modeled as a Taylor rule with interest rate smoothing. The monetary authority responds to CPI inflation, wage inflation and unemployment rates deviation from their respective targets. This rule allows to evaluate the trade-off between stabilizing inflation and mitigating labor income idiosyncratic risks.[3]

When measuring the welfare cost of business cycle fluctuations and dealing with the design of stabilization policies, both business cycle fluctuations and idiosyncratic risks are important. The ideal model should therefore take both factors into consideration. Representative agent NK-DSGE models can reproduce business cycle fluctuations, due to the rich set of shocks and frictions that were gradually introduced in these models, in an effort to match aggregate fluctuations (e.g. Christiano et al., 2005 and Smets and Wouters, 2007). However, idiosyncratic risks (such as Calvo price and wage rigidities or unemployment risks) are left in the background as households trade in state-contingent asset markets to hedge against those risks.[4] While this assumption preserves the representative agent frameworks,

[2] Michaud and Rothert (2018) show that pro-cyclical social transfers explain the different behaviour of government spending between advanced and emerging economies, and that they contribute to the excess volatility of consumption in emerging economies. Pro-cyclicality of government spending in emerging economies is also well documented (see Kaminsky et al., 2004 and Ilzetzki and Vegh, 2008).

[3] Note that I abstract from monetary policy response to exchange rate fluctuation to focus on the abovementioned trade-offs. Optimal monetary policy responses to exchange rate fluctuations is also an important topic in emerging economies. In a related study, Iyer (2016) shows that households excluded from financial markets could benefit from exchange rate stabilization because it reduces the volatility of the price of imported consumption goods. The model presented in this paper could also be easily applied to study this issue in the presence of labor market idiosyncratic risks.

[4] This is the case in benchmark models such as Erceg et al. (2000), Christiano et al. (2005), Smets and Wouters (2007) and Adolfson et al. (2007) for Calvo price and wage rigidities, as well as Walsh (2005) and Trigari (2009) for unemployment risks. Thomas (2008) and Gertler and Trigari (2009) combine these two

its empirical validity is questionable.[5] The next generation of Heterogeneous Agents New-Keynesian (HANK) models (e.g. Kaplan et al., 2018) relaxes this assumption and financial market incompleteness generates rich income, wealth and consumption dispersions. Yet, HANK models come at the cost of complex solution methods currently limiting the set of shocks, frictions and estimation methods that they can handle.[6] Consequently, these models generate less refined business cycle fluctuations. The model developed in this paper offers a compromise between those two strands of literature. It considers the effect of idiosyncratic risks on consumption dispersion, for households unable to accumulate wealth, in a large scale DSGE models that produce rich business cycle fluctuations driven by a large variety of aggregate shocks. This is an important consideration, as excluded households are the most vulnerable to idiosyncratic risks and business cycle fluctuations. The method described in this paper to keep track of the impact of excluded households' labor income dispersion on aggregate welfare is simple and could be easily applied to other (large scale) DSGE models with hand to mouth consumers.

I estimate the welfare costs of business cycles for included and excluded households at 1.25% and 4.25% of their steady-state level of consumption, respectively. The welfare cost is much higher for households excluded from asset markets, especially because of their inability to insure against labor market idiosyncratic risks. Indeed, while their costs are approximately four times greater than those incurred by included households, they would be lower if they could eliminate the idiosyncratic risk. The underlying mechanism is based on the interaction between business cycle fluctuations, idiosyncratic risks in the labor market and financial markets exclusion. In this paper, business cycle fluctuations exacerbate idiosyncratic risks via three channels. First, the outcome of the wage bargain depends on the state of the business cycle, which generates wage dispersion within each sector due to the staggered wage bargaining framework. Second, business cycle fluctuations cause sectoral wage differences. Third, business cycle fluctuations push up the average unemployment rate and generate volatility in replacement incomes as they rise during booms and fall during recessions.[7] These interactions between the business cycle and idiosyncratic risks generate more

types of risks.

[5] See Imrohoruglu (1989), Atkeson and Phelan (1994), Krusell and Smith (1999), Beaudry and Pages (2001), Gomes et al. (2001) and Krebs (2007).

[6] For example, Kaplan et al. (2018) consider only one type of aggregate shock (monetary policy).

[7] The negative correlation between job-finding rates and the unemployment rate can raise the average unemployment rate in the SAM model proposed by Hall (2005) and Shimer (2005). See Jung and Kuester (2011) and Hairault et al. (2010) for a detailed investigation of the mechanism. Anand et al. (2016) document an inverse relationship between job-finding rates and the unemployment rate during the global financial crisis in South Africa.

volatility in labor incomes at the household's level. For households excluded from financial markets behaving as hand-to-mouth consumers, it translates into substantial consumption fluctuations and welfare losses. I then evaluate the welfare costs of some specific aggregate shocks, taken one at a time in sequence, while setting all other shocks to zero. I find that shocks originating from the labor market (such as shocks related to the wage bargain and employment creation) disproportionately affect households excluded from financial markets, while TFP and cost-push shocks are especially costly for included households (which own the firms). In contrast, commodity price shocks largely affect both types of households.

What follows is that different degrees of exposure to different types of risks generate divergent preferences regarding monetary policy. To highlight this monetary policy trade-off, I evaluate optimal simple monetary policy rules, for included and excluded households, respectively.[8] While a strong response to CPI inflation deviation from target maximizes welfare for included households, excluded households would benefit the most from unemployment and wage inflation stabilization. This trade-off faced by the monetary authority is robust to changes in the value of key parameters, to different assumptions governing unemployed households' replacement incomes and to different types of (domestic and external) shocks driving the business cycle. Regardless of the source of business cycle fluctuation considered (such as domestic labor market, TFP and cost-push shocks or commodity price shocks), excluded households always favour a more aggressive response to unemployment and wage fluctuations. The welfare gains associated with these optimal simple rules compared to a benchmark (the estimated Taylor rule followed by the monetary authority) are relatively large. However, the welfare cost of business cycles remains substantial, especially for excluded households. Indeed, implementing their preferred policy rule would still result in welfare costs equivalent to 1.84% of consumption for this category of agents.

The remainder of this paper is organized as follows. Section two reviews the relevant literature. Section three presents the model and section four the empirical strategy. Section five gives the results. Finally, section six concludes.

[8] Simple rules determine the response of policy variables as a function of a small number of easily observable macroeconomic indicators (such as inflation and unemployment). Their simplicity and efficiency make them particularly attractive as stabilization tools. Moreover, optimal simple monetary policy rules often deliver a virtually identical level of welfare compared to the optimal Ramsey policy (e.g. Schmitt-Grohe and Uribe, 2007 and Gali and Monacelli, 2005). These rules were also used in NK-DSGE model adapted to fit small open emerging countries specificities by Hove et al. (2015), Iyer (2016) and Prasad and Zhang (2015).

2 Relation to the literature

2.1 The welfare cost of business cycles

In seminal works, Lucas (1987, 2003) argued that the welfare costs of aggregate consumption fluctuations are small in the US. However, aggregate consumption fluctuations hide heterogeneity at the households' level. One stream of literature therefore relaxes Lucas' agents' homogeneity and his perfect market hypothesis (see Imrohoruglu, 1989, Atkeson and Phelan, 1994, Krusell and Smith, 1999, Beaudry and Pages, 2001, Gomes et al., 2001 and Krebs, 2007). These papers demonstrate that the welfare cost of business cycles could be much higher for households excluded from financial markets and for those with little wealth.

The literature described above focuses on the US. However, since works by Lucas (1987) and Imrohoruglu (1989), it has become clear that two crucial ingredients of the welfare cost of business cycles are consumption volatility and the ability - or not - to insure against idiosyncratic risks. Business cycles in emerging and developing economies display more volatility (see Agenor et al., 2000, Rand and Tarp, 2002, Neumeyer and Perri, 2005, Aguiar and Gopinath, 2007 and Male, 2011). In this context, Pallage and Robe (2003) and Houssa (2013) demonstrate that excess consumption volatility translates into a higher welfare cost. However, these studies disregarded unequal wealth distribution and households' imperfect integration into financial markets preventing them from absorbing idiosyncratic shocks. This gap in the literature is important, because financial exclusion and unequal wealth distribution are important characteristics of emerging markets. Moreover, this paper relies on a structural model whose parameters are estimated on a large set of observed variables.

2.2 Stabilization with monetary policy

Following the gradual move among central banks, pioneered by New Zealand, towards a formal inflation targeting framework, an early literature studied optimal monetary policy in simple models with price rigidities (e.g. Ireland, 1997, Rotemberg and Woodford, 1997, 1999 and Clarida et al., 1999). In this context, price rigidities à la Calvo (1983) generate inefficient price dispersion in the form of an output loss. Many authors have built on those models by gradually increasing their complexity to gain in realism (e.g. Schmitt-Grohe and Uribe, 2007) and to consider small open economies (e.g. Gali and Monacelli, 2005). This steam of research shows that inflation targeting is the optimal monetary policy and that responding to output or the exchange rate can lead to substantial welfare losses.

Surprisingly, labor market considerations were absent from this early literature. Erceg et al. (2000) extend the baseline NK-DSGE model to consider price and wage stickiness. The volatility in aggregate wage inflation causes dispersion in individual wages, which generates inefficient fluctuations in individual hours worked. In this context, it is impossible for the central bank to stabilize the output-gap and price and wage inflation rates at the same time. Building on Mortensen and Pissarides (1994), Walsh (2005) and Trigari (2009) introduced SAM frictions into a NK-DSGE model with price stickiness. However, since Hall (2005) and Shimer (2005), it has become clear that wage stickiness could improve the qualitative predictions of these models. Many authors have therefore introduced real (e.g. Gertler and Trigari, 2009) and nominal (e.g. Bodart et al., 2006 and Gertler et al., 2008) staggered wage bargaining into an otherwise standard NK-DSGE model. In this context, Thomas (2008) shows that pure inflation targeting is inefficient. Indeed, as real wages can deviate from their optimal level, the central bank can use inflation to adjust real wages and therefore faces a trade-off between price and employment stability. Overall, these studies suggest that price stability should remain the central concern of monetary policy but that it could be supplemented with wage and employment stabilization objectives. Although these models maintain the representative agent hypothesis, they offer a natural framework to consider labor market idiosyncratic risks, which is used in this paper.

The literature has also recently considered heterogeneous agents in a context of imperfect financial markets with HANK models (e.g. Kaplan et al., 2018). In such frameworks, households with illiquid wealth gain the most from stabilization policies (Bayer et al., 2015) and unequal wealth distributions provoke divergent preferences for monetary policy (Gornemann et al., 2016). These models generate detailed wealth distribution but come at the cost of complex solution methods limiting their scope. They consequently do not consider the full set of shocks and frictions that have been able to produce realistic business cycle fluctuations (e.g. Christiano et al., 2005 and Smets and Wouters, 2007). This is an important shortcoming because the ability to match business cycle fluctuations is a prerequisite for properly measuring the welfare cost of business cycle fluctuations and designing appropriate stabilization policies. In this paper, I assume that a fraction of households are excluded from financial markets and unable to accumulate wealth. This assumption reflects the limited financial market inclusion and unequal wealth distribution in emerging markets. Moreover, it makes it possible to consider income and consumption dispersions for excluded households in an otherwise standard large-scale NK-DSGE model. In a similar vein, Ravn and Sterk (2016) build a tractable HANK model with SAM applied to an advanced economy. By postulating the existence of a limit on participation in the equity market and a borrowing limit in the bond market, the model endogenously creates three distinct categories of households.

In parallel, some papers focus on imperfect financial markets in emerging economies with two types of agents. But they explore different topics and do not consider consumption dispersion. For example, Iyer (2016) and Prasad and Zhang (2015) study the benefits of exchange rate targeting when some households are excluded from financial markets.

3 Model

The domestic economy is populated by two categories of households. The first category is included in financial and capital markets and accumulates bonds and physical capital. The second category is excluded from these markets. In addition, there are two types of firms (commodity and final good producers), a monetary authority and a government. The model incorporates nominal and real rigidities to quantitatively match observed fluctuations in aggregate variables. Moreover, SAM frictions with staggered wage bargaining generate idiosyncratic income risks in the labor market. Unemployment risks, cyclical sectoral wage differences and nominal wage rigidities generate dispersion in households' labor incomes. Financially excluded households are unable to trade in state-contingent liabilities to hedge against those risks. For this category of households, business cycle fluctuations and idiosyncratic risks interact to generate substantial consumption risks. The following sub-sections describe the domestic block of the model in detail. The rest of the world is captured by ARMA(1,1) processes governing the foreign interest rate and the price of commodities.

3.1 Households

The economy is populated by two types of agents: included and excluded households, henceforth denoted as IHs and EHs, respectively. Their expected lifetime utility is given by $\mathbb{W}_{i,t} = \mathrm{E}_0^i \sum_{t=0}^{\infty} \beta^t \mathbb{U}_{i,t}$, where E is the expectation operator, β the discount factor and

$$\mathbb{U}_{i,t} = \frac{(C_{i,t})^{1-\sigma_c} - 1}{1-\sigma_c} - A_h \frac{\left(N_{i,t}^p H_{i,t}^p + N_{i,t}^f H_{i,t}^f\right)^{1+\sigma_h}}{1+\sigma_h} - A_n \left(N_{i,t}^p + N_{i,t}^f\right). \tag{1}$$

Households attain utility from consumption $C_{i,t}$ and disutility from hours worked in the primary $H_{i,t}^p$ or secondary $H_{i,t}^f$ sectors. The term $N_{i,t}^p$ ($N_{i,t}^f$) represents employment and is equal to one when the agent is employed in the primary (secondary) sector and zero otherwise. Households cannot work in both sectors at the same time. The parameters σ_c and σ_h denote the inverse of the inter-temporal elasticity of substitution for consumption and the inverse of the elasticity of work effort, respectively; A_h is the relative importance of hours worked in the utility and A_n is a fixed disutility from holding a job. The composite consumption basket $C_{i,t}$ for any household i is given by the CES index of domestic and imported goods

$$C_{i,t} = \left[(1-\omega_c\varepsilon_{m,t})^{1/\eta}(C^d_{i,t})^{(\eta-1)/\eta} + (\omega_c\varepsilon_{m,t})^{1/\eta}\,(C^m_{i,t})^{(\eta-1)/\eta}\right]^{\eta/(\eta-1)}, \tag{2}$$

where C^d_t and C^m_t denote consumption of the domestic and imported good, respectively, ω_c is the steady-state share of imports in consumption and η is the elasticity of substitution between domestic and foreign goods. The exogenous process $\varepsilon_{m,t}$ is a shock to the home bias.

3.1.1 Financially included households

There is a continuum of IHs indexed by $i \in (0,1)$ with access to financial and capital markets. The representative agent maximizes the inter-temporal utility by choosing his or her consumption and investment levels, as well as domestic and foreign bond holdings.[9] For any given period t, IHs face the same budget constraint which is given, in nominal terms, by

$$\begin{aligned} & B_{i,t+1} + S_t B^*_{i,t+1} + P^c_t C_{i,t} + P^i_t\left(I^p_{i,t} + I^f_{i,t}\right) \\ = {} & R^{k,p}_t K^p_{i,t} + R^{k,f}_t K^f_{i,t} + (1-\tau^w)\left(\overline{W}^p_{i,t}N^p_{i,t} + \overline{W}^f_{i,t}N^f_{i,t}\right) + (1 - N^p_{i,t} - N^f_{i,t})\varpi_t \\ & + TR_{i,t} + SCS_{i,t} + \varepsilon_{b,t-1}R_{t-1}B_{i,t} + R^*_{t-1}\Phi(A_{t-1},\tilde{\phi}_{t-1})S_t B^*_{i,t}, \end{aligned} \tag{3}$$

where the subscript i indicator denotes the household's choice variables, whereas variables without a subscript are economy-wide aggregates. The variables $\overline{W}^p_{i,t}$ and $\overline{W}^f_{i,t}$ represent the period t labor income in the primary or secondary sectors.[10] B_t denotes the value of nominal domestic bonds, S_t is the nominal exchange rate representing the amount of local currency per unit of foreign currency and B^*_t the value of foreign bonds (in foreign currency). R_t and R^*_t are the domestic and foreign gross risk-free interest rates, respectively. The exogenous process $\varepsilon_{b,t}$ creates a wedge between policy and private interest rates. P^c_t is the CPI and P^i_t the investment good price index. Households invest I^f_t in private capital K^f_t used in the secondary sector and I^p_t in private capital K^p_t used in the primary sector. $R^{k,p}_t$ and $R^{k,f}_t$ denote the return on capital in the primary and final sectors, respectively. The term $TR_{i,t}$

[9] The domestic financial markets are assumed to be complete, thus each financially included household can insure against any type of idiosyncratic risk through the purchase of the appropriate portfolio of state-contingent securities. This prevents the frictions from causing these households to become heterogeneous, so the representative agent framework is still valid for this type of household.

[10] Note that $\overline{W}^p_{i,t}$ and $\overline{W}^f_{i,t}$ are not hourly wages, but wages over a period (here, one quarter).

represents transfers from the government and firms, $SCS_{i,t}$ is the household's net cash income from participating in state-contingent securities. The government collects labor income taxes τ^w to finance unemployment benefits ϖ_t.

Country risk premium In equation (3), the term $R^*_{t-1}\Phi(A_{t-1}, \tilde{\phi}_{t-1})$ represents the risk-adjusted gross interest rate paid by foreign bonds (in foreign currency). The function $\Phi(.)$ captures the country risk premium function of the real aggregate net foreign asset position $A_t \equiv \frac{S_t B^*_{t+1}}{P_t}$ and a time-varying shock to the risk premium $\tilde{\phi}_t$.[11] This function illustrates the imperfect integration in the international financial markets of the domestic economy and induces stationarity of the model.[12] Therefore, domestic households are charged a premium over the (exogenous) foreign interest rate R^*_t if the domestic economy is a net borrower ($B^*_t < 0$), and receive a lower remuneration on their savings if the domestic economy is a net lender ($B^*_t > 0$).

Capital accumulation Capital and investment are sector-specific. Capital accumulation is subject to investment adjustment costs. In the primary sector, it follows that

$$K^p_{t+1} = (1-\delta)K^p_t + \Upsilon_t \left(1 - \phi_i \left(\frac{I^p_t}{I^p_{t-1}} - 1\right)^2\right) I^p_t, \tag{4}$$

where δ is the depreciation rate and ϕ_i governs the investment adjustment cost. The variable Υ_t is a stationary investment-specific technology shock common to both sectors. The secondary sector capital accumulation rule is similar.

Investment basket The investment good in the primary sector is a CES aggregate of domestic ($I^{d,p}_t$) and imported investment inputs ($I^{m,p}_t$)

$$I^p_t = \left[(1-\omega_i\varepsilon_{m,t})^{1/\eta}(I^{d,p}_t)^{(\eta-1)/\eta} + (\omega_i\varepsilon_{m,t})^{1/\eta}\,(I^{m,p}_t)^{(\eta-1)/\eta}\right]^{\eta/(\eta-1)}, \tag{5}$$

where ω_i is the steady-state share of imports in investment. The investment basket in the secondary sector is similar.

[11] The function $\Phi(A_t, \tilde{\phi}_t) = \exp(-\tilde{\phi}_A(A_t - \overline{A}) + \tilde{\phi}_t)$ is strictly decreasing in A_t and satisfies $\Phi(\bar{A}, 0) = 1$. In particular, Adolfson et al. (2007) set $\bar{A} = 0$.

[12] See Schmitt-Grohe and Uribe (2003).

3.1.2 Financially excluded households

There is a continuum of EHs of mass 1 indexed by $e \in (0,1)$ with preferences given by (1). These households do not have access to financial and capital markets. Financial exclusion has two components. First, they are excluded from insurance markets and therefore unable to hedge against labor market idiosyncratic risks. Second, bond and capital markets exclusion implies that they are unable to transfer wealth inter-temporally. They consequently consume their entire labor income in every period as in Mankiw (2000).[13] Their budget constraint is given by

$$P_t^c C_{e,t} = (1-\tau^w)\left(\overline{W}_{e,t}^p N_{e,t}^p + \overline{W}_{e,t}^f N_{e,t}^f\right) + \left(1 - N_{e,t}^p - N_{e,t}^f\right)\varpi_t \ , \tag{6}$$

where $\overline{W}_{e,t}^p$ and $\overline{W}_{e,t}^f$ are wages in the primary and secondary sectors, respectively. This specification allows for heterogeneity in households' wages and introduces unemployment benefits ϖ_t.

3.2 Firms

There are two categories of goods: primary commodities and secondary products. The latter are either domestically produced or imported.

3.2.1 Commodity sector

The commodity good is produced under perfect competition in the domestic economy. The representative firm combines capital and labor to produce a commodity input Y_t^p and sell its products on the world market. The production function is given by

$$Y_t^p = Y_0^p \left(\frac{K_t^p}{K_0^p}\right)^{\alpha_p} \left(\frac{\varepsilon_{l,t} L_t^p}{L_0^p}\right)^{(1-\alpha_p-\beta_p)} , \tag{7}$$

where the terms Y_0^p, K_0^p and L_0^p are normalizing constants and only represent choices of units. The term ε_t^l is a labor-augmenting productivity shock common to the primary and secondary sectors, K_t^p is capital used in the mining sector and $L_t^p = \int_0^1 N_{i,t}^p H_{i,t}^p \mathrm{d}i + \int_0^1 N_{e,t}^p H_{e,t}^p \mathrm{d}e$ is the amount of labor in the primary sector. The income shares of capital and labor are given by

[13] With this respect, EHs are akin to the rule-of-thumb households introduced in Coenen and Straub (2005), Erceg et al. (2006) and Galí et al. (2007) and used in the context of developing and emerging economies by Medina and Soto (2007), Céspedes et al. (2012) and Prasad and Zhang (2015).

α_p and $1-\alpha_p-\beta_p$, respectively. Therefore, β_p captures decreasing returns to scale.[14] The commodity sector captures the impact of world commodity prices on the domestic economy. The world real commodity price $\frac{P_t^{p*}}{P_t^*}$ is driven by an exogenous ARMA(1,1) process.

3.2.2 Final good sector

The structure of the secondary sector can be arranged in three steps: *i)* production of an undifferentiated secondary good, *ii)* its differentiation with brand-naming technology and finally *iii)* its aggregation into consumption or investment good. Step one is performed by a secondary good producer. Steps two and three depend on intermediate and final distributors operating in the domestic, import and export markets, which introduce Calvo (1983) price stickiness.

Secondary good producer The secondary good is produced under perfect competition. The representative firm uses capital K_t^f and hires labor L_t^f to produce an undifferentiated secondary good denoted Y_t^f. The production function for the secondary good is given by

$$Y_t^f = Y_0^f \left(\frac{K_t^f}{K_0^f}\right)^{\alpha_f} \left(\frac{\varepsilon_{l,t} L_t^f}{L_0^f}\right)^{(1-\alpha_f)}, \tag{8}$$

where the terms Y_0^f, K_0^f and L_0^f are normalizing constants and only represent choices of units, α_f is the capital income share and labor is given by $L_t^f = \int_0^1 N_{i,t}^f H_{i,t}^f \mathrm{d}i + \int_0^1 N_{e,t}^f H_{e,t}^f \mathrm{d}e$.

Domestic distributors There are two types of domestic distributors: intermediate and final. There is a continuum of intermediate distributors, indexed by $j \in [0,1]$. Each intermediate distributor buys a homogeneous secondary good Y^f; turns it into a differentiated intermediate good (using a brand naming technology) and then sells it to a final distributor at price $P_{j,t}$. Every intermediate distributor is assumed to be a price taker in the secondary good markets (purchasing secondary goods at their marginal costs) and a monopoly supplier of its own variety (setting its own price).

The intermediate distributor follows a price adjustment rule à-la Calvo (1983). Every period t, with probability $(1-\xi_d)$, any intermediate distributor j is allowed to re-optimize its price by choosing the optimal price P_t^{new}.[15] With probability ξ_d, it cannot re-optimize,

[14] Decreasing returns to scale control the elasticity of commodity supply. It captures fixed production factors such as the stock of natural resources or land.

[15] Since all distributors allowed to reset their prices are virtually identical and will always choose the same price, the index j is dropped to simplify the notation. This price is subject to a standard cost-push shock

and it simply indexes its price for period $t+1$ according to the following rule:

$$P_{j,t+1} = (\pi_t)^{\kappa_d}(\overline{\pi})^{1-\kappa_d} P_{j,t},$$

where $\pi_t = \frac{P_t}{P_{t-1}}$ is the previous period's inflation rate, $\overline{\pi}$ is the inflation target; κ_d is an indexation parameter.

The final distributor is an aggregator which uses a continuum of differentiated intermediate goods to produce the final homogeneous good, which is then used for consumption and investment by domestic households and sold at price P_t. The final distributor is assumed to have the following CES production function:

$$J_t^d = \left[\int_0^1 \left(J_{j,t}^d\right)^{\frac{\epsilon_d - 1}{\epsilon_d}} dj\right]^{\frac{\epsilon_d}{\epsilon_d - 1}}, \ 1 < \epsilon_d, \tag{9}$$

where $J \in (C, I)$ refers to the consumption or investment good and ϵ_d is the elasticity of substitution between intermediate inputs. Consequently, the relative demand for a type j input is given by

$$J_{j,t}^d = \left(\frac{P_{j,t}}{P_t}\right)^{-\epsilon_d} J_t^d \ , \tag{10}$$

where P_t is the price index defined by

$$P_t = \left[\int_0^1 P_{j,t}^{1-\epsilon_d} dj\right]^{\frac{1}{1-\epsilon_d}} . \tag{11}$$

Exporting distributors The intermediate exporting firm buys a homogeneous domestic good Y^f from domestic secondary producers, turns it into a type-specific differentiated good using a brand naming technology and then sells it on the foreign market to an aggregator at price $P_{j,t}^x$ expressed in foreign currency.

Domestic intermediate exporting firms follow a Calvo price-setting rule and can optimally change their price only when they receive a random signal. In any period t, each exporting firm has a probability $(1-\xi_x)$ of re-optimizing its price by choosing $P_{new,t}^x$. With probability ξ_x, the importing firm cannot re-optimize at time t and, instead, it indexes its price according to the following formula: $P_{j,t+1}^x = (\pi_t^x)^{\kappa_x}(\overline{\pi})^{1-\kappa_x} P_{j,t}^x$ where $\pi_t^x = \frac{P_t^x}{P_{t-1}^x}$. This foreign currency price stickiness assumption implies short-run incomplete exchange rate pass-through to the export price.

described in the appendix.

The aggregator produces final exported goods sold at price P_t^x abroad. The final exported good aggregates a continuum of j differentiated exported goods, each supplied by a different firm, according to

$$X_t^f = \left[\int_0^l (\tilde{X}_{j,t})^{\frac{\epsilon_x - 1}{\epsilon_x}} dj \right]^{\frac{\epsilon_x}{\epsilon_x - 1}} , \; 1 < \epsilon_x \; , \tag{12}$$

where ϵ_x is the elasticity of substitution between intermediate inputs. Foreign demand for the aggregate final exported good is defined by

$$X_t^f = \left(\frac{P_t^x}{P_t^*} \right)^{-\eta_f} \varepsilon_{x,t} \; , \tag{13}$$

where $P_t^x = \left[\int_0^1 (P_{j,t}^x)^{1-\epsilon_x} dj \right]^{\frac{1}{1-\epsilon_x}}$ is the export price (denominated in export market currency). P_t^* is the price of the foreign good in foreign currency and $\varepsilon_{x,t}$ captures a foreign demand shock. The coefficient η_f is the foreign elasticity of substitution between foreign and domestic goods and allows for short-run deviations from the law of one price.

Importing distributors The (foreign-owned) intermediate importing firm buys a homogeneous foreign good in the world market at an exogenous price P_t^*. It turns it into a type-specific good using a differentiating technology (brand naming) and then sells it in the domestic market to an aggregator at price $P_{j,t}^m$.

Foreign intermediate importing firms follow a Calvo price-setting rule and can optimally change their price only when they receive a random signal. In any period t, each importing firm has a probability $(1 - \xi_m)$ of re-optimizing its price by choosing $P_{new,t}^m$[16]. With probability ξ_m, the importing firm cannot reoptimize at time t and, instead, it indexes its price according to the following formula: $P_{j,t+1}^m = (\pi_t^m)^{\kappa_m} (\overline{\pi})^{1-\kappa_m} P_{j,t}^m$ where $\pi_t^m = \frac{P_t^m}{P_{t-1}^m}$. This local currency price stickiness assumption implies incomplete exchange rate pass-through to the consumption and investment import prices.

The aggregator produces final imported consumption and investment goods sold at price P_t^m to households.[17] These goods are aggregated using a continuum of j differentiated imported goods. Each is supplied according to

[16] All importing firms that are allowed to re-optimize their price, in a given period, will choose the same price, therefore it is not necessary to use a firm index

[17] This assumption departs from Adolfson et al. (2007) by assuming that the imported good price is the same for both investment and consumption.

$$J_t^m = \left[\int_0^l (J_{j,t}^m)^{\frac{\epsilon_m - 1}{\epsilon_m}} dj \right]^{\frac{\epsilon_m}{\epsilon_m - 1}}, \ 1 < \epsilon_m, \quad (14)$$

where $J \in (C, I)$ and ϵ_m is the elasticity of substitution between intermediates in the imported consumption and investment sectors.

3.3 Labor market

I introduce SAM frictions with staggered wage bargaining following Gertler and Trigari (2009) and Thomas (2008). SAM frictions imply that vacancies are not automatically filled and they generate equilibrium unemployment. Staggered wage bargaining introduces wage dispersion and inertia. In this paper, I consider two sectors. Households employed in a particular sector cannot work in the other sector and do not search for another job. Unemployed households are perfectly mobile and search for jobs in both sectors. IHs and EHs are identical in term of skills and perfectly substitutable, both at the intensive and extensive margin.

3.3.1 Employment and the matching process

Here, I describe the matching process. Unemployed households search for jobs. Firms post vacancies to attract new workers and cannot discriminate between IHs and EHs. Therefore, IHs' and EHs' employment rates are identical. For the sake of simplicity, I focus on the primary sector. It is straightforward to extend these assumptions to the secondary sector.

The matching function In every period, some unemployed households are matched with firms. The number of matches in the primary sector is given by

$$M_t^p = \sigma_{m,p} (U_t)^{\sigma_m} (V_t^p)^{1-\sigma_m} , \quad (15)$$

where $\sigma_{m,p}$ is a scaling parameter and σ_m is the elasticity of matches to unemployment. The variable U_t is the unemployment level ($U_t/2$ is the unemployment rate) and V_t^p is the number of vacancies posted in the primary sectors. From this matching function, it is convenient to define the vacancy-filling rates:

$$q_t^p = \frac{M_t^p}{V_t^p} = \sigma_{m,p} \left(\frac{U_t}{V_t^p} \right)^{\sigma_m} , \quad (16)$$

as well as the job-finding rate:

$$p_t^p = \frac{M_t^p}{U_t} = \sigma_{m,p} \left(\frac{V_t^p}{U_t} \right)^{1-\sigma_m} . \tag{17}$$

Employment In every period, matches have an exogenous probability δ_n to break. Therefore, the law of motion of aggregate employment in the primary sector is

$$N_t^p = (1-\delta_n) N_{t-1}^p + M_t^p. \tag{18}$$

Vacancy posting and search costs Unemployed households are searching for a job at no cost. The cost of posting vacancies for a firm in the primary sector is given by

$$\frac{\chi_p}{1+\theta} \left(V_t^p \right)^{1+\theta} P_t + \varepsilon_{v,t} V_t^p P_t \ , \tag{19}$$

where χ_p is a scaling parameter and $\theta > 0$ implies that the cost is convex. The vacancy cost shock $\varepsilon_{v,t}$ is an exogenous AR(1) process with a mean equal to zero. In the secondary sector, the number of matches (M_t^f), the vacancy-filling rate (q_t^f), the job-finding rate (p_t^f), the law of motion of employment (N_t^f) and the vacancy posting cost are analogous to equations (15), (16), (17), (18) and (19), respectively.

3.3.2 Wage-setting and hours

The labor contract specifies the wage and hours worked. Hours are adjusted in every period to maximize the current global employment surplus - the sum of IH and EH employees and firms' surpluses - and identical for each household working in a particular sector. Wages are sticky and result from a staggered wage bargaining procedure. For simplicity, I here assume that firms and IHs bargain over wages, while EHs take the outcome of the bargain as given. A robustness exercise relaxes this assumption. In every period, a random fraction of previously employed IHs bargain with firms to share the IHs' employment surplus. An identical fraction of EHs take the outcome of this bargain as given and adjust their wage accordingly. Other previously employed IHs and EHs follow a partial indexation rule. When a match is formed, the new worker receives a wage randomly drawn from the present wage distribution.[18] Below, I focus on the primary sector. It is straightforward to extend these assumptions to the secondary sector.

[18] Since the firm hires a continuum of workers, it considers the aggregate wage for its vacancy posting decision.

Employees' surplus The IH i employee's surplus $S^p_{i,t}$ in the primary sector is defined by the contribution of the marginal job to household's lifetime utility expressed in monetary units. It is given by

$$\begin{aligned} S^p_{i,t} &= \frac{\partial \mathbb{W}_{i,t}}{\partial N^p_{i,t}} \left(\frac{1}{\upsilon_{i,t}}\right) \\ &= (1-\tau_w)\overline{W}^p_{i,t} - \varpi_t - \left[\frac{U(H^p_{i,t}) + A_n}{\upsilon_{i,t}} + \beta \frac{\upsilon_{i,t+1}}{\upsilon_{i,t}} \left(p^p_t S^{I,p}_{t+1} + p^f_t S^{I,f}_{t+1}\right)\right] \\ &+ (1-\delta_n)\beta \frac{\upsilon_{i,t+1}}{\upsilon_{i,t}} S^p_{i,t+1} , \end{aligned} \tag{20}$$

where $U(H^p_{i,t})$ is the disutility from hours worked and $\upsilon_{i,t}$ is the shadow value associated with constraint (3). The first two terms represent the nominal wage (net of tax) in excess to unemployment benefits. The terms in brackets are the relative disutility of labor efforts (expressed in monetary units) and the discounted expected value from searching for a job when unemployed. The latter depends on the probability of finding a job in the primary or secondary sectors and on the average employee's surplus in these sectors where $S^{I,p}_{t+1} = \int_0^1 S^p_{i,t+1} \mathrm{d}i$ and $S^{I,f}_{t+1} = \int_0^1 S^f_{i,t+1} \mathrm{d}i$. The final term is the discounted future employee's surplus conditional on keeping the job. The appendix shows how to derive expression (20).

Firms' surplus The present value of the representative firm's profits is given by:

$$\begin{aligned} \mathbb{P}^p_t &= P^p_t Y^p_t - \int_0^1 \overline{W}^p_{i,t} N^p_{i,t} \mathrm{d}i - \int_0^1 \overline{W}^p_{e,t} N^p_{e,t} \mathrm{d}e \\ &- \left(\frac{\chi_p}{1+\theta} \left(V^p_t\right)^{1+\theta} P_t + \varepsilon_{v,t} V^p_t P_t\right) - R^{k,p}_t K^p_t + \beta \frac{\upsilon_{t+1}}{\upsilon_t} \mathbb{P}^p_{t+1}, \end{aligned} \tag{21}$$

where the first term represents revenues, the second and third terms are the wages paid to IHs and EHs, respectively, the fourth term is the vacancy posting cost, the fifth term is the cost of renting capital and the final term is the discounted value of future profits. The firm's surplus from employing an IH i is given by

$$Z^p_{i,t} = \frac{\partial \mathbb{P}^p_t}{\partial N^p_{i,t}} = P^p_t \frac{\partial Y^p_t}{\partial N^p_{i,t}} - \overline{W}^p_{i,t} + (1-\delta_n)\beta \frac{\upsilon_{t+1}}{\upsilon_t} Z^p_{i,t+1} \tag{22}$$

where the first term is the value of output produced by this additional employee; the second term is the employee's wage cost and the final term is the firm's expected discounted future surplus conditional on keeping the worker.

Wage bargaining In every period, a fraction $1-\xi_w$ of IHs employed in the primary and secondary sectors receive a random signal to bargain over wages. The outcome of the bargain between firms and IHs in the primary sector consists in splitting the total employment surplus $S^{I,p*}_{t+s}+Z^{I,p*}_{t+s}$. In this expression, stars refer to contracts negotiated at time t. The optimal wage $\bar{W}^{p*}_t$ implies that workers receive a fraction $1-\omega_{w,t}$ of this surplus over the expected contract duration. An identical fraction $1-\xi_w$ of EHs reset their wages to $\bar{W}^{p*}_t$. See the appendix for more details on the computations.[19]

Wage indexation Any IH i (and any EH e) working in the primary sector that do not bargain at time t follow an indexation mechanism described by

$$\bar{W}^p_{i,t}=\left(\pi^c_{t-1}\right)^{\kappa_w}\left(\bar{\pi}\right)^{1-\kappa_w}\bar{W}^p_{i,t-1}\ , \tag{23}$$

such that wages are indexed to past CPI inflation $\pi^c_{t-1}=\frac{P^c_{t-1}}{P^c_{t-2}}$ and to the inflation target $\bar{\pi}$. The wage-indexation parameter κ_w determines the relative importance of past CPI inflation in the indexation process.

Hours decision Hours worked in every period in the primary sector maximize the overall present employment surplus. Therefore, the optimal level of hours $H^p_{i,t}$ equalizes the value of the marginal product of labor (expressed in utility term with firms' owners discount factor) $P^p_t\frac{\partial Y^p_t}{\partial N^p_{i,t}}\upsilon_t$ to the household marginal disutility from hours worked $\frac{\partial U(H^p_{i,t})}{\partial H^p_{i,t}}$. Hours worked are thus independent of wages and indentical for IHs and EHs because they share the same utility function and hours are separable in the utility function.

3.4 Public authorities

The public sector comprises a central bank and a government.

Central bank The monetary authority follows a simple Taylor rule:

$$R_t=\rho_r R_{t-1}+(1-\rho_r)\left(R+\tau_{\pi,c}\left(\pi^c_t-\bar{\pi}\right)-\tau_U\left(\frac{U_t-\bar{U}}{2}\right)+\tau_{\pi,w}\left(\pi^w_t-\bar{\pi}\right)\right)+\epsilon_{R,t}, \tag{24}$$

where ρ_r is the interest rate smoothing parameter, $\tau_{\pi,c}$ is the response to current CPI inflation deviation from its target $\bar{\pi}$, τ_U is the response to unemployment deviation from its target $\bar{U}$

[19] The assumption that only IHs are included in the wage bargaining greatly simplifies computations because they share the same discount factor with the firms.

and $\tau_{\pi,w}$ is the response to wage inflation. The exogenous process $\epsilon_{R,t}$ is a monetary policy shock.

Government The government follows a simple public consumption rule:

$$G_t = \rho_g G_{t-1} + (1 - \rho_g)\bar{G} + \varepsilon_{g,t}, \tag{25}$$

where $\bar{G}$ is the steady-state value of public consumption and $\varepsilon_{g,t}$ is a public consumption shock. Government consumption is composed of domestic goods only and financed via lump-sum transfers paid by IHs.

The government distributes labor income taxes to the unemployed. Therefore, each unemployed household receives

$$\varpi_{i,t} = \tau^w \left(\frac{\bar{W}_t^p N_t^p + \bar{W}_t^f N_t^f}{U_t} \right). \tag{26}$$

This rule produces pro-cyclical social transfers at a minimal cost in term of complexity. Indeed, it has no impact on EHs' aggregate consumption dynamics and it preserves Mankiw (2000)'s prediction: EHs' aggregate consumption level depends on aggregate labor income. Moreover, the government balances its budget in every period, which allows to abstract from government debt. In the robustness section, I present three alternative assumptions for the employees' outside option.

3.5 Closing market conditions and definitions

In equilibrium, the goods, labor and bond markets have to clear. The final goods aggregate resource constraint reads:

$$\left(C_t^d + I_t^d + G_t\right) \upsilon_t^d + X_t^f \upsilon_t^x \leq Y_t^f. \tag{27}$$

where

$$\upsilon_t^d = \int_0^1 \left(\frac{P_{i,t}}{P_t}\right)^{-\epsilon_d} di \tag{28}$$

is a measure of domestic price dispersion causing an input loss in the domestic distribution process (9), and

$$\upsilon_t^x = \int_0^1 \left(\frac{P_{i,t}^x}{P_t^x}\right)^{-\epsilon_x} di \tag{29}$$

is a measure of export price dispersion causing an input loss in the export distribution process (12). Those two price dispersion measures are bounded from below one. They imply that price dispersion increases the amount of inputs Y^f required to produce domestically consumed goods C^d, I^d or G and exported goods X^f.

The domestic bond market clears when the demand for liquidity from households equals the monetary injection by the central bank. Since the central bank money supply is perfectly inelastic at its policy rate, it is not necessary to define it. The foreign bond market clears when the positions of the exporting and importing firms equal the households' choice of foreign bond holdings. The net foreign asset position changes according to:

$$S_t B_{t+1}^* = R_{t-1}^* \Phi\left(A_{t-1}, \tilde{\phi}_{t-1}\right) S_t B_t^* + S_t\left(P_t^x X_t^f + P_t^{*p} Y_t^p\right) - P_t^m\left(C_t^m + I_t^m\right) \ , \tag{30}$$

Finally, the GDP identity is defined by

$$Y_t = C_t + I_t + G_t + X_t - M_t \ , \tag{31}$$

where $I_t = I_t^p + I_t^f$; $X_t = X_t^f + Y_t^p$ and $M_t = C_t^m + I_t^m$.

3.6 Aggregate welfare

This section introduces IHs and EHs' aggregate utility and describes the effect of idiosyncratic risks on EHs' utility. Details are presented in the appendix.

IHs' aggregate utility The aggregate utility level for IHs is given by $\mathbb{U}_t^I = \int_0^1 \mathbb{U}_{i,t} \mathrm{d}i$, which can be expressed as a function of aggregate variables:

$$\mathbb{U}_t^I = \frac{\left(C_t^I\right)^{1-\sigma_c} - 1}{1-\sigma_c} - \frac{N_t^p}{2}\left(\frac{A_h (H_t^p)^{1+\sigma_h}}{1+\sigma_h} + A_n\right) - \frac{N_t^f}{2}\left(\frac{A_h (H_t^f)^{1+\sigma_h}}{1+\sigma_h} + A_n\right) \ , \tag{32}$$

where C_t^I is the IHs' aggregate consumption level and $\frac{N_t^p}{2}$ and $\frac{N_t^f}{2}$ represent the share of IHs employed in the primary and secondary sectors, respectively.

EHs' aggregate utility EHs' aggregate level of utility is given by $\mathbb{U}_t^E = \int_0^1 \mathbb{U}_{e,t} de$, which can be expressed as:

$$\begin{aligned}\mathbb{U}_t^E &= \frac{N_t^p}{2}\frac{\left(C_t^{E,P}\right)^{1-\sigma_c}\upsilon_t^{cp}-1}{1-\sigma_c}+\frac{N_t^f}{2}\frac{\left(C_t^{E,F}\right)^{1-\sigma_c}\upsilon_t^{cf}-1}{1-\sigma_c}+\frac{U_t}{2}\frac{\left(C_t^{E,U}\right)^{1-\sigma_c}-1}{1-\sigma_c} \\ &- \frac{N_t^p}{2}\left(\frac{A_h(H_t^p)^{1+\sigma_h}}{1+\sigma_h}+A_n\right)-\frac{N_t^f}{2}\left(\frac{A_h(H_t^f)^{1+\sigma_h}}{1+\sigma_h}+A_n\right),\end{aligned} \tag{33}$$

where $C_t^{E,P}$, $C_t^{E,F}$ and $C_t^{E,U}$ represent the average consumption level of EHs employed in the primary sector, employed in the secondary sector or unemployed, respectively. Sectoral aggregate wage differences and unemployment risks thus directly affect EHs utility, via different consumption levels. Moreover, the terms υ_t^{cp} and υ_t^{cf} capture the impact of labor income dispersion within the primary and secondary sectors on EHs' aggregate utility, respectively. These terms account for staggered wage bargaining risks.[20] They are given by:

$$\upsilon_t^{cp} = \int_0^1 \left(\frac{\bar{W}_{e,t}^p}{\bar{W}_t^p}\right)^{(1-\sigma_c)} de. \tag{34}$$

$$\upsilon_t^{cf} = \int_0^1 \left(\frac{\bar{W}_{e,t}^f}{\bar{W}_t^f}\right)^{(1-\sigma_c)} de. \tag{35}$$

At steady-state, when all individual wages $\bar{W}_{e,t}$ are equal to the market average $\bar{W}_t$, these terms are equal to one. When $0 < \sigma_c < 1$, these terms are bounded from above one. If all individual wages are not identical, these terms are strictly smaller than one, which implies a welfare loss in equation (33). When $\sigma_c > 1$, these terms are bounded from below one. If all individual wages are not identical, these terms are strictly larger than one, which also implies a welfare loss in equation (33) because the $(1-\sigma_c)$ denominator takes a negative value.

4 Empirical Methodology

This section sets out the methodology. First, it outlines the estimation methods. Second, it presents the different shocks used in the estimation, to compute the welfare cost of business cycles and to perform monetary policy experiments. Third, it defines the measures used to express the welfare costs and to rank alternative policies.

[20] Note that in contrast to Erceg et al. (2000), there is no hours dispersion in this framework.

4.1 Bayesian estimation

The model is estimated with Bayesian methods (e.g. DeJong et al., 2000; Otrok, 2001; and Schorfheide, 2000)[21]. This section presents the dataset, the value of some key estimated parameters, their identification, and the value of some other calibrated parameters.

4.1.1 Data

The model is estimated with Bayesian methods using 10 domestic and 2 foreign variables. The dataset includes domestic GDP; private consumption; investment; exports and imports; employment; consumer price index; aggregate wage index; risk-free rate; and nominal effective exchange rate. Foreign variables include the US risk-free rate and a commodity price index measured as an average of world coal, platinum, silver, gold and aluminum prices. This index includes important South African commodities. Data range from 1994Q1 to 2017Q4 to exclude the apartheid period in South Africa (characterized by political and economic instability).[22] Data sources and transformations are presented in table 15.

4.1.2 Estimated parameters

The priors and posteriors of estimated parameters are reported in table 5. Some estimated parameters deserve particular attention. Nominal price and wage rigidities are crucial since they reduce firms' and households' ability to adjust their prices and wages to business cycle fluctuations. They generate price and wage dispersions that are costly in term of welfare. The mode of the domestic price Calvo parameter ξ_d is 0.78 which implies an average price duration of 4.5 quarters. Wages are relatively sticky: $\xi_w = 0.91$. This implies an average wage duration of two years and three quarter (conditional on the fact that the worker keeps his job).[23] The estimated Taylor rule coefficients show that the SARB responded to inflation fluctuations ($\tau_{\pi,c}$=1.71), which is consistent with its mandate and the introduction of inflation targeting. In addition, changes in interest rates were smooth (ρ_r=0.85). The response to unemployment deviation from its target is small ($\tau_u = 0.08$). At the estimation stage, I set $\tau_{\pi,w}$=0. The methodologies proposed by Andrle (2010) and Iskrev (2010) implemented in Dynare were used to check parameters identification.

[21] Using DYNARE. See Adjemian et al. (2011).

[22] Houssa et al. (2019) also experiment stopping in 2009Q1 to avoid most of the zero lower bound period in the US (which is difficult to capture with a simple Taylor rule) as well as starting in 2000Q1 which corresponds to the introduction of formal inflation targeting in South Africa. Estimated parameters were relatively stable.

[23] The unconditional duration is 6.5 quarters. This takes both renegotiation and exogenous separation probabilities into account.

4.1.3 Calibrated parameters

Some other parameters are calibrated (see table 4). Considering the crucial role of the labor market in this paper, I elaborate on the calibration of this sector. The equilibrium unemployment rate is calibrated to 10%. Although the unemployment rate in South Africa remained close to 25% over the estimation period, more than 60% of the jobless are classified as long-term unemployed (OECD data and Banerjee et al., 2008). Calibrating the unemployment rate to 10% therefore offers a better description of the transitory unemployment dynamics generated by the model. The land share β_p is calibrated to 0.31 to ensure that the mining sector represents 11% of GDP while it only accounts 6.7% of the labor force, on average (South African Chamber of Mines). The (quarterly) separation rate δ_n is calibrated to 0.07 based on the labor market transition probabilities in Anand et al. (2016). These assumptions generate a job-finding rate of 4% and 59% in the primary and secondary sectors. The scaling parameters $\sigma_{m,p}$ and $\sigma_{m,f}$ in the matching function are adjusted so that the probability of filling a vacancy equals 0.5 at steady state. χ_p and χ_f are set such that the employment surplus amounts to 5% of the wage. The labor income tax rate τ_w is calibrated to 5%, which implies that unemployment benefits amount to 45% of the wage at steady state. The workers' share of the employment surplus ω_w and the matching elasticity to unemployment σ_m are calibrated to 0.5 following Gertler and Trigari (2009). The curvature parameter in the vacancy posting cost function θ is set to 1 following Thomas (2008). The disutility from holding a job A_n adjusts such that the above calibration hold at steady state. The relative importance of labor in utility A_h is calibrated so that agents devote 30% of their time to labor activities and only represents a choice of unit.

Some other parameters deserve particular attention. First, the foreign interest rate elasticity to net foreign asset position ϕ_a captures the degree of integration of the emerging economy in global financial markets. As ϕ_a decreases, the cost of international risk-sharing falls and so does the welfare cost of business cycles. In the baseline, I use $\phi_a = 10^{-3}$ following Schmitt-Grohe and Uribe (2003). In robustness exercises, I first follow Adolfson et al. (2007) and set ϕ_a to 0.01 and then follow Brzoza-Brzezina and Kotlowski (2016) and set ϕ_a to 10^{-4}. Second, the input demand elasticity ϵ_d influences the output wastes in equations (28) and (29) generated by inflation volatility. In the baseline, I follow Schmitt-Grohe and Uribe (2007) and use a value of 5. In a robustness exercise, I set this parameter to 10. All other parameters are calibrated to match the mean of observed variables.

4.2 Structural shocks

Table 1 reports the 13 innovations analyzed in this paper.

Table 1: Structural shocks

	Symbol	Process	Est.	WC	MP	RS	Description
Foreign							
Interest rate	R_t^*	ARMA(1)	✓	✓	✓		Exogenous foreign interest rate
Commodity	$\frac{P_t^{p*}}{P_t^*}$	ARMA(1)	✓	✓	✓	✓	Exogenous commodity price
SOE							
UIP	$\tilde{\phi}_t$	AR(1)	✓			✓	Country risk premium
Imp. volume	$\varepsilon_{m,t}$	AR(1)	✓				Change in home bias
Exp. volume	$\varepsilon_{x,t}$	AR(1)	✓	✓	✓		Change in foreign demand
Domestic							
Wedge	$\varepsilon_{b,t}$	AR(1)	✓	✓	✓		Private sector risk-premium
Gov. cons.	$\varepsilon_{g,t}$	AR(1)	✓	✓	✓		Government consumption
Inv. spe.	Υ_t	AR(1)	✓	✓	✓		Investment efficiency shock
Monetary policy	$\varepsilon_{R,t}$	IID	✓	✓			Deviation from Taylor rule
Productivity	$\varepsilon_{l,t}$	AR(1)				✓	Labor-augmenting productivity
Cost-push	$\varepsilon_{d,t}$	AR(1)	✓	✓	✓	✓	Cost-push shock (final good)
Wage bargaining	$\omega_{w,t}$	AR(1)	✓	✓	✓	✓	Change in bargaining power
Vacancy cost	$\varepsilon_{v,t}$	AR(1)	✓	✓	✓	✓	Vacancy posting cost

I use twelve shocks in the estimation stage, which matches the number of observed variables. The labor-augmenting productivity shock is excluded from the estimation stage because hours are not available in the data.[24] Ten shocks are used to compute the welfare costs of business cycles. At this stage, I additionally exclude the import volume shock as this shock directly enters households' preferences. I also exclude the UIP shock. With a low foreign interest rate elasticity to the net foreign asset position, this shock generates unrealistic net foreign asset accumulation by IHs in the long run. When evaluating monetary policies, I additionally exclude the monetary policy shock, thereby reducing the number of innovations to nine for this specific step. In robustness exercises, I isolate the effect of each aggregate supply shock. They consist of labor-augmenting productivity, cost-push, wage bargaining and vacancy cost shocks. Their analysis is of particular importance as they entail a trade-off between employment and inflation stabilization. I also consider commodity price shocks which are important drivers of business cycle fluctuations in many emerging economies such as South Africa.

[24] Labour inputs can be adjusted at the intensive and extensive margins. Hours worked by employee - in addition to employment - are thus necessary to identify TFP as a residual between output and the use of productive inputs.

4.3 Welfare measures

The welfare cost of business cycles This paper measures the welfare cost of business cycle fluctuations using a second-order approximation to the model (Schmitt-Grohe and Uribe, 2004).[25] The welfare cost of business cycles is defined along the lines of Lucas (1987) as the share of consumption that an agent would be ready to give up in every period to insulate the economy from all shocks and therefore eliminate aggregate fluctuations. This measure is provided for the two categories of households. A second-order approximation implies that the variance of shocks can have an impact on the mean of endogenous variables. This could make the volatile environment artificially attractive if, for example, precautionary motives encourage capital accumulation. Conditional welfare measures are therefore computed. They solve this issue by imposing that all simulations (i.e. with or without shocks) start from the same initial point (including the same value of capital). In this paper, this common starting point is the deterministic steady state. Unconditional welfare cost measures are also reported. They can be interpreted as the long-term cost of business cycles.

Comparison of simple policy rules This paper also explores potential welfare gains from alternative monetary policy rules. It focuses on simple and implementable monetary rules (Schmitt-Grohe and Uribe, 2007). Those rules determine the response of policy variables as a function of a small number of easily observable macroeconomic indicators (such as inflation and unemployment) and deliver uniqueness of the rational expectation equilibrium. As such, they include the rule advocated by Taylor (1993) as well as many modified versions proposed in the literature. A simple evaluation of conditional aggregate welfare measures would be enough to rank alternative policy rules. However, conditional compensation measures are also provided to assess the magnitude of the difference in welfare. It is defined as the fraction of consumption that an agent would be ready to abandon to be transferred from the benchmark economy to an alternative economy. The computations are provided in appendix D.

5 Empirical Results

This section presents the results. First, it computes the welfare cost of business cycle fluctuations. Second, it evaluates optimal simple monetary policy rules.

[25] The literature has also used the linear-quadratic approach of Benigno and Woodford (2005) and Benigno and Woodford (2012). Although this approach delivers a closed form (as a function of deep parameters) solution to the welfare loss function, the complexity of this model would make computation difficult.

5.1 Welfare costs of business cycles and the role of financial markets

In this section, I measure the welfare cost of business cycles for IHs and EHs. As set out in the model section, EHs are exposed to three different types of labor income idiosyncratic risks: unemployment, sectoral wage differences and staggered wage bargaining. To quantify and isolate the impact of each type of labor market idiosyncratic risk, I additionally compute the welfare cost of business cycles under three different scenarios. First, I remove staggered wage bargaining risks, by assuming that every EHs can share their income with their peers working in the same sector. Second, I also eliminate average sectoral wage difference risks, by assuming that all employed EHs can share their income. Finally, I remove all types of idiosyncratic risk - including unemployment risk - by allowing all EHs to share their income.[26]

Table 2: Welfare cost of business cycle fluctuations

Welfare Effects	Cdt cost	relative to IH	Uncdt cost	relative to IH
IH	1.253	1.000	0.573	1.000
EH	4.215	3.364	4.380	7.642
EH (sectoral)	2.978	2.377	3.005	5.243
EH (work)	2.973	2.373	2.998	5.231
EH (full)	0.810	0.646	0.597	1.041

Note: Welfare costs expressed as percentage points of (permanent) steady-state consumption. Conditional costs in the first column assume that the stochastic economy initially starts from its deterministic steady state. Unconditional costs in the third column. Second and fourth columns report relative conditional and unconditional costs expressed as a fraction of IHs' cost, respectively.

Table 2 reports the welfare cost of business cycle fluctuations. The welfare cost is substantially larger for EHs. While the welfare cost represents 1.25% of steady-state consumption for IHs, it is as high as 4.21% for EHs. When EHs can share risks with their peers working in the same sector, the welfare cost of business cycles declines to 2.98%. Therefore, the inability to insure against staggered wage bargaining risks generating wage dispersion in each sector exacerbates the welfare costs of business cycles for about 1.2 percentage point of steady-state consumption. When they are additionally able to share risks with all employed households, thereby canceling out sector-specific wage differentials, the welfare cost of business cycles barely changes (it only declines by 0.005 percentage points). Sectoral differences in average wages therefore seem to play a marginal role. Third, when all EHs share risks, the welfare

[26] The utility in equation (33) is therefore re-evaluated with $\upsilon_t^{cp} = \upsilon_t^{cf} = 1$ and $C_t^{RP} \neq C_t^{RF} \neq C_t^{RU}$ to remove staggered wage bargaining risks, with $\upsilon_t^{cp} = \upsilon_t^{cf} = 1$ and $C_t^{RP} = C_t^{RF} \neq C_t^{RU}$ to additionally cancel out sectoral wage differences and $C_t^{RP} = C_t^{RF} = C_t^{RU}$ and $\upsilon_t^{cp} = \upsilon_t^{cf} = 1$ to eliminate all forms of idiosyncratic risk (including unemployment).

cost of business cycles drops to 0.81%. This substantial drop indicates that unemployment risks are crucial.

How does the business cycle interact with unemployment idiosyncratic risks to produce large welfare losses? In short, business cycle fluctuations increase both the probability of occurrence and the severity of the unemployment risk. Business cycle fluctuations actually push up the average unemployment rate. This mechanism derives from the curvature of the matching function and from the empirical negative correlation between the unemployment rate and job-finding rates. Moreover, business cycle fluctuations make employees' outside options more volatile. In the baseline scenario, unemployment benefits are tied to labor income tax receipts (equation 26). As an illustration, imagine that a recession hits the economy. The recession raises the unemployment rate and lowers labor income tax receipts, which implies that unemployment benefits are cut. Consequently, it is worse to be laid off during a recession.[27] Since their consumption levels are very low when unemployed, they are ready to pay a large premium to reduce the probability of occurrence of unemployment and to avoid further consumption volatility if the unemployment risk materializes.[28]

The staggered wage bargaining risk also amplifies the welfare cost of business cycle fluctuations for EHs, for at least two reasons. First, inflation fluctuations affect real wages, for workers who are not allowed to reset their wages. Second, the timing of negotiations matters, as the value of the employment surplus changes over the business cycle. Indeed, a typical business cycle downturn leads to a drop in the value of the employment surplus. For households facing negotiations, wages are cut. These risks generate income and consumption dispersion for EHs and translate into sizeable welfare losses. The least important idiosyncratic risk is the sectoral aggregate wage difference. In the bargaining framework, the aggregate wage in one sector influences wage-setting in the other sector via its impact on employees' outside options. Average wages in the primary and secondary sectors are therefore highly correlated.[29] Moreover, only a small fraction of workers are employed in the primary sector. This makes the effects of risk-sharing between sector marginal.

When EHs are able to eliminate all three types of idiosyncratic risks, their welfare cost of business cycle fluctuations drops to a low value, which could even be lower than the cost

[27] Other arguments have been developed in the literature to show that it is worse to be laid off during recessions. Notably, Krusell et al. (2009) recognize that prolonged periods of unemployment - which are more likely during recessions - exhaust poor households' savings with large welfare effects. In robustness exercises, I consider two alternatives which deliver similar results.

[28] In a related framework, Santis (2007) argues that eliminating aggregate fluctuations might bring large welfare gains when agents already face substantial idiosyncratic risks because the welfare cost of consumption fluctuations is an increasing and convex function of the total amount of risk.

[29] This is especially true in this model, as I do not introduce sector-specific shocks.

experienced by IHs. It therefore seems that capital and bond markets exclusion does not amplify the welfare cost of business cycles for households having access to the insurance markets. In this specific case, exclusion from bond and capital markets does not increase consumption volatility and consequently does not raise the welfare cost of business cycle fluctuations. Three characteristics of the model provide an explanation. First, aggregate consumption is usually more volatile than output in emerging markets. However, EHs' aggregate consumption follows aggregate labor incomes and therefore cannot be much more volatile than GDP. It implies that IHs' consumption volatility increases to match the aggregate consumption volatility.[30] Second, there are important risks linked to holding any type of assets (such as capital and foreign assets), which can make IHs' aggregate incomes more volatile. Third, IHs own the firms and are therefore directly exposed to the input waste related to price dispersion.

A few words of caution relate to the interpretation of this latter result. This paper does not provide any evidence on the effects of bond and capital markets exclusion when households have no access to insurance. It would require a third category of households - having access to bonds and capital but excluded from state-contingent asset markets - that cannot be accommodated in a typical DSGE model.[31] In this framework, one would expect bonds to play a crucial role as a self-insurance tool. Moreover, this latter result does not mean that bond and capital markets exclusion does not generate inequality. In this model, it actually does: IHs enjoy a higher average consumption level.

Finally, I evaluate the welfare costs of some specific shocks, taken one at a time in sequence, while setting all other shocks to zero. This exercise reveals that wage bargaining and vacancy cost shocks are much more costly for EHs compared to IHs. These shocks directly increase labor income idiosyncratic risks and thus disproportionately affect EHs. In contrast, cost-push shocks are very costly for IHs, while they could be welfare increasing for EHs.[32] Because IHs own the firms, they directly pay for the output loss related to price dispersion in equation (28). Commodity price shocks, which are important drivers of business cycle fluctuations in many emerging markets (including South Africa), are very costly to both IHs and EHs. Alone, they represent a welfare loss equivalent to 0.53 and 1.21% of consumption for IHs and EHs, respectively.

[30] Bhattacharya and Patnaik (2016) find a similar result.

[31] Idiosyncratic risks would make this type of agent heterogeneous with respect to capital and bond holdings and the representative agent framework would break. An option be to assume that this type of agent follows simple rules of thumb for their savings decisions.

[32] More details on the welfare costs of cost-push shocks are provided in the next section.

5.2 Optimal simple monetary policy rules

Different degrees of exposure to different types of risk - such as unemployment and staggered wage bargaining risks - generate different preferences regarding the conduct of monetary policy. In this section, I show that IHs favor stronger policy responses to CPI inflation deviation from target, while EHs benefit the most from unemployment and wage stabilization.

For this purpose, I evaluate optimal simple rules from the point of view of IHs and EHs, denoted as IH-OSR and EH-OSR, respectively. I restrict my attention to monetary policy rules responding to CPI inflation, wage inflation, and unemployment deviations from their respective targets while allowing for interest rate smoothing, as described in equation (24). The parameter ρ_r is restricted to the $[0, 0.95[$ interval to avoid hyper-persistent policies. The sum of $\tau_{\pi,c}$, τ_u and $\tau_{\pi,w}$ is constrained to be smaller than 10. As argued by Schmitt-Grohe and Uribe (2007), excessively large coefficients could be difficult to communicate to the public. Moreover, $\tau_{\pi,c} > 1.1$ ensures that the Taylor principle holds and that Blanchard Kahn conditions are met. Finally, since monetary policy shocks reduce welfare, these shocks are set to zero. In a first step, I compare optimal simple rules when the economy is driven by a large variety of domestic and foreign demand and supply shocks, which is meant to capture the South African business cycle. In a second step, I describe how, according to each category of agents, monetary policy should respond to specific supply shocks (including cost-push, wage bargaining, vacancy cost and TFP shocks) and to commodity price shocks. Results are presented in table 3. In order to dig into the underlying mechanisms, the impact of IH-OSR and EH-OSR on the mean and variance of some key variables is compared to benchmark rules in tables 9 to 14. Figures 1 to 5 show the IRFs for each of the shocks considered, for different monetary policy rules.

Baseline scenario In the baseline economy driven by all types of shocks, the IH-OSR requires a strong response to CPI inflation fluctuations ($\tau_{\pi,c} = 8.9$), with a small weight on unemployment ($\tau_u = 0.89$) and almost no response to wage inflation ($\tau_{\pi,w} = 0.19$). In contrast, the EH-OSR places a larger weight on unemployment ($\tau_u = 5.01$) and wage inflation ($\tau_{\pi,w} = 3.7$), and a smaller weight on CPI inflation ($\tau_{\pi,c} = 1.13$). This simple experiment shows a stark contrast in monetary policy preferences for IHs and EHs. These differences relate to the interaction between business cycle fluctuations, labor income idiosyncratic risks and monetary policies. Indeed, monetary policies responding to unemployment fluctuations mitigate the unemployment idiosyncratic risk, while monetary policies responding to wage inflation mitigate the staggered wage bargaining risk. These policies therefore (disproportionately) benefit EHs. Table 9 documents the impact of different types of policy (such as

Table 3: Optimal simple rules

Baseline	ρ_r	$\tau_{\pi.c}$	τ_u	$\tau_{\pi.w}$	Cost: IH	Cost: EH
IH-OSR	0.263	8.901	0.895	0.189	0.704	3.734
EH-OSR	0.528	1.128	5.011	3.702	1.462	1.844
Cost-push	ρ_r	$\tau_{\pi.c}$	τ_u	$\tau_{\pi.w}$	Cost: IH	Cost: EH
IH-OSR	0.354	9.954	0.044	0.001	0.239	0.470
EH-OSR	0.001	1.100	8.896	0.000	0.837	-0.609
Wage bargain	ρ_r	$\tau_{\pi.c}$	τ_u	$\tau_{\pi.w}$	Cost: IH	Cost: EH
IH-OSR	0.900	2.199	1.651	6.130	0.057	1.890
EH-OSR	0.528	1.111	5.411	3.470	0.181	1.474
Vacancy cost	ρ_r	$\tau_{\pi.c}$	τ_u	$\tau_{\pi.w}$	Cost: IH	Cost: EH
IH-OSR	0.001	7.681	0.000	2.293	0.022	0.549
EH-OSR	0.571	1.100	2.705	6.195	0.205	0.099
Commodity Price	ρ_r	$\tau_{\pi.c}$	τ_u	$\tau_{\pi.w}$	Cost: IH	Cost: EH
IH-OSR	0.948	1.105	0.197	0.005	0.416	1.038
EH-OSR	0.875	1.102	5.090	0.002	0.494	0.770
TFP	ρ_r	$\tau_{\pi.c}$	τ_u	$\tau_{\pi.w}$	Cost: IH	Cost: EH
IH-OSR	0.252	8.059	1.673	0.176	0.294	0.157
EH-OSR	0.572	2.957	6.391	0.543	0.301	0.135

Note: Optimal coefficients in columns one to four. Fifth and last columns report conditional welfare costs for IH and EH related to each policy rules, respectively.

the IH-OSR and the EH-OSR, but also policies that aggressively respond to CPI inflation, unemployment or wage inflation) on the mean and variance of key variables (such as inflation and unemployment). It shows that policies aiming at stabilizing wage inflation reduce wage dispersion. This has a positive impact on employed EHs' consumption volatility (at the individual level). It also shows that unemployment stabilization policies lower replacement income volatility, which reduces unemployed EHs' consumption volatility. This type of policy additionally lowers the average unemployment rate by mitigating the adverse effects of business cycles on the average employment rate. Therefore, EHs prefer unemployment and wage inflation stabilization because those policies mitigate their exposure to idiosyncratic risks in the labor market. In contrast, inflation stabilization policies mitigate the inefficient price dispersion, which disproportionately benefits IHs who own the firms. Therefore, IHs place more weight on CPI inflation stabilization. In what follows, I evaluate the IH-OSR and EH-OSR to specific shocks and describe the mechanisms driving these results.

Cost-push shocks The IH-OSR fully commits to inflation stabilization when the economy faces cost-push shocks. This is a standard result. In contrast, the EH-OSR places a minimal weight on CPI inflation stabilization ($\tau_{\pi,c} = 1.1$) and a large weight on the unemployment rate ($\tau_u = 8.9$). Figure 1 compares the IRFs to cost-push shocks with the IH-OSR and the EH-OSR (to a baseline with $\rho_r = 0.85$, $\tau_{pi} = 1.5$ and $\tau_U = \tau_w = 0$). As expected, a stronger response to CPI inflation stabilizes prices, which benefits IHs, but generates more unemployment volatility, which disproportionately hurts EHs due to their exposure to unemployment risks. In contrast, employment stabilization policies increase inflation volatility, which in turn generates inefficient price dispersion affecting IHs who own firms, but mitigates EHs' unemployment risks, via a reduction in the mean and variance of the unemployment rate. It should be noted that cost-push shocks have a peculiar impact on EHs' welfare. They could actually be welfare enhancing for EHs. This is driven by the endogenous IHs' response to cost-push shocks. Indeed, these shocks encourage IHs to work extra hours and to accumulate more capital, as a precautionary strategy to compensate for the output loss related to price dispersion (see table 10). This increases the marginal productivity of employees, drives up wages and eventually EHs' average consumption levels. By exacerbating price dispersion, monetary poly rules targeting the unemployment rate can therefore increase EHs' average consumption levels.

Wage bargaining shocks On the one hand, the IH-OSR to wage bargaining shocks requires a large weight on wage inflation stabilization ($\tau_{\pi,w} = 6.13$) and smaller weights on

CPI inflation and unemployment ($\tau_{\pi,c} = 2.2$ and $\tau_u = 1.65$). This strategy focuses on the source of the shock. Figure 2 and table 11 show that the IH-OSR still toterate substantial price and IH consumption fluctuations, due to the relatively large weight on unemployment, but reduces the average unemployment rate. Among the 5 rules displayed in table 11, the IH-OSR is the only one that reduces the average unemployment (and mitigates the drop in IH average consumption level) at a relatively low cost in term of inflation volatility. On the other hand, the EH-OSR consists of an aggressive unemployment stabilization policy ($\tau_u = 5.41$). It also places an important weight on wage inflation ($\tau_{\pi,w} = 3.47$), but a minimal weight on CPI inflation ($\tau_{\pi,c} = 1.11$). Figure 2 shows that the EH-OSR exacerbates inflation volatility, but mitigate fluctuations of real wages and unemployment rates. They therefore reduce employed and unemployed EHs' consumption fluctuations. Moreover, this type of shock has a substantial impact on the level of unemployment, which makes employment stabilization policies more desirable, especially for EHs (see table 11). Also note that a policy which stabilizes wage inflation brings some benefits, as it reduces employed EHs' consumption dispersion. A strong response to wage inflation would, however, increase the unemployment mean and variance. This encourages EHs to place a larger weight on unemployment fluctuations, even when the economy is driven by wage bargaining shocks.

Vacancy cost shocks When the economy is driven by vacancy cost shocks, the IH-OSR has a large weight on CPI inflation fluctuations ($\tau_{\pi,c} = 7.68$), a small weight on wage inflation ($\tau_{\pi,w} = 2.29$) and no weight on unemployment. This, again, contrasts with the EH-OSR which gives more weight to wage inflation and unemployment ($\tau_{\pi,w} = 6.19$ and $\tau_u = 2.7$) than to CPI inflation ($\tau_{\pi,c} = 1.1$). Figure 3 and table 12 show a strong trade-off between CPI inflation and unemployment stabilization objectives. When vacancy costs are low, policies aiming at stabilizing the unemployment rate can only discourage employment creation through higher interest rates, which generate a relatively large drop in IHs' consumption, a large appreciation and a large decline in prices. Due to the staggered wage bargaining process, this drop in prices generates an increase in real wages. This increase in real wages in turn boosts EHs' consumption demand and mitigates the impact of the initial monetary policy tightening. Unemployment stabilization therefore comes at a heavy cost to IHs in the form of a large increase in IHs' consumption and price volatilities. This explains why IHs prefer not to accommodate unemployment fluctuations. In contrast, EHs still favor a relatively strong unemployment stabilization policy, because the drop in employment volatility compensates for the increase in employed EHs' aggregate consumption volatility.

Commodity price shocks I now turn to commodity price shocks. In this case, the IH-OSR shows a gradual ($\rho_r = 0.95$) and moderate response to both CPI inflation and unemployment fluctuations ($\tau_{\pi,c} = 1.1$ and $\tau_u = 0.2$). The EH-OSR has a larger weight on unemployment fluctuations ($\tau_{\pi,c} = 1.1$ and $\tau_u = 5.09$). The low weight on CPI inflation in the IH-OSR may come as a surprise. However, because commodity price shocks behave as aggregate demand shocks (see figure 4), policy rules responding to the unemployment rate can also stabilize CPI inflation as long as τ_u is not too large. In terms of inflation and unemployment volatility, the impact of the IH-OSR is similar to the anti-inflation rule (with $\rho_r = 0.85$, $\tau_{\pi,c} = 5$ and $\tau_u = \tau_{\pi,w} = 0$) in table 13. The main difference between these two rules is that the IH-OSR has one additional benefit: it reduces the average unemployment rate. EHs prefer to place a larger weight on unemployment fluctuations. Therefore, the EH-OSR generates more inflation volatility, but less unemployment volatility. It should also be noted that commodity price shocks potentially cause large welfare losses for both IHs and EHs. These shocks therefore trigger precautionary savings for IHs. These precautionary savings nevertheless take a different form compared to cost-push shocks. In this case, IHs accumulate more foreign bonds, but less primary sector capital. This strategy lowers their exposure to commodity price fluctuations.

TFP shocks Although TFP shocks are not introduced in the estimation, I evaluate the optimal policy response to TFP shocks in the final good sector as a robustness exercise. I calibrate the variance of this shock to 1% and the autoregressive coefficient to 0.99 to generate persistent TFP fluctuations. In this case, the IH-OSR shows a large weight on CPI inflation stabilization ($\tau_{\pi,c} = 8.06$) and lower weights on unemployment and wage inflation ($\tau_u = 1.67$ and $\tau_{\pi,w} = 0.18$). In contrast, the EH-OSR has larger weights on unemployment ($\tau_u = 6.39$) compared to CPI and wage inflation ($\tau_{\pi,c} = 2.04$ and $\tau_{\pi,w} = 0.54$).

6 Model validation and robustness checks

Moments and income dispersion To evaluate the welfare costs of business cycle fluctuations and the impact of monetary policies, the model should be able to generate realistic business cycle fluctuations and income dispersion. Table 6 shows that the estimated model reproduces the South Africa business cycle. Indeed, the variance, auto-correlation and correlation with GDP of aggregate simulated and observed variables are similar (with the notable exception of trade and foreign variables). In particular, co-movements between key variables such as GDP, CPI inflation, employment, wage inflation and the policy rate are well approximated by the model. Moreover, the model generates labor income dispersion. The South African National Income Dynamics Study (NIDS) database provides information on labor market income at the household level. Ranchhod (2013) describes this database and computes the average within-individual coefficient of variation to argue that income is very volatile at the household level in South Africa.[33] He reports a value of 0.64 using the first three waves of the NIDS. The present model generates a within-individual coefficient of variation of 0.33 for labor incomes (assigning a zero wage to the unemployed). The model therefore captures a substantial fraction of income dispersion, while leaving some scope for other factors not included in the model (such as different skill levels).

Calibration I perform a robustness analysis to changes in the value of some calibrated parameters such as the risk-premium elasticity to the net foreign asset position (ϕ_a) and to the input demand elasticity (ϵ_d). Moreover, I test the impact of external multiplicative habit formation in consumption (introduced by Abel, 1990 and Gali, 1994).[34] Results are reported in tables 7 and 8. Conclusions remain qualitatively unchanged: EHs want to place a larger weight on unemployment and wage inflation stabilization. In particular, an increase in ϵ_d encourages IHs to place a larger weight on CPI inflation, which exacerbates the trade-off faced by the monetary authority. Changes in ϕ_a do not seem to affect the optimal simple rules' weights, although it has a substantial impact on IHs' welfare through their ability to smooth consumption using foreign bond markets. External habits lower the welfare costs of business cycles for both IHs and EHs because they mitigate the effect of lower aggregate consumption level caused by the lower average employment level that accompanies business cycle fluctuations in search and matching models. The impact of external habits on the optimal simple rule remains limited.

Temporary unemployment benefits as the outside option I perform a robustness exercise using an alternative assumption governing unemployed households' outside options. I now consider temporary unemployment benefits. For a maximum of two periods, unemployed households receive a fraction of the wage they received prior to entering unemployment given by $\varpi_{i,t} = 0.5\bar{W}_{i,t-1}$. Households entering long-term unemployment lose their unemployment benefits but receive a minimal level of transfer calibrated to 25% of EHs' level of consumption at steady state. This assumption fits the South African institutional frame-

[33] The within-individual coefficient of variation takes, for each individual, the ratio of its standard deviation in income (over time) to its average income.

[34] I use multiplicative habit instead of additive habit because the latter would complicate the aggregation of EHs' welfare.

work described in the appendix. As expected, the assumption governing the outside option has a minor impact on IHs. Note, however, that this rule exacerbates IHs' consumption volatility, which causes an increase in their welfare costs, and a small increase on the weight assigned to unemployment fluctuations in their preferred rule. In contrast, EHs experience smaller consumption fluctuations, which causes a small drop in their welfare costs. This assumption has an important effect on the EH-OSR. Indeed, as unemployment benefits are tied to wages, wages dispersion causes unemployment benefits dispersion, and wage inflation stabilization becomes their primary concern. In this case, the monetary authority faces a trade-off between CPI and wage inflation stabilization.

The informal sector as the outside option Next, I assume that the government does not provide unemployment benefits, but that the unemployed work in the informal sector. Each unemployed household inelastically supplies x units of a home production good C_t^H which enters the consumption basket (2) as follows:
$C_{i,t} = \left[(1-\omega_c-\omega_h)^{1/\eta}(C_{i,t}^d)^{(\eta-1)/\eta} + (\omega_c)^{1/\eta}(C_{i,t}^m)^{(\eta-1)/\eta} + (\omega_h)^{1/\eta}(C_{i,t}^h)^{(\eta-1)/\eta}\right]^{\eta/(\eta-1)}$.
I calibrate ω_h such that the value of home production represents 50% of the wage in the formal sector at steady state. Under this assumption, there is an interaction between the unemployment rate and the value of the replacement income. For example, an increase in the unemployment rate raises the supply of the home good and therefore pushes down its price, reducing the value of households' home production. In this case, the IH-OSR and EH-OSR are similar to the baseline.

Counter-cyclical unemployment benefits As demonstrated in Michaud and Rothert (2018), social transfers tend to be pro-cyclical in emerging markets, while they are counter-cyclical in advanced economies. How much would the results in this paper be affected by counter-cyclical unemployment benefits? I perform a simple experiment where the government pays a CPI-indexed transfers to the unemployed allowing each unemployed EHs to purchase a constant amount of consumption goods. In this case, the welfare cost of business cycle is reduced for EHs because business cycle fluctuations do not affect EHs consumption when unemployed. This also reduces the importance of the unemployment risk, and thus reduces the weight of unemployment in the EH-OSR. Counter-cyclical social transfers mitigate the trade-off between inflation and unemployment fluctuations faced by the monetary authority. In this case, EHs favor wage stabilisation policies which mitigate the staggered wage bargaining risk.

Optimizing EHs In this paper, I assumed that EHs are not involved in the wage bargain but rather take the outcome of the bargain as given. This assumption simplifies the resolution of the model and its exposition. To relax this assumption, EHs' wages are set by sharing the expected employment surplus (details are presented in the appendix).

Compared to the baseline, I document two main differences regarding EHs' wages. First, their steady-state level of wage is now lower because their outside option is worse compared to IHs (when unemployed, EHs can only consume their unemployment benefits, while IHs benefit from returns on bonds, capital and state contingent claims). Second, EHs wages are more volatile, because their outside option is more dependant on business cycle fluctuations. This is clearly illustrated by figure 6, which shows the dynamic response of EHs' wages to a monetary policy shock compared to the baseline.

What follows is that allowing EHs to bargain does not change the main results of the paper. I find that the welfare cost of business cycles remains elevated for EHs, and that it is due to their inability to insure against idiosyncratic risks in the labor market. The EH-OSR still implies unemployment and wage stabilization, while the IH-OSR focus on inflation. This monetary policy trade-off is even slightly stronger than in the baseline model, as shown in table 8. Also note that in this case, business cycles could be welfare increasing for IHs, because EHs respond to business cycle fluctuations by accepting lower wages on average, which increases the average employment level and allows IHs to maintain a higher average consumption level.

UIP shocks UIP shocks (affecting the exchange rate) are excluded from the baseline welfare and monetary policy analysis because they deliver peculiar results. Here, I describe their effects and show that the results are robust to their introduction. Surprisingly, I find that UIP shocks could be welfare increasing for both IHs and EHs, although it is more likely to be the case for IHs. These shocks encourage IHs to accumulate a lot of net foreign assets (about 125% of GDP when calibrating the UIP shock to its estimated mode) and generate term of trade appreciation. This allows IHs to increase their average level of consumption while at the same time reducing hours worked in the medium and long run.

How could these shocks be welfare increasing, for both IHs and EHs? Precautionary savings can explain the foreign assets accumulation. However, savings required to accumulate these assets have a detrimental impact on welfare in the short run, which should be captured by conditional welfare measures. Alone, they can not explain why UIP shocks are welfare increasing for IHs, and they do not directly help EHs. I propose two potential explanations. First, UIP shocks cause large import price fluctuations, which offer option effects, in the sense that households can take opportunity of low import prices to accumulate more capital (via imported investment inputs) and to consume more foreign goods when they are cheap.[35] Second, households do not internalize the effect of their net foreign asset position on the country risk premium and on the term of trade. It is also possible that UIP shocks, by generating precautionary savings in foreign assets, increase welfare via a reduction in the country risk premium and a term of trade appreciation. These explanations are coherent with the fact that UIP shocks cause substantial foreign asset accumulation and an appreciation in the term of trade. How does this help EHs, who do not accumulate net foreign assets? They also benefit from the term of trade appreciation. Moreover, in the short-run, IHs precautionary savings encourage job creation and reduces the unemployment risk faced EHs.

There is one crucial parameter driving these results: the risk premium elasticity to the net foreign asset position. When this parameter gets larger, UIP shocks cease to be welfare increasing. In this case, when IHs tries to accumulate foreign assets, the return on foreign asset decreases, which limits the efficiency of this strategy.

When evaluating the optimal monetary policy response to UIP shocks, I find that both IHs and EHs benefit from passive monetary policies, tolerating large fluctuations in the exchange rate, CPI and unemployment rate. However, including UIP shocks in the analysis do not change the main results. When the economy is driven by a large variety of shocks (including the UIP shock), EHs still favour stronger policy responses to unemployment and wage fluctuations. The weights on the IH-OSR and EH-OSR barely changes.

7 Conclusion

This paper measures the cost of business cycle fluctuations and the effects of alternative monetary policies in a small open emerging economy. It builds a large-scale NK-DSGE model with labor market idiosyncratic risks and imperfect capital and financial markets inclusion. It is applied to South Africa.

Results show that the welfare costs of business cycles are substantial in the emerging economy and that they are larger for households excluded from capital and financial markets. Their inability to hedge against unemployment and staggered wage bargaining risks is a key determinant of their welfare costs. It follows that different degrees of exposure to different types of risks generate divergent preferences regarding the conduct of monetary policy. On the one hand, more aggressive anti-inflation policy benefits households with access to

[35] Lester et al. (2014) and Cho et al. (2015) show that TFP shocks could be welfare enhancing in a RBC model and describe similar option effects.

financial markets. On the other hand, responding to unemployment and wage fluctuations is more likely to benefit households excluded from these markets. This trade-off faced by the monetary authority is robust to changes in the value of key parameters, to different assumptions governing unemployed households' replacement incomes and to different types of shocks driving the business cycle. In the three cases considered, which sequentially tie replacement incomes to aggregate labor incomes, to individual wages prior to entering unemployment, or to returns from working in an informal sector, IHs place more weight on CPI inflation stabilization, while EHs prefer unemployment and wage inflation stabilization. The relative weight assigned by EHs to these latter two objectives depends on the nature of the replacement income.

This paper draws on two strands of literature. On the one hand, representative agent NK-DSGE models can reproduce business cycle fluctuations, due to the rich set of shocks and frictions that were gradually introduced in these models, in an effort to match aggregate fluctuations. On the other hand, HANK models generate realistic income and consumption dispersion. However, their complexity limits the set of shocks, frictions and estimation methods that they can handle, which limits their ability to reproduce the business cycle. This paper offers a compromise, by exploring the effect of consumption dispersion, for households unable to accumulate wealth, in a large scale DSGE models that produce rich business cycle fluctuations.

Two crucial assumptions were made. First, I assume that a fraction of households are excluded from financial markets, thereby limiting their ability to eliminate idiosyncratic risks. Second, I also assume that these households are unable to accumulate wealth. Under these assumptions, it is possible to consider consumption dispersion in a large scale DSGE model. These assumptions, although very strong, are meant to capture the empirical importance of imperfect financial market inclusion and unequal wealth distribution that characterize emerging markets.

Finally, this paper raises different questions. First, considering the fact that large welfare costs of business cycles remain, especially for EHs, it would be interesting to consider the relative efficiency of fiscal policies. Second, there is a large body of literature evaluating optimal monetary policy responses to exchange rate fluctuations. This framework could easily be adjusted to address these questions, from the point of view of households included or excluded from financial markets.

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Table 4: Calibrated parameters and targets

Parameter	Description	Baseline
h	Hours devoted to work	0.3000
$\bar{\pi}$	Inflation rate target	1.0150
$\bar{U}/2$	Unemployment rate target	0.1000
R	Mean risk-free rate	1.0250
τ_w	Labor income tax	0.0500
δ	Capital depreciation rate	0.0200
α_p	Capital inc. share in prim. sector	0.3333
α_d	Capital inc. share in sec. sector	0.3333
y^p/y	Mining sector share in GDP	0.1100
$n^p/(n^p+n^f)$	Mining sector share in empl.	0.0670
ω_c	Imports share in consumption	0.2000
ω_i	Imports share in investment	0.5000
ω_x	Imports share in exports	0.4000
a/y	Foreign Debt to GDP ratio	0.0000
g/y	Gov. consumption to GDP ratio	0.1950
ϕ_a	Debt-elastic foreign interest rate	0.0001
$\kappa_d=\kappa_x=\kappa_m$	Price indexation	0.2000
ϵ_d	Input demand elasticity	5.0000
δ_n	Job separation rate	0.0700
θ	Vacancy costs elast.	1.0000
σ_m	Matching elast. to unempl.	0.5000
ω_w	Workers surplus	0.5000
κ_w	wage indexation	0.5000
σ_c	Cons. subst. elast.	2.0000
σ_l	Labor sup. elast.	2.0000

Table 5: Estimated shock processes and parameters

Shocks: Std	Description	Mode
ε_b	Wedge	0.0056
Υ	Inv. specific	0.1704
ε_R	Mon. Pol.	0.0022
ε_d	Cost-push	0.0394
ω_w	Wage bargain	0.1258
ε_v	Vacancy cost	0.0283
$\tilde{\phi}$	UIP	0.0091
ε_m	Import volume	0.0249
ε_x	Export volume	0.0490
R^*	Mon. Pol.*	0.0012
$\frac{P^{p*}}{P^*}$	Com. Price*	0.0649
Shocks: AR(1)	Description	Mode
ρ_b	Wedge	0.839
ρ_Υ	Inv. specific	0.469
ρ_d	Cost-push	0.521
$\rho_{\omega w}$	Wage bargain	0.205
ρ_v	Vacancy cost	0.727
ρ_ϕ	UIP	0.855
ρ_m	Import volume	0.900
ρ_x	Export volume	0.935
Shocks: ARMA(1)	Description	Mode
R^*	Mon. Pol.*: AR	0.936
R^*	Mon. Pol.*: MA	0.516
$\frac{P^{p*}}{P^*}$	Com. Price*: AR	0.959
$\frac{P^{p*}}{P^*}$	Com. Price*: MA	0.401
Shocks: correlation	Description	Mode
$\varepsilon_x, \varepsilon_m$	Corr($\varepsilon_x, \varepsilon_m$)	0.952
Structural parameters	Description	Mode
ξ_d	Calvo final good	0.785
ξ_m	Calvo impots	0.791
ξ_x	Calvo exports	0.827
ξ_w	Calvo wages	0.909
κ_w	Wage indexation	0.441
ϕ_i	Invest. adj. cost	7.481
η_f	Exports price elast.	0.677
η	Imports price elast.	1.215
Monetary policy	Description	Mode
ρ_r	Int. rate smooth.	0.845
τ_{π^c}	CB inflation resp.	1.709
τ_u	CB Unempl. resp.	0.085

Table 6: Moments: data vs DSGE model

	Std		AR(1)		Corr with GDP		Employment		CPI		Wages		Interest rate	
	DATA	DSGE	DATA	DSGE	DATA	DSGE	DATA	DSGE	DATA	DSGE	DATA	DSGE	DATA	DSGE
GDP	1.78	2.00	0.90	0.75	1.00	1.00	0.72	0.72	-0.06	-0.19	-0.09	0.06	0.05	-0.22
Employment	2.11	2.60	0.89	0.82	0.72	0.72	1.00	1.00	-0.05	-0.12	-0.30	-0.23	-0.11	-0.18
Private cons	2.47	2.39	0.94	0.70	0.83	0.67	0.75	0.63	-0.28	-0.35	-0.17	0.09	0.00	-0.30
Investment	6.47	7.29	0.88	0.88	0.62	0.27	0.59	0.20	0.15	-0.04	-0.07	0.03	0.16	-0.09
Publ. cons.	2.94	2.33	0.92	0.89	0.35	0.17	0.03	0.12	-0.06	-0.01	-0.11	0.00	-0.30	-0.06
Exports	6.69	6.64	0.62	0.70	0.65	0.36	0.54	0.21	-0.08	0.10	-0.06	0.07	0.14	0.04
Imports	8.55	6.87	0.80	0.75	0.71	0.07	0.65	0.10	-0.18	0.00	-0.04	0.09	-0.02	-0.04
CPI	2.35	2.77	0.84	0.86	-0.06	-0.19	-0.05	-0.12	1.00	1.00	0.38	0.51	0.50	0.73
Wages	2.89	3.29	0.71	0.81	-0.09	0.06	-0.30	-0.23	0.38	0.51	1.00	1.00	0.59	0.41
Interest rate	4.17	2.93	0.97	0.87	0.05	-0.22	-0.11	-0.18	0.50	0.73	0.59	0.41	1.00	1.00
NEER	5.76	6.44	0.22	-0.09	0.04	0.04	0.13	0.00	0.07	0.01	0.00	-0.03	0.09	-0.03
US int. rate	2.84	1.69	0.99	0.93	0.38	-0.04	0.21	0.04	0.21	0.07	0.30	-0.02	0.77	0.10
Com. price	17.52	25.07	0.81	0.93	0.49	0.06	0.32	0.09	-0.16	0.02	0.06	0.10	-0.12	0.09

Note: Moments of simulated (DSGE) variables based on an average over 50 rounds of 92 periods. Most variables expressed in YoY growth rate. Interest rates in level. NEER in QoQ growth rate.

Table 7: Welfare costs - sensitivity analysis

Habit	Cdt cost	relative to IH	Uncdt cost	relative to IH
IH	0.579	1.000	0.289	1.000
EH	3.898	6.735	4.122	14.261
EH (sectoral)	2.647	4.573	2.733	9.455
EH (work)	2.641	4.564	2.726	9.430
EH (full)	0.430	0.742	0.291	1.005
$\phi_a = 0.01$	Cdt cost	relative to IH	Uncdt cost	relative to IH
IH	1.622	1.000	1.822	1.000
EH	4.421	2.725	4.924	2.702
EH (sectoral)	3.186	1.964	3.559	1.953
EH (work)	3.182	1.962	3.554	1.950
EH (full)	0.886	0.546	1.085	0.595
$\phi_a = 0.0001$	Cdt cost	relative to IH	Uncdt cost	relative to IH
IH	0.835	1.000	-9.322	1.000
EH	4.021	4.816	1.981	-0.213
EH (sectoral)	2.781	3.331	0.539	-0.058
EH (work)	2.773	3.322	0.520	-0.056
EH (full)	0.714	0.856	-2.034	0.218
$\epsilon_d = 10$	Cdt cost	relative to IH	Uncdt cost	relative to IH
IH	2.333	1.000	1.636	1.000
EH	4.212	1.805	4.348	2.658
EH (sectoral)	2.969	1.272	2.965	1.813
EH (work)	2.963	1.270	2.958	1.808
EH (full)	0.915	0.392	0.626	0.382
$UB = f(wages)$	Cdt cost	relative to IH	Uncdt cost	relative to IH
IH	1.443	1.000	0.833	1.000
EH	3.419	2.370	3.584	4.305
EH (sectoral)	1.963	1.361	1.967	2.362
EH (work)	1.957	1.357	1.960	2.353
EH (full)	0.601	0.417	0.346	0.415
Informal sector	Cdt cost	relative to IH	Uncdt cost	relative to IH
IH	1.219	1.000	0.572	1.000
EH	3.583	2.940	3.668	6.410
EH (sectoral)	2.327	1.910	2.269	3.966
EH (work)	2.321	1.905	2.262	3.953
EH (full)	0.748	0.614	0.535	0.935
UB=constant	Cdt cost	relative to IH	Uncdt cost	relative to IH
IH	1.693	1.000	1.077	1.000
EH	2.079	1.228	2.069	1.920
EH (sectoral)	0.812	0.480	0.658	0.610
EH (work)	0.806	0.476	0.650	0.603
EH (full)	0.447	0.264	0.185	0.172
Optimizing EHs	Cdt cost	relative to OH	Uncdt cost	relative to OH
IH	0.002	-	-0.867	-
EH	3.961	-	4.217	-

Table 8: Optimal simple rules - sensitivity analysis

Habit	ρ_r	$\tau_{\pi,c}$	τ_u	$\tau_{\pi,w}$	Cost: IH	Cost: EH
IH-OSR	0.290	9.170	0.788	0.035	0.311	3.400
EH-OSR	0.000	1.100	4.475	4.423	0.677	1.705
$\phi_a = 0.01$	ρ_r	$\tau_{\pi,c}$	τ_u	$\tau_{\pi,w}$	Cost: IH	Cost: EH
IH-OSR	0.261	8.996	0.963	0.039	1.048	3.836
EH-OSR	0.533	1.105	5.140	3.725	1.805	1.916
$\phi_a = 0.0001$	ρ_r	$\tau_{\pi,c}$	τ_u	$\tau_{\pi,w}$	Cost: IH	Cost: EH
IH-OSR	0.257	8.900	0.858	0.224	0.314	3.653
EH-OSR	0.520	1.129	4.952	3.707	1.081	1.760
$\epsilon_d = 10$	ρ_r	$\tau_{\pi,c}$	τ_u	$\tau_{\pi,w}$	Cost: IH	Cost: EH
IH-OSR	0.100	9.552	0.430	0.013	1.129	4.292
EH-OSR	0.723	1.581	4.130	4.208	2.732	2.012
UB linked to wages	ρ_r	$\tau_{\pi,c}$	τ_u	$\tau_{\pi,w}$	Cost: IH	Cost: EH
IH-OSR	0.334	8.409	1.473	0.100	0.821	2.796
EH-OSR	0.411	1.103	2.828	3.188	1.349	1.976
Informal sector	ρ_r	$\tau_{\pi,c}$	τ_u	$\tau_{\pi,w}$	Cost: IH	Cost: EH
IH-OSR	0.329	8.110	0.981	0.837	0.686	3.042
EH-OSR	0.431	1.105	3.540	3.467	1.294	1.798
UB constant	ρ_r	$\tau_{\pi,c}$	τ_u	$\tau_{\pi,w}$	Cost: IH	Cost: EH
IH-OSR	0.384	8.107	1.830	0.044	0.949	1.831
EH-OSR	0.480	1.114	1.310	2.783	1.229	1.591
Optimzing EH	ρ_r	$\tau_{\pi,c}$	τ_u	$\tau_{\pi,w}$	Cost: IH	Cost: EH
IH-OSR	0.248	9.887	0.002	0.077	-0.722	4.154
EH-OSR	0.019	1.127	4.091	4.617	1.047	2.023

Table 9: Effects of alternative policy rules - all shocks

	Baseline		CPI Inflation		Unemployment		Wage inflation		IH OSR		EH OSR	
Welfare	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.
IH	1.693		0.989	0.713	1.438	0.260	1.138	0.563	0.704	0.998	1.462	0.236
EH	5.723		4.695	1.081	2.098	3.714	4.180	1.614	3.734	2.069	1.844	3.964
EH (sect.)	4.514		3.519	1.034	0.731	3.822	3.068	1.496	2.558	2.010	0.637	3.914
EH (work)	4.509		3.514	1.034	0.726	3.822	3.062	1.496	2.552	2.010	0.632	3.914
EH (full)	1.028		0.872	0.157	0.444	0.589	0.772	0.259	0.837	0.193	0.477	0.556
Pol. Obj.	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
π^c	-0.092	0.954	-0.007	0.559	0.038	1.255	-0.022	0.776	0.024	0.465	0.015	1.305
U	0.901	2.899	0.514	2.771	0.029	0.961	0.459	2.559	0.279	2.342	0.019	0.744
Utility	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
C^I	-1.033	2.971	-0.505	2.887	-0.887	2.637	-0.619	2.895	-0.299	3.269	-0.885	2.894
$C^{E.p}$	2.325	5.453	1.807	5.552	1.264	5.175	1.781	5.568	1.354	5.512	1.240	5.350
$C^{E.f}$	0.642	4.414	0.223	4.453	0.152	3.811	0.278	4.417	-0.096	4.362	0.105	3.987
$C^{E.u}$	-0.305	30.060	2.885	28.929	1.086	12.204	2.355	26.873	2.851	25.035	0.626	9.075
H^p	1.713	3.641	1.221	3.723	1.102	3.657	1.253	3.718	0.925	3.696	1.110	3.694
H^f	0.938	2.169	0.500	2.219	0.613	2.015	0.580	2.152	0.272	2.254	0.622	2.002
υ^{cp}	1.719		1.641		1.742		1.551		1.604		1.576	
υ^{cf}	1.657		1.580		1.742		1.482		1.552		1.532	
Dispersion	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
υ^d	0.415		0.188		0.602		0.291		0.115		0.623	
υ^x	0.179		0.181		0.196		0.189		0.186		0.201	
$\tilde{S}^p$	0.985		0.955		0.857		0.930		0.925		0.847	
$\tilde{S}^f$	0.344		0.328		0.309		0.326		0.318		0.304	
Stocks	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
K^p	-2.785	9.804	-2.593	9.598	-2.402	9.227	-2.571	9.470	-2.583	9.412	-2.452	9.161
K^f	-0.190	4.371	-0.141	4.227	-0.132	4.028	-0.113	4.171	-0.256	4.112	-0.138	3.981
A	22.285	47.533	22.109	46.821	20.884	45.932	21.663	46.777	21.984	46.657	21.067	45.813

Note: Baseline rule: $\rho_r = 0.85$, $\tau_{\pi,c} = 1.5$, $\tau_u = \tau_{\pi,w} = 0$. CPI inflation: $\rho_r = 0.85$, $\tau_{\pi,c} = 5$, $\tau_u = \tau_{\pi,w} = 0$. Unemployment: $\rho_r = 0.85$, $\tau_{\pi,c} = 1.5$, $\tau_u = 1.5$, $\tau_{\pi,w} = 0$. Wage inflation: $\rho_r = 0.85$, $\tau_{\pi,c} = 1.5$, $\tau_u = 0$, $\tau_{\pi,w} = 1.5$. IH-OSR and EH-OSR: see optimal coefficients' values in table 3. Most variables expressed in % deviation from their steady-state. Unemployment rate in percentage-point deviation from ss. $\tilde{S}^p$ and $\tilde{S}^f$ as percentage of investment lost as adjustment cost. A as a percentage of GDP at ss. Simulated moments based on 250 series of 100 periods.

Table 10: Effects of alternative policy rules - Cost-push shocks

	Baseline		CPI inflation		Unemployment		Wage inflation		IH OSR		EH OSR	
Welfare	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.
IH	0.476		0.350	0.127	0.646	-0.171	0.464	0.012	0.239	0.239	0.837	-0.365
EH	-0.351		-0.064	-0.287	-0.533	0.182	-0.325	-0.025	0.470	-0.825	-0.609	0.257
EH (sect.)	-0.360		-0.083	-0.277	-0.536	0.175	-0.335	-0.025	0.433	-0.798	-0.609	0.248
EH (work)	-0.360		-0.083	-0.277	-0.536	0.175	-0.335	-0.025	0.433	-0.798	-0.609	0.248
EH (full)	-0.471		-0.335	-0.136	-0.558	0.087	-0.458	-0.013	-0.057	-0.415	-0.600	0.128
Pol. Obj.	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
π^c	-0.002	0.628	-0.002	0.474	-0.010	0.782	-0.004	0.609	-0.004	0.269	-0.013	0.964
U	-0.011	0.717	0.024	0.939	-0.005	0.371	0.001	0.714	0.098	1.168	0.000	0.056
Utility	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
C^I	-0.220	0.740	-0.142	1.272	-0.343	0.322	-0.220	0.800	-0.058	2.363	-0.472	0.270
$C^{E.p}$	0.569	1.371	0.394	1.250	0.739	1.502	0.557	1.314	0.097	1.285	0.865	1.705
$C^{E.f}$	0.663	1.600	0.529	1.502	0.800	1.705	0.658	1.543	0.294	1.570	0.898	1.883
$C^{E.u}$	1.408	8.875	1.300	11.179	1.052	5.496	1.286	8.962	0.734	13.388	0.905	2.401
H^p	0.340	0.301	0.242	0.291	0.463	0.292	0.333	0.272	0.126	0.337	0.590	0.341
H^f	0.381	0.864	0.302	0.920	0.487	0.858	0.377	0.858	0.212	1.198	0.601	0.871
υ^{cp}	0.004		0.010		0.000		0.004		0.022		0.003	
υ^{cf}	0.013		0.025		0.003		0.013		0.049		0.001	
Dispersion	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
υ^d	0.218		0.140		0.303		0.207		0.055		0.417	
υ^x	0.007		0.006		0.010		0.007		0.006		0.013	
$\tilde{S}^p$	0.002		0.006		0.000		0.002		0.015		0.003	
$\tilde{S}^f$	0.004		0.009		0.000		0.004		0.019		0.001	
Stocks	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
K^p	0.308	0.205	0.250	0.237	0.260	0.184	0.276	0.167	0.107	0.353	0.225	0.243
K^f	0.526	0.244	0.430	0.264	0.544	0.219	0.496	0.242	0.246	0.236	0.592	0.240
A	-0.646	0.828	-0.597	1.840	-0.902	0.853	-0.750	0.923	-0.414	3.818	-0.804	1.769

Note: Baseline rule: $\rho_r = 0.85$, $\tau_{\pi,c} = 1.5$, $\tau_u = \tau_{\pi,w} = 0$. *CPI inflation:* $\rho_r = 0.85$, $\tau_{\pi,c} = 5$, $\tau_u = \tau_{\pi,w} = 0$. *Unemployment:* $\rho_r = 0.85$, $\tau_{\pi,c} = 1.5$, $\tau_u = 1.5$, $\tau_{\pi,w} = 0$. *Wage inflation:* $\rho_r = 0.85$, $\tau_{\pi,c} = 1.5$, $\tau_u = 0$, $\tau_{\pi,w} = 1.5$. *IH-OSR and EH-OSR: see optimal coefficients' values in table 3. Most variables expressed in % deviation from their steady-state. Unemployment rate in percentage-point deviation from ss.* $\tilde{S}^p$ *and* $\tilde{S}^f$ *as percentage of investment lost as adjustment cost.* A *as a percentage of GDP at ss. Simulated moments based on 250 series of 100 periods.*

Table 11: Effects of alternative policy rules - Wage bargain shocks

	Baseline		CPI inflation		Unemployment		Wage inflation		IH OSR		EH OSR	
Welfare	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.
IH	0.216		0.210	0.006	0.233	-0.017	0.188	0.028	0.057	0.159	0.181	0.035
EH	2.511		2.777	-0.274	1.578	0.948	2.536	-0.025	1.890	0.633	1.474	1.053
EH (sect.)	1.309		1.606	-0.301	0.227	1.085	1.428	-0.121	0.811	0.502	0.272	1.040
EH (work)	1.309		1.606	-0.301	0.227	1.085	1.428	-0.121	0.811	0.502	0.272	1.040
EH (full)	0.302		0.380	-0.078	0.188	0.114	0.372	-0.071	0.338	-0.037	0.221	0.081
Pol. Obj.	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
π^c	-0.002	0.128	-0.001	0.035	0.047	0.620	-0.009	0.152	0.021	0.336	0.026	0.594
U	0.318	1.358	0.361	1.552	0.021	0.265	0.322	1.470	0.118	1.166	0.021	0.389
Utility	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
C^I	-0.164	0.732	-0.158	0.901	-0.173	0.248	-0.138	1.162	-0.039	1.404	-0.127	1.009
$C^{E.p}$	0.214	3.102	0.212	3.274	-0.122	2.157	0.161	3.231	-0.087	2.967	-0.116	2.273
$C^{E.f}$	0.220	3.259	0.204	3.428	-0.050	2.307	0.141	3.359	-0.108	3.072	-0.100	2.388
$C^{E.u}$	-1.351	11.785	-1.194	13.550	-0.255	1.933	-1.251	12.702	-0.157	9.793	-0.257	2.067
H^p	0.213	0.811	0.231	0.901	0.077	0.353	0.208	0.841	0.078	0.689	0.074	0.389
H^f	0.195	1.081	0.207	1.149	0.089	0.744	0.183	1.058	0.057	0.882	0.069	0.656
υ^{cp}	1.474		1.449		1.607		1.377		1.335		1.461	
υ^{cf}	1.531		1.501		1.681		1.413		1.356		1.495	
Dispersion	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
υ^d	0.008		0.001		0.132		0.007		0.035		0.113	
υ^x	0.005		0.006		0.001		0.006		0.006		0.002	
$\tilde{S}^p$	0.006		0.009		0.000		0.011		0.010		0.002	
$\tilde{S}^f$	0.002		0.003		0.001		0.006		0.007		0.002	
Stocks	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
K^p	-0.204	0.700	-0.244	0.834	-0.078	0.229	-0.239	0.671	-0.163	0.374	-0.097	0.340
K^f	-0.057	0.397	-0.060	0.487	-0.056	0.215	-0.071	0.450	-0.063	0.276	-0.059	0.177
A	0.162	2.539	0.237	2.914	0.223	1.393	0.158	3.675	0.036	4.292	0.189	3.181

Note: Baseline rule: $\rho_r = 0.85$, $\tau_{\pi,c} = 1.5$, $\tau_u = \tau_{\pi,w} = 0$. CPI inflation: $\rho_r = 0.85$, $\tau_{\pi,c} = 5$, $\tau_u = \tau_{\pi,w} = 0$. Unemployment: $\rho_r = 0.85$, $\tau_{\pi,c} = 1.5$, $\tau_u = 1.5$, $\tau_{\pi,w} = 0$. Wage inflation: $\rho_r = 0.85$, $\tau_{\pi,c} = 1.5$, $\tau_u = 0$, $\tau_{\pi,w} = 1.5$. IH-OSR and EH-OSR: see optimal coefficients' values in table 3. Most variables expressed in % deviation from their steady-state. Unemployment rate in percentage-point deviation from ss. $\tilde{S}^p$ and $\tilde{S}^f$ as percentage of investment lost as adjustment cost. A as a percentage of GDP at ss. Simulated moments based on 250 series of 100 periods.

Table 12: Effects of alternative policy rules - Vacancy cost shocks

	Baseline		CPI inflation		Unemployment		Wage inflation		IH OSR		EH OSR	
Welfare	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.
IH	0.029		0.024	0.005	0.299	-0.272	0.029	-0.001	0.022	0.006	0.205	-0.177
EH	0.416		0.511	-0.095	0.158	0.258	0.409	0.006	0.549	-0.135	0.099	0.317
EH (sect.)	0.414		0.507	-0.094	0.145	0.270	0.408	0.006	0.546	-0.133	0.092	0.322
EH (work)	0.414		0.507	-0.094	0.145	0.270	0.408	0.006	0.546	-0.133	0.092	0.322
EH (full)	-0.064		-0.047	-0.016	0.016	-0.080	-0.065	0.002	-0.037	-0.027	-0.035	-0.029
Pol. Obj.	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
π^c	0.000	0.111	0.000	0.058	-0.019	0.625	-0.001	0.115	0.000	0.041	-0.013	0.522
U	-0.045	1.572	-0.035	1.657	0.007	0.688	-0.045	1.561	-0.030	1.681	-0.025	0.857
Utility	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
C^I	-0.015	0.191	-0.012	0.318	-0.194	0.984	-0.016	0.181	-0.011	0.415	-0.131	0.753
$C^{E.p}$	0.078	0.653	0.071	0.616	0.077	1.394	0.080	0.643	0.065	0.627	0.085	1.246
$C^{E.f}$	0.050	0.614	0.044	0.584	0.077	1.314	0.052	0.602	0.039	0.600	0.075	1.174
$C^{E.u}$	3.527	18.421	3.716	19.314	0.607	8.798	3.500	18.294	3.742	19.568	1.286	10.631
H^p	0.026	0.510	0.027	0.534	0.130	0.276	0.027	0.507	0.026	0.540	0.091	0.310
H^f	0.009	0.747	0.009	0.745	0.124	0.706	0.010	0.743	0.010	0.729	0.081	0.701
υ^{cp}	0.004		0.005		0.013		0.003		0.006		0.007	
υ^{cf}	0.002		0.004		0.016		0.002		0.005		0.009	
Dispersion	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
υ^d	0.006		0.002		0.130		0.006		0.001		0.091	
υ^x	0.002		0.002		0.000		0.002		0.003		0.000	
$\tilde{S}^p$	0.000		0.001		0.009		0.000		0.001		0.005	
$\tilde{S}^f$	0.000		0.001		0.009		0.000		0.001		0.005	
Stocks	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
K^p	0.038	0.057	0.028	0.085	-0.019	0.443	0.036	0.044	0.020	0.087	0.015	0.353
K^f	0.019	0.077	0.015	0.101	-0.023	0.398	0.017	0.064	0.012	0.098	0.000	0.314
A	0.051	0.656	0.050	0.511	0.374	2.985	0.047	0.663	0.049	0.529	0.309	2.468

Note: Baseline rule: $\rho_r = 0.85$, $\tau_{\pi,c} = 1.5$, $\tau_u = \tau_{\pi,w} = 0$. CPI inflation: $\rho_r = 0.85$, $\tau_{\pi,c} = 5$, $\tau_u = \tau_{\pi,w} = 0$. Unemployment: $\rho_r = 0.85$, $\tau_{\pi,c} = 1.5$, $\tau_u = 1.5$, $\tau_{\pi,w} = 0$. Wage inflation: $\rho_r = 0.85$, $\tau_{\pi,c} = 1.5$, $\tau_u = 0$, $\tau_{\pi,w} = 1.5$. IH-OSR and EH-OSR: see optimal coefficients' values in table 3. Most variables expressed in % deviation from their steady-state. Unemployment rate in percentage-point deviation from ss. $\tilde{S}^p$ and $\tilde{S}^f$ as percentage of investment lost as adjustment cost. A as a percentage of GDP at ss. Simulated moments based on 250 series of 100 periods.

Table 13: Effects of alternative policy rules - Commodity price shocks

	Baseline		CPI inflation		Unemployment		Wage inflation		IH OSR		EH OSR	
Welfare	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.
IH	0.616		0.585	0.032	0.482	0.134	0.553	0.064	0.416	0.200	0.494	0.123
EH	1.598		1.324	0.278	0.789	0.815	1.139	0.464	1.038	0.565	0.770	0.835
EH (sect.)	1.569		1.306	0.267	0.783	0.793	1.127	0.448	1.021	0.555	0.764	0.812
EH (work)	1.564		1.301	0.267	0.779	0.792	1.122	0.448	1.016	0.555	0.759	0.812
EH (full)	0.864		0.811	0.054	0.749	0.116	0.776	0.089	0.807	0.058	0.757	0.108
Pol. Obj.	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
π^c	0.003	0.116	0.001	0.022	0.024	0.307	0.006	0.084	0.042	0.060	0.024	0.387
U	0.194	1.106	0.163	0.907	0.008	0.227	0.116	0.720	0.016	0.863	0.001	0.067
Utility	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
C^I	-0.517	1.767	-0.504	1.705	-0.429	1.645	-0.478	1.671	-0.376	1.711	-0.438	1.652
$C^{E.p}$	0.933	3.471	0.802	3.691	0.179	3.940	0.646	3.752	0.583	3.624	0.036	4.028
$C^{E.f}$	-0.713	1.501	-0.697	1.649	-0.794	1.711	-0.712	1.640	-0.885	1.561	-0.796	1.775
$C^{E.u}$	-1.328	12.061	-1.456	9.996	-0.691	3.690	-1.285	8.213	-0.047	9.707	-0.698	2.423
H^p	0.864	3.129	0.775	3.189	0.433	3.385	0.680	3.239	0.646	3.192	0.366	3.441
H^f	0.141	0.731	0.127	0.747	0.054	0.817	0.105	0.760	0.014	0.751	0.060	0.829
υ^{cp}	0.159		0.141		0.079		0.122		0.135		0.066	
υ^{cf}	0.023		0.013		0.002		0.007		0.013		0.003	
Dispersion	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
υ^d	0.018		0.008		0.006		0.003		0.007		0.014	
υ^x	0.106		0.110		0.125		0.114		0.111		0.129	
$\tilde{S}^p$	0.623		0.598		0.506		0.572		0.592		0.485	
$\tilde{S}^f$	0.014		0.013		0.007		0.010		0.012		0.007	
Stocks	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
K^p	-3.817	8.387	-3.816	8.128	-3.674	7.669	-3.759	7.996	-3.722	8.153	-3.656	7.570
K^f	-0.875	2.384	-0.884	2.251	-0.836	2.094	-0.862	2.200	-0.820	2.268	-0.835	2.063
A	16.508	37.230	16.229	36.808	15.708	35.986	16.106	36.638	16.423	36.788	15.522	35.704

Note: Baseline rule: $\rho_r = 0.85$, $\tau_{\pi,c} = 1.5$, $\tau_u = \tau_{\pi,w} = 0$. CPI inflation: $\rho_r = 0.85$, $\tau_{\pi,c} = 5$, $\tau_u = \tau_{\pi,w} = 0$. Unemployment: $\rho_r = 0.85$, $\tau_{\pi,c} = 1.5$, $\tau_u = 1.5$, $\tau_{\pi,w} = 0$. Wage inflation: $\rho_r = 0.85$, $\tau_{\pi,c} = 1.5$, $\tau_u = 0$, $\tau_{\pi,w} = 1.5$. IH-OSR and EH-OSR: see optimal coefficients' values in table 3. Most variables expressed in % deviation from their steady-state. Unemployment rate in percentage-point deviation from ss. $\tilde{S}^p$ and $\tilde{S}^f$ as percentage of investment lost as adjustment cost. A as a percentage of GDP at ss. Simulated moments based on 250 series of 100 periods.

Table 14: Effects of alternative policy rules - TFP shocks

	Baseline		CPI inflation		Unemployment		Wage inflation		IH OSR		EH OSR	
Welfare	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.	Cdt cost	Prem.
IH	0.348		0.306	0.042	0.309	0.039	0.311	0.038	0.294	0.055	0.301	0.048
EH	0.269		0.212	0.057	0.144	0.125	0.176	0.093	0.157	0.112	0.135	0.134
EH (sect.)	0.266		0.209	0.057	0.143	0.123	0.174	0.092	0.155	0.111	0.135	0.131
EH (work)	0.266		0.209	0.057	0.143	0.123	0.174	0.092	0.155	0.111	0.134	0.131
EH (full)	0.137		0.135	0.002	0.136	0.001	0.130	0.007	0.131	0.007	0.134	0.004
Pol. Obj.	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
π^c	-0.013	0.107	-0.002	0.041	0.000	0.180	-0.003	0.103	-0.001	0.074	0.000	0.165
U	0.051	0.293	0.017	0.371	0.004	0.080	0.014	0.243	0.005	0.242	0.001	0.044
Utility	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
C^I	-0.187	2.066	-0.145	2.203	-0.163	1.994	-0.156	2.103	-0.138	2.178	-0.153	2.048
$C^{E.p}$	0.024	1.522	-0.010	1.367	-0.054	1.538	-0.022	1.426	-0.031	1.457	-0.052	1.543
$C^{E.f}$	-0.005	1.255	-0.059	1.103	-0.068	1.280	-0.055	1.160	-0.068	1.202	-0.070	1.291
$C^{E.u}$	-0.459	3.603	-0.004	4.605	-0.101	1.778	-0.092	3.386	-0.013	3.261	-0.077	1.543
H^p	0.164	0.778	0.147	0.873	0.125	0.737	0.140	0.815	0.132	0.820	0.123	0.746
H^f	0.152	1.127	0.126	1.191	0.120	1.080	0.125	1.147	0.116	1.127	0.117	1.065
υ^{cp}	0.004		0.006		0.001		0.003		0.004		0.002	
υ^{cf}	0.002		0.003		0.000		0.001		0.001		0.000	
Dispersion	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
υ^d	0.009		0.003		0.017		0.008		0.004		0.014	
υ^x	0.013		0.013		0.011		0.012		0.013		0.012	
$\tilde{S}^p$	0.030		0.033		0.024		0.029		0.030		0.024	
$\tilde{S}^f$	0.005		0.006		0.003		0.004		0.005		0.003	
Stocks	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
K^p	-0.035	2.693	-0.020	2.756	-0.025	2.530	-0.019	2.667	-0.025	2.626	-0.029	2.509
K^f	0.054	0.939	0.068	0.974	0.054	0.829	0.062	0.911	0.064	0.916	0.056	0.834
A	0.694	2.719	0.794	2.907	0.720	2.399	0.747	2.665	0.802	2.845	0.770	2.536

Note: Baseline rule: $\rho_r = 0.85$, $\tau_{\pi,c} = 1.5$, $\tau_u = \tau_{\pi,w} = 0$. *CPI inflation:* $\rho_r = 0.85$, $\tau_{\pi,c} = 5$, $\tau_u = \tau_{\pi,w} = 0$. *Unemployment:* $\rho_r = 0.85$, $\tau_{\pi,c} = 1.5$, $\tau_u = 1.5$, $\tau_{\pi,w} = 0$. *Wage inflation:* $\rho_r = 0.85$, $\tau_{\pi,c} = 1.5$, $\tau_u = 0$, $\tau_{\pi,w} = 1.5$. *IH-OSR and EH-OSR: see optimal coefficients' values in table 3. Most variables expressed in % deviation from their steady-state. Unemployment rate in percentage-point deviation from ss.* $\tilde{S}^p$ *and* $\tilde{S}^f$ *as percentage of investment lost as adjustment cost.* A *as a percentage of GDP at ss. Simulated moments based on 250 series of 100 periods.*

Figure 1: IRFs - Cost-push shock

Note: Variables expressed in percentage deviation from steady-state. Inflation and interest rates annualized. Unemployment rate in percentage points. Horizon in quarters. Baseline model ($\tau_{pi} = 1.5$ and $\tau_U = \tau_w = 0$, solid lines), IH-OSR to cost-push shocks (in dashed-blue) and EH-OSR (in dashed-red).

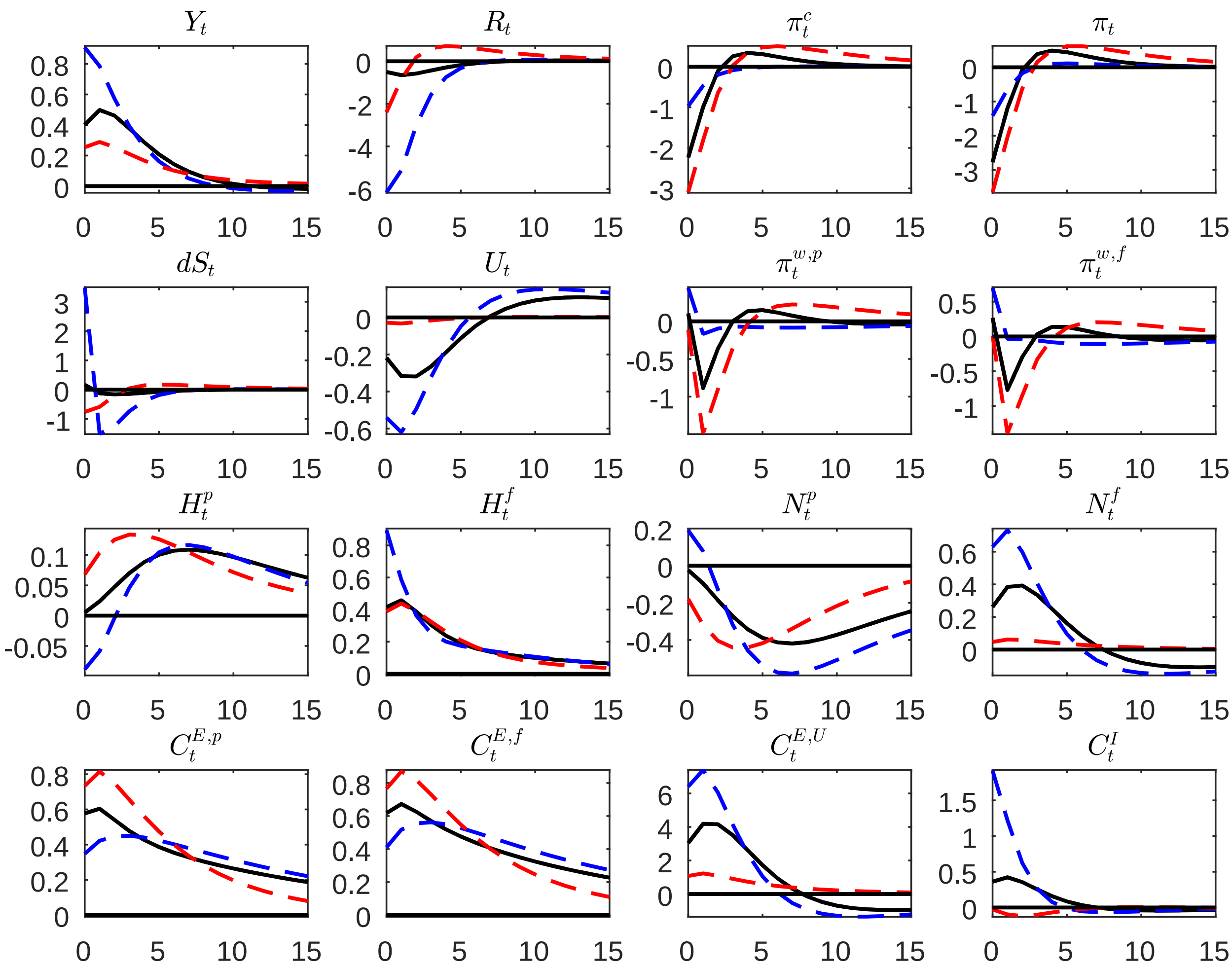


Figure 2: IRFs - Wage bargain shock

Note: Variables expressed in percentage deviation from steady-state. Inflation and interest rates annualized. Unemployment rate in percentage points. Horizon in quarters. Baseline model ($\tau_{pi} = 1.5$ and $\tau_U = \tau_w = 0$, solid lines), IH-OSR to wage bargain shocks (in dashed-blue) and EH-OSR (in dashed-red).

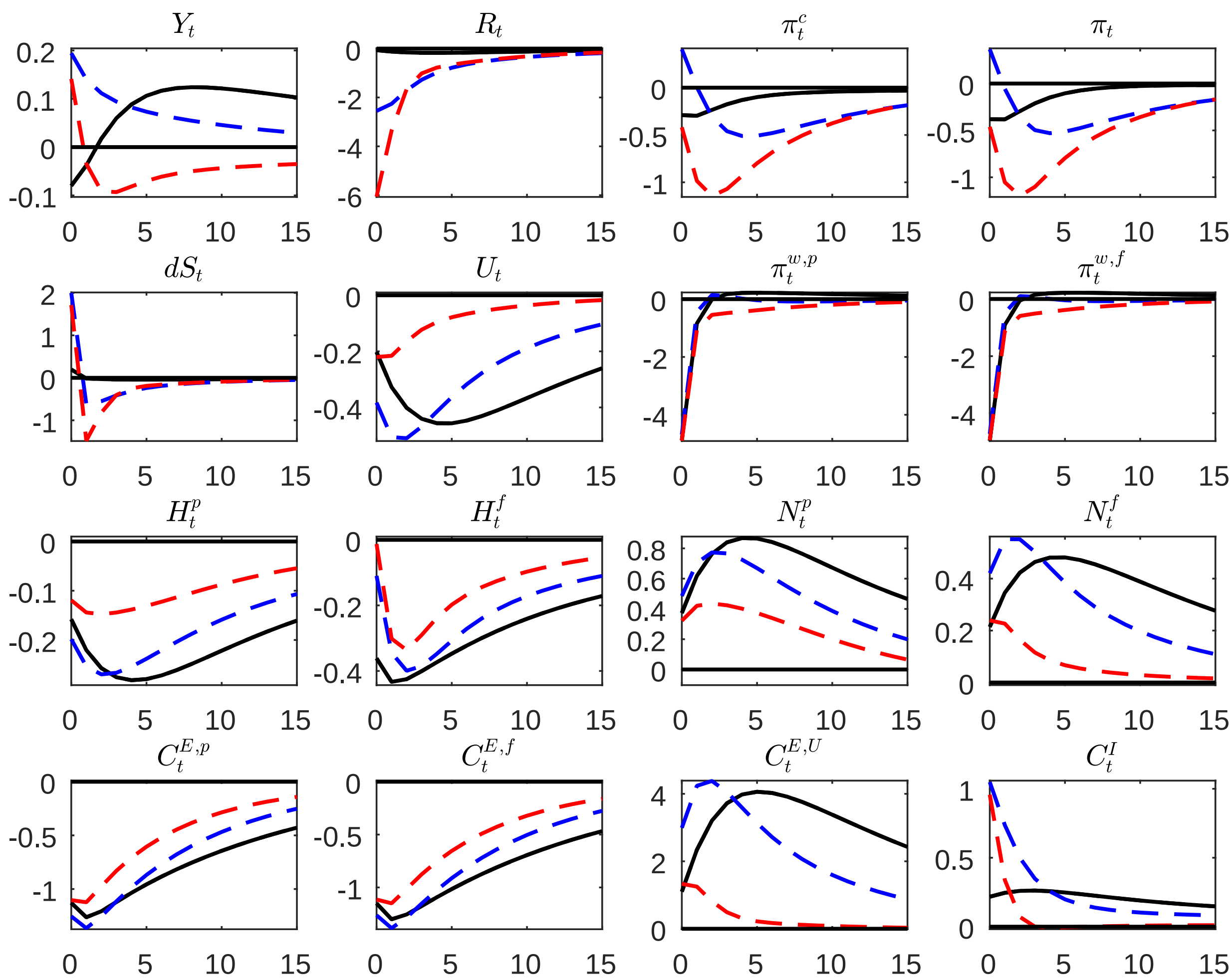


Figure 3: IRFs - Vacancy cost shock

Note: Variables expressed in percentage deviation from steady-state. Inflation and interest rates annualized. Unemployment rate in percentage points. Horizon in quarters. Baseline model ($\tau_{pi} = 1.5$ and $\tau_U = \tau_w = 0$, solid lines), IH-OSR to vacancy cost shocks (in dashed-blue) and EH-OSR (in dashed-red).

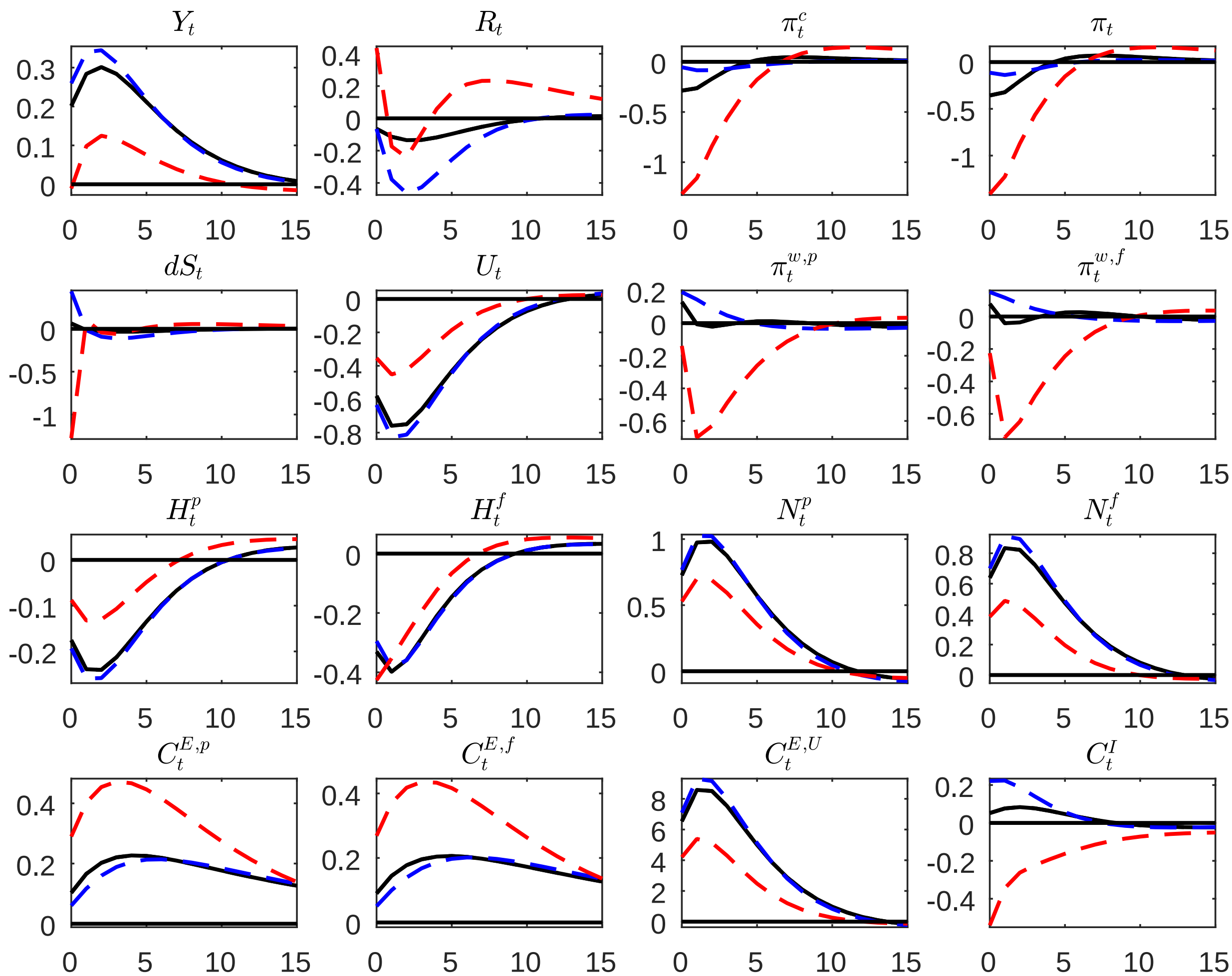


Figure 4: IRFs - Commodity price shock

Note: Variables expressed in percentage deviation from steady-state. Inflation and interest rates annualized. Unemployment rate in percentage points. Horizon in quarters. Baseline model ($\tau_{pi} = 1.5$ and $\tau_U = \tau_w = 0$, solid lines), IH-OSR to commodity price shocks (in dashed-blue) and EH-OSR (in dashed-red).

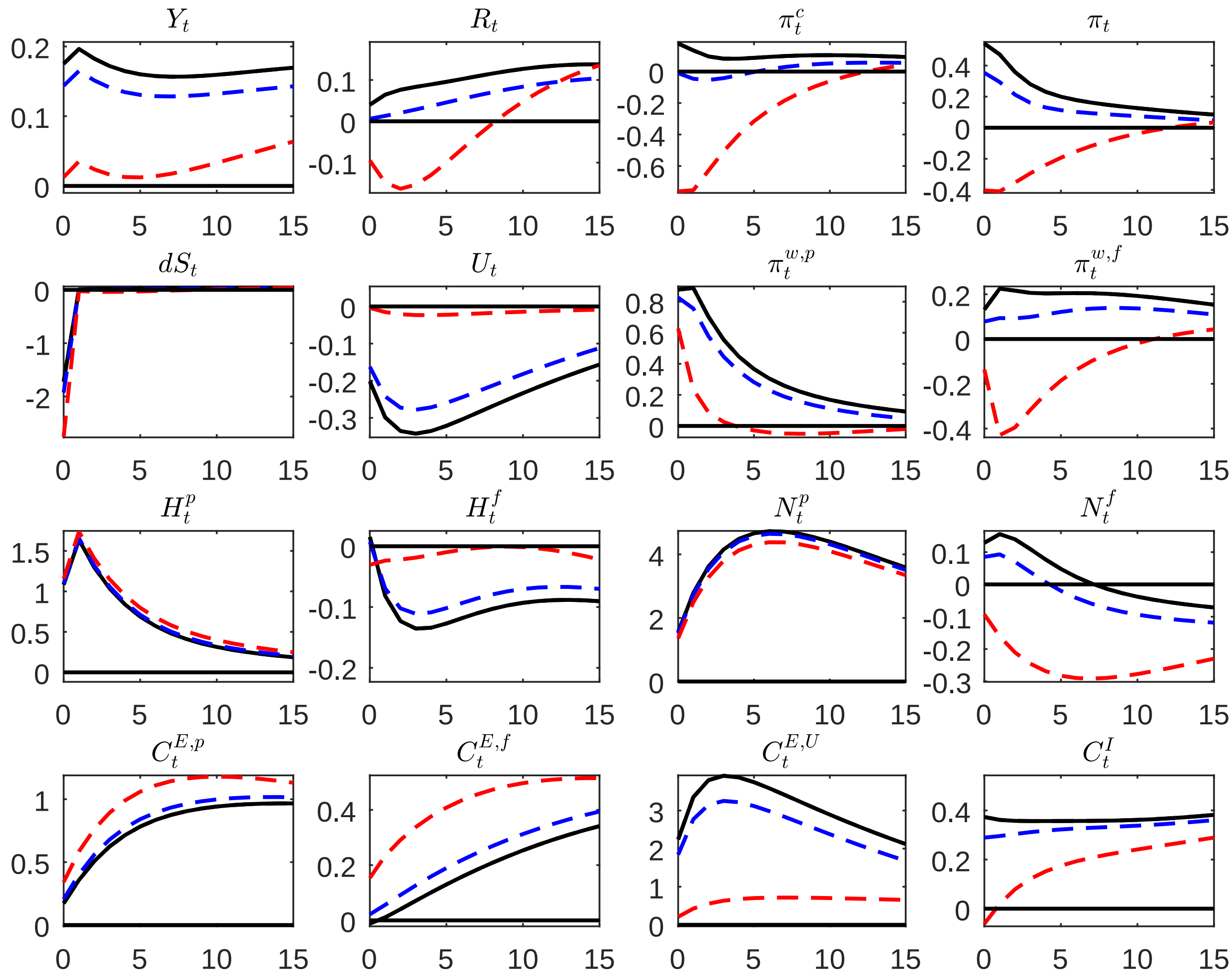


Figure 5: IRFs - TFP shock

Note: Variables expressed in percentage deviation from steady-state. Inflation and interest rates annualized. Unemployment rate in percentage points. Horizon in quarters. Baseline model ($\tau_{pi} = 1.5$ and $\tau_U = \tau_w = 0$, solid lines), IH-OSR to TFP shocks (in dashed-blue) and EH-OSR (in dashed-red).

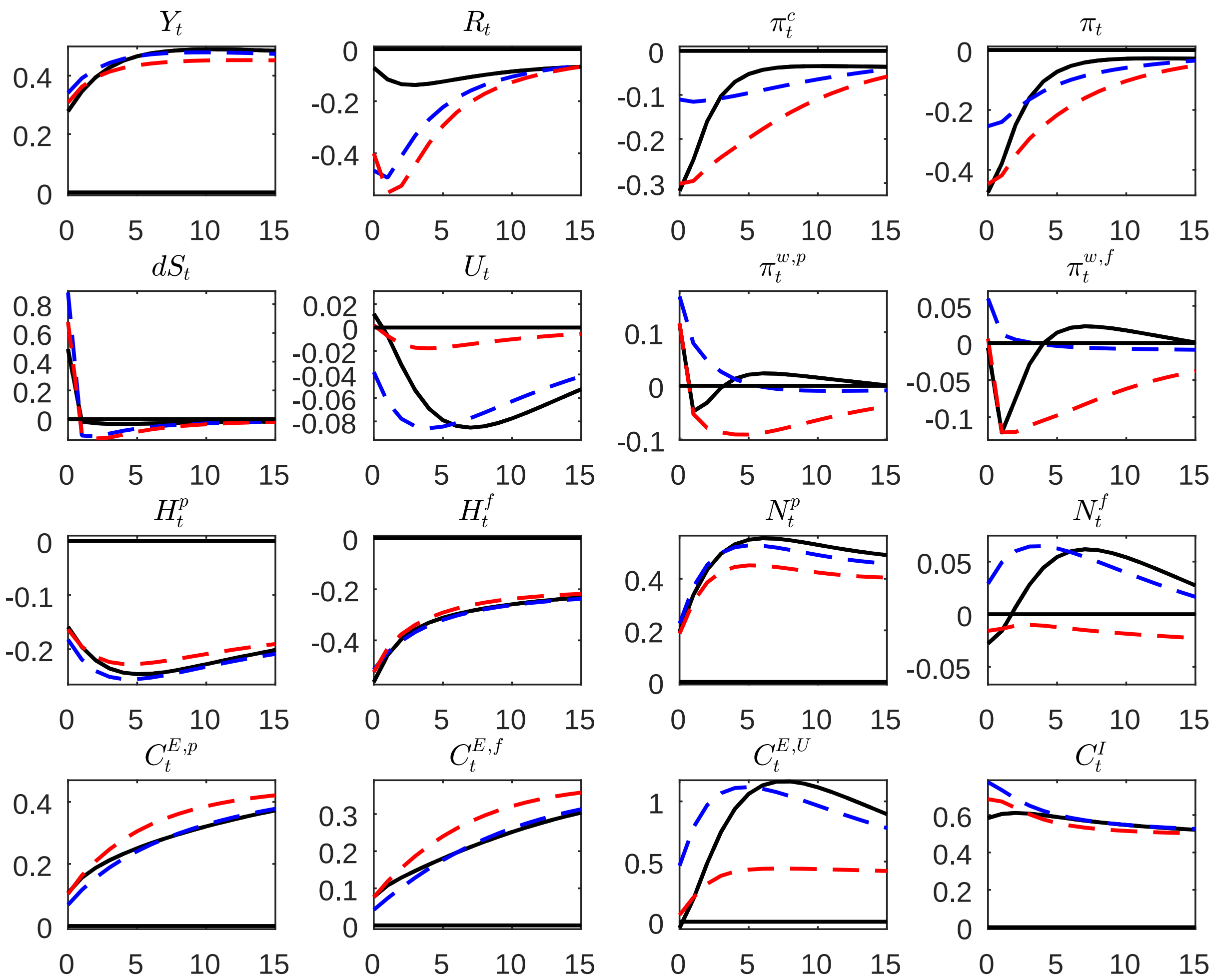
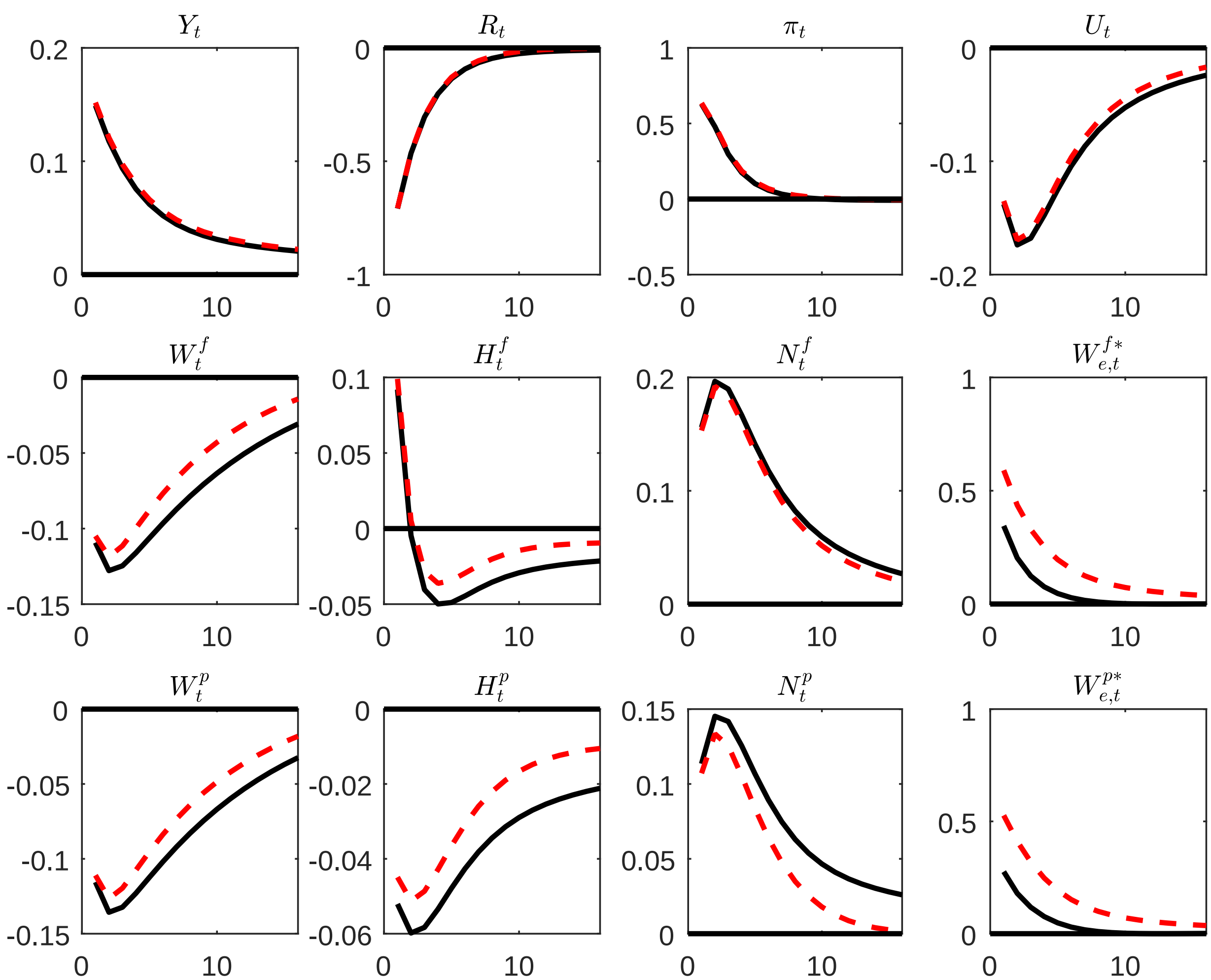


Figure 6: IRFs - MP shock with optimizing EHs

Note: Variables expressed in percentage deviation from steady-state. Inflation and interest rates annualized. Unemployment rate in percentage points. Horizon in quarters. Baseline model (solid black lines) and optimizing EHs model (dashed-red). $W^{p*}_{e,t}$ *and* $W^{f*}_{e,t}$ *are renegociating EHs' wages in the primary and secondary sectors. In the baseline model, these wages are set by IHs and firms, while in the alternative, they are the result of a bargain between EHs and firms.*



A Background on the South African economy

A.1 The labor market

This section describes the South African labor market. Its objective is to isolate the empirically relevant features required to build the model presented in section 3. First, the unemployment rate is very high: it fluctuated around 25% over the post-Apartheid period. Moreover, almost 65% of the unemployed have been without a job for over a year and many of them have never worked (Banerjee et al., 2008). Second, union density is relatively high in South Africa (37.5% compared to 30% on average in OECD countries). Labor unions (together with the Bargaining Councils framework) allow workers to extract a wage premium (Bhorat et al., 2012), could have a negative impact on employment (Magruder, 2012 and von Fintel, 2017) and could generate slow wage adjustment to the unemployment rate (von Fintel, 2016). Third, agreements reached in Bargaining Council can - under some condition - be extended to non-parties (see Bhorat et al., 2012). Fourth, unemployment benefits are tied to past wages and temporary. In this context, it is natural to consider SAM frictions within a staggered wage bargaining framework. It also motivates the use of temporary unemployment benefits as the employees' outside option, and the simplifying assumption that some households (in this case EHs) have to take the outcome of some wage bargaining as given. For more details on the institutional framework governing collective bargaining and the unemployment insurance scheme, the interested reader is referred to Godfrey et al. (2007), Bhorat et al. (2009) and Bhorat et al. (2013). For a detailed description of the state of labor unions in South Africa, see Bhorat et al. (2014) and Armstrong and Steenkamp (2008).

A.2 Wealth distribution financial markets inclusion

In this paper, I make two crucial assumptions. First, some households are excluded from financial markets. Second, some households own no wealth. Together, these assumptions leave a substantial fraction of households exposed to labor income risks. This section reviews the evidence for South Africa. The World Bank financial inclusion database (average over three waves of data in 2011, 2014 and 2017) shows that only 64% of households have an account at any financial institution (and more households use their account to collect government benefits than to receive wages). Moreover, only 26% and 10% borrowed or saved at a financial institution, respectively. In fact, 37% of households have not saved any money over a one-year period. Orthofer (2016) studies wealth distribution in South Africa.

Combining two sources of information: the National Income Dynamics Survey (NIDS) and personal income tax records, she finds that wealth is heavily concentrated in South Africa. Indeed, the top-10% holds more than 90% of all wealth (financial and non-financial) while the bottom-80% owns close to zero wealth. The Gini coefficient is as high as 0.95. Considering that South African households face substantial income risks (e.g. Ranchhod, 2013 and Anand et al., 2016 based on NIDS data) these stylized facts could have large implications on the welfare cost of business cycle fluctuations.

A.3 Monetary policy

The South African Reserve Bank (SARB) operate under an inflation targeting framework. The SARB currently aims for a range of 3 to 6 percent for the year-on-year increase in the headline CPI on a continuous basis. The SARB conducts its main refinancing operation - called the weekly seven-day repurchase auction - with commercial banks. The repo rate - set by the Monetary Policy Committee - determines the rate at which the SARB lends funds to the banks against liquid assets. This framework justifies the use of a Taylor rule in the model. Moreover, it could be applied to other emerging markets. Indeed, many emerging countries abandoned exchange rate targeting in favor of inflation targeting after the wave of currency crises in the 1994-2001 period.[36] Prior to this period, the SARB implemented different frameworks. From 1986 to 1998, the SARB used a cash-reserve based system with pre-announced monetary targets primarily aimed at combating inflation. Monetary policy was relatively opaque and the SARB progressively moved to an eclectic approach using a set of indicators including the exchange rate and the output gap (Aron and Muellbauer, 2007). Since 1998, the SARB mainly operates under a repo system. See Mollentze (2000), Aron and Muellbauer (2002) and Muyambiri and Odhiambo (2014) for a detailed description of the evolution of monetary policy in South Africa.

[36] See Frankel (2011) for a survey on monetary policy in emerging countries.

B Complete set of equilibrium conditions

This appendix provides the reader with the details on how to derive the complete set of equilibrium conditions for households, firms and the labor market. In addition, for some equations, it shows how they are implemented in *Dynare*. Those equations have been expressed following the convention that lower-case variables denote the stationarized equivalent of their upper case counterparts. In particular, some variables have a nominal trend because of the positive inflation rate target.

B.1 Households

The consumption demand functions for the domestic and the imported goods are given by:

$$C_t^d = (1-\omega_c)\left[\frac{P_t}{P_t^C}\right]^{-\eta} C_t, \tag{36}$$

$$C_t^m = \omega_c\left[\frac{P_t^m}{P_t^C}\right]^{-\eta} C_t, \tag{37}$$

where P_t is the domestic good price, P_t^m the imported good price and P_t^c represents the Consumer price index (CPI) and is given by:

$$P_t^c = \left[(1-\omega_c)(P_t)^{1-\eta} + \omega_c (P_t^m)^{1-\eta}\right]^{1/(1-\eta)}.$$

which is made stationary as follows:

$$(\pi_t^c)^{1-\eta_c} = (1-\omega_c)\left(\pi_t \frac{P_{t-1}}{P_{t-1}^c}\right)^{1-\eta_c} + \omega_c\left(\pi_t^m \frac{P_{t-1}^m}{P_{t-1}^c}\right)^{1-\eta_c} \tag{38}$$

where gross inflation rates are defined as: $\pi_t^c = \frac{P_t^c}{P_{t-1}^c}$; $\pi_t = \frac{P_t}{P_{t-1}}$ and $\pi_t = \frac{P_t^m}{P_{t-1}^m}$. Note that some price ratios are explicitly defined to save on notations. In Dynare, it requires to define a variable for each price ratio.

B.1.1 Financially included households

IHs maximize their utility with respect to domestic and foreign bonds holding and consumption. The First Order Conditions (FOCs) associated with IHs with shadow value υ_t^I on their budget constraint (3) are given by:

$$w.r.t.\ C_t^I \quad : \quad \left(C_t^I\right)^{-\sigma_c} = \psi_t^I \frac{P_t^c}{P_t} \tag{39}$$

$$w.r.t.\ B_{t+1} \quad : \quad \psi_t^I = \beta \mathrm{E}_t \frac{\psi_{t+1}^I}{\pi_{t+1}} \varepsilon_{b,t} R_t \tag{40}$$

$$w.r.t.\ B_{t+1}^* \quad : \quad \psi_t^I = \beta \mathrm{E}_t \frac{\psi_{t+1}^I}{\pi_{t+1}} \frac{S_{t+1}}{S_t} \varepsilon_{b,t} R_t^* \Phi(A_t, \tilde{\phi}_t) \tag{41}$$

where these variables are stationarized following Altig et al. (2003) such that $x_t = \frac{X_t}{P_t}$ for nominal variables while the Lagrange multiplier is redefined as $\psi_t^I = v_t^I P_t$.

IHs also maximize their utility with respect to the capital stock and investment in each sector. For the primary sector:

$$w.r.t.\ K_{t+1}^p \quad : \quad \psi_t \frac{P_t^{k,p}}{P_t} = \beta \psi_{t+1} \left(r_{t+1}^{k,p} + (1-\delta) \frac{P_{t+1}^{k,p}}{P_{t+1}} \right) \tag{42}$$

$$w.r.t.\ I_t^p \quad : \quad -\psi_t \frac{P_t^i}{P_t} + \psi_t \frac{P_t^{k,p}}{P_t} \Upsilon_t \left(1 - \tilde{S}\left(\frac{I_t^p}{I_{t-1}^p}\right) - \tilde{S}'\left(\frac{I_t^p}{I_{t-1}^p}\right) \frac{I_t^p}{I_{t-1}^p} \right)$$

$$+ \quad \beta \mathrm{E}_t \left(\frac{P_{t+1}^{k,p}}{P_{t+1}} \psi_{t+1} \Upsilon_{t+1} \tilde{S}' \left(\frac{I_{t+1}^p}{I_t^p}\right) \left(\frac{I_{t+1}^p}{I_t^p}\right)^2 \right) = 0 \tag{43}$$

where $r_t^{k,p} \equiv \frac{R_t^{k,p}}{P_t}$ is the rental rate of capital corresponding to the marginal productivity of capital and $\frac{P_t^{k,p}}{P_t}$ is the real price of the capital good.

Country risk premium Combining the FOCs with respect to domestic and foreign bonds gives the uncovered interest rate parity (UIP) condition:

$$R_t = R_t^* \Phi(A_t, \tilde{\phi}_t) \mathrm{E}_t \frac{S_{t+1}}{S_t}$$

This last equality shows that the spread between domestic and foreign nominal risk-free rates depends on the anticipated domestic currency depreciation, the country-wide foreign debt and UIP shocks.

Capital Accumulation The capital accumulation rule reads:

$$K_{t+1}^p = (1-\delta) K_t^p + \Upsilon_t (1 - \tilde{S}(I_t^p / I_{t-1}^p)) I_t^p \tag{44}$$

Investment Basket Domestic and imported investments are given by:

$$I_t^{d,p} = (1-\omega_i)\left[\frac{P_t}{P_t^i}\right]^{-\eta} I_t^p, \tag{45}$$

$$I_t^{m,p} = \omega_i \left[\frac{P_t^m}{P_t^i}\right]^{-\eta} I_t^p, \tag{46}$$

where P_t^i is the aggregate investment price given by:

$$P_t^i = \left[(1-\omega_i)(P_t)^{1-\eta} + \omega_i (P_t^m)^{1-\eta}\right]^{1/(1-\eta)}$$

which is made stationary as follows:

$$\left(\pi_t^i\right)^{1-\eta_i} = (1-\omega_i)\left(\pi_t \frac{P_{t-1}}{P_{t-1}^i}\right)^{1-\eta_i} + \omega_i \left(\pi_t^m \frac{P_{t-1}^m}{P_{t-1}^i}\right)^{1-\eta_i} \tag{47}$$

where $\pi_t^i = \frac{P_t^i}{P_{t-1}^i}$.

B.1.2 Financially excluded households

EHs' aggregate stationary budget constraint is given by

$$\int_0^1 P_t^c C_{e,t} \mathrm{d}l = \int_0^1 \left[(1-\tau^w)\left(\overline{W}_{e,t}^p N_{e,t}^p + \overline{W}_{e,t}^f N_{e,t}^f\right) + (1 - N_{e,t}^p - N_{e,t}^f)\varpi\right] \mathrm{d}e \ ,$$

EHs can be employed in the primary sector, employed in the secondary sector or unemployed. Therefore,

$$\frac{P_t^c}{P_t} C_t^{E,P} = (1-\tau^w)\overline{w}_t^p \tag{48}$$

$$\frac{P_t^c}{P_t} C_t^{E,F} = (1-\tau^w)\overline{w}_t^f \tag{49}$$

$$\frac{P_t^c}{P_t} C_t^{E,U} = \varpi_t \tag{50}$$

and aggregate EHs consumption is

$$C_t^E = \frac{1}{2}\left(N_t^p C_t^{E,P} + N_t^f C_t^{E,F} + U_t C_t^{E,U}\right) \tag{51}$$

B.2 Firms

Here is the profit maximization problem of the firms in the commodity and manufacturing sectors.

B.2.1 Commodity sector

Commodity producers combine capital K_t^p, labor $L_t^p = \frac{N_t^p}{2}(H_t^{I,p} + H_t^{E,p})$ and land (fixed to 1) to produce a commodity input. Demand for capital follows from cost minimization:

$$r_t^{k,p} = \alpha_p \frac{Y_t^p}{K_t^p} \frac{S_t P_t^{*p}}{P_t} \tag{52}$$

B.2.2 Secondary sector

Secondary good producers The FOC for capital derives from cost minimization:

$$r_t^{k,f} = \alpha_f \frac{Y_t^f}{K_t^f} mc_t \tag{53}$$

Domestic Distributors The optimization problem faced by the intermediate distributor j when setting its price at time t taking aggregator's demand as given reads:

$$\max_{P_t^{new}} \mathrm{E}_t \sum_{s=0}^{\infty} (\beta \xi_d)^s \upsilon_{t+s} \left(P_{j,t+s} - \varepsilon_{d,t+s} MC_{t+s} \right) Y_{j,t+s}^d$$

where

$$\begin{aligned} P_{j,t+s} &= (\pi_t ... \pi_{t+s-1})^{\kappa_d} (\bar{\pi})^{(1-\kappa_d)s} P_t^{new} \\ Y_{j,t+s}^d &= \left(\frac{(\pi_t ... \pi_{t+s-1})^{\kappa_d} (\bar{\pi})^{(1-\kappa_d)s} P_t^{new}}{P_{t+s}} \right)^{-\epsilon_d} Y_{t+s}^d \\ Y_{t+s}^d &= C_{t+s}^d + I_{t+s}^d + G_{t+s} \end{aligned}$$

and where $\varepsilon_{d,t}$ introduces a cost-push shock. These expressions can be used to rewrite the maximization problem as:

$$\mathrm{E}_t \sum_{s=0}^{\infty} (\beta \xi_d)^s \psi_{t+s}^I \left(\frac{(\Pi_{t,t+s-1})^{\kappa_d} (\bar{\pi})^{(1-\kappa_d)s} p_t^{new}}{\Pi_{t+1,t+s}} - \varepsilon_{d,t+s} mc_{t+s} \right) \left(\frac{(\Pi_{t,t+s-1})^{\kappa_d} (\bar{\pi})^{(1-\kappa_d)s} p_t^{new}}{\Pi_{t+1,t+s}} \right)^{-\epsilon_d} Y_{t+s}^d$$

where $p_t^{new} = \frac{P_t^{new}}{P_t}$. Distributing for convenience gives:

$$\mathrm{E}_t \sum_{s=0}^{\infty} (\beta\xi_d)^s \psi_{t+s}^I \left(\left(\frac{(\Pi_{t,t+s-1})^{\kappa_d} (\bar{\pi})^{(1-\kappa_d)s} p_t^{new}}{\Pi_{t+1,t+s}} \right)^{1-\epsilon_d} - \varepsilon_{d,t+s} mc_{t+s} \left(\frac{(\Pi_{t,t+s-1})^{\kappa_d} (\bar{\pi})^{(1-\kappa_d)s} p_t^{new}}{\Pi_{t+1,t+s}} \right)^{-\epsilon_d} \right) Y_{t+s}^d$$

The FOC with respect to p_t^{new} reads:

$$(\epsilon_d - 1) \left(p_t^{new}\right)^{-\epsilon_d} \mathrm{E}_t \sum_{s=0}^{\infty} (\beta\xi_d)^s \psi_{t+s}^I \left(\frac{(\Pi_{t,t+s-1})^{\kappa_d} (\bar{\pi})^{(1-\kappa_d)s}}{\Pi_{t+1,t+s}} \right)^{1-\epsilon_d} Y_{t+s}^d$$
$$= \epsilon_d \left(p_t^{new}\right)^{-\epsilon_d - 1} \mathrm{E}_t \sum_{s=0}^{\infty} (\beta\xi_d)^s \psi_{t+s}^I \left(\frac{(\Pi_{t,t+s-1})^{\kappa_d} (\bar{\pi})^{(1-\kappa_d)s}}{\Pi_{t+1,t+s}} \right)^{-\epsilon_d} \varepsilon_{d,t+s} mc_{t+s} Y_{t+s}^d$$

and can be rewritten as:

$$p_t^{new} = \frac{\epsilon_d}{\epsilon_d - 1} \frac{\mathrm{E}_t \sum_{s=0}^{\infty} (\beta\xi_d)^s \psi_{t+s}^I \left(\frac{(\Pi_{t,t+s-1})^{\kappa_d} (\bar{\pi})^{(1-\kappa_d)s}}{\Pi_{t+1,t+s}} \right)^{-\epsilon_d} \varepsilon_{d,t+s} mc_{t+s} Y_{t+s}^d}{\mathrm{E}_t \sum_{s=0}^{\infty} (\beta\xi_d)^s \psi_{t+s}^I \left(\frac{(\Pi_{t,t+s-1})^{\kappa_d} (\bar{\pi})^{(1-\kappa_d)s}}{\Pi_{t+1,t+s}} \right)^{1-\epsilon_d} Y_{t+s}^d}$$

which can also be rewritten as a set of three equations:

$$p_t^{new} = \frac{\epsilon_d}{\epsilon_d - 1} \frac{X_{1,t}^D}{X_{2,t}^D} \tag{54}$$

$$X_{1,t}^D = \psi_t^I \varepsilon_{d,t} mc_t (C_t^d + I_t^d + G_t) + \beta\xi_d \left(\frac{\pi_t^{\kappa_d} \bar{\pi}^{1-\kappa_d}}{\pi_{t+1}} \right)^{-\epsilon_d} \mathrm{E}_t X_{1,t+1}^D \tag{55}$$

$$X_{2,t}^D = \psi_t^I (C_t^d + I_t^d + G_t) + \beta\xi_d \left(\frac{\pi_t^{\kappa_d} \bar{\pi}^{1-\kappa_d}}{\pi_{t+1}} \right)^{1-\epsilon_d} \mathrm{E}_t X_{2,t+1}^D \tag{56}$$

In addition, the domestic price index evolves according to:

$$1 = \xi_d \left(\frac{\pi_{t-1}^{\kappa_d} \bar{\pi}^{1-\kappa_d}}{\pi_t} \right)^{1-\epsilon_d} + (1 - \xi_d) \left(p_t^{new}\right)^{1-\epsilon_d} \tag{57}$$

Finally, the price dispersion measure

$$v_t^d = \int_0^1 \left(\frac{P_{j,t}}{P_t} \right)^{-\epsilon_d} di$$

can be written as:

$$\upsilon_t^d = (1-\xi_d)\left(\frac{P_t^{new}}{P_t}\right)^{-\epsilon_d} + \int_{1-\xi_d}^{1}\left(\frac{(\pi_{t-1})^{\kappa_d}(\overline{\pi})^{1-\kappa_d}P_{j,t-1}}{P_t}\right)^{-\epsilon_d} di$$

which simplifies to:

$$\upsilon_t^d = (1-\xi_d)\left(p_t^{new}\right)^{-\epsilon_d} + \int_{1-\xi_d}^{1}\left(\frac{(\pi_{t-1})^{\kappa_d}(\overline{\pi})^{1-\kappa_d}p_{j,t-1}}{\pi_t}\right)^{-\epsilon_d} di$$

then to:

$$\upsilon_t^d = (1-\xi_d)\left(p_t^{new}\right)^{-\epsilon_d} + \xi_d\left(\frac{(\pi_{t-1})^{\kappa_d}(\overline{\pi})^{1-\kappa_d}}{\pi_t}\right)^{-\epsilon_d} \upsilon_{t-1}^d \tag{58}$$

which is a function of aggregate variables only.

Importing and exporting distributors Optimization in the importing and exporting distributors price-setting problem is similar to the domestic good price-setting problem presented above. The difference with Adolfson et al. (2007) is that I only consider one import Phillips curve and do not distinguish between imported investment and consumption goods.

B.3 Labor market

This subsection describes the FOCs in the primary sector. It is straightforward to extend these FOCs to the final good sector.

Employees' surplus First, I show how to compute the employee's surplus in (20). Let's rewritte households lifetime utility recursively as

$$\mathbb{W}_{i,t} = \frac{(C_{i,t})^{1-\sigma_c}-1}{1-\sigma_c} - A_h\frac{\left(N_{i,t}^p H_{i,t}^p + N_{i,t}^f H_{i,t}^f\right)^{1+\sigma_h}}{1+\sigma_h} - A_n\left(N_{i,t}^p + N_{i,t}^f\right) + \beta \mathrm{E}_t \mathbb{W}_{i,t+1}, \tag{59}$$

Substituting $C_{i,t}$ with the constraint (3) gives

$$\mathbb{W}_{i,t} = \frac{\left(\frac{(1-\tau^w)\left(\overline{W}^p_{i,t}N^p_{i,t}+\overline{W}^f_{i,t}N^f_{i,t}\right)+(1-N^p_{i,t}-N^f_{i,t})\varpi_t+...}{P^c_t}\right)^{1-\sigma_c}-1}{1-\sigma_c} - A_h\frac{\left(N^p_{i,t}H^p_{i,t}+N^f_{i,t}H^f_{i,t}\right)^{1+\sigma_h}}{1+\sigma_h} - A_n\left(N^p_{i,t}+N^f_{i,t}\right)+\beta\mathrm{E}_t\mathbb{W}_{i,t+1}, \quad (60)$$

Applying the chain rule, compute $\frac{\partial \mathbb{W}_{i,t}}{\partial N^p_{i,t}}$ as

$$\frac{\partial \mathbb{W}_{i,t}}{\partial N^p_{i,t}} = \left((1-\tau_w)\overline{W}^p_{i,t}-\varpi_t\right)\frac{(C_{i,t})^{-\sigma_c}}{P^c_t}-\left(U(H^p_{i,t})+A_n\right) + \beta\mathrm{E}_t\left(\frac{\partial \mathbb{W}_{i,t+1}}{\partial N^p_{i,t+1}}\frac{\partial N^p_{i,t+1}}{\partial N^p_{i,t}}+\frac{\partial \mathbb{W}_{i,t+1}}{\partial N^f_{i,t+1}}\frac{\partial N^f_{i,t+1}}{\partial N^p_{i,t}}\right) \quad (61)$$

Then, using (17) and (18) to get $\mathrm{E}_tN^p_{i,t+1}=(1-\delta_n)N^p_{i,t}+P^p_t(1-N^p_{i,t+1}-N^f_{i,t+1})$. Similarly, $\mathrm{E}_tN^f_{i,t+1}=(1-\delta_n)N^f_{i,t}+P^f_t(1-N^p_{i,t+1}-N^f_{i,t+1})$. One can thus evaluate $\frac{\partial N^p_{i,t+1}}{\partial N^p_{i,t}}$ and $\frac{\partial N^f_{i,t+1}}{\partial N^p_{i,t}}$ to get

$$\frac{\partial \mathbb{W}_{i,t}}{\partial N^p_{i,t}} = \left((1-\tau_w)\overline{W}^p_{i,t}-\varpi_t\right)\frac{(C_{i,t})^{-\sigma_c}}{P^c_t}-\left(U(H^p_{i,t})+A_n\right) + \beta\mathrm{E}_t\left(\frac{\partial \mathbb{W}_{i,t+1}}{\partial N^p_{i,t+1}}\left((1-\delta_n)-P^p_t\right)+\frac{\partial \mathbb{W}_{i,t+1}}{\partial N^f_{i,t+1}}P^f_t\right) \quad (62)$$

which gives the employee's surplus (20) using FOC (39). In stationary form, the aggregate employees' surplus for IHs reads:

$$S^{I,p}_t=(1-\tau_w)\overline{w}^p_t-\varpi_t-\left[\frac{U(H^p_t)+A_n}{\upsilon_t}+\beta\frac{\psi^I_{t+1}}{\psi^I_t}\left(p^p_tS^{I,p}_{t+1}+p^f_tS^{I,f}_{t+1}\right)\right]+(1-\delta_n)\beta\frac{\psi^I_{t+1}}{\psi^I_t}S^{I,p}_{t+1} \quad (63)$$

Let us define the minimum wage level acceptable for IHs in the flexible wage environment as:

$$(1-\tau_w)\overline{w}^{min,I,p}_t=\varpi_t+\left[\frac{U(H^p_t)+A_n}{\upsilon_t}+\beta\frac{\psi^I_{t+1}}{\psi^I_t}\left(p^p_tS^{I,p}_{t+1}+p^f_tS^{I,f}_{t+1}\right)\right] \quad (64)$$

Firms' surplus In stationary form, the firms' aggregate surplus is:

$$Z_t^p \quad = \tfrac{P_t^p}{P_t}(1-\alpha_p-\beta_p)\tfrac{Y_t}{L_t^p}H_t^p - \overline{w}_t^p + (1-\delta_n)\beta\tfrac{\psi_{t+1}^I}{\psi_t^I}Z_{t+1}^p \tag{65}$$

Let us define the maximum wage level acceptable in the flexible wage environment as:

$$\overline{w}_t^{max,p} = \frac{P_t^p}{P_t}(1-\alpha_p-\beta_p)\frac{Y_t}{L_t^p}H_t^p \tag{66}$$

Wage bargaining Bargaining is modeled following Thomas (2008). Firms and employed IHs set the wage such that IHs receive an expected share $\omega_{w,t}$ of the total surplus $S_t^{I,p} + Z_t^p$ over the contract duration. For every period, there is a targeted wage $\overline{w}_t^{tar,I,p}$ that would satisfy the surplus-sharing rule:

$$\overline{w}_t^{tar,p} = \omega_{w,t}\overline{w}_t^{max,p} + (1-\omega_{w,t})\overline{w}_t^{min,I,p} \tag{67}$$

Since each contract has a probability δ_n to stop in every period, and since each worker has a probability $1-\xi_w$ to renegotiate, the optimal wage has to satisfy

$$\mathrm{E}_0^i\sum_{s=0}^{\infty}(\beta\xi_w)^s(1-\delta_n)^s\frac{\psi_{t+s}^I}{\psi_t^I}\left(\overline{w}_t^{new,p}\left(\frac{\left(\pi_t^c...\pi_{t+s-1}^c\right)^{\kappa_w}\bar{\pi}^{(1-\kappa_w)s}}{\left(\pi_{t+1}...\pi_{t+s}\right)}\right)-\overline{w}_{t+s}^{tar,p}\right)=0.$$

This equation can be written as a set of three equations to avoid the infinite sum:

$$\overline{w}_t^{new,p} = \frac{Z_{1,t}}{Z_{2,t}} \tag{68}$$

$$Z_{1,t} = \psi_t^I\overline{w}_t^{tar,p} + \beta\xi_w(1-\delta_n)Z_{1,t+1} \tag{69}$$

$$Z_{2,t} = \psi_t^I + \beta\xi_w(1-\delta_n)\left(\frac{\left(\pi_t^c\right)^{\kappa_w}\bar{\pi}^{(1-\kappa_w)}}{\pi_{t+1}}\right)Z_{2,t+1} \tag{70}$$

Aggregate wages In the primary sector, wages evolve according to

$$\bar{w}_t^p = (1-\xi_w)\overline{w}_t^{new,p} + \frac{\left(\pi_{t-1}^c\right)^{\kappa_w}\left(\bar{\pi}\right)^{1-\kappa_w}}{\pi_t}\bar{w}_{t-1}^p \tag{71}$$

Hours decision Hours are set to maximize the global surplus. The marginal utility of hours worked (the production value in term of consumption utility for IHs who own the firms) must equalize the average disutility (from labor efforts) for IHs and EHs:

$$P_t^p \frac{\partial Y_t^p}{\partial N_{i,t}^p} \upsilon_t = \frac{\partial U(H_{i,t}^p)}{\partial H_{i,t}^p}. \tag{72}$$

which gives the same results for every IHs and EHs.

Employment decision Firms in the primary sector maximize their profits w.r.t. vacancies. The FOC is:

$$\frac{\chi \left(V_t^p\right)^\theta + \varepsilon_{v,t}}{q_t^p} = \overline{w}_t^{max,p} - \overline{w}_t^p + \beta \frac{\psi_{t+1}^I}{\psi_t^I} \left[(1-\delta_n) \frac{\chi \left(V_{t+1}^p\right)^\theta + \varepsilon_{v,t+1}}{q_{t+1}^p} \right]$$

B.4 EHs wage bargain

Here, I present the EHs wage bargain introduced as a robustness exercise. The EHs employees' surplus in the primary sector is:

$$\begin{aligned} \frac{\Delta \mathbb{W}_{e,t}}{\Delta N_{e,t}^p} &= \mathbb{W}_{e,t}\left(N_{e,t}^p = 1\right) - \mathbb{W}_{e,t}\left(U_{e,t}^p = 1\right) \\ &= \frac{\left(\frac{(1-\tau_w) W_{e,t}^p}{P_t^c}\right)^{1-\sigma_c} - 1}{1-\sigma_c} - \left(A_h \frac{\left(H_{e,t}^p\right)^{1+\sigma_h}}{1+\sigma_h} + A_n \right) \\ &- \frac{\left(C_{e,t}^U\right)^{1-\sigma_c} - 1}{1-\sigma_c} - \beta \left(p_t^p \frac{\Delta \mathbb{W}_{e,t+1}}{\Delta N_{e,t+1}^p} + p_t^f \frac{\Delta \mathbb{W}_{e,t}}{\Delta N_{e,t+1}^f} \right) \\ &+ (1-\delta_n) \beta \frac{\Delta \mathbb{W}_{e,t+1}}{\Delta N_{e,t+1}^p}, \end{aligned} \tag{73}$$

where the first term is the utility of consumption for the employed household (expressed as a function of his wage), the second term is dis-utility from work, the third term is the utility of consumption for the unemployed household, the fourth is the option value of searching for a job when unemployed, and the last is the discounted future employee's surplus conditional on keeping the job. This surplus is expressed in utility term, but can be translated in monetary unit (from the point of view of an unemployed EH) with $S_{e,t}^p = \frac{\Delta \mathbb{W}_{e,t}}{\Delta N_{e,t}^p} / \left(C_{e,t}^U\right)^{-\sigma_c}$. The outcome of the bargain between firms and EHs in the primary sector consists in splitting the total employment surplus $S_{t+s}^{E,p*} + Z_{t+s}^{E,p*}$. In this expression, the firm surplus $Z_{t+s}^{E,p*}$ is analogue to equation (22) and stars refer to contracts negotiated at time t. The optimal wage $\bar{W}_{e,t}^{p*}$ implies that workers receive a fraction $1-\omega_{w,t}$ of this surplus over the expected contract duration.

B.5 Aggregate Welfare

IHs' aggregate utility The aggregate utility level for IHs is described in the paper.

EH's aggregate utility Expressing EHs' aggregate welfare as a function of employment and labor income in each sectors using their budget constraint (6) reads:

$$
\begin{aligned}
\mathbb{U}_t^E &= \int_0^{N_t^p} \frac{\left(\frac{(1-\tau_w)\bar{W}_{e,t}^p}{P_t^c}\right)^{1-\sigma_c} - 1}{1-\sigma_c} \mathrm{d}e + \int_0^{N_t^f} \frac{\left(\frac{(1-\tau_w)\bar{W}_{e,t}^f}{P_t^c}\right)^{1-\sigma_c} - 1}{1-\sigma_c} \mathrm{d}e + \int_0^{U_t} \frac{\left(C_{e,t}^U\right)^{1-\sigma_c} - 1}{1-\sigma_c} \mathrm{d}e \\
&- \int_0^{N_t^p} \left(\frac{A_h (H_t^p)^{1+\sigma_h}}{1+\sigma_h} + A_n\right) \mathrm{d}e - \int_0^{N_t^f} \left(\frac{A_h (H_t^f)^{1+\sigma_h}}{1+\sigma_h} + A_n\right) \mathrm{d}e \ , \qquad (74)
\end{aligned}
$$

Then, multiply the numerator and denominator in the first two terms by their respective aggregate sectoral wages and re-arranging gives:

$$
\mathbb{U}_t^E = \int_0^{N_t^p} \frac{\left(\frac{(1-\tau_w)\bar{W}_t^p}{P_t^c}\right)^{1-\sigma_c} \left(\frac{\bar{W}_{e,t}^p}{\bar{W}_t^p}\right)^{1-\sigma_c} - 1}{1-\sigma_c} \mathrm{d}e + \int_0^{N_t^f} \frac{\left(\frac{(1-\tau_w)\bar{W}_t^f}{P_t^c}\right)^{1-\sigma_c} \left(\frac{\bar{W}_{e,t}^f}{\bar{W}_t^f}\right)^{1-\sigma_c} - 1}{1-\sigma_c} \mathrm{d}e + ...,
$$

Using υ_t^{cp} and υ_t^{cf} definitions in (34) and (35), EHs' utility simplifies to:

$$
\begin{aligned}
\mathbb{U}_t^E &= \frac{1}{2} \left(N_t^p \frac{\left(C_t^{E,p}\right)^{1-\sigma_c} \upsilon_t^{cp} - 1}{1-\sigma_c} + N_t^f \frac{\left(C_t^{E,f}\right)^{1-\sigma_c} \upsilon_t^{cf} - 1}{1-\sigma_c} \right) \qquad (75) \\
&+ \frac{1}{2} \left[U_t \frac{\left(C_t^{E,U}\right)^{1-\sigma_c} - 1}{1-\sigma_c} - N_t^p \left(\frac{A_h (H_t^{E,p})^{1+\sigma_h}}{1+\sigma_h} + A_n\right) - N_t^f \left(\frac{A_h (H_t^{E,f})^{1+\sigma_h}}{1+\sigma_h} + A_n\right) \right].
\end{aligned}
$$

Finally, it is also possible express υ_t^{cp} and υ_t^{cf} as:

$$
\upsilon_t^{cp} = (1-\xi_w) \left(\frac{\bar{w}_t^{E,p*}}{\bar{w}_t^{E,p}}\right)^{(1-\epsilon_w)(1-\sigma_c)} + \xi_w \left(\frac{\bar{w}_{t-1}^{E,p} \left(\pi_{t-1}^c\right)^{\kappa_w} \left(\bar{\pi}\right)^{1-\kappa_w}}{\bar{w}_t^{E,p} \pi_t}\right)^{(1-\epsilon_w)(1-\sigma_c)} \upsilon_{t-1}^{cp} \qquad (76)
$$

$$
\upsilon_t^{cf} = (1-\xi_w) \left(\frac{\bar{w}_t^{E,f*}}{\bar{w}_t^{E,f}}\right)^{(1-\epsilon_w)(1-\sigma_c)} + \xi_w \left(\frac{\bar{w}_{t-1}^{E,f} \left(\pi_{t-1}^c\right)^{\kappa_w} \left(\bar{\pi}\right)^{1-\kappa_w}}{\bar{w}_t^{E,f} \pi_t}\right)^{(1-\epsilon_w)(1-\sigma_c)} \upsilon_{t-1}^{cf} \qquad (77)
$$

C Steady state

Here are the details on the computation of steady-state for the domestic economy.

Calibration and choice of units First some variables are calibrated to some values reflecting some freedom in the choice of units:

$$
\begin{aligned}
Y^f &= Y_0^f = 1 \\
P_0 &= P_0^* = 1 \\
h_i &= h_e = 1/3
\end{aligned}
$$

where Y_0^f and P_0 are free choices of units and $h = 1/3$ ensures that agents devote on average $1/3$ of their time to labor activities and simply imposes to calibrate A_h accordingly. There is a fraction $U = \bar{U}$ of agents that are unemployed. Others work in the primary sector: $N^p = 0.067(2-U)$ or in the secondary sector: $N^f = (1-0.067)(2-U)$. At steady-state, $H^p = H^f = 1/3$ and $L^p = N^p H^p$ and $L^f = N^f H^f$.

The primary commodity sector's share in GDP is calibrated to ω_p to match its empirical counterpart. it implies that $Y = \frac{Y^f}{1-\omega_p}$ and $Y^p = Y_0^p = \omega_p Y$

I assume that inflation and the risk-free rates are the same in the domestic and foreign economies ($\pi = \pi^*$ and $R = R^*$). They are calibrated to match the empirical mean of domestic variables. It requires to set $\bar{\pi}$ accordingly in the Taylor rule. The discount factor $\beta = \frac{\pi}{R}$ to accommodate this choice for the interest rate. These assumptions imply that $dS = 1$ (through the UIP condition). Therefore, all inflations rates are equal to π. By carefully calibrating mark-ups[37] for each distributor, all relative prices γ equalize to one at steady-state.

Households Turning to patient households FOCs, the assumptions presented allow to pin down the real price of capital and its rental rate to

$$
\begin{aligned}
p_{k'} &= \frac{P^k}{P} = \frac{P^i}{P} = 1 \\
r^k &= \frac{p_{k'}(1-(1-\delta)\beta)}{\beta}
\end{aligned}
$$

where the real price of capital and its rental rate are the same in both sectors at steady-state.

[37] Mark-ups in the export and domestic distribution sectors are identical

Final good sector Turning to final good distributors, the marginal costs are given by:

$$mc = mc^x = \frac{\epsilon_d - 1}{\epsilon_d}$$

The normalized CES production function in the final good sector implies that

$$MC_t Y_t^f = R_t^{k,f} K_t^f + \overline{W}_t^f N_t^f$$

where the capital income share at steady-state is given (in their stationary form) by

$$r^{k,f} K^f = \alpha mc Y^f$$

which implies that

$$K^f = \frac{\alpha Y^f mc}{r^k}$$

It also implies that the value of investment goods is:

$$I^f = \delta K^f$$

Primary good sector Using once again a Normalized production function implies that

$$S_t P_t^{*p} Y_t^p = R_t^{k,p} K_t^p + \overline{W}_t^p N_t^p + landshare_t$$

where R_t^L is the rental rate of the land input. It implies that

$$r^{k,p} K^p = \alpha_p Y^p$$

which implies

$$K^p = \frac{\alpha_p Y^p}{r^k}$$

Therefore,

$$I^p = \delta K^p$$

Aggregate resource constraints Total, imported and domestic investments are given by $I = I^f + I^p$, $I^m = \omega_i I$ and $I^d = (1 - \omega_i) I$.

The aggregate resource constraint evaluated at steady state reads

$$Y^f - G = C^d + I^d + X^f$$

Plugging steady state domestic consumption values from households yields

$$Y^f - G = (1 - \omega_c)C + I^d + X^f$$

The net foreign assets accumulation rule gives

$$C^m + I^m = Y^p + X^f + \left(\frac{R}{\pi} - 1\right) A$$

Plugging steady state value of imported consumption, we have

$$\omega_c C + I^m = Y^p + X^f + \left(\frac{R}{\pi} - 1\right) A$$

Assuming the net foreign asset position[38] is calibrated, there are two equations with only X^f and C unknown. Solving yields

$$\begin{aligned} C &= Y^f - (I^m + I^d + G) + Y^p + \left(\frac{R}{\pi} - 1\right) A \\ X^f &= Y^f - G - C^d - I^d \end{aligned}$$

It implies that $C^m = \omega_c C$ and $C^d = (1 - \omega_c)C$.

Beveridge curve The law of motion of employment implies that

$$\delta_n N^p = q^p V^p$$
$$\delta_n N^p = p^p U$$

Since employment in each sectors N^p, N^f, the unemployment rate $U/2$ and the vacancy rate $\frac{V^p}{N^p}$ are set to attain steady-state targets

$$q^p = \frac{\delta_n N^p}{V^p}$$
$$p^p = \frac{\delta_n N^p}{U}$$

[38] Any net foreign asset position A can be made consistent with steady state when $\bar{A} = A$ in $\Phi(.)$.

Wages The maximum wage values are given by

$$\overline{w}^{max,f} = mc(1-\alpha_f)\frac{Y^f}{N^f}$$
$$\overline{w}^{max,p} = (1-\alpha_p-\beta_p)\frac{Y^p}{N^p}$$

where $\beta_p = 1-\alpha_p - \frac{mc(1-\alpha_f)Y^f}{Y^p}\frac{L^p}{L^f}$ such that $\overline{w}^{max,f} = \overline{w}^{max,p}$. I then assume that $\overline{w}^{min,p} = 0.95\overline{w}^{max,p}$, such that the employment surplus represents 5% of the wage. The equilibrium wage is then simply given by $\overline{w}^p = (0.95 + 0.05\omega_w)\overline{w}^{max,p}$.

Disaggregated consumption The consumption of EHs is given by

$$C^E = \frac{1}{2}\left[(1-\tau_w)(\bar{w}^p N^p + \bar{w}^f N^f) + U\varpi\right]$$

The consumption level of IHs is then simply given by $C^I = C - C^E$. With C^I, it is possible to compute υ and then the employment surplus with:

$$S^{I,p} = \frac{(1-\tau_w)(\overline{w}^f - \overline{w}^{min,f})}{1-(1-\delta_n)\beta}.$$

Implied parameters This strategy requires to calibrate χ_p such that the following condition holds:

$$\overline{w}^p = \overline{w}^{max,p} - \left(\frac{1}{\beta} - (1-\delta_n)\right)\frac{\chi_p}{\delta_n}\left(V^p\right)^{1+\theta}$$

and to calibrate A_n such that

$$(1-\tau_w)\overline{w}^{min,p} = \varpi + \left[\frac{U(H^p)+A_n}{\upsilon} + \beta\left(p^p S^{I,p} + p^f S^{I,f}\right)\right] \quad (78)$$

The strategy to find steady-state in the other sector is similar and yields identical results.

D Welfare cost measures

Conditional compensation measures are defined as the fraction of consumption that an agent would be ready to give up in the economy l to be equally well off in that economy than in an alternative economy v, when both economies state variables are initially identical. This appendix shows how to compute conditional compensation for EHs. The method to derive this measure for IHs is similar.

The maximum fraction λ of consumption that household e would be ready to give up in economy l to be as well off as under economy v should satisfy

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \int_0^1 \left[\frac{((1-\lambda)C_{e,l,t})^{1-\sigma_c} - 1}{1-\sigma_c} - A_h \frac{(N^p_{e,l,t} H^p_{e,l,t} + N^f_{e,l,t} H^f_{e,l,t})^{1+\sigma_h}}{1+\sigma_h} - A_n (N^p_{e,l,t} + N^f_{e,l,t}) \right] \mathrm{d}e$$
$$= \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \int_0^1 \left[\frac{(C_{e,v,t})^{1-\sigma_c} - 1}{1-\sigma_c} - A_h \frac{(N^p_{e,v,t} H^p_{e,v,t} + N^f_{e,v,t} H^f_{e,v,t})^{1+\sigma_h}}{1+\sigma_h} - A_n (N^p_{e,v,t} + N^f_{e,v,t}) \right] \mathrm{d}e.$$

to make this household indifferent between the two environments. In this expression, the conditional expectation operator E_0 conditions on the initial state of the economy (assumed to be its steady-state) and integrates over the probability density of aggregate disturbances. The integral explicitly integrates over households' idiosyncratic shocks. This expression can be solved for λ such that

$$\lambda = 1 - \left(\frac{\mathrm{E}_0 W\left(\mathbf{C}^{E,v}\right) + \mathrm{E}_0 W\left(\mathbf{h}^{E,v}\right) - \mathrm{E}_0 W\left(\mathbf{h}^{E,l}\right) + \frac{1}{(1-\beta)(1-\sigma_c)}}{\mathrm{E}_0 W\left(\mathbf{C}^{E,l}\right) + \frac{1}{(1-\beta)(1-\sigma_c)}} \right)^{\frac{1}{(1-\sigma_c)}} \tag{79}$$

can be used to measure welfare costs. This expression for λ can be evaluated provided that we can evaluate the functions $\mathrm{E}_0 W(.)$. These functions are given by

$$\mathrm{E}_0 W\left(\mathbf{C}^{E}\right) = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{N^p_t}{2} \frac{\left(C^{E,P}_t\right)^{1-\sigma_c} v^{cp}_t - 1}{1-\sigma_c} + \frac{N^f_t}{2} \frac{\left(C^{E,F}_t\right)^{1-\sigma_c} v^{cf}_t - 1}{1-\sigma_c} + \frac{U_t}{2} \frac{\left(C^{E,U}_t\right)^{1-\sigma_c} - 1}{1-\sigma_c} \right\}$$
$$\mathrm{E}_0 W\left(\mathbf{h}^{E}\right) = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ -\frac{N^p_t}{2} \frac{A_h (H^p_t)^{1+\sigma_h}}{1+\sigma_h} - \frac{N^f_t}{2} \frac{A_h (H^f_t)^{1+\sigma_h}}{1+\sigma_h} - A_n (N^p_t + N^f_t) \right\}$$

E Observation equations and data

Here, I describe observation equations, data sources and data transformations. I have a set of 10 domestic and 2 foreign observed variables linked to the model:

$$\begin{pmatrix} 100\log\left(GDP_t/GDP_{t-4}\right) \\ 100\log\left(CONS_t/CONS_{t-4}\right) \\ 100\log\left(INV_t/INV_{t-4}\right) \\ 100\log\left(EXP_t/EXP_{t-4}\right) \\ 100\log\left(IMP_t/IMP_{t-4}\right) \\ 100\log\left(EMP_t/EMP_{t-4}\right) \\ REPO_t \\ 100\log\left(CPI_t/CPI_{t-4}\right) \\ 100\log\left(WAGE_t/WAGE_{t-4}\right) \\ -100\log\left(NEER_t/NEER_{t-1}\right) \\ --- \\ FFR_t \\ 100\log\left(\frac{CP_t^*/CPI_t^*}{CP_{t-4}^*/CPI_{t-4}^*}\right) \end{pmatrix} = \begin{pmatrix} \bar{\gamma}^y \\ \bar{\gamma}^c \\ \bar{\gamma}^i \\ \bar{\gamma}^x \\ \bar{\gamma}^m \\ \bar{\gamma}^n \\ \bar{\gamma}^r \\ \bar{\gamma}^{\pi^c} \\ \bar{\gamma}^{\pi^w} \\ \bar{\gamma}^{\Delta S} \\ - \\ \bar{\gamma}^{r*} \\ \bar{\gamma}^{cp*} \end{pmatrix} + \begin{pmatrix} 100\log\left(y_t/y_{t-4}\right) \\ 100\log\left(c_t/c_{t-4}\right) \\ 100\log\left(i_t/i_{t-4}\right) \\ 100\log\left(x_t/x_{t-4}\right) \\ 100\log\left(m_t/m_{t-4}\right) \\ 100\log\left((N_t^p + N_t^f)/(N_{t-4}^p + N_{t-4}^f)\right) \\ 400R_t \\ 100\log\left(\pi_t^c\pi_{t-1}^c\pi_{t-2}^c\pi_{t-3}^c\right) \\ 100\log\left(\pi_t^w\pi_{t-1}^w\pi_{t-2}^w\pi_{t-3}^w\right) \\ 100\log\left(\Delta S_t\right) \\ --- \\ 400R_t^* \\ 100\log\left(\gamma_t^{p*}/\gamma_{t-4}^{p*}\right) \end{pmatrix} + \begin{pmatrix} \epsilon_t^y \\ \epsilon_t^c \\ \epsilon_t^i \\ \epsilon_t^x \\ \epsilon_t^m \\ \epsilon_t^n \\ \epsilon_t^r \\ \epsilon_t^{\pi^c} \\ \epsilon_t^{\pi^w} \\ \epsilon_t^{\Delta S} \\ - \\ \epsilon_t^{r*} \\ \epsilon_t^{cp*} \end{pmatrix}$$

where $\bar{\gamma}$ are constants calibrated at the corresponding observed series mean. This departs from the traditional view that the trend in real variables should be identical. However, considering that trade shares have been growing in South Africa over the estimation period (starting after the end of the apartheid), I allow for different means in the observation equations. Similar arguments hold for average domestic and foreign interest rates. Measurement errors ϵ are calibrated to relatively small values for all variables

Table 15: Data sources and transformations

South African data	Source	Transformation
GDP	Stat SA	GDP. Constant price. YoY.
Employment	SARB	Employment in the private sector (index). YoY.
Consumption	Stat SA	Final Consumption Expenditure, Households. Constant price. YoY.
Investment	Stat SA	Gross Fixed Capital Formation. Constant price. YoY.
Exports	Stat SA	Exports. Constant prices. YoY.
Imports	Stat SA	Imports. Constant prices. YoY.
CPI	Stat SA	Consumer Price Index, Urban Areas, All Items. YoY.
Wage	SARB	Labor Cost Index - Wages and Salaries. Current Prices. YoY.
Risk-free rate	SARB	Repo Rate. Annual rate in level.
NEER	BIS	Nominal broad effective exchange rate. QoQ.
Foreign data	**Source**	**Transformation**
US Risk-free rate	Wu and Xia (2016)	Effective Fed Fund rate.
	and Fred	Replaced by its shadow rate over the 2009Q3 to 2015Q4 period.
Commodity Price	World Bank	Commodity prices deflated with US CPI.
		Average of coal, aluminum, platinum and silver. YoY.

YoY = growth rate same quarter of the previous year. QoQ = quarter on quarter growth rate.

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