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Fiscal Policy in Brazil through the Lens

of an Estimated DSGE model*

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Abstract

This paper takes Brazilian data to an open economy DSGE model that features realistic aspects of fiscal policy in Brazil. The model incorporates primary surplus targets, cyclical expenditures and social programs in the form of public transfers, public investment and distortive taxation. We test for two competing specifications of the role of public capital in the real economy. Bayesian model comparison favors the infrastructure approach to public capital. The presence of non-Ricardian households allows fiscal policy shocks to affect real economy aggregates and distribution. The model is used to address questions regarding the effect of shocks to different fiscal policy instruments upon the business cycle. We also investigate whether recent fiscal policy in Brazil has exerted significant inflationary pressures.

Keywords: DSGE, fiscal policy, monetary policy, government investment, public capital, primary surplus, heterogeneous agents, market frictions, Bayesian estimation

JEL Classification: E32; E62; E63

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1 Introduction

The recent global financial crisis has brought fiscal policy back into spotlight. Facing major recession outlooks and approaching the zero lower bound of interest rates, developed economies have put forth significant fiscal stimuli as an attempt to boost economic recovery. In emerging markets, fiscal policy stimuli were also promptly set up to fight the recessionary risks of the crisis. In the specific case of Brazil, although the crisis abated much quicker than in developed economies (Figure 1), fiscal stimuli have not been completely withdrawn (Figure 2).

For some time now there has been a local debate on whether and to what extent the recent expansionary stance of Brazilian fiscal policy, put in place during the recent crisis, could jeopardize the achievement of inflation targets. Advocates in favor of fiscal interventions often argue that not all the adopted fiscal measures are inflationary; public investments, for instance, could be favorable to balanced growth through the supply side. Notwithstanding, the local debate still lacks an analytical tool that can properly account for the intricate economic responses of both fiscal and monetary policies in action.

This paper explores one possible tool for the analysis of fiscal and monetary policy in Brazil. We adapt a state-of-the-art open economy DGSE model to account for a more realistic setting of the fiscal policy from the standpoint of policy practice in Brazil. We bring the model to Brazilian data to investigate the dynamic responses of the economy to fiscal policy shocks and the effects of their interaction with monetary policy. The main questions we address are: 1) how does the type of fiscal expenditure matter for the business cycle?; 2) to what extent can an expansionist shock to the primary surplus put the accomplishment of central bank's inflation target at risk?; and 3) has the conduct of fiscal policy in Brazil in recent years put pressure on inflation?

The fiscal setting of the model departs from the tradition in the DSGE literature of addressing fiscal policy exclusively through lump sum taxes/transfers and a mean-reverting rule for current government expenditures. First, we introduce a state-dependent (net-of-interest) primary balance rule. With the implementation of an IMF

agreement back in 1998, Brazil committed to a primary surplus target that was intended to drive public debt to more sustainable levels in the long run. The target was to be complied with on a quarterly basis. The IMF agreement was renewed in 2001, amid a series of external and domestic shocks, including an energy shortage, and was extended and augmented in 2003.

In December 2005, the Brazilian government made an early full repayment of the outstanding debt with the IMF. Such an act also implied that the targets set forth in the IMF agreement would cease to be enforced. Notwithstanding, the government understood that the market factored in a commitment to a debt-reducing primary surplus target as a good sign of sound fiscal management, thus improving sovereign credit ratings and alleviating the burden of new issuances of public debt. The Brazilian government then decided to keep on announcing primary surplus targets for the fiscal years, and in general enforced an anti-cyclic budget execution.

The DSGE literature has experimented with some non-trivial state-dependent fiscal rules. In most cases, the preferred specification is based on rules for current government expenditures or taxes that respond to output and to debt[1]. In practice, a government with targets for the primary balance makes concomitant decisions on all sorts of expenditures, revenues, transfers, subsidies, tax recovery and exemptions. The identified shocks to the primary surplus rule in our model are thus a summary measure of changes in policymakers' preferences.

The second adaptation we introduce in our model is to let the government intervene in the economy through the accumulation of public capital, with an impact on factor productivity and in the overall demand for investment goods.

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[1] Medina and Soto (2007) analyze three types of fiscal rules: one where government expenditures adjust to satisfy government's budget constraint, another where government taxes do such as task, and the last one where government expenditures as a share of GDP adjust to meet a target for the "structural" balance, measured as the nominal fiscal result adjusted for cyclical revenues from government's budget flow. Forni et. al. (2009) use tax rules that react to the debt-to-GDP ratio, and report that expenditure rules yield similar impact of the fiscal shocks to the economy. In CMS, lump-sum taxes are the chosen instrument to stabilize the debt-to-GDP ratio. Ratto et. al. (2009) introduce a rule for public investment that responds to the business cycle.

We test for two competing specifications of the way public capital affects factor productivity in Brazil. In the first specification, which draws from the work of Ratto et. al. (2009), we let public capital augment factor productivity at no direct cost for the firm. Public capital in this case can be interpreted as an externality to the private productive sector. As Macdonald (2008) points out, this is the most standard way of estimating production functions in economies with relevant public infrastructure, but it misses the important point that such expenditures are financed by society, and sometimes financing can be directly associated with the economic activity that is more intense on the use of such public capital goods. In our specification, financing of public capital is indirect, through the general tax system, and is not factored into the cost accounting of firms.

In the second specification of the role of public capital in the economy, we assume that the costs associated with the use of public capital are born by its direct users, the intermediate goods firms. We also assume that, to a certain extent, firms can selectively choose between public and private capital services. This modeling choice was intended to capture the significant presence of the Brazilian government in the productive sector of the economy. In spite of a vast number of privatizations carried out over the past decades, Brazil still has a substantial number of mixed-capital firms (118 federal enterprises, as of January 2010) on top of high and increasing public loans to finance private capital[2]. Some of these loans are extended with guarantees in the form of ownership transfers of funded capital to the government. Although this type of capital belongs to the government, it does not possess the characteristics of a public good: it is employed uniquely at the production of the individual firm and does not produce externalities to the other firms of the economy.

To allow fiscal policy to have an effect on aggregate consumption, we follow Coenen, McAdam and Straub (2008), hereinafter referred to as CMS, and introduce non-Ricardian agents in the model.[3] These agents are optimizing consumers, but, in addition to being constrained on their access to capital markets and investment choices, non-

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[2] As of October 2010, total outstanding loans extended by public financial institutions amounted to 19.8% of GDP.

[3] Although the 59% of non-Ricardian agents calibrated for the domestic economy is higher than the 25% calibrated for the Euro Area, it is close to the 50% used in Galí et. al. (2004), and is substantially lower than the 70% considered for Chile in Medina and Soto (2007).

Ricardian agents in our model are less productive than the other group of agents. This assumption is necessary to allow for a steady state where different groups of workers can work the same amount of hours but earning different wages.

The fourth novelty in our fiscal setup is the introduction of social programs in the form of transfers to the worse-off. For the past years, these programs have gained a lot of importance in the Brazilian policy agenda. The most popular program, "Bolsa Família", has consisted of monthly transfers of public funds to about 11 million households in Brazil.

The rest of the model follows the essence of the calibrated version of ECB's New Area Wide Model presented in CMS. In addition to the changes we introduce in the fiscal setup and the assumption of labor heterogeneity, we modify the final goods price index and the recursive representation of wage setting decision rules and wage dispersion index[4], and introduce risk premia in the negotiation of foreign and domestic debt, the former playing an active role even in the steady state so as to account for the fact that real interest rates in Brazil are substantially higher than in the developed world. As in the estimated version of ECB's NAWM presented in Christoffel, Coenen and Warne (2008), hereinafter referred to as CCW, our model features trending growth in labor productivity.

We estimate the model using Bayesian methods. The data density favors the model that specifies public capital as an externality to firms. We use this model as benchmark to produce Bayesian impulse responses to the shocks in the model. From the IRFs, we show that: 1) the type of fiscal expenditures greatly matters for the business cycle; 2) fiscal shocks are usually inflationary; 3) fiscal policy preferences have not been identified as important drivers of the recent path of consumer inflation in Brazil; but 4) fiscal policy preferences have played an important role in the historical execution of the primary surplus.

In addition, we conduct policy exercises and show that greater reaction of fiscal policy to deviations of public debt or GDP growth from their steady states can significantly

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[4] The details on the theoretical revisions can be found in Valli and Carvalho (2010).

destabilize the model's dynamics. On the other hand, stronger reaction of the monetary authority to output growth produces muter responses to inflation and output after monetary policy shocks.

Motivated by the policy debate about the possibility of reducing the primary surplus target in Brazil, we analyze the model's dynamics under a drastic reduction in the target. We show that this would not enact significant changes in the dynamic responses of real and nominal variables of the model; however, and quite importantly, such a reduction in the target can only be accomplished if the ratio of public debt to GDP is also sharply cut down. Otherwise, the economy can undergo explosive paths.

Our simulations also show that the presence of non-Ricardian agents has important implications for the responses of real variables to fiscal policy shocks, notwithstanding the fact that our non-Ricardian agents are intertemporal optimizers, yet with more restraints than the Ricardians.

The paper is organized as follows. Section 2 provides an overview of the model. Section 3 details the estimation procedure, reporting on the strategy for calibrating the steady state of the model, the reasons underlying the choices of priors, and also describing the data and the shocks. Section 4 analyses the impulse responses of the model and presents the historical decomposition of some key macroeconomic variables. Section 5 reports on some policy exercises. The last section concludes the paper.

2 The model

Figure 3 depicts the core structure of the model. The model is composed of two economies of different sizes that interact in goods and financial markets. The foreign economy is modeled exactly like in CMS. The domestic economy is described in details below.

2.1. Households

The domestic economy has a continuum of households, which are grouped into two sets. The first, henceforth referred to as group $I = [0, 1 - \omega)$, contains individuals with full access to savings technologies and with better labor skills. The other group, henceforth referred to as $J = [1 - \omega, 1]$, is composed of non-Ricardian agents who can smooth consumption intertemporally only by holding non-interest-bearing money balances.

Household $i \in I$ chooses consumption $C_{i,t}$ and labor services $N_{i,t}$ to maximize the separable intertemporal utility with external habit formation

$$E_t\left\{\sum_{k=0}^{\infty} \beta^k\left[e_{C,t+k}\frac{1}{1-\sigma}\left(C_{i,t+k} - \kappa C_{I,t+k-1}\right)^{1-\sigma} - e_{N,t+k}\frac{1}{1+\zeta}\left(N_{i,t+k}^{1+\zeta}\right)\right]\right\} \tag{1}$$

where $e_{C,t+k}$ and $e_{N,t+k}$ are shocks to consumption and labor preferences, the parameter κ is the external habit persistence, β is the intertemporal discount factor, $1/\sigma$ is the intertemporal elasticity of consumption substitution, $1/\zeta$ is the elasticity of labor effort relative to the real wage, and δ is the depreciation rate of capital.

Consumer i's optimization problem is subject to the budget constraint

$$\left(1 + \tau_t^C + \Gamma_\nu(\nu_{i,t})\right)P_{C,t}C_{i,t} + P_{I,t}I_{i,H,t} + \left(e_{RP,t}R_t\right)^{-1}B_{i,t+1} \tag{2}$$
$$+ \left(e_{RPF,t}R_{F,t}\right)^{-1}S_t B_{i,t+1}^F + M_{i,t} + \Xi_{i,t} + \Phi_{i,t}$$

$$= \left(1 - \tau_t^N - \tau_t^{Wh}\right)W_{i,t}N_{i,t} + (1 - \tau_t^K)\left[u_{i,t}R_{K,H,t} - \Gamma_u(u_{i,t})P_{I,t}\right]K_{i,H,t}$$
$$+ \tau_t^K\delta\,P_{I,t}K_{i,H,t} + (1 - \tau_t^D)D_{i,t} + TR_{i,t} - T_{i,t} + B_{i,t} + S_t B_{i,t}^F$$
$$+ M_{i,t-1}$$

where, on the expenditure side, $I_{i,H,t}$ is private investment in capital goods, $B_{i,t+1}$ are domestic government bonds, $B_{i,t+1}^F$ are foreign private bonds, R_t is the riskless free rate,

$R_{F,t}$ is the interest rate on foreign bonds, $e_{RP,t}$ and $e_{RPF,t}$ are risk premia over domestic and international bonds, respectively, S_t is the nominal exchange rate, $M_{i,t}$ are money holdings, $\Xi_{i,t}$ is a lump sum rebate on the foreign risk premium, and $\Phi_{i,t}$ is the stock of contingent securities negotiated within group I, acting as insurance against risks on labor income. In addition, $\Gamma_v(v_{i,t})$ is a transaction cost on consumption and $v_{i,t}$ is the money-velocity of consumption. On the earnings side, $W_{i,t}$ is the wage earned by household i for one unit of labor services, $K_{i,H,t}$ is the stock of private capital, $u_{i,t}$ is teady state nominal $e\Gamma_u(u_{i,t})$ is the cost of deviating from the steady state rate of capital utilization, $R_{K,H,t}$ is the gross rate of the return on private capital, $D_{i,t}$ are dividends, and $TR_{i,t}$ are transfers from the government. Taxes are: τ_t^C (consumption), τ_t^N (labor income), τ_t^{Wh} (social security), τ_t^K (capital income), τ_t^D (dividends) and $T_{i,t}$ (lump sum, active only for the foreign economy). Price indices are $P_{C,t}$ and $P_{I,t}$, the prices of final consumption and investment goods, respectively. Cost functions are detailed in the Appendix.

The risk premium on internationally traded bonds follows:

$$e_{RPF,t} = e_{RPF}.\exp\left\{-\gamma_{RPF,1}\left(B_{F,t}/Y_{t-1} - b_F\right) - \gamma_{RPF,2}\left(E_t\left(\frac{S_{t+1}}{S_t}\right) - \Delta S\right) + \varepsilon_{RPF,t}\right\}$$

where ΔS is the steady state change in the nominal exchange rate, b_F is the steady state foreign-debt-to-GDP ratio, and $\varepsilon_{RPF,t}$ is a white noise shock. We let e_{RPF} correspond to a steady state risk premium that allows for country-specific real interest rates. To this end, we need to introduce the lump-sum rebate on the risk premium, $\Xi_{i,t}$, so that these flows do not impact the balance of payments of the foreign country[5].

The accumulation of private capital follows the equation:

$$K_{i,H,t+1} = (1 - \delta)K_{i,H,t} + e_{I,t}\left(1 - \Gamma_I\left(I_{i,H,t}/I_{i,H,t-1}\right)\right)I_{i,H,t} \tag{3}$$

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[5] For simplicity, we assume that $\Xi_{i,t} = \Xi_{j,t}$.

where $I_{i,H,t}$ is private investment, Γ_I is a cost to adjusting investment plans, and $e_{I,t}$ is a shock to investment efficiency.

Households in group J are non-Ricardian agents that maximize a utility function analogous to (1), but are refrained from carrying out investment decisions, except for holding non-interest bearing money balances.

Within each group, households compete in a monopolistically competitive labor market. By setting wage $W_{i,t}$, household i commits to meeting any labor demand $N_{i,t}$. Wages are set à la Calvo, with a probability $(1-\xi_I)$ of optimizing each period. Optimizing households in group I choose the same wage $\tilde{W}_{i,t}$, which we denote by $\tilde{W}_{I,t}$. Households that do not optimize readjust their wages based on a geometric average of past and steady state consumer inflation $\overline{W}_{i,t} := \left(\dfrac{P_{C,t-1}}{P_{C,t-2}}\right)^{\chi_I} \pi_C^{1-\chi_I} W_{i,t-1}$. As the non-optimizing wage does not perfectly track the trend growth of the economy, there will be wage dispersion amongst households in the steady state[6].

Household i's optimization with respect to the wage $\tilde{W}_{i,t}$ yields the first order condition, which is the same for every optimizing household in group I:

$$
E_t\left\{\sum_{k=0}^{\infty}(\xi_I\beta)^k N_{i,t+k}\left[\left(\Lambda_{i,t+k}\left(1-\tau_{t+k}^N-\tau_{t+k}^{W_h}\right)\frac{\tilde{W}_{I,t}}{P_{C,t+k}}\left(\frac{P_{C,t+k-1}}{P_{C,t-1}}\right)^{\chi_I}\pi_C^{(1-\chi_I)k}\right.\right.\right.
$$
$$
\left.\left.\left.- e_{W,t+k}\,e_{N,t+k}\left(N_{i,t+k}\right)^{\zeta}\right)\right]\right\}=0 \tag{4}
$$

---

where $\dfrac{\Lambda_{i,t}}{P_{C,t}}$ is the Lagrange multiplier for the budget constraint, and $e_{W,t+k}$ is, in the absence of staggering, a time varying markup of the real wage: $e_{W,t} = \rho_W e_{W,t-1} + (1 - \rho_W)\left(\dfrac{\eta_I}{\eta_I - 1}\right) + \varepsilon_{W,t}$.

Equation (4) can be expressed in the following recursive form:

$$(1-\omega)^{\zeta} \cdot \left(\frac{\tilde{W}_{I,t}}{P_{C,t}}\right)^{1+\eta_I \cdot \zeta} = e_{W,t}\, e_{N,t} \cdot \frac{F_{I,t}}{G_{I,t}} \tag{5}$$

where

$$F_{I,t} := \left(\left(\frac{W_{I,t}}{P_{C,t}}\right)^{\eta_I} N_t^I\right)^{1+\zeta} + \xi_I \cdot \beta \cdot E_t\left\{\left(\frac{\pi_{C,t+1}}{\pi_{C,t}^{\chi_I} \cdot \pi_C^{1-\chi_I}}\right)^{\eta_I(1+\zeta)} \cdot F_{I,t+1}\right\}$$

$$G_{I,t} := \Lambda_{I,t}\left(1 - \tau_t^N - \tau_t^{W_h}\right)\left(\frac{W_{I,t}}{P_{C,t}}\right)^{\eta_I} N_t^I + \xi_I \cdot \beta \cdot E_t\left\{\left(\frac{\pi_{C,t+1}}{\pi_{C,t}^{\chi_I} \cdot \pi_C^{1-\chi_I}}\right)^{\eta_I - 1} \cdot G_{I,t+1}\right\}$$

and N_t^I is households group I aggregate labor demanded by firms, and $W_{I,t}$ is household group I's aggregate wage index. Superscripts in the labor variable represent demand. Subscripts represent supply.

Wage setting in group J is analogous to that of group I. The Calvo probability of readjusting wages is $(1 - \xi_J)$ and all other group-specific variables are expressed with the j or J indices (respectively for individuals or for the group).

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2.2 Production

The productive sector of the economy comprises firms that produce tradable intermediate goods and non-tradable final goods. Price frictions are introduced only in the block of intermediate goods firms.

2.2.1 Intermediate goods firms

Continuums of firms, indexed by $f \in [0,1]$, employ capital and labor services to produce tradable intermediate goods $Y_{f,t}$ under monopolistic competition. We introduce two alternative ways in which public capital affects private productivity.

In the first specification, public capital augments factor productivity with no counterpart in input costs. We label it "infrastructure approach to public capital". Under this approach, firm f's production function is

$$Y_{f,t} = z_t . \left(K_t^G\right)^{\alpha_G} \left(K_{f,t}^{H,S}\right)^{\alpha} . \left(zn_t . N_{f,t}^D\right)^{1-\alpha} - \psi . zn_t . \left(K_t^G\right)^{\frac{\alpha_G}{1-\alpha_G}} \tag{6}$$

where $N_{f,t}^D$ are aggregate labor services, K_t^G is the stock of public capital, $K_{f,t}^{H,S}$ are private capital services, ψ are fixed costs that ensure zero profit in the steady state, and z_t and zn_t are respectively (temporary) neutral and (permanent) labor-augmenting productivity shocks. In equilibrium, $K_{f,t}^{H,S} = u_{I,t} K_{f,t}^H$ where K_f^H is the stock of private capital used by firm f.

In the second specification of the production function of intermediate goods, which we label "mixed-capital economy", we follow Valli and Carvalho (2010) and assume that firms competitively rent capital services from the government, $K_{G,f,t}^S$, and from households in group I, $K_{H,f,t}^S$, and transform them into the total capital input $K_{f,t}^S$ through the following CES technology:

$$K_{f,t}^{S} = \left[\left(1 - \omega_g\right)^{1-\eta_g} . \left(K_{H,f,t}^{S}\right)^{\frac{\eta_g-1}{\eta_g}} + \left(\omega_g\right)^{1-\eta_g} . \left(K_{G,f,t}^{S}\right)^{\frac{\eta_g-1}{\eta_g}} \right]^{\frac{\eta_g}{\eta_g-1}} \tag{7}$$

where ω_g is the economy's degree of dependence on government investment and η_g stands for the elasticity of substitution between private and public capital services, and also relates to the sensitivity of demand to the cost variation in each type of capital.

The production function in the mixed-capital economy becomes:

$$Y_{f,t} = z_t . \left(K_{f,t}^{S}\right)^{\alpha} . \left(zn_t . N_{f,t}^{D}\right)^{1-\alpha} - \psi . zn_t \tag{8}$$

where, in equilibrium, $K_{f,t}^{S} = u_{I,t} K_{f,t}$, where $K_{f,t}$ is the stock of capital used by firm f.

For a given total demand for capital services, the mixed capital firm minimizes the total cost of private and public capital services, solving:

$$\min_{K_{H,f,t}^{S}, K_{G,f,t}^{S}} R_{K,t}^{H} K_{H,f,t}^{S} + R_{K,t}^{G} K_{G,f,t}^{S} \tag{9}$$

subject to (7).

The rental rate for private capital services results from the equilibrium conditions in the private capital market. The rental rate for government capital services also results from equilibrium conditions, this time in the market for government capital services, but, in steady state, we calibrate ω_g in order to let the rental rate for public capital goods exclusively cover expenses with capital depreciation, so as to reproduce the fact that public capital is usually subsidized[7].

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[7] This assumption is also used in Macdonald (2008).

First order conditions to the problem of the mixed-capital firm yield the average rate of return on capital and the aggregate demand functions for each type of capital goods services:

$$R_{K,t} = \left((1-\omega_g).\left(R_{K,t}^H\right)^{1-\eta_g} + \omega_g.\left(R_{K,t}^G\right)^{1-\eta_g} \right)^{\frac{1}{1-\eta_g}}$$

(10)

$$K_{G,t}^S = \omega_g \left(\frac{R_{G,t}}{R_{K,t}} \right)^{-\eta_g} K_t^S$$

(11)

$$K_{H,t}^S = \left(1-\omega_g\right) \left(\frac{R_{H,t}}{R_{K,t}} \right)^{-\eta_g} K_t^S$$

(12)

All firms are identical since they solve the same optimization problem. The aggregate composition of capital services rented by intermediate goods firms can be restated by suppressing the subscript "f" from (7), using (10), and aggregating the different types of capital services across firms:

$$K_t^S = \left((1-\omega_g)^{1/\eta_g} \left(K_{H,t}^S\right)^{\frac{\eta_g-1}{\eta_g}} + \omega_g^{1/\eta_g} \left(K_{G,t}^S\right)^{\frac{\eta_g-1}{\eta_g}} \right)^{\frac{\eta_g}{\eta_g-1}}$$

(13)

Regardless of the approach to modeling public capital, we assume that firms rent labor services from groups with unequal labor skills. We assume that the individuals that are more constrained on their investment possibilities are also the ones with lower levels of labor skills. This modeling strategy allows for a steady state where skillful workers can earn more yet working the same amount of hours as the less skilled. In Brazil, labor contracts usually stipulate an 8-hour work-day. The freely negotiable terms in labor contracts are usually monthly nominal wages. The country is also globally known for its uneven income distribution. The same can be said for the distribution of labor income. According to the PNAD survey conducted by the Statistics Bureau (IBGE) in the year 2007, individuals earning less than 2 minimum wages (equivalent to USD 195 per

month at that time) amounted to 59.26% of the total economically active population. The other share of the population earned almost 3 times as much in average.

The labor input used by firm f in the production of intermediate goods is a composite of labor demanded to both groups of households. In addition to a population-size adjustment (ω) to the firm's labor demand, we add the parameter $v_\omega \in \left[0, \frac{1}{\omega}\right]$ to introduce a bias in favor of more skilled workers. The resulting labor composite obtains from the following transformation technology

$$N_{f,t}^D := \left((1-v_\omega \omega)^{1/\eta} \left(N_{f,t}^I\right)^{1-1/\eta} + (v_\omega \omega)^{1/\eta} \left(N_{f,t}^J\right)^{1-1/\eta}\right)^{\eta/(\eta-1)} \tag{14}$$

where

$$N_{f,t}^I := \left[\left(\frac{1}{1-\omega}\right)^{1/\eta_I} \int_0^{1-\omega} \left(N_{f,t}^i\right)^{1-1/\eta_I} di\right]^{\eta_I/(\eta_I-1)} \tag{15}$$

$$N_{f,t}^J := \left[\left(\frac{1}{\omega}\right)^{1/\eta_J} \int_{1-\omega}^1 \left(N_{f,t}^j\right)^{1-1/\eta_J} dj\right]^{\eta_J/(\eta_J-1)} \tag{16}$$

and where η is the price-elasticity to demand for specific labor bundles, η_I and η_J are the price-elasticities for specific labor varieties. The special case when $v_\omega = 1$ corresponds to the equally skilled workers.

Taking average wages ($W_{I,t}$ and $W_{J,t}$) in both groups as given, firms choose how much labor to hire by minimizing total labor cost $W_{I,t} N_{f,t}^I + W_{J,t} N_{f,t}^J$ subject to (14). It follows from first order conditions that the aggregate wage is

$$W_t = \left[(1-v_\omega . \omega).W_{I,t}^{1-\eta} + v_\omega . \omega . W_{J,t}^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{17}$$

and the aggregate demand functions for each group of households are:

$$N_t^I = (1 - \nu_\omega . \omega) \cdot \left(\frac{W_{I,t}}{W_t} \right)^{-\eta} . N_t^D \tag{18}$$

$$N_t^J = \nu_\omega . \omega \cdot \left(\frac{W_{J,t}}{W_t} \right)^{-\eta} . N_t^D \tag{19}$$

Intermediate goods prices are set under monopolistic competition, with Calvo-type price rigidities. We assume local currency pricing. Let $P_{H,f,t}$ and $P_{X,f,t}$ be the prices for goods sold by firm f in the domestic and foreign markets, with ξ_H and ξ_X denoting the probability that the firm will not optimize prices in each of these markets. Non-optimizing domestic and foreign firms adjust their prices according to the rules

$$\overline{P}_{H,f,t} := \left(\frac{P_{H,t-1}}{P_{H,t-2}} \right)^{\chi_H} (\pi_H)^{1-\chi_H} P_{H,f,t-1} \tag{20}$$

$$\overline{P}_{X,f,t} := \left(\frac{P_{X,t-1}}{P_{X,t-2}} \right)^{\chi_X} (\pi_X)^{1-\chi_X} P_{X,f,t-1} \tag{21}$$

where π_H and π_X are domestic and foreign intermediate goods' steady state inflation rates.

Optimizing firms choose the prices $\tilde{P}_{H,f,t}$ and $\tilde{P}_{X,f,t}$ to maximize the expected discounted sum of nominal profits:

$$E_t \left[\sum_{k=0}^{\infty} \Lambda_{I,t,t+k} \left((\xi_H)^k D_{H,f,t+k} + (\xi_X)^k D_{X,f,t+k} \right) \right] \tag{22}$$

where $\Lambda_{I,t,t+k}$ is household I's average discount factor, given by

$$\Lambda_{I,t,t+k} = \frac{1}{1-\omega} \int_0^{1-\omega} \beta^k \frac{\Lambda_{i,t+k}}{\Lambda_{i,t}} \frac{P_{C,t}}{P_{C,t+k}} di \qquad (23)$$

and nominal profits, net of fixed costs, are defined as

$$D_{H,f,t} = \left(P_{H,f,t} - MC_t\right)H_{f,t} \qquad (24)$$

$$D_{X,f,t} = \left(S_t P_{X,f,t} - MC_t\right)X_{f,t} \qquad (25)$$

Optimization is subject to the price indexation rule, to domestic and foreign demand for firm f's goods, $H_{f,t}$ and $X_{f,t}$, taking as given the marginal cost, the exchange rate and aggregate demand.

First order conditions for the pricing decisions yield

$$E_t\left[\sum_{k=0}^{\infty}(\xi_H)^k \Lambda_{I,t,t+k}\left(\tilde{P}_{H,t}\left(\frac{P_{H,t+k-1}}{P_{H,t-1}}\right)^{\chi_H}(\pi_H)^{(1-\chi_H)k} - e_{P,t+k}MC_{t+k}\right)H_{f,t+k}\right] = 0 \qquad (26)$$

and

$$E_t\left[\sum_{k=0}^{\infty}(\xi_X)^k \Lambda_{I,t,t+k}\left(S_{t+k}\tilde{P}_{X,t}\left(\frac{P_{X,t+k-1}}{P_{X,t-1}}\right)^{\chi_X}(\pi_X)^{(1-\chi_X)k} - e_{P,t+k}MC_{t+k}\right)X_{f,t+k}\right] = 0 \qquad (27)$$

where $e_{P,t}$ represents a time-varying markup of prices in the absence of staggering, with $e_{P,t} = \rho_W e_{P,t-1} + (1-\rho_W)\left(\frac{\theta}{\theta-1}\right) + \varepsilon_{P,t}$, where $\varepsilon_{P,t}$ is white noise. For simplicity we assume that the markup processes for both domestic and exported goods are the same.

As firms are identical, they face the same optimization problem, choosing the same optimal price $\tilde{P}_{H,f,t} = \tilde{P}_{H,t}$ and $\tilde{P}_{X,f,t} = \tilde{P}_{X,t}$.

Pricing equations (26) and (27) can be restated recursively as

$$\frac{\tilde{P}_{H,t}}{P_{H,t}} = e_{P,t}\frac{F_{H,t}}{G_{H,t}} \tag{28}$$

$$\frac{\tilde{P}_{X,t}}{P_{X,t}} = e_{P,t}\frac{F_{X,t}}{G_{X,t}} \tag{29}$$

where

$$F_{H,t} := MC_t.H_t + \xi_H \beta E_t \left\{ \frac{\Lambda^*_{I,t+1}}{\Lambda^*_{I,t}}.\left(\frac{\pi_{H,t+1}}{\pi_{H,t}^{\chi_H}\pi_H^{1-\chi_H}} \right)^{\theta} F_{H,t+1} \right\}$$

$$G_{H,t} := P_{H,t}.H_t + \xi_H \beta E_t \left\{ \frac{\Lambda^*_{I,t+1}}{\Lambda^*_{I,t}}.\left(\frac{\pi_{H,t+1}}{\pi_{H,t}^{\chi_H}\pi_H^{1-\chi_H}} \right)^{\theta-1} G_{H,t+1} \right\}$$

$$F_{X,t} = MC_t.X_t + \xi_X.\beta.E_t \left\{ \frac{\pi_{\Lambda_I,t+1}}{\pi_{C,t+1}}.\left(\frac{\pi_{X,t+1}}{\pi_{X,t}^{\chi_X}.\pi_X^{1-\chi_X}} \right)^{\theta}.F_{X,t+1} \right\}$$

$$G_{X,t} = S_t.P_{X,t}.X_t + \xi_X.\beta.E_t \left\{ \frac{\pi_{\Lambda_I,t+1}}{\pi_{C,t+1}}.\left(\frac{\pi_{X,t+1}}{\pi_{X,t}^{\chi_X}.\pi_X^{1-\chi_X}} \right)^{\theta-1}.G_{X,t+1} \right\}$$

Aggregating over firms, domestic and export intermediate goods prices are

$$P_{H,t} = \left[(1-\xi_H).(\tilde{P}_{H,t})^{1-\theta} + \xi_H.(\overline{P}_{H,t})^{1-\theta} \right]^{1/(1-\theta)}$$

$$\tag{30}$$

$$P_{X,t} = \left[(1 - \xi_X).(\tilde{P}_{X,t})^{1-\theta} + \xi_X.(\overline{P}_{X,t})^{1-\theta}\right]^{1/(1-\theta)}$$

(31)

2.2.2 Final goods firms

The economy has three firms producing non-tradable final goods. One specializes in the production of private consumption goods, another in public consumption goods, and the third in investment goods. Except for the firm that produces public consumption goods, all final goods' producers combine domestic and imported intermediate goods in their production line.

To produce private consumption goods, Q_t^C, the firm purchases bundles of domestic H_t^C and foreign IM_t^C intermediate goods. To adjust its imported share of inputs, the firm faces the cost $\Gamma_{IM^C}\left(\dfrac{IM_t^C}{Q_t^C}, e_{IM,t}\right)$, where $e_{IM,t}$ is an import demand shock.

Letting ν_C denote the bias towards domestic intermediate goods, the technology to produce private consumption goods is

$$Q_t^C := \left\{ \begin{array}{l} (\nu_C)^{1/\mu_C}\left[H_t^C\right]^{1-1/\mu_C} + \\ (1-\nu_C)^{1/\mu_C}\left[\left(1 - \Gamma_{IM^C}(IM_t^C/Q_t^C)\right)IM_t^C\right]^{1-1/\mu_C} \end{array} \right\}^{\mu_C/(\mu_C-1)}$$

(32)

where

$$H_t^C := \left(\int (H_{f,t}^C)^{1-1/\theta} df \right)^{\theta/(\theta-1)}$$

$$IM_t^C := \left(\int_0^1 (IM_{f^*,t}^C)^{1-1/\theta^*} df^* \right)^{\theta^*/(\theta^*-1)}$$

The firm will minimize total input costs

$$\min_{H_t^C, IM_t^C} P_{H,t}.H_t^C + P_{IM,t}.IM_t^C \qquad (33)$$

subject to the technology constraint (32) taking intermediate goods prices as given.

The existence of an adjustment cost to the share of imported goods in the production of final goods invalidates the standard result that the Lagrange multiplier of the technology constraint equals the price index of final goods. The price index of private consumption goods that ensures that the producing firm operates under perfect competition is[8]:

$$P_{C,t} = \left(\Omega_t^C\right)^{1-\mu_C}\left(\lambda_t^C\right)^{\mu_C} \qquad (35)$$

where

$$\lambda_t^C = \left[\nu_C P_{H,t}^{1-\mu_C} + (1-\nu_C)\left(P_{IM,t}/\Gamma^3{}_{IM^C}(IM_t^C/Q_t^C)\right)^{1-\mu_C}\right]^{\frac{1}{1-\mu_C}} \qquad (35)$$

$$\Omega_t^C = \left\{ \nu_C\left(P_{H,t}\right)^{1-\mu_C} + (1-\nu_C)\left(\frac{\Gamma^3{}_{IM^C}(IM_t^C/Q_t^C)}{\left(1-\Gamma_{IM^C}(IM_t^C/Q_t^C)\right)}\right) \atop \times\left(P_{IM,t}/\Gamma^3{}_{IM^C}(IM_t^C/Q_t^C)\right)^{1-\mu_C} \right\}^{\frac{1}{1-\mu_C}} \qquad (36)$$

In general, first order conditions and equation (34) can be combined to yield the following demand equations:

$$H_t^C = \nu_C\left(\frac{P_{H,t}}{\Omega_t^C}\right)^{1-\mu_C}\left(\frac{P_{H,t}}{P_{C,t}}\right)^{-\mu_C} Q_t^C \qquad (37)$$

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[8] Details of the derivation of (34) are shown in Valli and Carvalho (2010).

$$IM_t^C = (1-v_C)\left(\frac{P_{C,t}}{\Omega_t^C}\right)^{1-\mu_C}\left(\frac{P_{IM,t}/\Gamma^{\Im}_{IM^C}(IM_t^C/Q_t^C)}{P_{C,t}}\right)^{-\mu_C}\frac{Q_t^C}{1-\Gamma_{IM^C}(IM_t^C/Q_t^C)} \qquad (38)$$

The description of the model for investment goods is analogous, and the import demand shock that affects the cost to adjust the import basket is exactly the same.

2.3 Fiscal authority

The domestic fiscal authority pursues a primary surplus target (sp) expressed in terms of GDP, levies taxes on consumption, labor, capital and dividends, makes biased transfers, and adjusts expenditures and budget financing accordingly.

To account for the fact that the focal fiscal variable in Brazil is the (net-of-interest) primary balance, we introduce a rule for the primary surplus that responds to business cycle conditions and to the deviations of the public debt-to-GDP ratio from its steady-state:

$$\begin{aligned} sp_t = \rho_{sp}.sp_{t-1} + \\ (1-\rho_{sp}).\left\{sp+\phi_{B_Y}\left(b_{Y,t}-b_Y\right)\right\}+\phi_{sp,gy}\left(g_{Y,t-1}-g_Y\right)-\varepsilon_{sp,t} \end{aligned} \qquad (39)$$

where sp is the primary surplus target, $sp_t = \dfrac{SP_t}{P_{Y,t}.Y_t}$, SP_t is the nominal level of the primary surplus, $b_{Y,t} = \dfrac{B_t}{P_{Y,t-1}Y_{t-1}}$, $g_{Y,t} = \dfrac{Y_t}{Y_{t-1}}$, the unindexed counterparts are steady-state ratios, and $\varepsilon_{sp,t}$ is a white noise shock to the primary surplus.

We introduce social programs in the form of biased transfers of public funds. Total transfers (TR_t) are distributed to each household group according to:

$$TR_{I,t} := \frac{(1 - \omega.v_{tr})}{1 - \omega} TR_t \tag{40}$$

$$TR_{J,t} := v_{tr}.TR_t \tag{41}$$

where v_{tr} is the bias in transfers in favor of group *J,* and

$$\left(\frac{TR_t}{P_{Y,t}.Y_t} \right) = (1 - \rho_{tr}).tr + \rho_{tr}.\left(\frac{TR_t}{P_{Y,t}.Y_t} \right) + \varepsilon_{tr,t} \tag{42}$$

where *tr* is the steady state value of government transfers, and $\varepsilon_{tr,t}$ represents a white noise shock.

Government's capital accumulation follows the equation

$$K_{G,t+1} = (1 - \delta)K_{G,t} + e_{I,t}\left(1 - \Gamma_I\left(I_{G,t}/I_{G,t-1}\right) \right) I_{G,t}$$

where $I_{G,t}$ is public investment and, for simplicity, $e_{I,t}$ is the same shock to the efficiency of investment that affects private capital accumulation.

Government investment follows an autoregressive rule of the form

$$ig_t = \left(1 - \rho_{ig}\right)ig + \rho_{ig}.ig_{t-1} + \varepsilon_{ig,t} \tag{43}$$

The government budget constraint is thus

$$\tau_t^C P_{C,t}C_t + (\tau_t^N + \tau_t^{W_h} + \tau_t^{W_f}).W_t.N_t^D + \tau_t^K\left(R_{K,t}.u_{I,t} - (\Gamma_u(u_{I,t}) + \delta).P_{I,t}\right)K_t$$
$$+ \tau_t^D.D_t + T_t + \left(e_{RP,t}R_t\right)^{-1}.B_{t+1} + M_t + u_{I,t}.R_{G,t}.K_{G,t} - P_{G,t}G_t - TR_t - B_t$$
$$- M_{t-1} - P_{I,t}.I_{G,t} = 0 \tag{44}$$

with $T_t = 0$ for the domestic economy. Equation (44) can be recast in terms of the primary surplus:

$$SP_t = (B_t - (e_{RP} R_t)^{-1}.B_{t+1}) - (M_t - M_{t-1}) \tag{45}$$

The former expression makes it clear that, in this model, money not only has an effective role in real decisions, but also matters for the adjustment of fiscal accounts. Increased money supply can alleviate the financial burden from public debt, a feature that approximates the theoretical model to the real conduct of economic policy.

As the primary surplus can also be stated as the difference between public revenues and expenditures, government consumption in this model will adapt endogenously so that the other fiscal instruments follow their stated rules.

2.4 Monetary authority

The monetary authority sets nominal interest rates and issues as much money as demanded by the public. To set interest rates, it follows a forward-looking rule that is compatible with an inflation targeting regime

$$\begin{aligned} R_t^4 = \phi_R.R_{t-1}^4 + (1-\phi_R). & \left[R^4 + \phi_\Pi E_t \left(\frac{P_{C,t+3}}{P_{C,t-1}} - \Pi \right) \right] \\ & + \phi_{g_Y} \left(g_{Y,t-1} - g_Y \right) + \phi_e \left[\left(\frac{S_t}{S_{t-1}} \right)^4 - \Delta S^4 \right] + \varepsilon_{R,t} \end{aligned} \tag{46}$$

where Π is the annual inflation target, R^4 is the annualized quarterly nominal equilibrium interest rate, which satisfies $R^4 = \beta^{-4}.\Pi$, g_Y is the steady state output growth rate, ΔS is the steady state nominal exchange rate variation, and $\varepsilon_{R,t}$ is a white noise shock to the interest rate rule.

3 Bayesian Estimation

We estimate the parameters for the domestic economy using Bayesian inference methods[9]. Below are the procedures adopted to this end.

3.1 Calibration

First we stationarize the model so that the variables are expressed as shares of GDP. Except for hours worked, real variables are divided by real GDP to handle the unit root that arises from the permanent labor productivity shock and, in the case of the infrastructure approach to public capital, from the trend in public capital. Nominal variables are transformed to shares of nominal GDP as prices also trend due to our assumption of non-null steady state inflation.

The foreign economy is entirely calibrated, following the parameterization presented in CMS.

Some parameters of the domestic economy are calibrated. Following the standard procedure, price levels and capital utilization are normalized to 1, while profits and adjustment costs are set to zero. Some endogenous variables are calibrated so as to reproduce Brazilian historical averages during the inflation targeting regime (Table 1), and they consequently pin down the steady state values for most of the remaining endogenous variables of the model.

Most of the parameters that affect the steady state of the model were also calibrated. Their values are shown in Table 2. In the absence of reasonable proxies in the literature for Brazil, some of these parameters were set at the same values as in CMS. A few others were calibrated to ensure that some desired relations hold in the steady state. The labor demand bias, v_ω, for instance, was calibrated to ensure that households' groups I

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[9] We use Dynare to conduct the log-linear approximation of the model to the calibrated steady state and to perform all estimation routines. We run 2 chains of 2 million draws of the Metropolis Hastings to estimate the posterior.

and J work the same amount of hours. The home biases v_C and v_I were obtained from the demand equations of imported goods using the steady state value of consumption and investment goods, in addition to the quantum of imports.

With the exception of consumption taxes, τ^C, which were calibrated following Siqueira et. al. (2001), Brazilian tax rates were set based on the current tax laws. Notwithstanding, these laws allow for a great variety of exemptions and usually differentiate tax rates according to taxable bases. As such, they are not concise references for calibration. However, to our knowledge there is no aggregate data we could refer to for such a purpose, and so we chose the tax rates that are most commonly applied.

We calibrated the price-elasticity to demand of government investment goods, η_g, to a value that is close to 1, arbitrarily approximating it to a Cobb-Douglas technology. This enabled us to calibrate v_g from the rental rate for government capital, which we assumed to be just enough to cover expenditures with depreciation.

In lack of quarterly data on household distribution, the wage indexation parameter of non-Ricardian households was set so as to equal the estimated mean of the same parameter for Ricardian households. The Calvo-probabilities of price optimization in the intermediate goods sector, χ_H and χ_X, were also fixed, as attempts to estimate them resulted in a wide region of model indeterminacy. They were set at 0.30, a value that closely reflects the average price rigidity in Brazilian CPI-micro-data, which is of about 1.3 quarters (Gouvea, 2007).

3.2 The data

We used the following (seasonally-adjusted) time series to estimate the parameters of the domestic economy:

- Consumer inflation $\pi_{C,t}$: quarterly inflation of the IPCA (Índice de Preços ao Consumidor Amplo – IBGE);

- Nominal interest rate R_t: quarterly effective nominal base rate (Selic);

- Total investment $P_{I,t}I_t \big/ P_{Y,t}Y_t$: seasonally adjusted quarterly nominal flows of gross fixed capital formation and inventory change in the national accounts as a share of quarterly GDP;

- Exports $P_{X,t}X_t \big/ P_{Y,t}Y_t$: seasonally adjusted quarterly nominal flows of exports in the national accounts as a share of quarterly GDP;

- Exports inflation $\pi_{X,t}$: quarterly inflation rate of Brazilian export prices calculated in USD by Funcex;

- Exports $P_{IM,t}IM_t \big/ P_{Y,t}Y_t$: seasonally adjusted quarterly nominal flows of imports in the national accounts as a share of quarterly GDP;

- Private consumption $P_{C,t}C_t \big/ P_{Y,t}Y_t$: seasonally adjusted quarterly nominal flows of household consumption in the national accounts as a share of quarterly GDP;

- Government consumption $P_{G,t}G_t \big/ P_{Y,t}Y_t$: seasonally adjusted quarterly nominal flows of government expenditures in the national accounts as a share of quarterly GDP;

- Installed capacity utilization $u_{i,t}$: quarterly capacity utilization published by FGV, normalized using the average of the series;

- Exchange rate variation S_t/S_{t-1}: quarterly nominal BRL/USD exchange rate variation;

- Primary surplus sp_t: seasonally adjusted primary surplus of the consolidated government (methodology that does not include Petrobrás in the public sector[10]) as a share of GDP.

The data were sampled from the inflation targeting period in Brazil (1999:Q1 to 2010:Q2). From 1994 to 1998, although inflation was low, monetary policy followed a fixed exchange rate band regime. To avoid contamination of estimations with such an important structural break, we chose to use the smaller sample.

As Guerron-Quintana (2007) pointed out, the data set chosen for the estimation matters for parameter identification. In our attempt to include the most number of series available, we noticed that the inclusion of monetary aggregates and available labor market series destabilized the estimations, and maximization algorithms could generally not find any optimum. We thus chose to exclude them from our data sample.

3.3 Shocks

We estimate the model with the following shocks:

- Total factor productivity, z - Monetary policy, ε_R

- Labor productivity, zn - Primary surplus, ε_{SP}

- Consumption preferences, e_C - Public transfers, e_{tr}

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[10] As the series for the primary surplus excluding Petrobrás is only available from 2002:Q1 on, we regressed the series with and without Petrobrás using the sample when both are available to obtain an estimate of the primary surplus without Petrobrás for the period 1991:Q1 to 2001:Q4.

- Gap between domestic and foreign labor productivity, e_{rzn}

- Government investment, e_{ig}

- Foreign risk premium, e_{RPF}

- Investment efficiency, e_I

- Domestic risk premium, e_{RP}

- Wage markup, e_W

- Import bias, e_{IM}

- Price markup, e_P

The shock to labor preferences, e_N, was too poorly identified in the initial rounds of estimation and was dropped from the final estimation reported in this paper.

Except for monetary policy and primary surplus shocks, which are white noise, all other shocks follow AR processes that converge to a steady state. In the mixed-capital economy, we assume that the process that governs the labor productivity shock follows:

$$\frac{zn_t}{zn_{t-1}} = (1 - \rho_{zn}) \cdot gy + \rho_{zn} \cdot \frac{zn_{t-1}}{zn_{t-2}} + \varepsilon_{zn,t} \tag{47}$$

where gy is the steady state output growth, which also equals the steady state rate of labor productivity under this approach to public capital. In addition, $\varepsilon_{zn,t}$ is an exogenous white noise process. We also assume that the normalized labor-augmenting technology shock in the domestic economy can temporarily deviate from that of the foreign economy:

$$e_{rzn,t} \equiv \frac{zn_t^*}{zn_t} = (1 - \rho_{rzn}) \cdot e_{rzn} + \rho_{rzn} \cdot e_{rzn,t-1} + \varepsilon_{rzn,t} \tag{48}$$

where $zn_t^* = \frac{zn_t^*}{Y_t^*}$ and $zn_t = \frac{zn_t}{Y_t}$ and $\varepsilon_{rzn,t}$ is a white noise shock.

For the infrastructure approach to public capital, there are two sources of trending growth in the economy, and so the process that governs the labor productivity shock is:

$$\frac{zn_t}{zn_{t-1}} = (1-\rho_{zn}).gy^{1-\frac{\alpha_G}{1-\alpha}} + \rho_{zn}.\frac{zn_{t-1}}{zn_{t-2}} + \varepsilon_{zn,t} \tag{47'}$$

and the difference in the normalized shock to domestic labor productivity from that in the foreign economy follows:

$$e_{rzn,t} \equiv \frac{zn_t^*}{zn_t} = (1-\rho_{rzn}).e_{rzn} + \rho_{rzn}.e_{rzn,t-1} + \varepsilon_{rzn,t} \tag{48'}$$

where, in this case, $zn_t^* = \dfrac{zn_t^*}{Y_t^{*1-\frac{\alpha_G^*}{1-\alpha^*}}}$ and $zn_t = \dfrac{zn_t}{Y_t^{1-\frac{\alpha_G}{1-\alpha}}}$.

The steady state of the shocks to the wage and price markups are respectively $\frac{\eta}{\eta-1}$ and $\frac{\theta}{\theta-1}$. Measurement errors were also included for national accounts series, as, in addition to suffering from substantial and frequent revisions, these series do not incorporate federal companies' financial flows into government accounts.

3.4 Estimation

The parameters were estimated after the model was log-linearized around the steady state. Table 3 shows prior and posterior moments.

For the choice of prior means, we used information from Brazilian-specific empirical evidence, whenever available, or took an agnostic stance of setting the priors at the center of traditionally chosen distributions or at the mode of the posteriors reported for the Euro Zone in CCW. In general, our priors were more diffuse than those in CCW. Below is a more detailed description of the priors we set based on Brazilian data:

- The priors for the coefficients in the primary surplus rule were set at the point estimates of the partial-equilibrium regression shown in Valli and Carvalho (2010), run on a sample from 1996 to 2009.

- For the monetary policy rule, our prior means were set at the point estimates of the Taylor rule presented in Minella and Souza-Sobrinho (2009)[11].

- The prior means for the autoregressive components of the shocks were agnostically set at 0.5, corresponding to the center of beta or uniform distributions in the [0,1] interval. The only exception was the shock to the wage markup, with a mean set at the NAWM mode.

The estimated data density favored the model where public capital is taken as an externality to firms (the infrastructure approach). For the same choice of priors we have just described, excluding the exchange rate component in the Taylor rule, the Lapplace approximation to the log data density of the mixed capital model was 977.77, compared to 1003.65 obtained under the infrastructure approach. In the analysis that follows, we report the estimates of the model under the infrastructure approach to public capital, assuming that there is an exchange rate component in the Taylor rule.

Figure 4 shows plots of the prior and posterior distributions for each estimated parameter, and Figure 5 shows convergence diagnostics. Some of the shapes of the posteriors are not well behaved (sometimes non-smooth or multimodal) in spite of a reasonable number of draws in each chain of the Metropolis Hastings algorithm[12]. The analyses that follow are based on the posterior means as calculated in the standard code of Dynare.

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[11] Our policy rules were estimated with only one lag in the policy instrument. The prior mean for the autoregressive components were thus set as the sum of the point estimates of the two lags in the individual regressions we just mentioned.

[12] So far, the computational resources available to this project have not allowed us to successfully handle estimates with a much greater number of draws.

The estimated means suggest that price and wage indexation in Brazil is substantially higher than in the Euro Zone[13]. Notwithstanding, monetary policy in Brazil is much more responsive to deviations of inflation from the targets. The response to output conditions is practically null, a result that was also obtained in partial-equilibrium regressions presented in Minella and Souza-Sobrinho (2009). Still compared to the Euro Zone, the autoregressive component of the rule in our estimations is much higher, and we also find a significant, yet small, response of the policy rate to exchange rate variations.

The estimated primary surplus rule is less responsive to the public debt than suggested by the partial equilibrium regression presented in Valli and Carvalho (2010). The fiscal response to the business cycle is practically negligible. As such, the fiscal rule is very close to a simple autoregressive rule, with a moderate autoregressive component (0.55). Inertia in public investment is relatively high (0.786), contrasting with the low regressiveness of public transfers (0.332).

4 Impulse Responses and Shock Decomposition

4.1 *Impulse responses to fiscal* Shocks

Figures 6 to 8 show impulse responses to shocks to fiscal variables in the model. The median responses are shown in bold lines, within the 90% confidence interval plotted with thinner lines, drawn from the posterior distribution. The shocks are in the magnitude of a 1 standard deviation from the steady state of the variables they directly affect.

An expansionist shock to the primary surplus (as a share of GDP) leads to increases in both government consumption and public investment (both in levels and as shares of GDP). This heats the economy as intermediate goods firms attempt to meet the increased demand for their goods. Firms are able to hire more labor, under a marginal

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[13] We take CCW as a reference for Euro Zone estimates.

reduction in real wages. This triggers an expansion in private consumption, which, together with the rise in government consumption, sustains output levels above the trend for over a year. The increased demand for consumer goods allows for the pass-through of the intermediate goods inflation to consumer prices, and thus consumer inflation rises. Monetary policy reacts to the inflationary conditions expected for the future and helps bring inflation back to the steady state. The interest rate reaction is not too intense because of the forward lookingness of the rule. Most of the effects of the primary surplus shock, including that on output, fade out within two years. The increase in the ratio of public debt to GDP, however, is very long-lasting.

An expansionist shock to government transfers (as a share of GDP) also has short-lived effects but the cycles it creates are quite different from those of the primary surplus shock. The transfers shock requires a strong reduction in government consumption and public investment (both as a share of GDP) so that the primary fiscal rule is fulfilled. As the transfers are biased towards the population that has restricted access to investment, consumption in this group rises above the trend. Yet, the increase in private consumption is not enough to ensure output expansion upon impact of the shock. It is only when government consumption returns to the steady state and thus stop depressing the demand for intermediate goods that output can take advantage of the greater demand from consumers and momentarily peaks above the trend. The shock to transfers has a mild and short-lived inflationary impact, likely due to the fact that the autoregressive component of the transfer rule is low, allowing the shock to dissipate fast.

An expansionist shock to government investment (as a share of GDP) requires a significant reduction in the ratio of government consumption to GDP so that the primary surplus rule is fulfilled. However, as the output strongly accelerates from the increased demand for intermediate goods to produce investment goods, detrended levels of government consumption fall only in the initial quarters, recovering soon after. The boost in output helps reduce the debt-to-GDP ratio, and the primary fiscal rule can also act so as to enact expansionary effects upon the economy. A heated labor market allows for a substantial increase in private consumption, with an important inflationary impact. The impact on CPI inflation is much stronger than that observed after a shock to the

primary surplus, but it fades out a little faster. The effects on real variables, including those on output, are long-lasting.

4.2 Impulse responses to the other shocks

Figure 9 shows the impulse response to a monetary policy shock. As expected, the shock drives output down, by depressing investment and private consumption. Firms cut down on their demand for labor, and employment falls. The rise in interest rates puts pressure on the debt service, which in turn requires a reduction in government consumption that further dampens output. The nominal exchange rate appreciates. All these effects result in a drop of intermediate goods inflation, passing through to consumer prices. The trough in inflation is in the first quarter after the shock hits the economy.

It is not clear what one should expect for the shape of the response of consumer inflation to a monetary policy shock in Brazil. Figure 10 replicates the responses obtained in Minella (2001), where he estimates a monthly VAR for the period 1994:09 to 2000:12 with standard endogenous variables in addition to the country risk premium. All of the responses are hump-shaped, but the trough occurs within the first three months after the shock. However, if we update the estimations to include the most recent data, the responses show a price puzzle in the first three months, and the trough is achieved later, in the sixth month (Panel A of Figure 11). If we use the same set of endogenous variables to estimate a quarterly VAR imposing the same ordering as in Minella (2001), we obtain greater uncertainty in the responses, with the central prediction indicating troughs in the 2nd and 5th quarters (Panel B of Figure 11). The shape of the response also considerably changes if we replace industrial production by GDP in the set of regressors (Panel C of Figure 11). In this case, the evidence of a price puzzle remerges and the trough of the response distinguishably occurs in the 5th quarter. Finally, if we replace the country risk premium for the nominal exchange rate in the set of regressors (Panel D of Figure 11), we find a completely different response where inflation does not drop after a shock to the exchange rate.

Figure 12 shows the impulse responses of a shock to the domestic risk premium. The shape of the responses resemble those of a monetary policy shock, as, similarly to the shock to the interest rate, the shock to the domestic risk premium represents a higher cost of borrowing to the government and a higher opportunity cost for investment. After the shock, the monetary policy instrument is fine-tuned to try to counterbalance the contractionist impact of the shock to the domestic risk premium.

Figure 13 shows the impulse responses of a shock to the foreign risk premium. It first transmits through the UIP, and as the shock hits, the exchange rate depreciates. Favorable terms of trade help boost exports and dampen imports, causing output to rise up above the trend. Greater labor demand helps private consumption to increase. Demand pressures feed through intermediate and consumer prices, and monetary policy reacts to get inflation back on the steady state.

Figure 14 shows the impulse responses to a temporary total factor productivity shock. On impact, the shock allows firms to cut down on their (nominal) marginal cost and on labor demand. As the prices of intermediate goods are set as a markup over marginal costs, they fall after the shock hits. Their passthrough to the GDP deflator implies a slight increase in real wages. Both factors, price drops and real wage increases, are factored into consumer decisions, and thus private consumption rises. Price drops of intermediate goods are also translated into reductions in export prices, partially compensated by a depreciated exchange rate. The rise in demand from consumers, investors and exporters allows output to enact a substantial expansion, so high as to allow government consumption to rise above the trend yet keeping its share to GDP below the steady state for a number of quarters.

In contrast, a shock to permanent (labor-augmenting) productivity (Figure 15) implies a rise in firms' demand for labor, putting pressure on real wages. The rise in marginal costs and the increased demand for final consumption and investment goods translate into generalized price increases.

4.3 Historical decomposition

Figure 16 shows the historical decomposition of key macroeconomic variables in Brazil during the inflation targeting regime. As the plots with all shocks to the model are visually messy, we chose to depict only the shocks that mostly impacted each series.

Monetary policy shocks, which are traditionally interpreted as shocks to policymakers' preferences, have played a minor role in the setting of nominal interest rates in Brazil. Overall, shocks to firms' productivity, domestic risk premium and price markups have been more influential in the setting of the monetary policy rate.

Productivity shocks have also played a significant role in the cycles of consumer inflation, primary surplus to GDP and consumption to GDP. As the model implies close correspondence of (permanent) labor-productivity shocks in the domestic and foreign economy, it is customary to interpret these shocks as a transmission channel of global shocks to the domestic economy. The importance of such shocks in the decomposition of historical series should thus be reflecting the fact that Brazil has been often hit by a number of shocks stemming from abroad.

Aside from technological shocks, the domestic risk premium and price markup shocks have also been highly influential to inflation in Brazil. The plots suggest that, more recently, price markups have been the main upward-pressing force to consumer inflation in the country.

As to the primary surplus to GDP, fiscal policy shocks have been quite important as well. Until 2003, the shocks to fiscal preferences were usually in the direction of enacting expansionist policies so as to countervail the contractionist impact of productivity shocks. This reversed in 2004, and from then to a few months after the global financial crisis of 2008, fiscal policy preferences were contractionist. The crisis triggered the reversal of fiscal policy preferences towards expansionist decisions. Moreover, domestic risk premium shocks have put substantial downward pressure to primary surpluses.

As to private consumption (as a share of GDP), expansionist shocks were mainly technology shocks and shocks to public transfers and public investment, especially after 2003, coinciding with the presidential term of Mr. Lula. The domestic risk premium was the main shock pushing consumption downwards.

5 Policy exercises

Figures 17 to 21 show policy exercises carried out with simulations of the model at the mean of the estimated posterior distribution of the parameters.

After the global financial crisis in 2008, the Brazilian government has systematically attained lower than targeted primary surpluses. In 2010, amid presidential elections, the future maintenance of the target levels was even called into question. Figure 17 shows what would happen to the main dynamics of the economy should the target for the primary surplus be drastically cut down to 1.5% of GDP. The dynamic responses of output and inflation would not post relevant changes under the parameterized model. However, for this new target to be sustainable, which is to say in other words that for the model to have a well-defined equilibrium, the public debt to GDP ratio should be cut off in more than half.

Figure 18 shows what one can expect for the model dynamics if the government increases its commitment to the steady-state level of public debt as a share of GDP. If the response to the debt in the fiscal rule increases almost tenfold, from the estimated 0.017 to 0.10, the same expansionist shock to the primary surplus rule causes output to initially expand by the same amount, yet returning to the steady state a little more sluggishly. Inflation rises a little more and is also a little more persistent to return to the steady state. The most pronounced change is in the public debt path, which reverses back to the steady state a lot faster. If the response to debt in the fiscal rule is increased to 0.20, the dynamic responses of the model become highly cyclical, reaching regions of indeterminacy for values of the debt coefficient in the fiscal rule higher than 0.20.

Figure 19 shows an analogous exercise, where instead we change the response of the fiscal rule to output growth. Increasing the reaction of the primary surplus to output growth from 0.038 to 0.10 causes relatively little changes in the dynamics of output, inflation, debt and the primary surplus. However, if the reaction hikes to 0.50, the dynamic responses of the model to a primary surplus shock become extremely cyclical.

On the other hand, if the monetary authority chooses to react more to output growth (Figure 20), contractionist shocks to the interest rate generally produce muter dynamic responses.

We also conduct exercises changing the share of non-Ricardian agents in the population (Figure 21). We find an important sensitivity of the dynamics of real variables to this feature of the model. The lower the share of non-Ricardian agents, the muter the responses of real variables to a fiscal shock to the primary surplus. This result is in line with the literature. In Galí et. al. (2004), the sensitivity of aggregate consumption responses to a government spending shock is attributed to the presence of rule-of-thumb consumers, calibrated at 50%, and to the presence of sticky prices. Notice, however, that in our model non-Ricardians make intertemporallly optimal decisions, yet under restrained investment options.

6 Conclusion

In this paper, we employ Bayesian methods to estimate the parameters of the Brazilian economy, modeled as an open-economy where fiscal policy is implemented through a rich set of instruments: primary surplus, public investment, and social transfers. There are both Ricardian and non-Ricardian agents, rendering fiscal policies important driver of business cycles.

We show that the dynamic responses of the model are sensitive to the fiscal instrument that is being shocked. In general, the responses of real variables, including GDP, to shocks to the primary surplus or to public transfers fade out before the end of the second year. On the other hand, shocks to public investment are much longer lived. The path undertaken by fiscal variables also depends on the type of the shock. Expansionist shocks to the primary surplus are executed through increases in both government consumption and investment whilst expansionist shocks to public transfers are accompanied by reductions in public consumption and investment so that the primary surplus rule is fulfilled. All fiscal shocks are inflationary.

We decompose the main macroeconomic series in Brazil during the inflation targeting regime into the estimated shocks of the model. We find that technology shocks have been important drivers of real and nominal variables. However, other shocks have played relevant roles as well.

The setting of the monetary policy rate, for instance, has been significantly affected by the domestic risk premium and price markups. Interestingly, the shocks to policy preferences have not been important drivers of interest rates in Brazil.

For the execution of the primary surplus, however, the opposite holds. We find that until 2003, fiscal policy preferences were usually in the direction of enacting expansionist policies. This reversed in 2004, and from then until a few months after the global financial crisis of 2008, fiscal preferences were contractionist. After the crisis, fiscal policy preferences reversed again towards expansion following the global trend of fighting the crisis with fiscal incentives. In addition to policy preferences, shocks to the

domestic risk premium have also exerted important expansionist pressures on the execution of the primary surplus.

Private consumption (as a share of GDP) has also been importantly affected by expansionist shocks to public transfers and public investment, especially after 2003, coinciding with the presidential term of Mr. Lula. The domestic risk premium shock was the main dampening force to consumption.

Historical decomposition of consumer inflation does not show a relevant participation of policy shocks. Aside from technology shocks, the main drivers of consumer inflation in Brazil have been the domestic risk premium and price markups.

We also conduct simulations with the estimated model so as to assess the dynamic impact of policy changes. In the first exercise, we show that a substantial cut in the primary surplus target does not imply substantial changes in the model's dynamics. However, such a drastic policy change can only be accomplished with a substantial restructuring of the public debt, with a reduction in its level by more than 50%.

In the second exercise, we show that too strong responses of the fiscal rule for the primary surplus to deviations of the public debt or GDP growth from their steady states can significantly destabilize the model economy, introducing important cyclicalities in real and nominal variables.

In the third exercise, we show that should the Brazilian monetary authority decide to increase its reaction to output growth, the responses of both inflation and output to monetary policy shocks will be muter.

Finally we show that a reduction in the share of non-Ricardian agents in the model produce muter responses of the fiscal shock to the primary surplus upon aggregate consumption and real wages. This result is regardless of the fact that in our model non-Ricardian agents are intertemporal optimizers, yet with more restraints regarding their access to investment options.

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APPENDIX

Cost functions

We describe below the functional form for each of the cost functions in the paper.

Consumption transactions cost:

$$\Gamma_v(v_{h,t}) := \gamma_{v,1} \cdot v_{h,t} + \gamma_{v,2} \cdot v_{h,t}^{-1} - 2\sqrt{\gamma_{v,1} \cdot \gamma_{v,2}} \tag{A.1}$$

Cost on the utilization of capital:

$$\Gamma_u(u_{i,t}) := \gamma_{u,1}(u_{i,t} - 1) + \frac{\gamma_{u,2}}{2}(u_{i,t} - 1)^2 \tag{A.2}$$

Cost on the adjustment of the level of investment:

$$\Gamma_I\left(\frac{I_{i,t}}{I_{i,t-1}}\right) := \frac{\gamma_I}{2}\left(\frac{I_{i,t}}{I_{i,t-1}} - g_Y\right)^2 \tag{A.3}$$

where g_Y is the trend growth rate of the economy.

Cost on the adjustment of the import share in the production of final consumption goods:

$$\Gamma_{IM^C}\left(\frac{IM_t^C}{Q_t^C}\right) := \frac{\gamma_{IM^C}}{2}\left((e_{IM,t})^{1/\gamma_{IM^C}} \frac{IM_t^C}{IM_{t-1}^C}\frac{Q_{t-1}^C}{Q_t^C} - 1\right)^2 \tag{A.4}$$

Cost on the adjustment of the import share in the production of investment goods:

$$\Gamma_{IM^I}\left(\frac{IM_t^I}{Q_t^I}\right) := \frac{\gamma_{IM^I}}{2}\left((e_{IM,t})^{1/\gamma_{IM^I}} \frac{IM_t^I}{IM_{t-1}^I}\frac{Q_{t-1}^I}{Q_t^I} - 1\right)^2 \tag{A.5}$$

$$\Gamma_{IM^C}^3(IM_t^C/Q_t^C) := 1 - \Gamma_{IM^C}(IM_t^C/Q_t^C) - \Gamma_{IM^C}'(IM_t^C/Q_t^C).(IM_t^C/Q_t^C) \tag{A.6}$$

$$\Gamma_{IM^I}^3(IM_t^I/Q_t^I) := 1 - \Gamma_{IM^I}(IM_t^I/Q_t^I) - \Gamma_{IM^I}'(IM_t^I/Q_t^I).(IM_t^I/Q_t^I) \tag{A.7}$$

TABLES AND FIGURES

Table 1: Steady State Ratios for the Brazilian Economy

Model variable	Description	Calibrated value
$\pi, \bar{\pi}$	Consumer inflation, inflation target	4.92% p.y.
g_y	Output growth	2.5% p.y.
$P_I I_G / P_Y Y$	Government investment	1.86% of GDP
$SP / P_Y Y$	Primary surplus	3.38% of GDP
$M_1 / P_Y Y$	Money balances	16.1% of GDP
$SR_F^{-1} B_F / P_Y Y$	Net foreign debt	-16.33% of quarterly GDP
R / π	Real interest rate	7.5% p.y.
$P_C C / P_Y Y$	Private consumption	61.8% p.y.

Table 2: Calibrated parameters for Brazil

Parameter	Value	Description	Source of calibration
A. Households			
σ	1.0	Inverse of the intertemporal elasticity of substitution	Log-linear utility
ζ	2.0	Inverse of the Frisch elasticity of labor supply	ECB NAWM (CMS)
δ	0.025	Depreciation rate	ECB NAWM (CMS)
ω	0.59260	Size of household J	Brazil's PNAD survey 2007
$\xi_I, \xi_J,$	0.765, 0.75	Fraction of households not setting wages optimally each quarter	NAWM (CCW, CMS)
β	0.9882	Intertemporal discount factor	To obtain 7.5% p.y. real interest rate
sz	0.0053	Relative size of the domestic economy	To fulfill the trade balance equation
B. Intermediate-good firms			
α	0.3	Share of capital income in value added	ECB NAWM (CMS)
z	1.0	Stationary total productivity level	ECB NAWM (CMS)
η	6.0	Price elasticity of demand for labor bundles	ECB NAWM (CMS)
η_I	6.0	Price elasticity of demand for labor of household I	ECB NAWM (CMS)
η_J	6.0	Price elasticity of demand for labor of household J	ECB NAWM (CMS)
υ_ω	0.003	Labor demand bias	
C. Final-good firms			
υ_C	0.875	Home bias in the production of consumption final goods	To fulfill steady state equations
υ_I	0.731	Home bias in the production of investment final goods	To fulfill steady state equations
θ	6.0	Price elasticity of demand for the intermediate-good variety	ECB NAWM (CMS)
D. Fiscal authority			
τ^C	0.162	Consumption tax rate	Siqueira, Nogueira, Souza (2001)
τ^D	0.15	Dividend tax rate	Tax law (general terms)
τ^K	0.15	Capital income tax rate	Tax law (general terms)

τ^N	0.15	Labor income tax rate	Tax law (general terms)
τ^{W_h}	0.11	Rate of social security contributions by households	Tax law (general terms)
τ^{W_f}	0.20	Rate of social security contributions by firms	Tax law (general terms)
η_g	1.001	Elasticity of substitution between private and public investment goods	Cobb-Douglas technology

E. Adjustment and transaction costs

$\gamma_{v,2}$	0.15	Parameter of transaction cost function	ECB NAWM (CMS)
$\gamma_{u,2}$	0.007	Parameter of capital utilization cost function	ECB NAWM (CMS)

Table 3: Prior and Posterior Distributions of the Estimated Parameters

Log Data Density: 1153.8359

			Posterior			Prior		
			mean	*confidence interval*		*mean*	*distrib*	*SD*
		Autoregressive parameters						
rhz	ρ_Z	Temporary technology	0.991	0.976	1.000	0.500	unif	0.29
rhzn	ρ_{zn}	Labor (permanent) productivity	0.836	0.810	0.860	0.500	unif	0.29
rhrzn	ρ_{rzn}	Gap between labor productivities	0.989	0.976	1.000	0.500	unif	0.29
rhtr	ρ_{tr}	Public transfers	0.332	0.283	0.374	0.500	beta	0.20
rhig	ρ_{ig}	Public investment	0.786	0.754	0.835	0.500	beta	0.20
rhzec	$\rho_{\varepsilon c}$	Consumption preferences	0.432	0.406	0.457	0.500	beta	0.10
rhzeim	$\rho_{\varepsilon im}$	Import demand	0.475	0.447	0.501	0.500	beta	0.10
rhzei	ρ_{zei}	Investment efficiency	0.478	0.459	0.496	0.500	beta	0.10
rhzerp	$\rho_{\varepsilon rp}$	Domestic risk premium	0.449	0.424	0.469	0.500	beta	0.10
rhzemkw	$\rho_{\varepsilon w}$	Wage markup	0.670	0.645	0.689	0.670	beta	0.10
rhzemkp	$\rho_{\varepsilon p}$	Price markup	0.470	0.438	0.508	0.500	beta	0.10
		Fiscal rule						
phby	ϕ_{By}	Debt stabilization coefficient	0.017	0.012	0.024	0.041	norm	0.40
rhsp1	ρ_{sp}	Autoregressive coefficient	0.550	0.518	0.579	0.500	unif	0.29
phspgy	$\phi_{sp,gy}$	Business cycle coefficient	0.038	(0.003)	0.091	0.0	norm	0.20
		Monetary policy rule						
phm	ϕ_{π}	Inflation deviation to the target	2.850	2.805	2.895	1.570	norm	0.40
phr1	ρ_{R1}	Autoregressive coefficient	0.761	0.724	0.795	0.490	unif	0.28
phgy	ϕ_{gy}	Business cycle coefficient	0.023	(0.007)	0.065	0.500	norm	0.40
phins	ϕ_e	Exchange rate variation	(0.012)	(0.020)	(0.005)	0.0	norm	0.10
		Preferences						
kp	κ	Habit persistence	0.579	0.566	0.592	0.566	beta	0.05
		Pricing parameters						
chi	χ_I	Wage indexation	0.915	0.892	0.938	0.635	beta	0.20
chh	χ_H	Price indexation (Domestic goods)	0.786	0.759	0.816	0.417	beta	0.20
chx	χ_X	Price indexation (Export goods)	0.912	0.887	0.939	0.498	beta	0.20
		Home bias						
mic	μ_{ic}	Consumption goods	0.748	0.682	0.798	1.943	norm	0.40
mii	μ_{ii}	Imported goods	1.483	1.427	1.544	1.595	gamm	0.25
		Parameters of the cost functions						
gmi	γ_I	Investment efficiency	2.353	1.859	3.031	5.169	gamm	2.00
gmimc	γ_{IMc}	Import adjustment (consumption goods)	6.076	5.722	6.662	5.596	gamm	2.00
gmimi	γ_{IMi}	Import adjustment (investment goods)	0.153	-	0.412	0.404	gamm	2.00
		Risk premium parameter						
gmbf1	$\gamma_{RPF,1}$	Debt stabilization coefficient	0.043	0.023	0.061	0.500	unif	0.29
gmbf12	$\gamma_{RPF,2}$	Exchange rate variation	0.136	0.125	0.151	0.200	norm	0.10

		Posterior			Prior		
		mean	confidence interval		mean	distrib	SD
Standard deviation of shocks							
ε_R	Monetary policy	0.022	0.017	0.025	0.100	invg	2.00
ε_Z	Temporary technology	0.028	0.022	0.035	0.100	invg	2.00
ε_{zn}	Labor (permanent) productivity	0.031	0.024	0.037	0.100	invg	2.00
ε_{rzn}	Deviation to foreign labor productivity	0.099	0.057	0.139	0.100	invg	2.00
ε_{tr}	Public transfers	0.018	0.015	0.021	0.100	invg	2.00
ε_{sp}	Primary surplus	0.017	0.014	0.020	0.100	invg	2.00
ε_{ig}	Public investment	0.015	0.012	0.017	0.100	invg	2.00
ε_c	Consumption preferences	0.093	0.062	0.126	0.100	invg	2.00
ε_{rpf}	Foreign risk premium	0.143	0.102	0.185	0.100	invg	2.00
ε_{im}	Import demand	0.115	0.090	0.147	0.100	invg	2.00
ε_i	Investment efficiency	0.103	0.054	0.145	0.100	invg	2.00
ε_{rp}	Domestic risk premium	0.047	0.027	0.064	0.100	invg	2.00
ε_w	Wage markup	0.044	0.025	0.062	0.100	invg	2.00
ε_p	Price markup	0.027	0.021	0.033	0.100	invg	2.00
SD of measurement errors							
	Investment expenditures	0.002	0.000	0.004	0.001	invg	2.00
	Exports expenditures	0.009	0.007	0.010	0.001	invg	2.00
	Private consumption expenditures	0.001	0.000	0.002	0.001	invg	2.00
	Imports expenditures	0.001	0.000	0.001	0.001	invg	2.00
	Government consumption expenditures	0.001	0.000	0.001	0.001	invg	2.00

Figure 1: Brazilian GDP
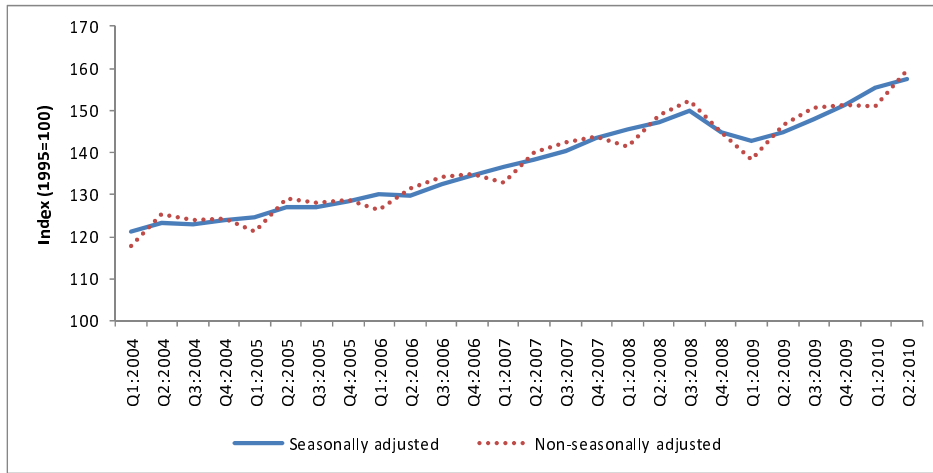
Figure 2: Selected Fiscal Expenditures and Public Banks' Loans in Brazil
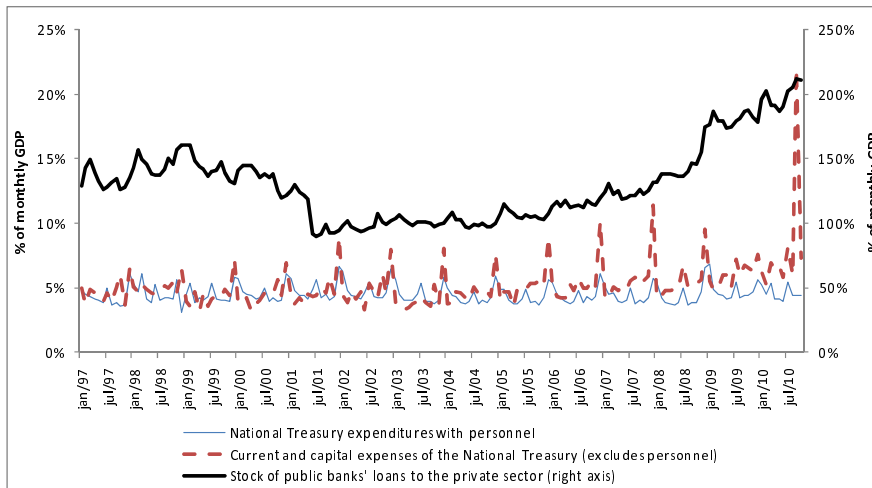
Figure 3: The map of the core structure of the model
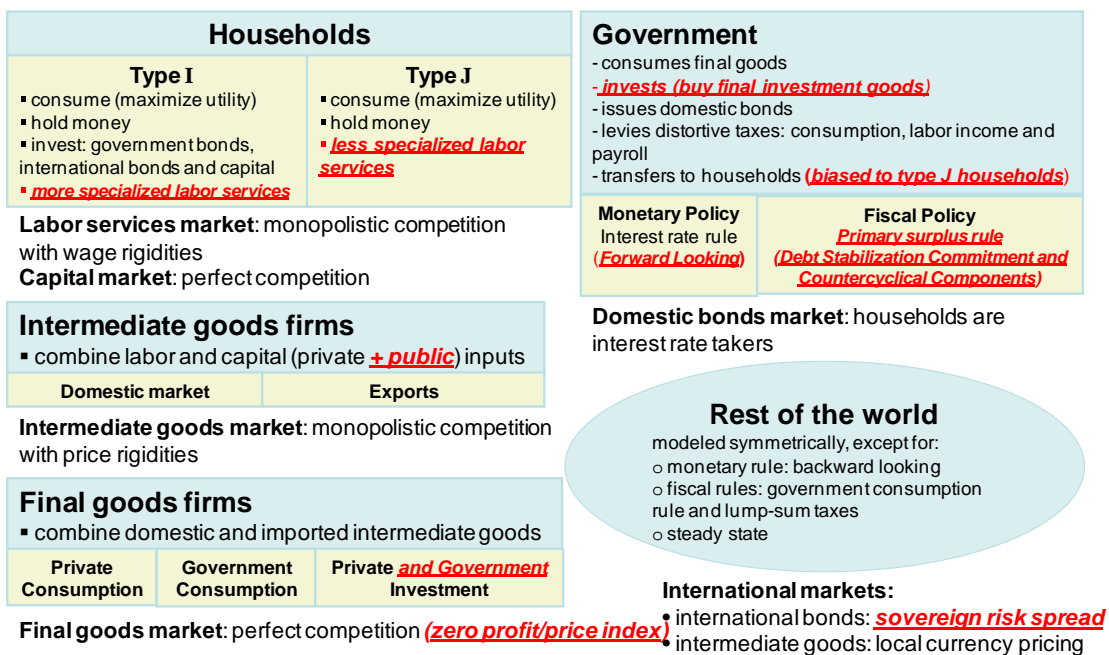
Figure 4: Prior and Posterior Distributions
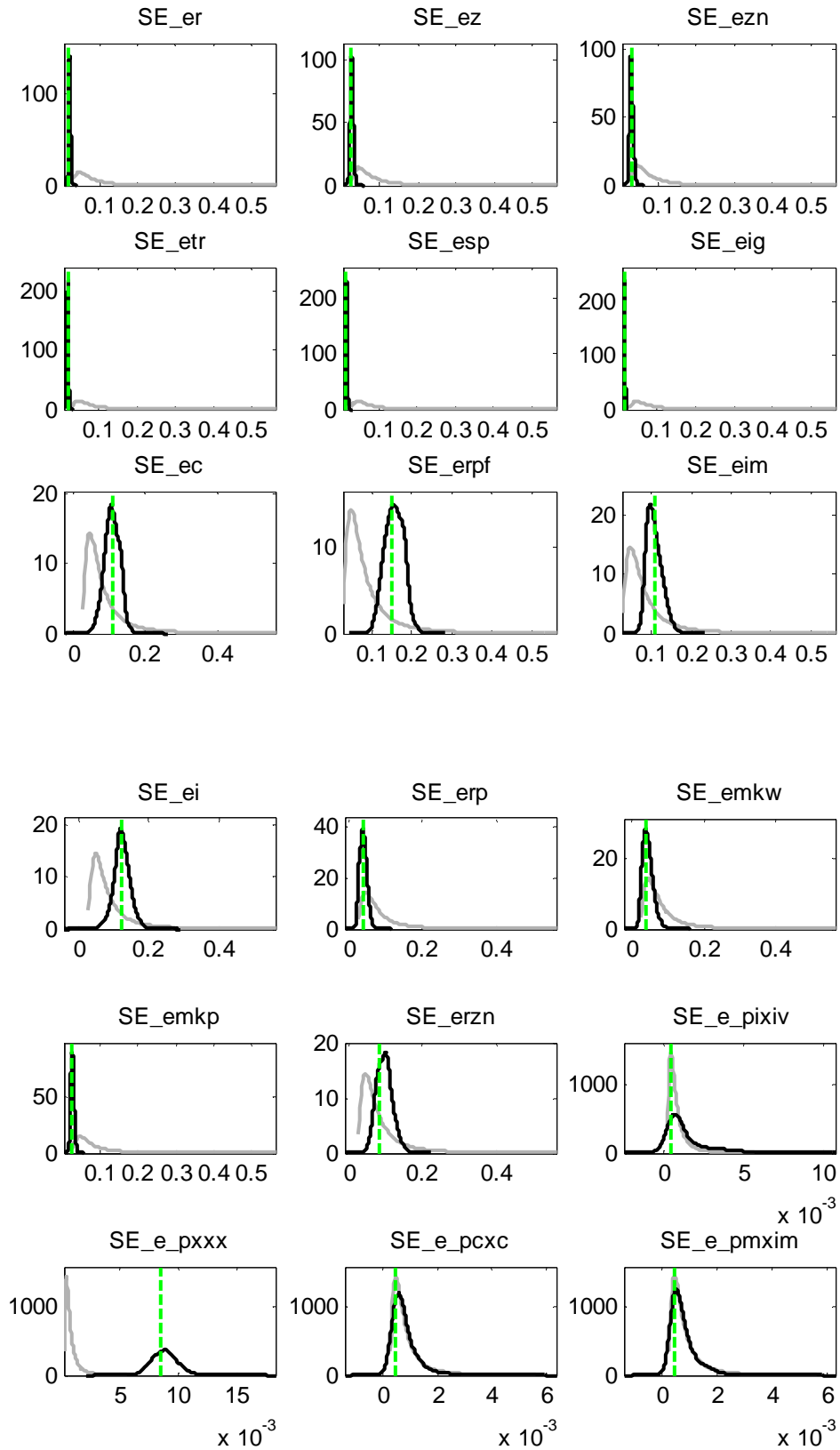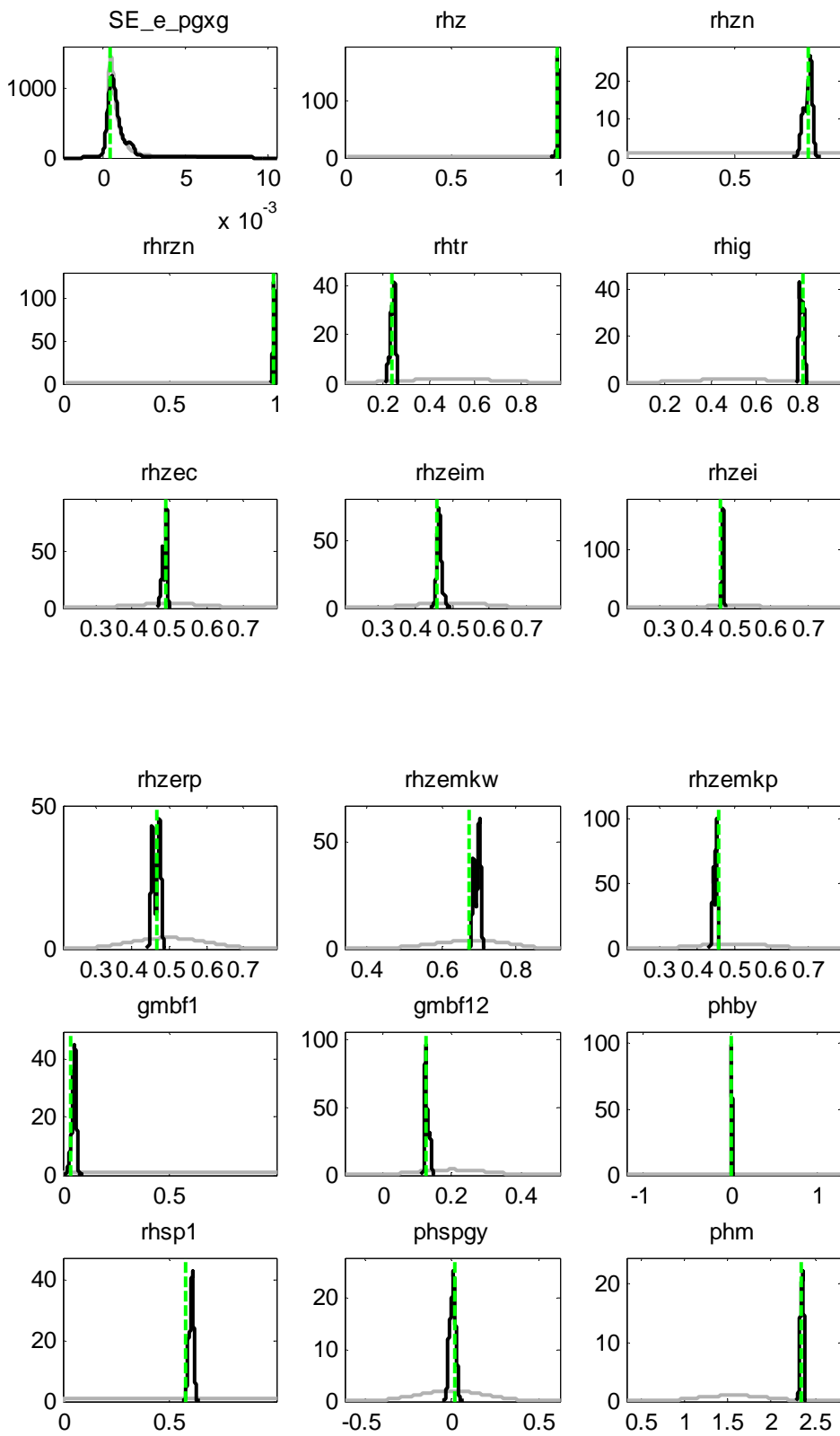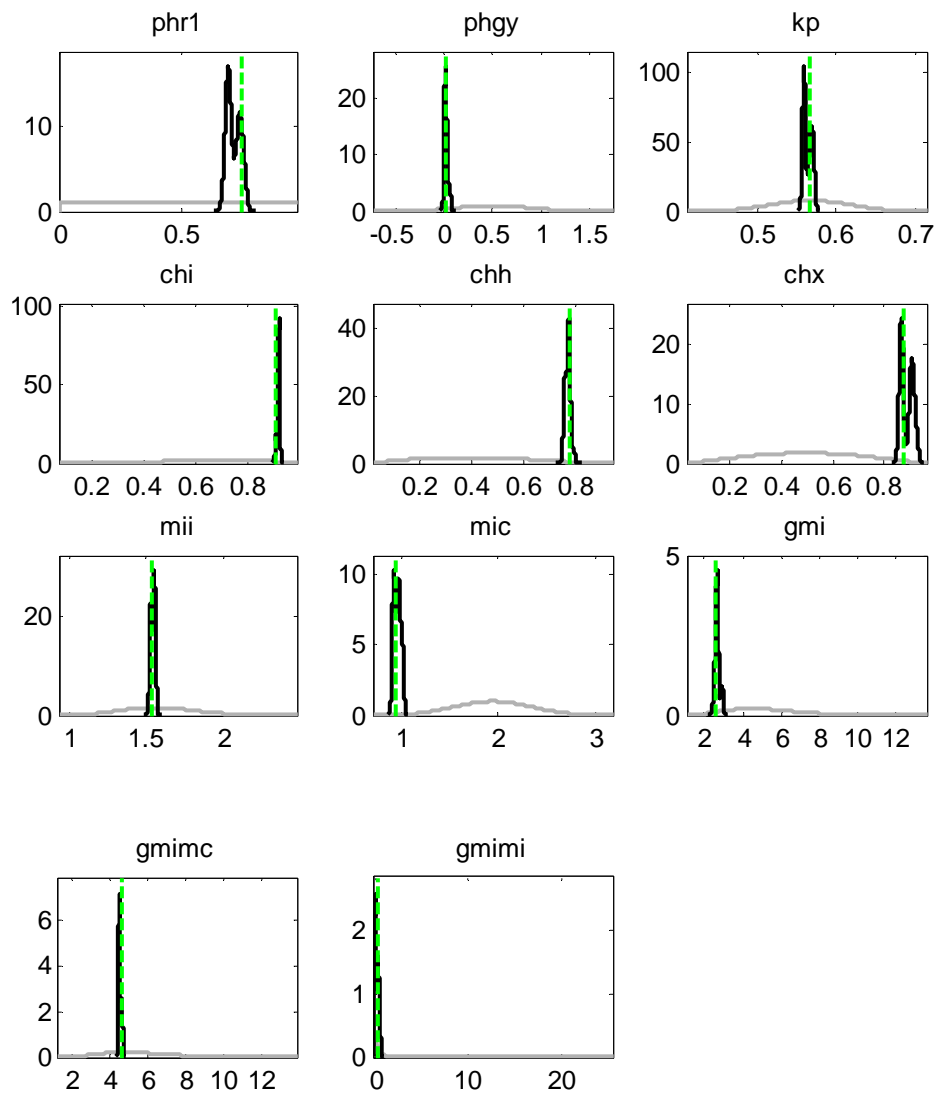
Figure 5: Convergence Diagnostics
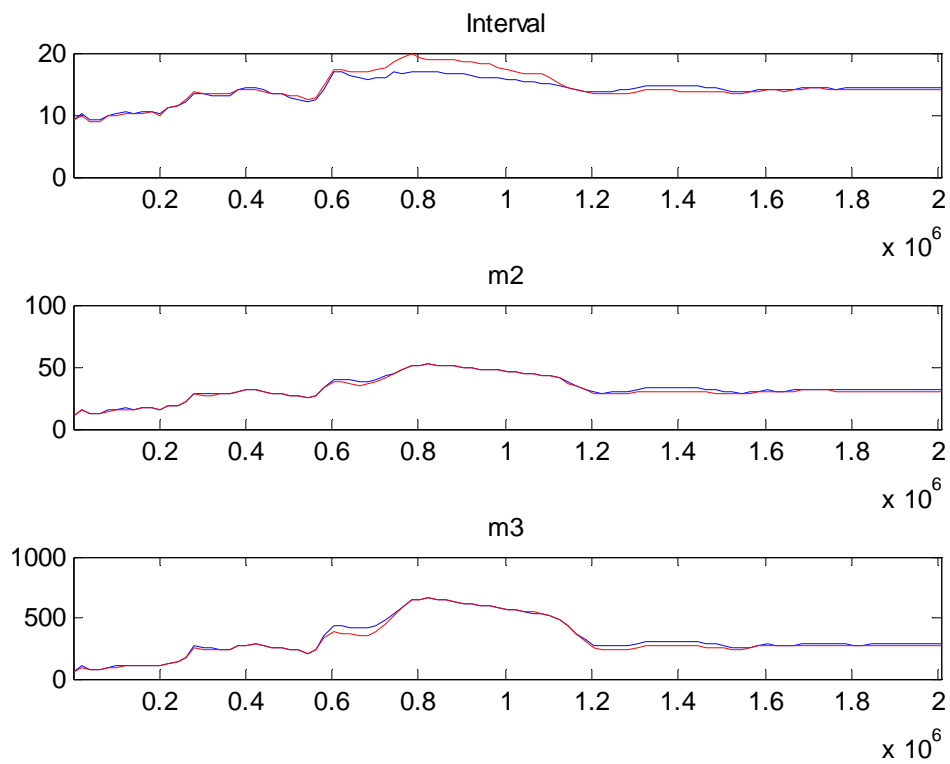
Figure 6: Impulse responses to a 1 s.d. shock to the primary surplus/GDP
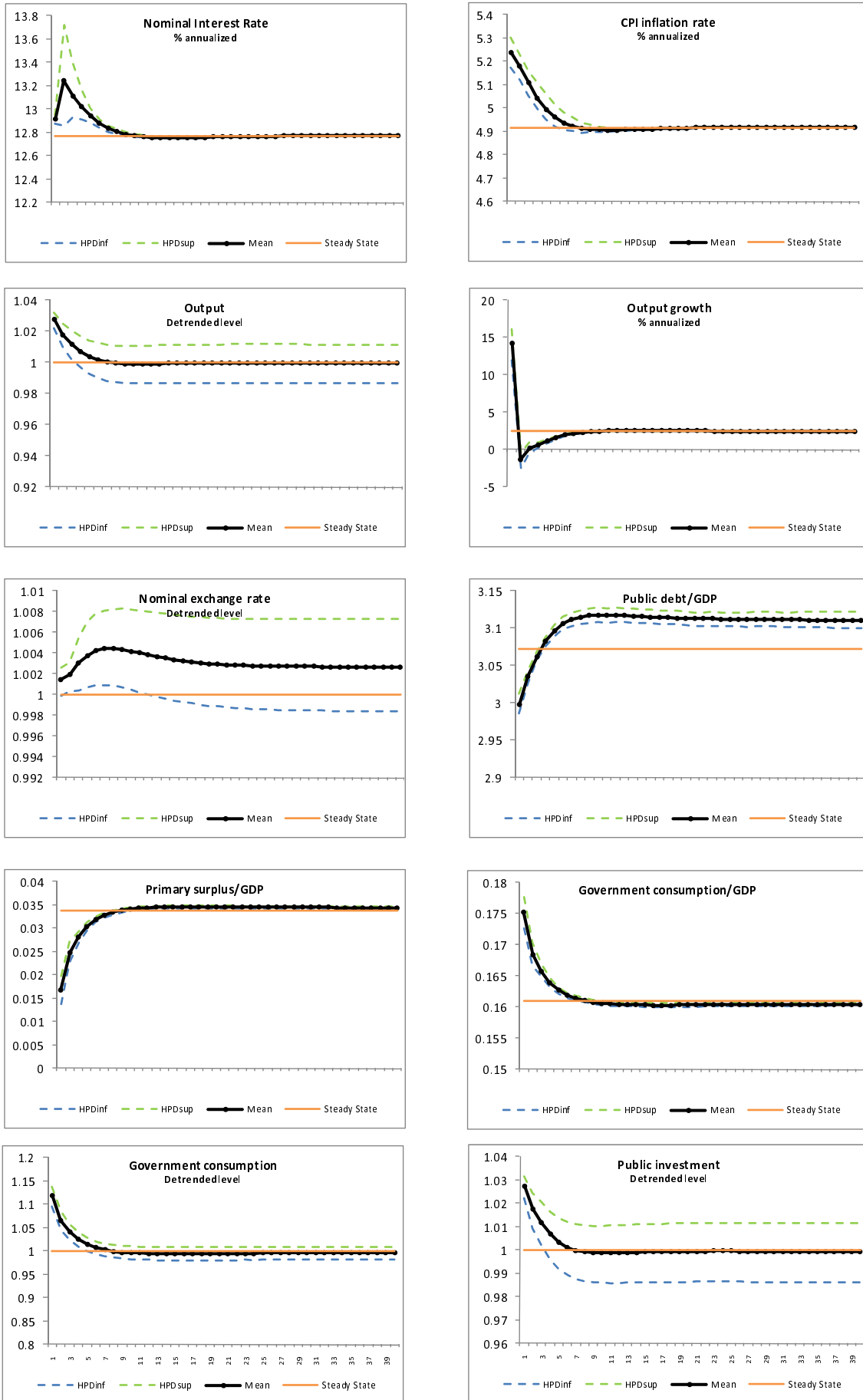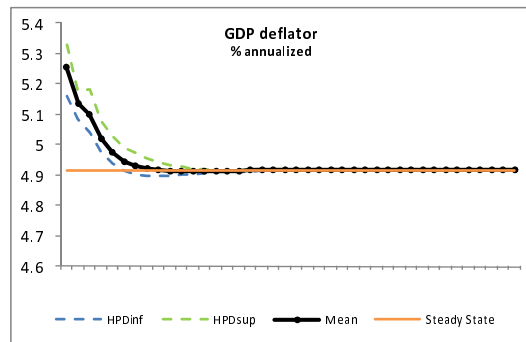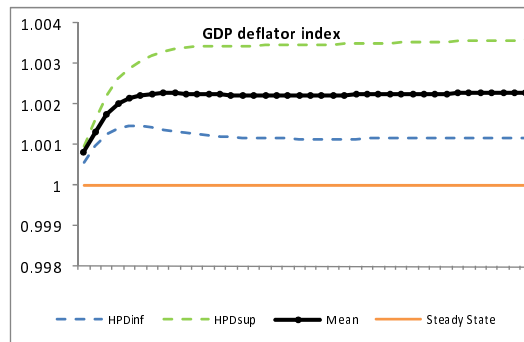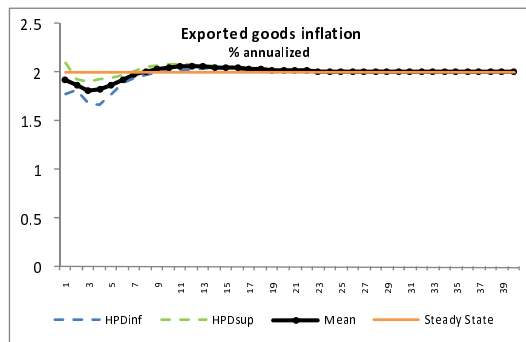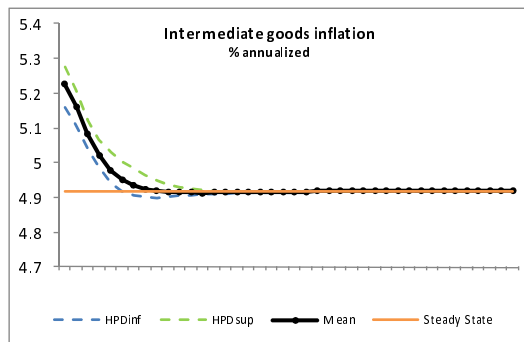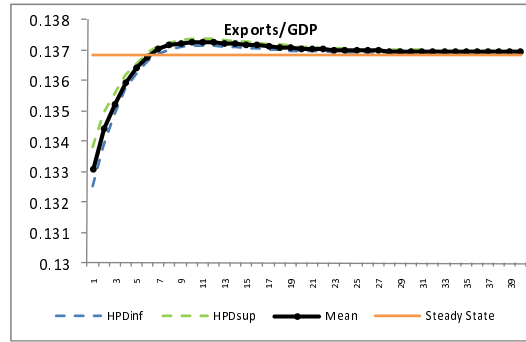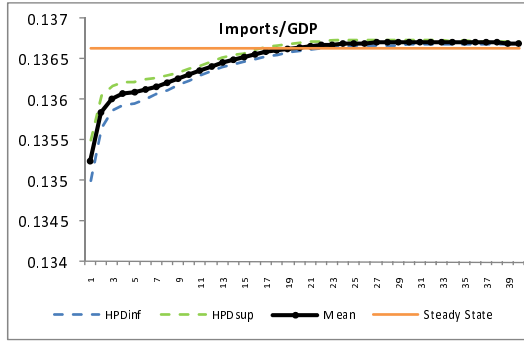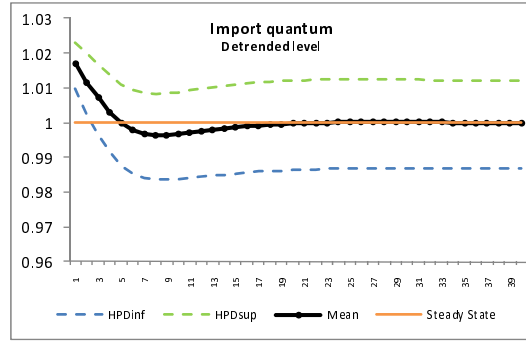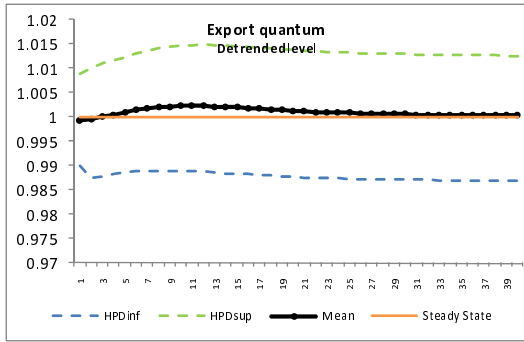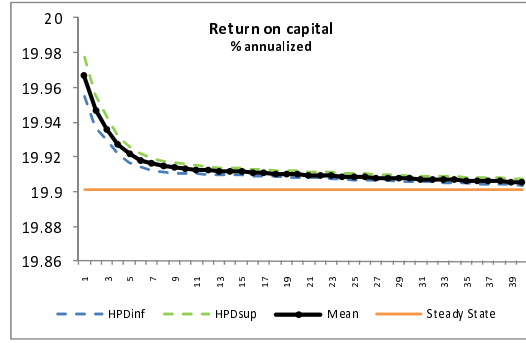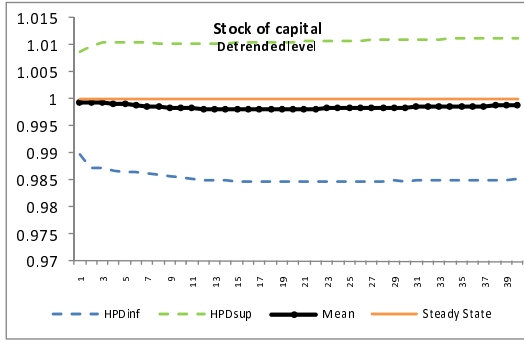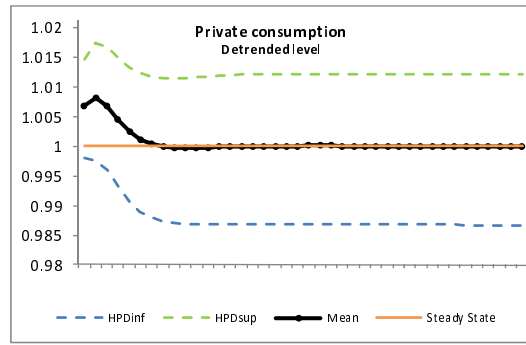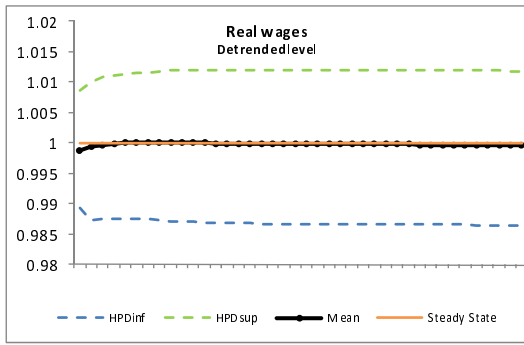
Figure 7: Impulse responses to a 1 s.d. shock to public transfers/GDP
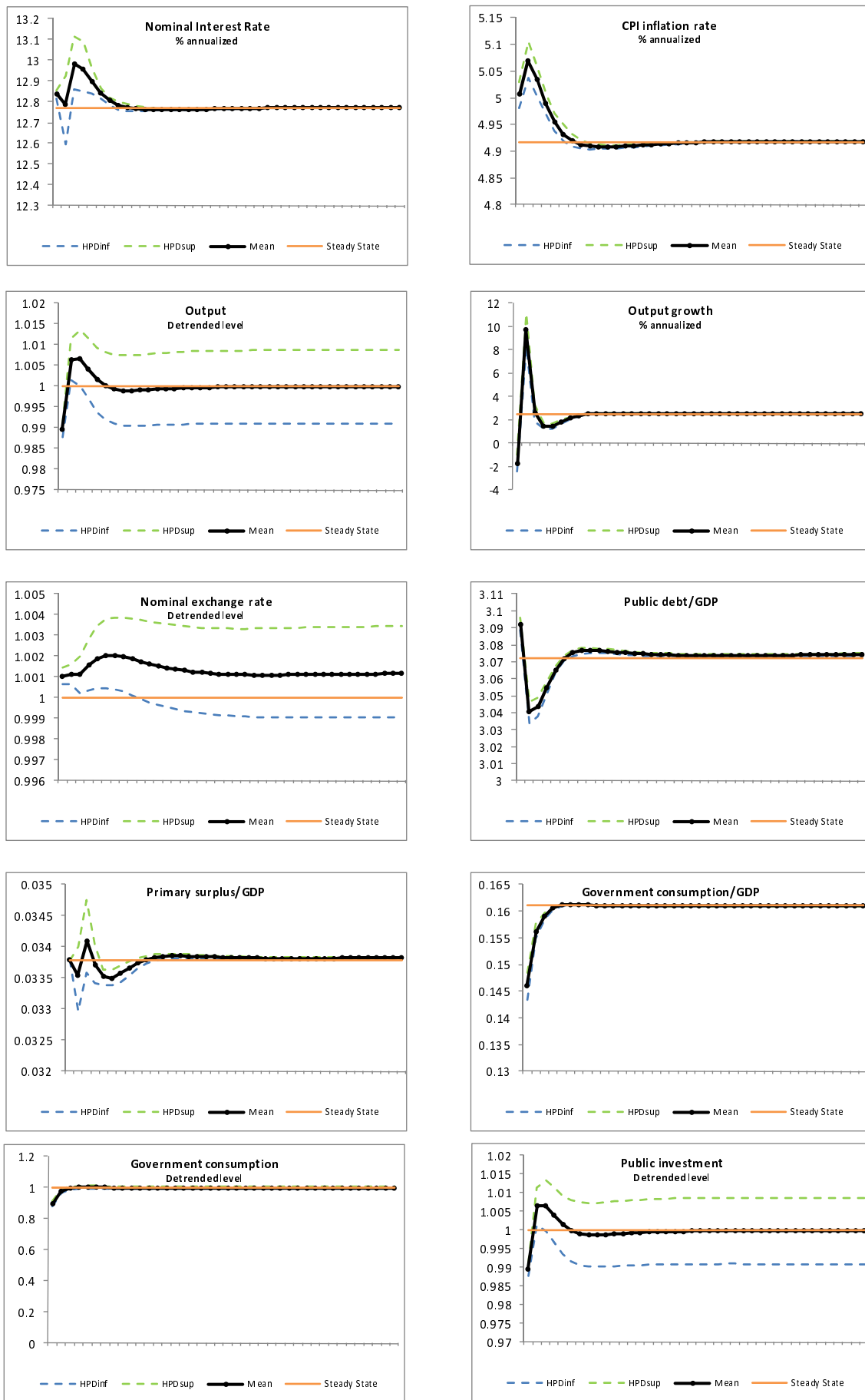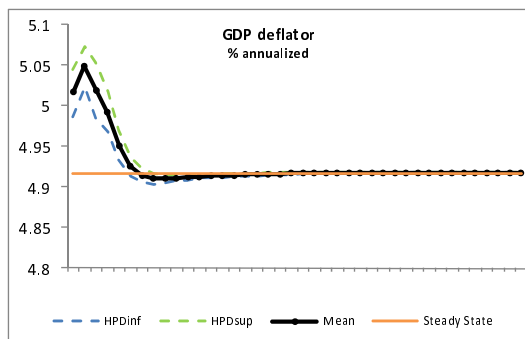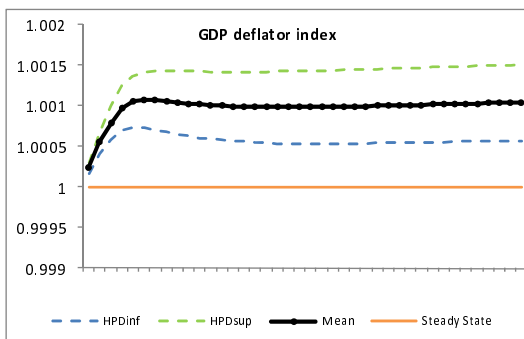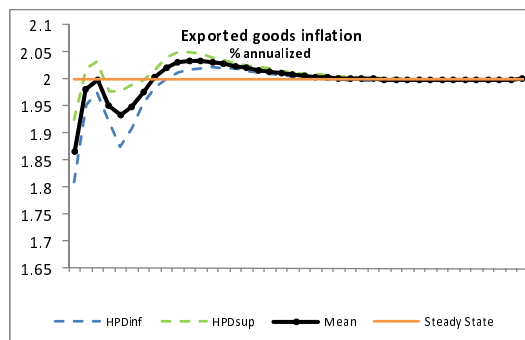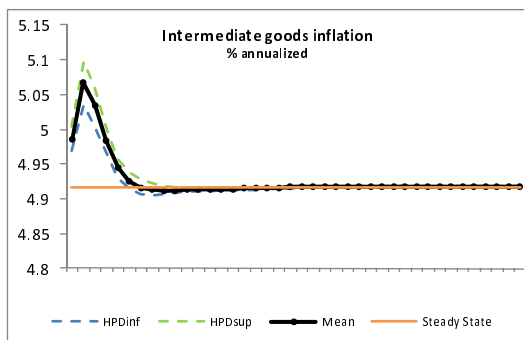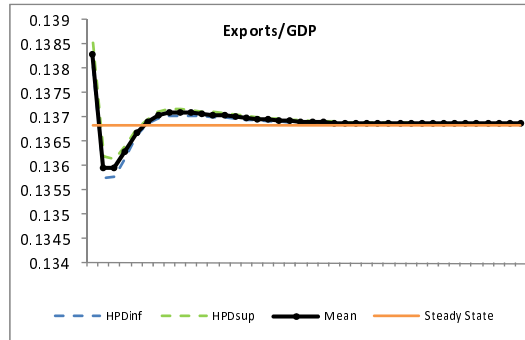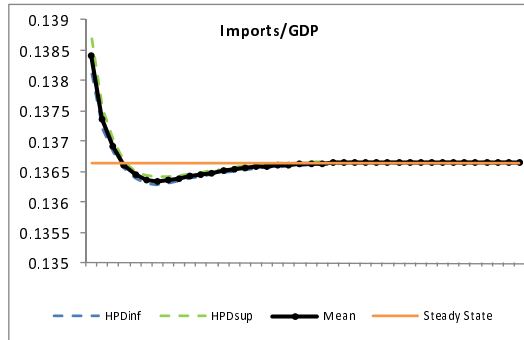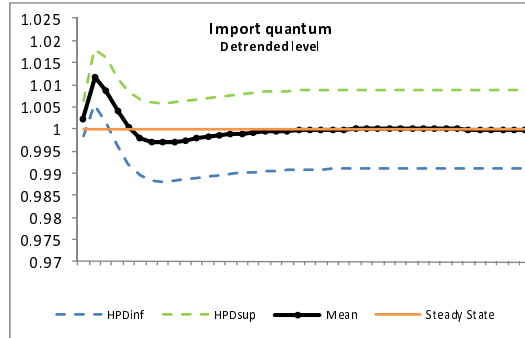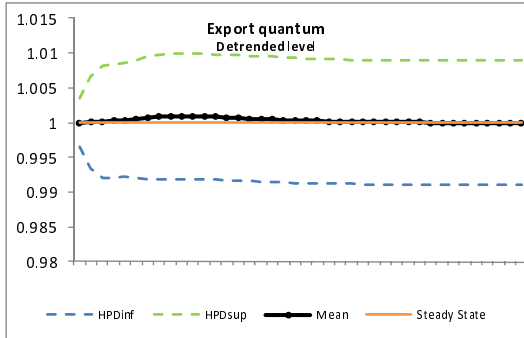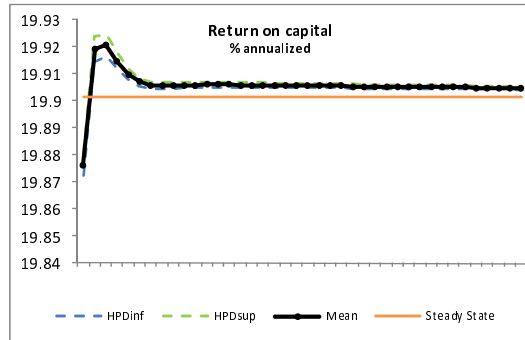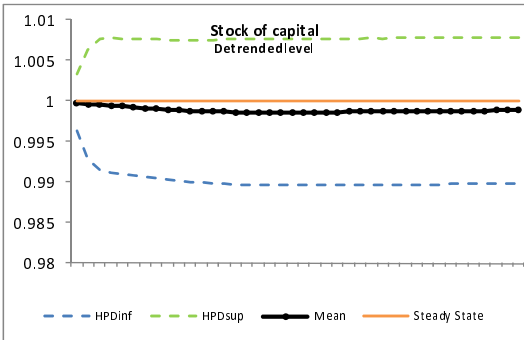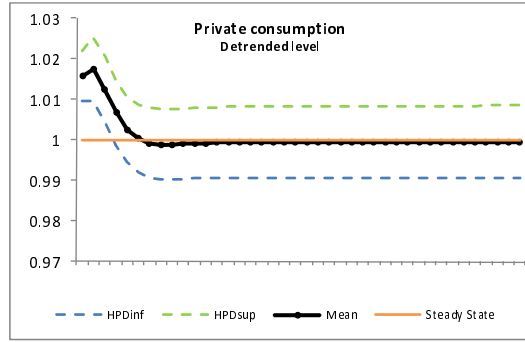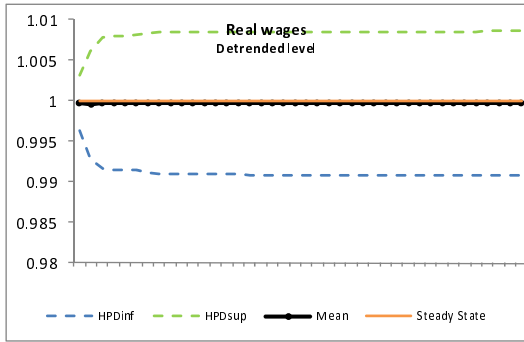
Figure 8: Impulse responses to a 1 s.d. shock to public investment/GDP

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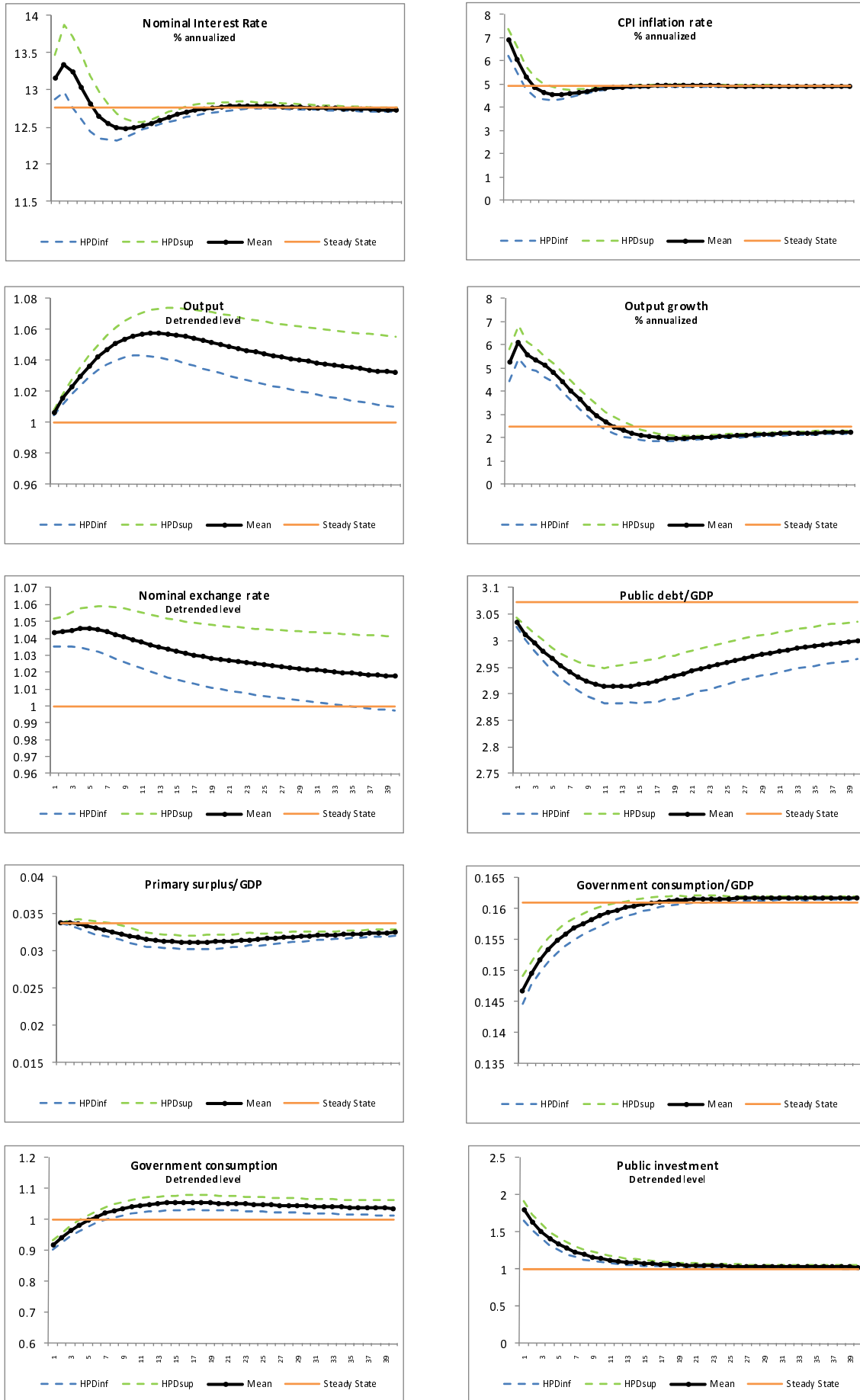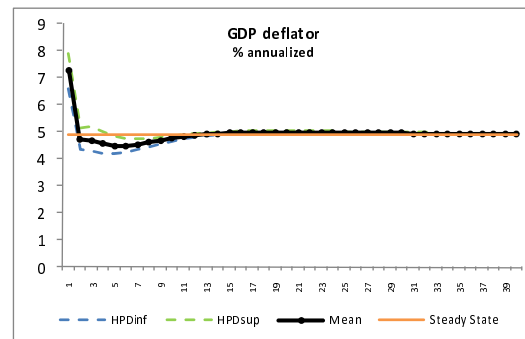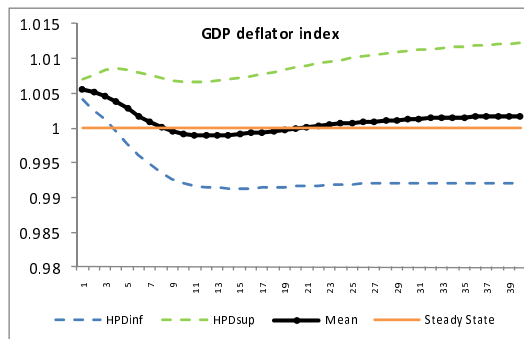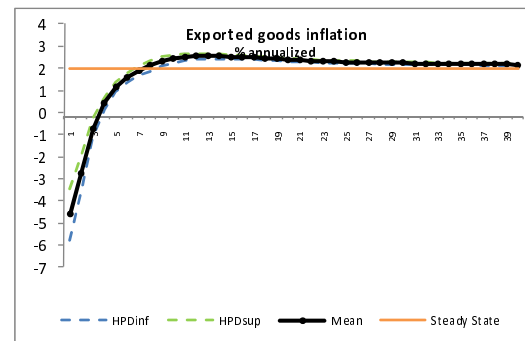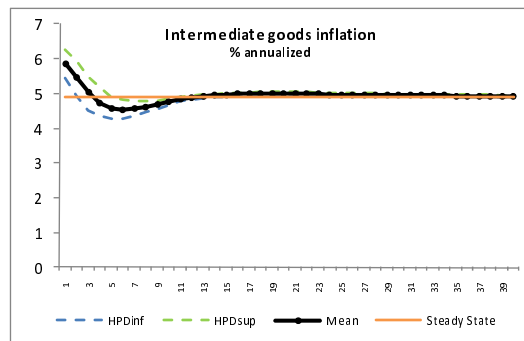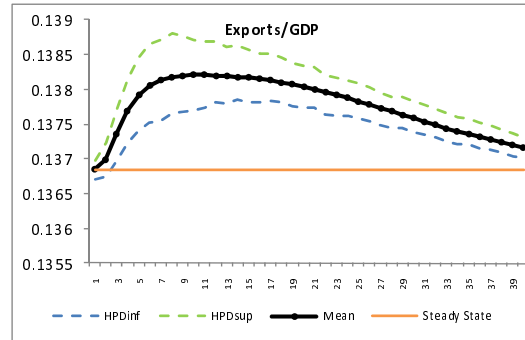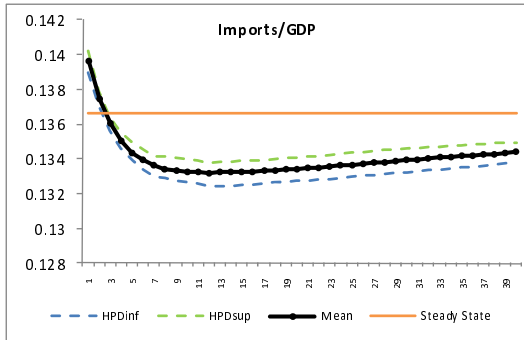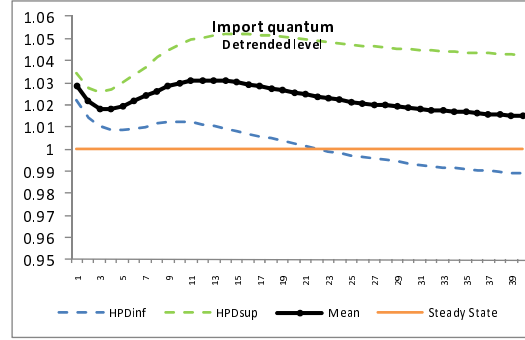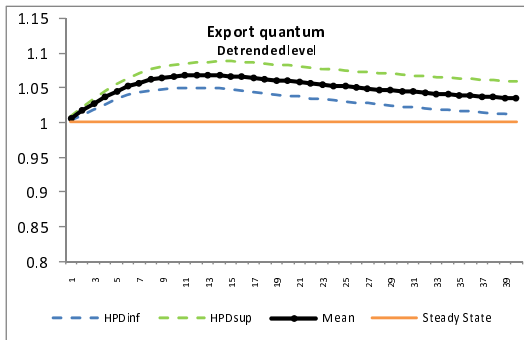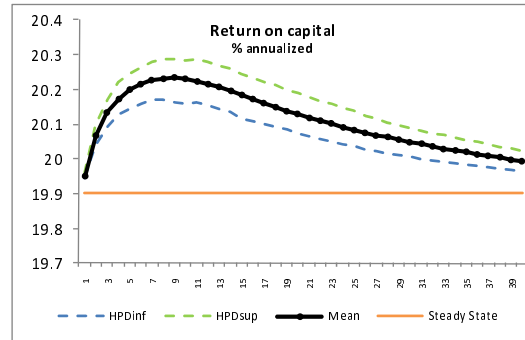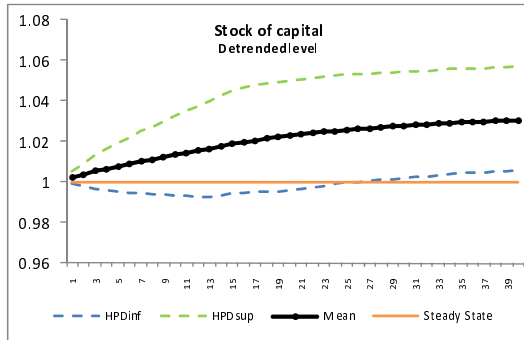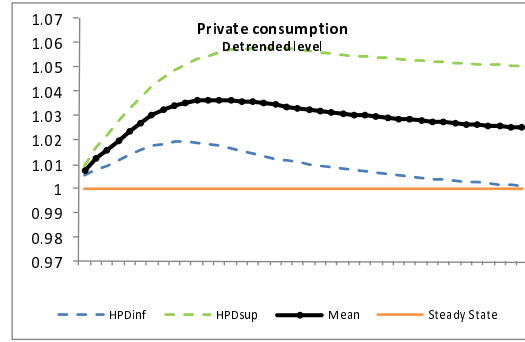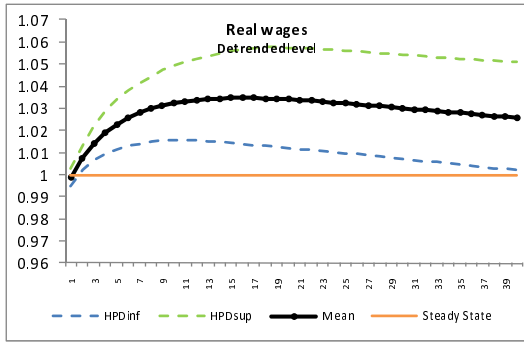
Figure 9: Impulse responses to a 1 s.d. shock to the monetary policy rate
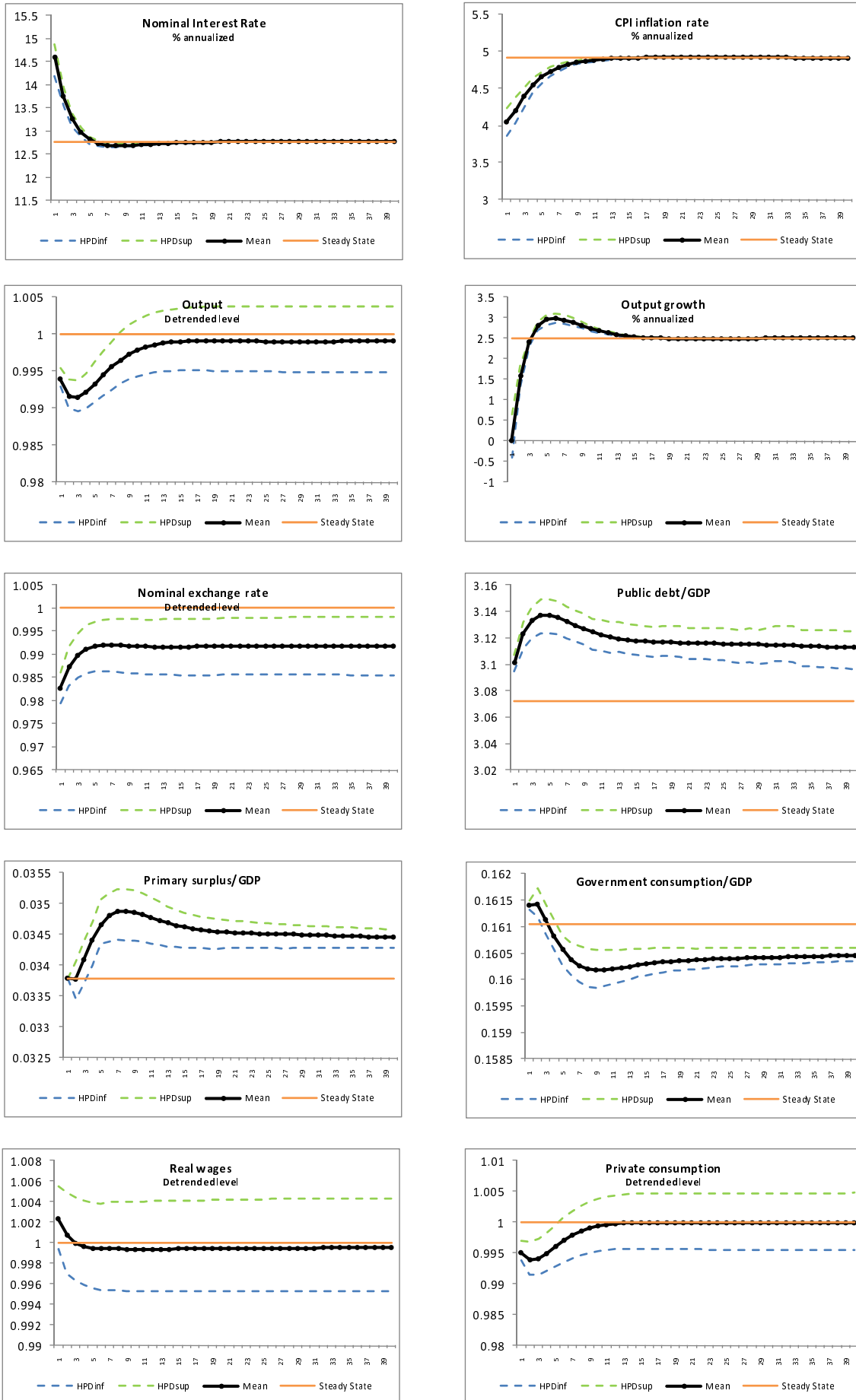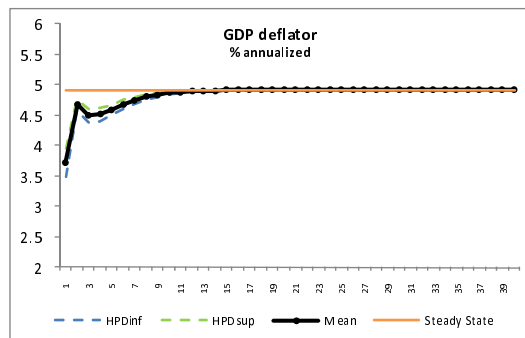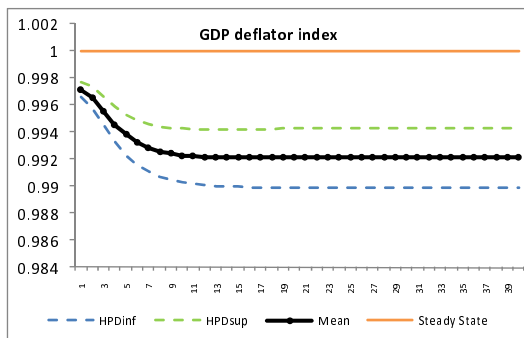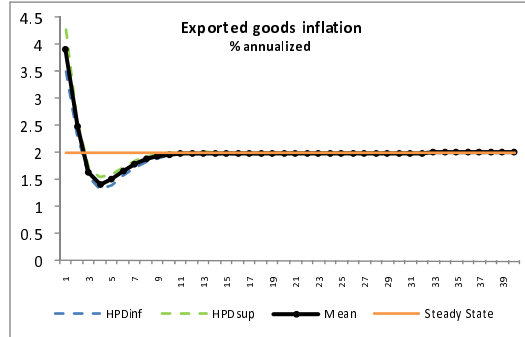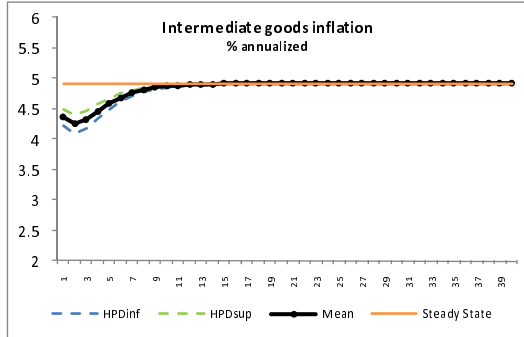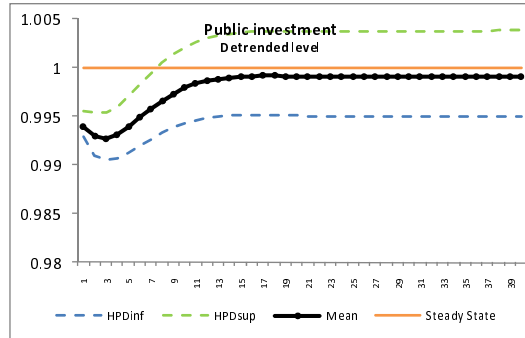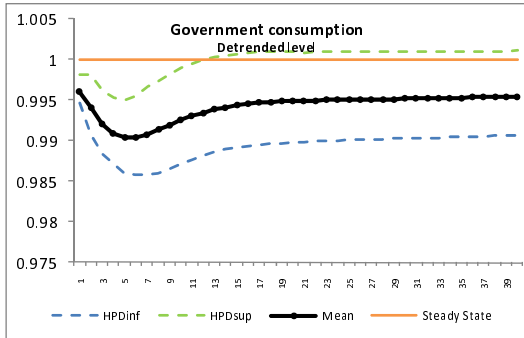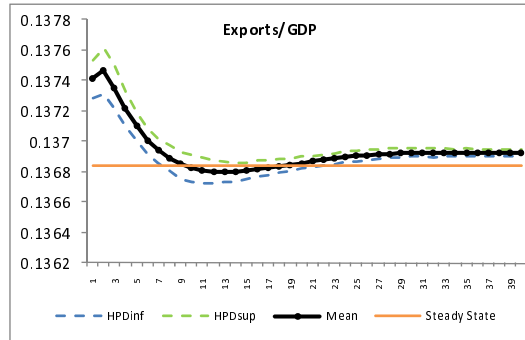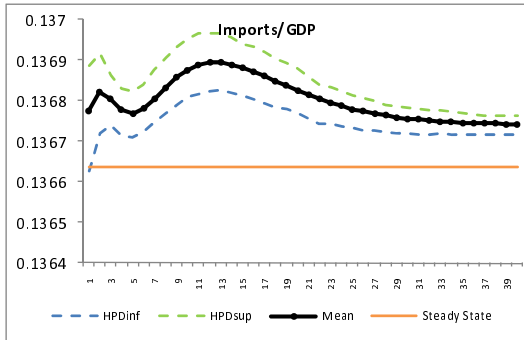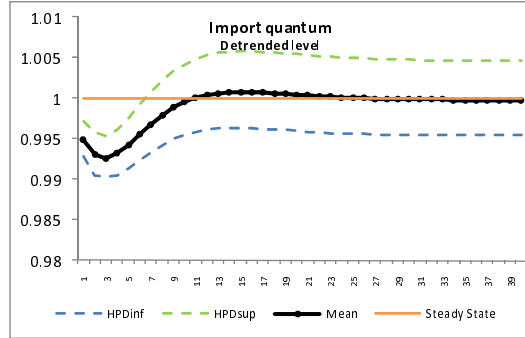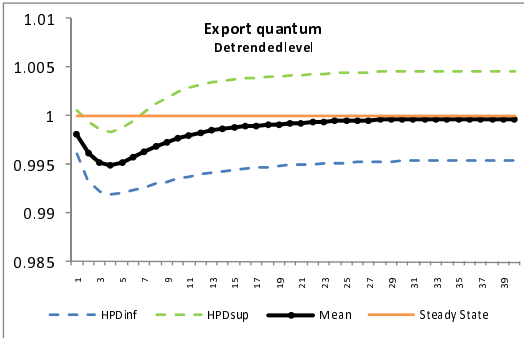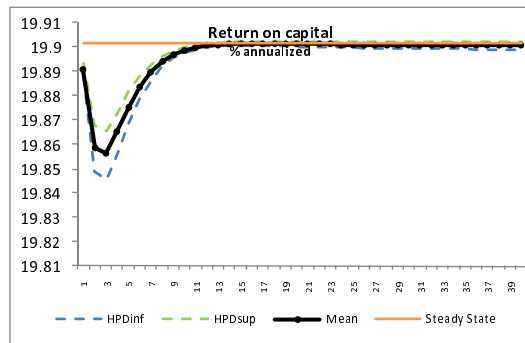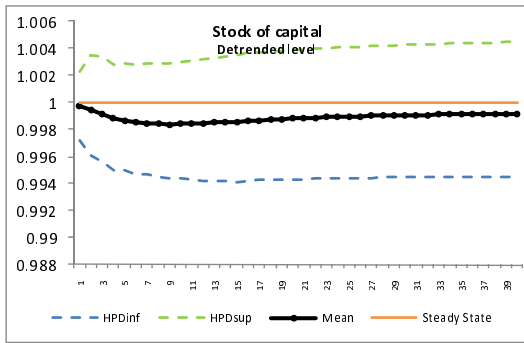
Figure 10: Replication of Figure 10 in Minella (2001): Responses to an Interest Rate Shock Using Monthly VAR estimation Including Country Risk Premium (EMBI) for the Sample Period 1994:09 to 2000:12
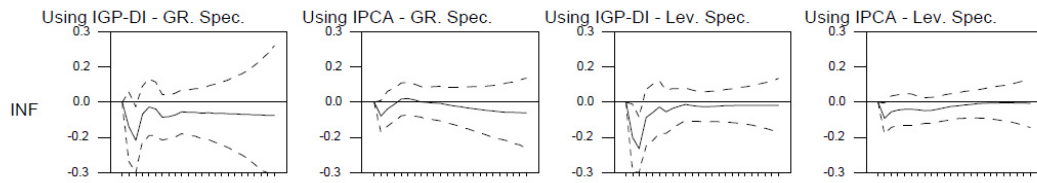
Figure 11: Consumer inflation response to an interest rate shock: Updating the monthly level estimation in Minella (2001) with the country risk premium included in the set of regressors. Sampled Period: 1994:09 to 2009:12

Panel A: Monthly estimation and responses

Response of IPCA to R
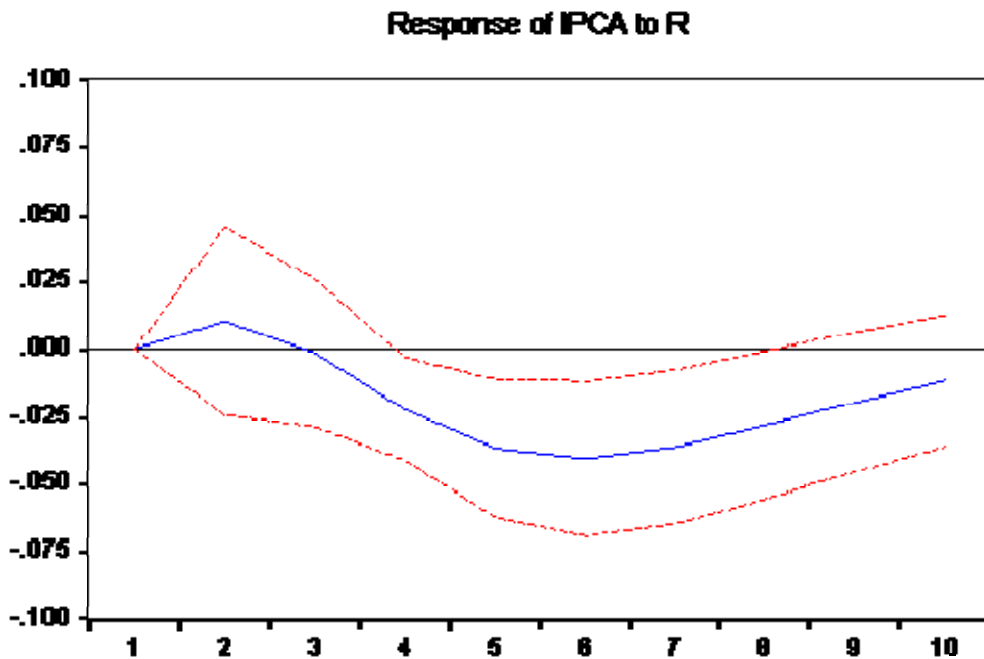
Panel B: Quarterly estimation and responses

Response of IPCA_3MM to R_3MM
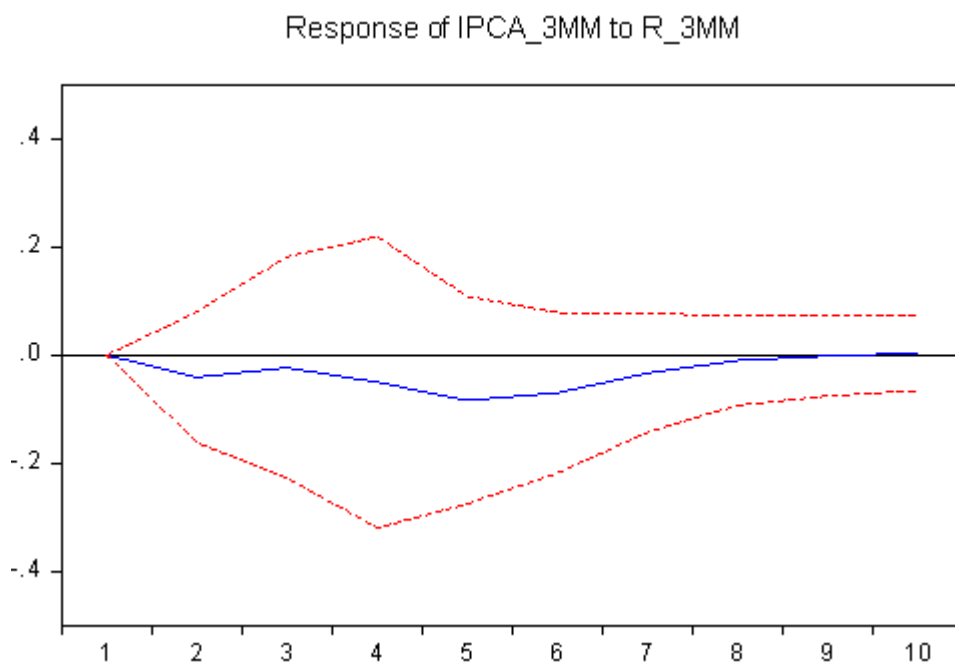
Panel C: Quarterly estimation and responses with GDP replacing the Industrial Production Series

Response of IPCA_3MM to R_3MM
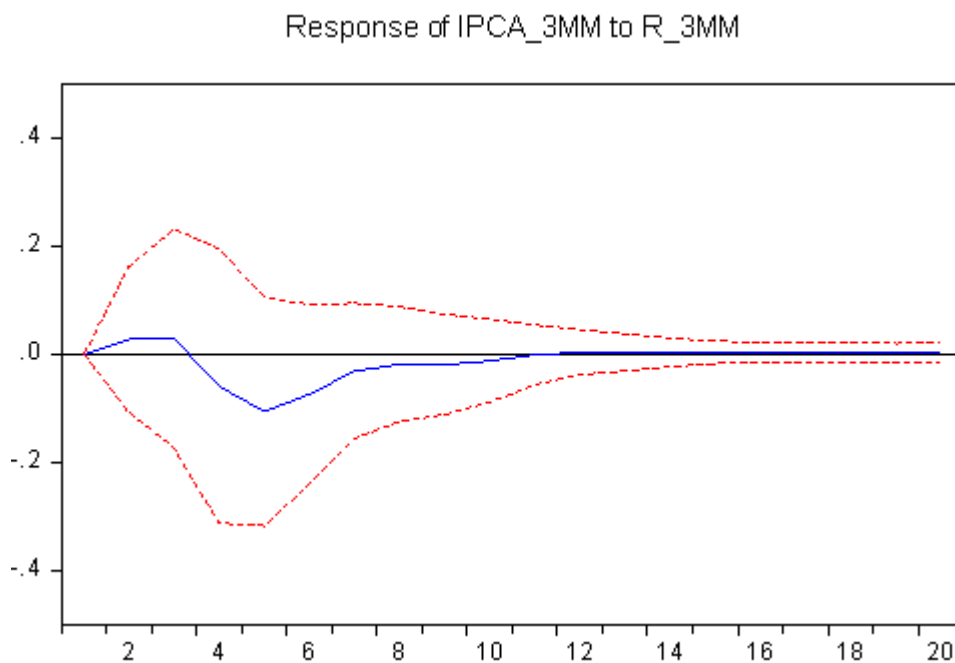
Panel D: Quarterly estimation and responses with GDP and Nominal Exchange Rate Variation respectively replacing Industrial Production and Country Risk Premium in the Set of Endogenous Variables

Response of IPCA_3MM to R_3MM
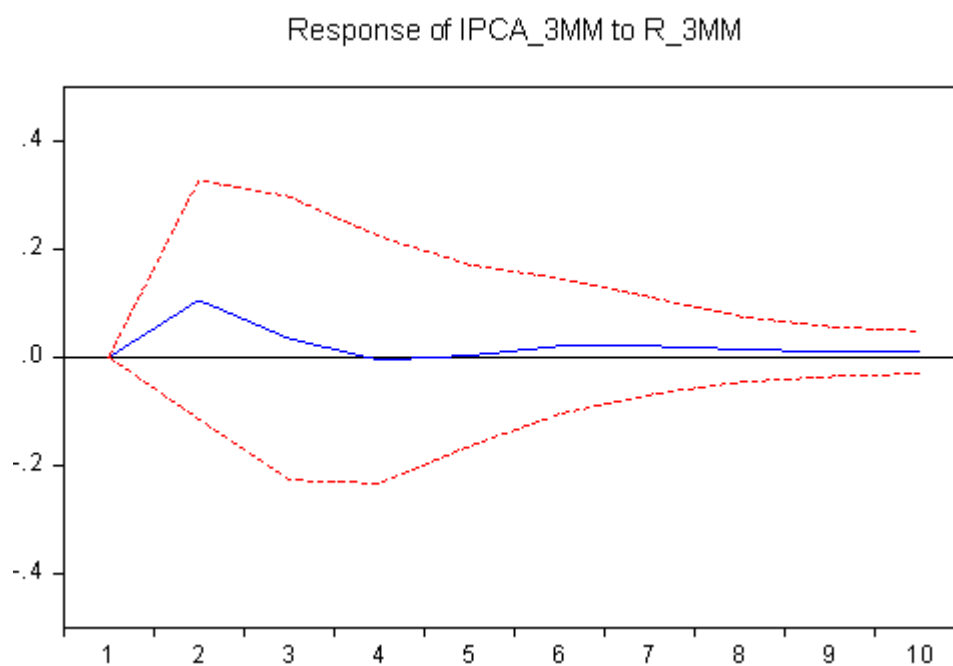
Figure 12: Impulse responses to a 1 s.d. shock to the domestic risk premium
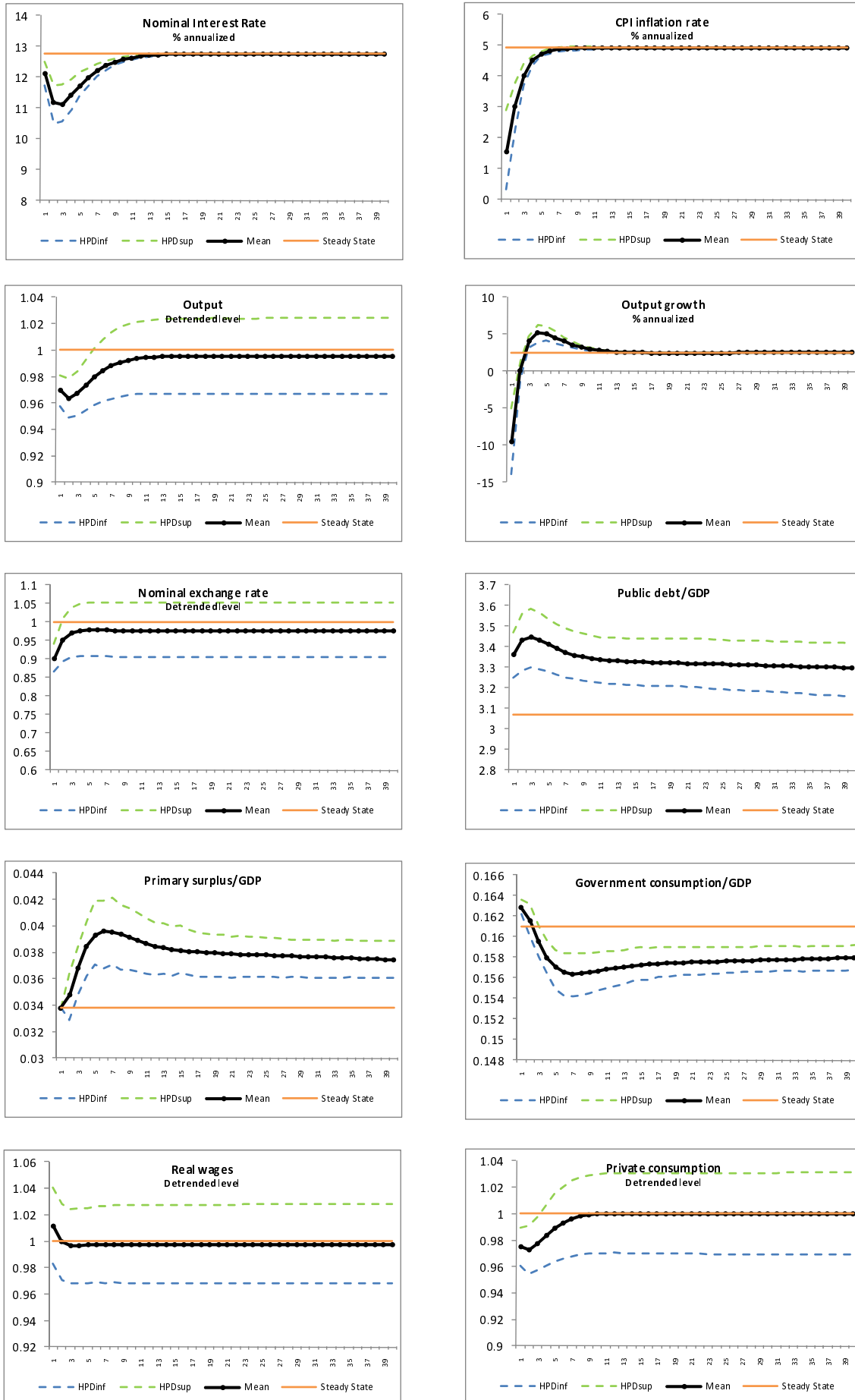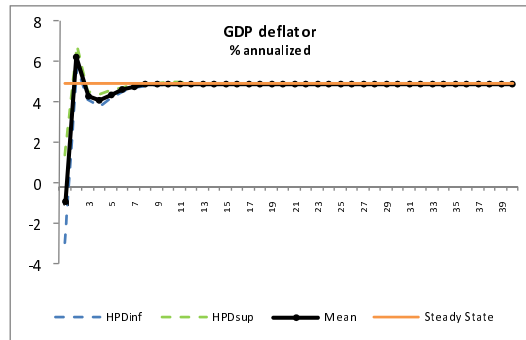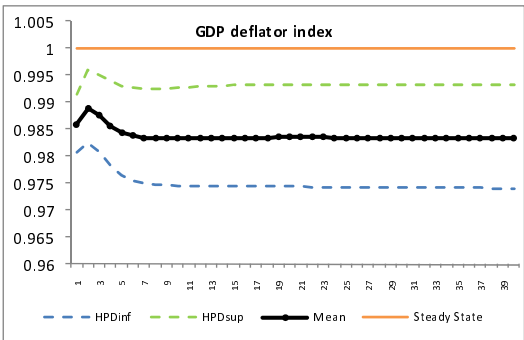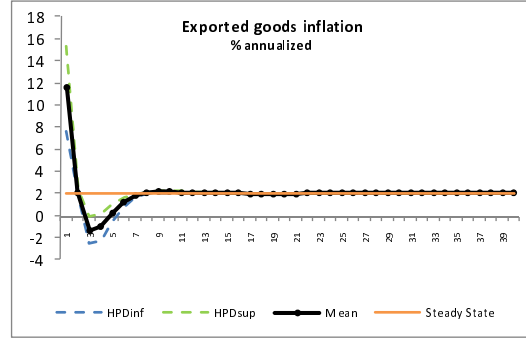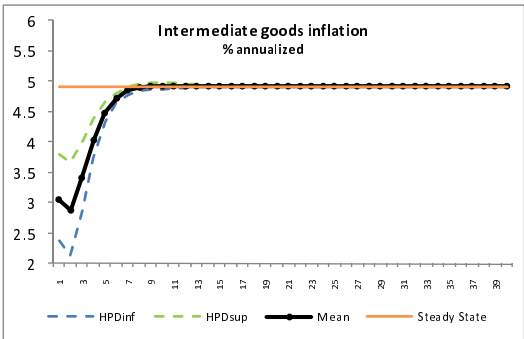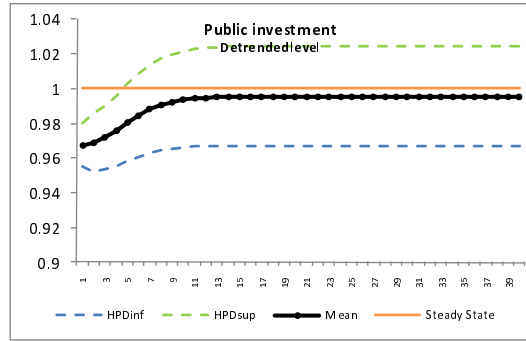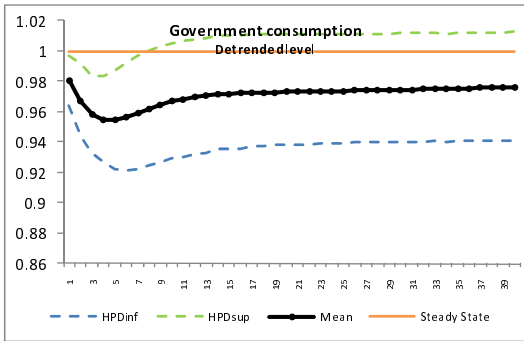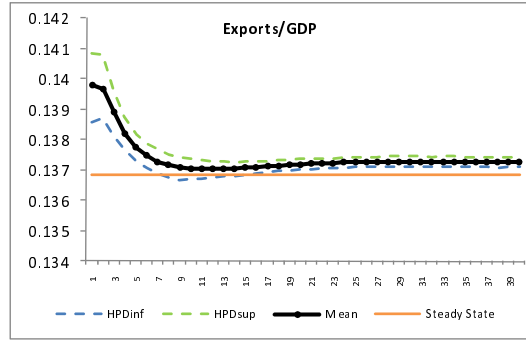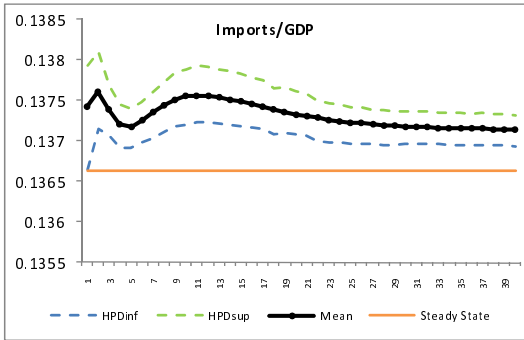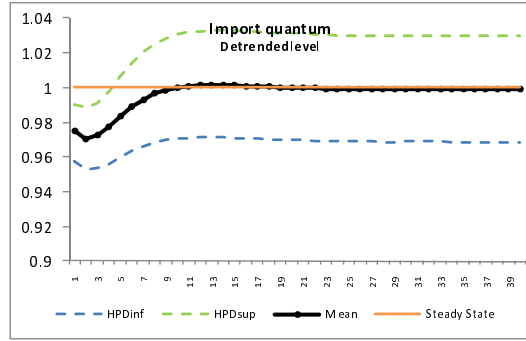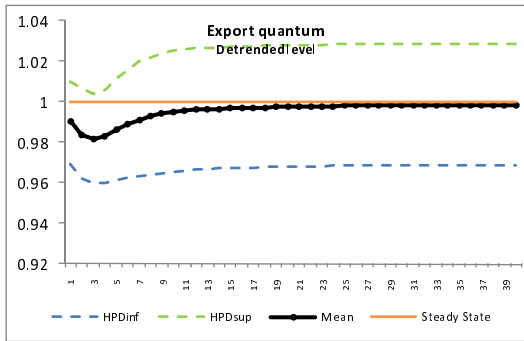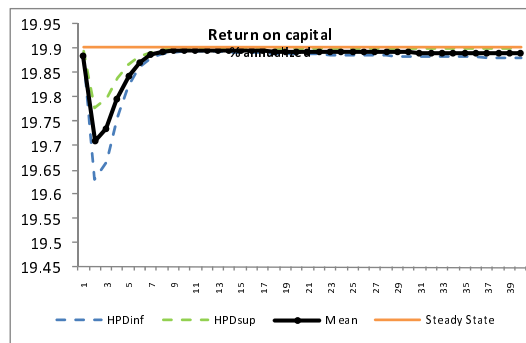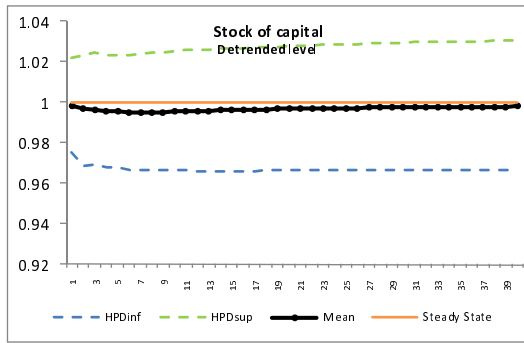
Figure 13: Impulse responses to a 1 s.d. shock to the foreign risk premium

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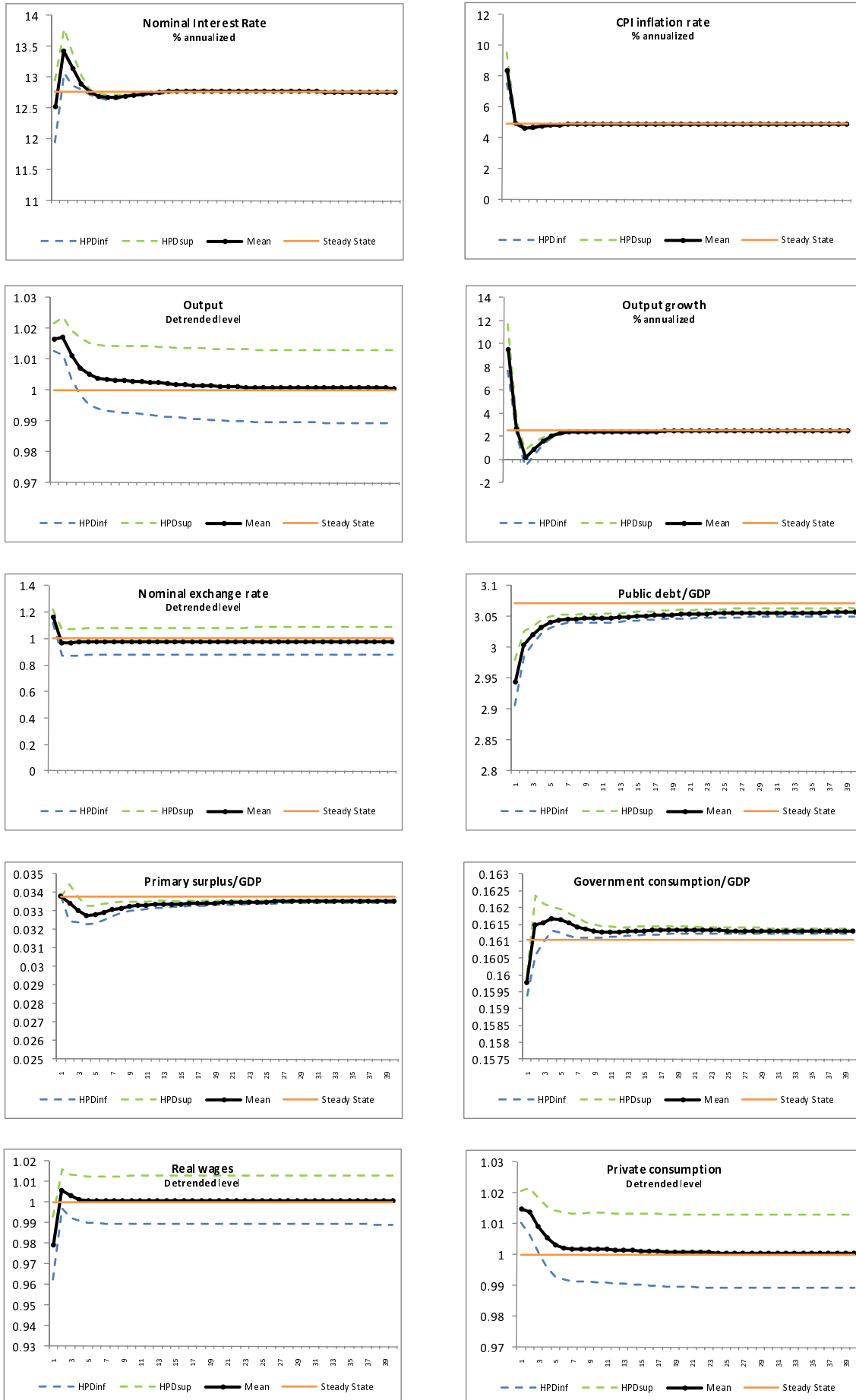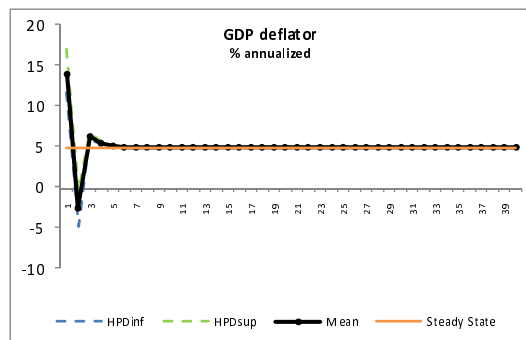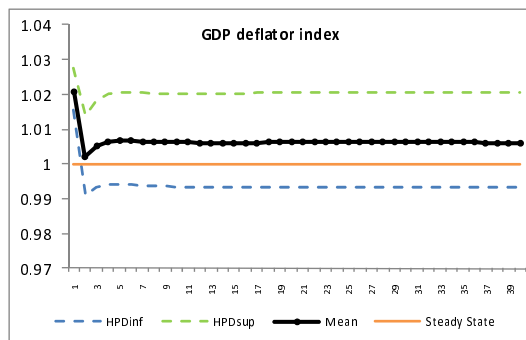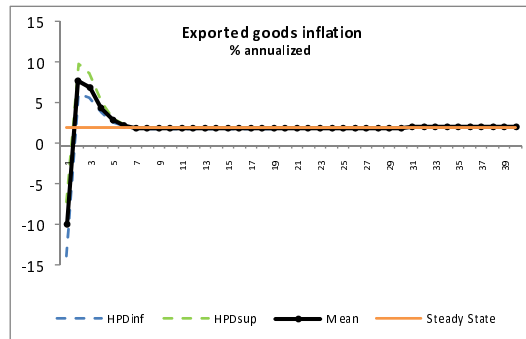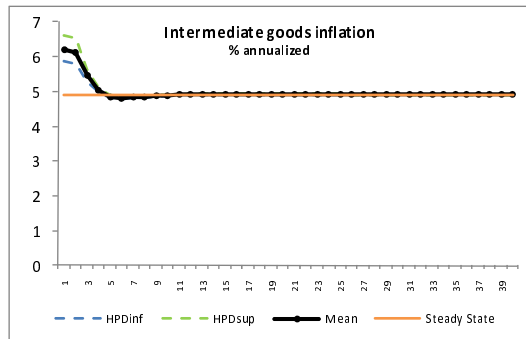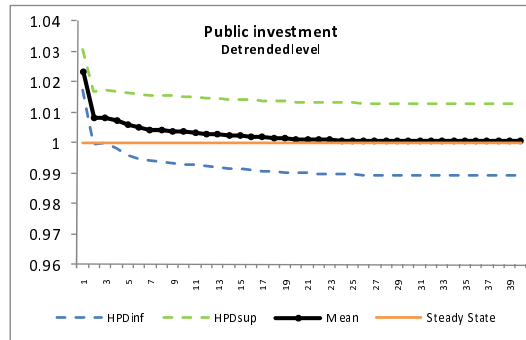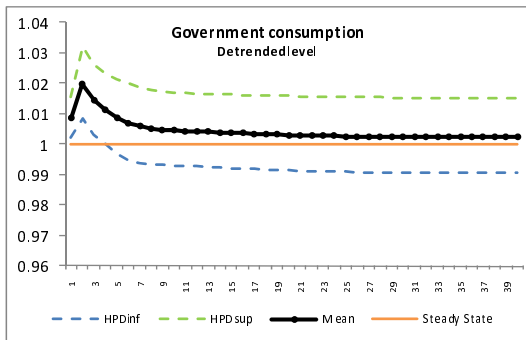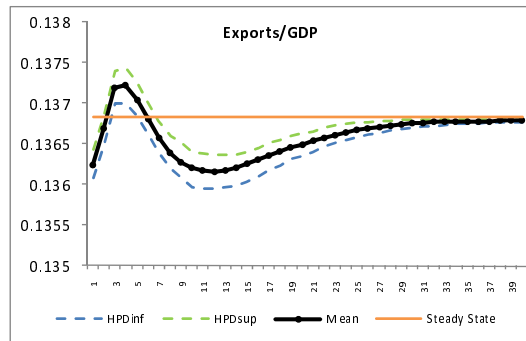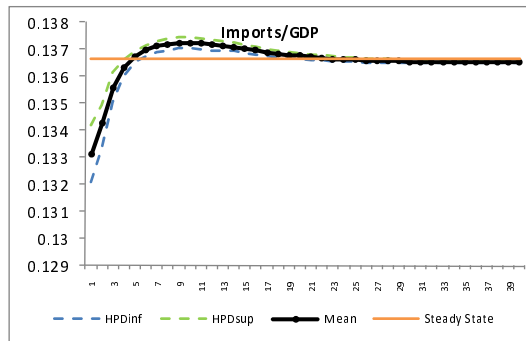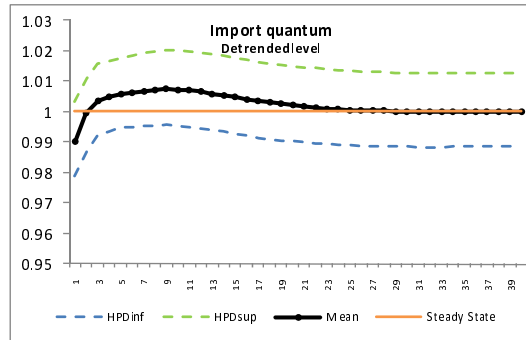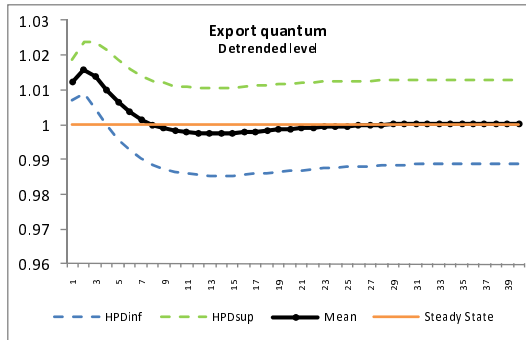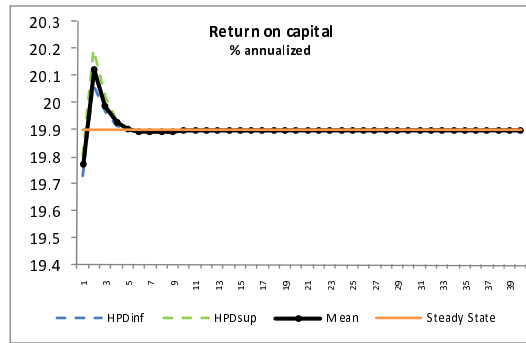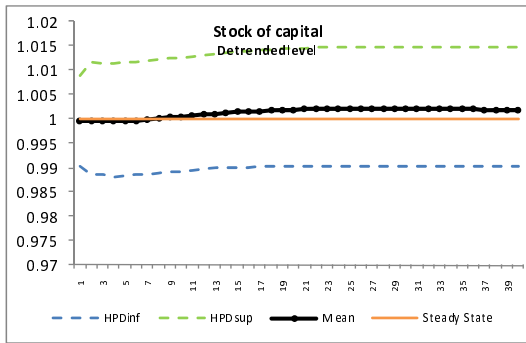
Figure 14: Impulse responses to a 1 s.d. temporary (total factor) productivity shock
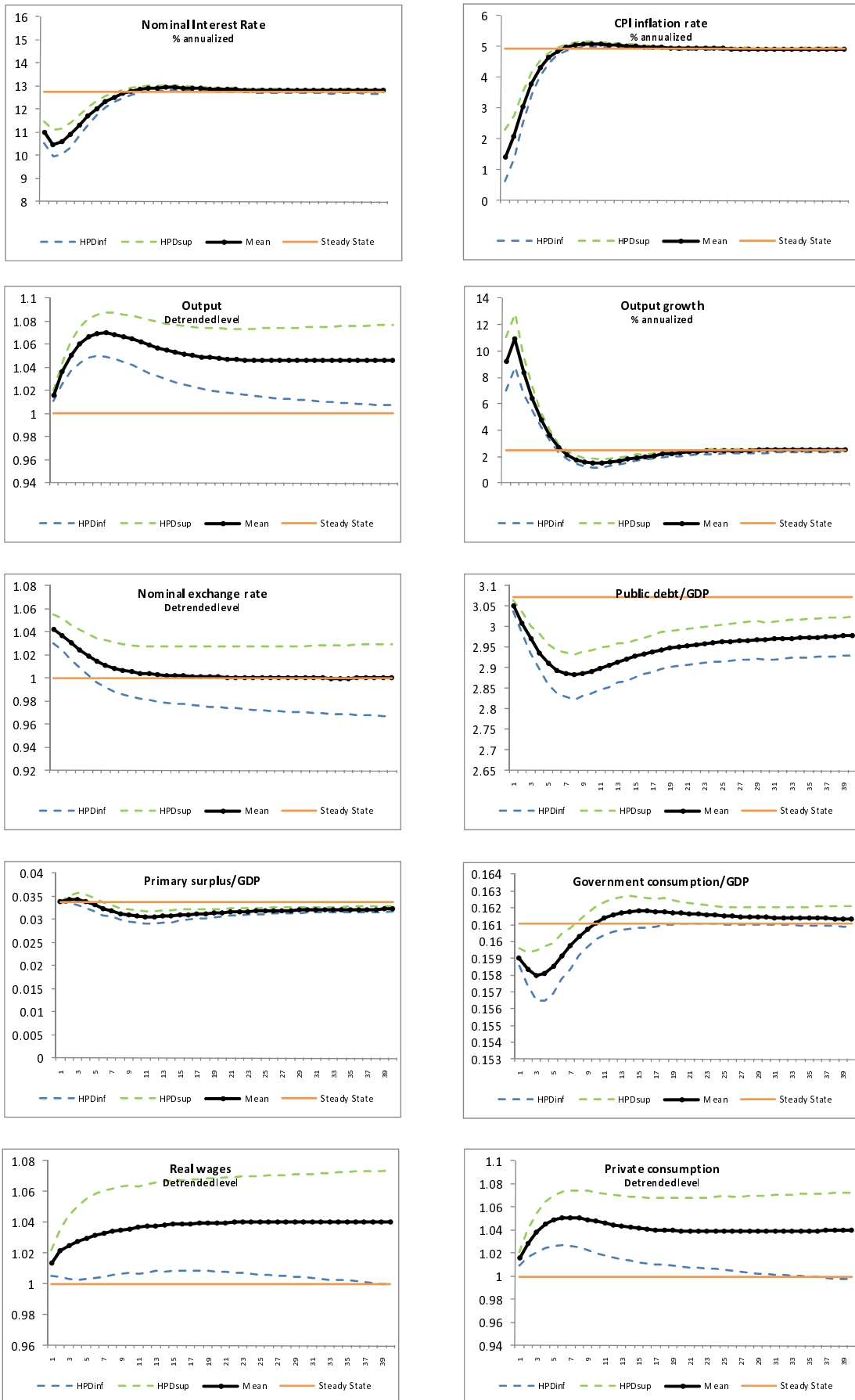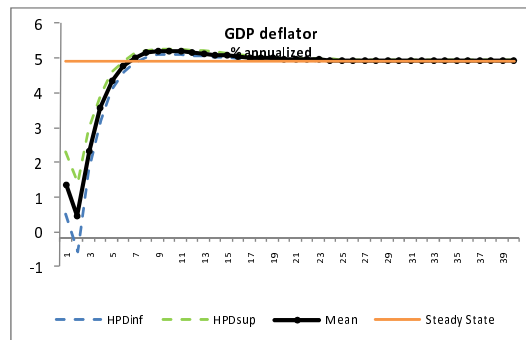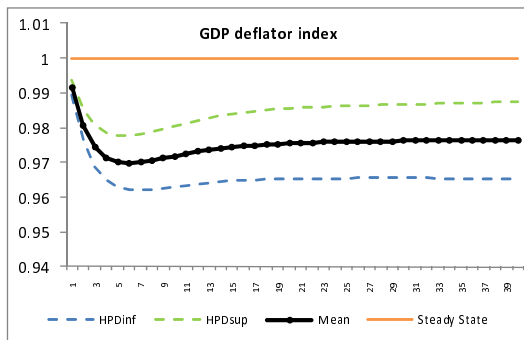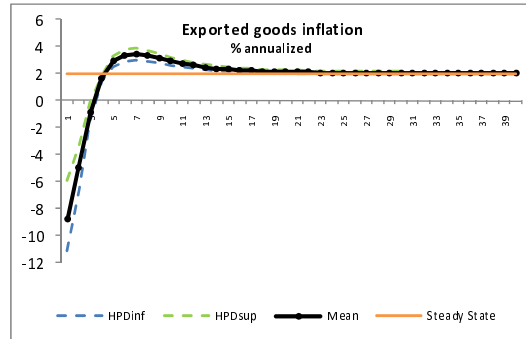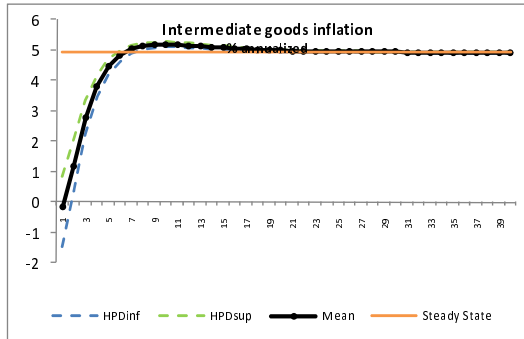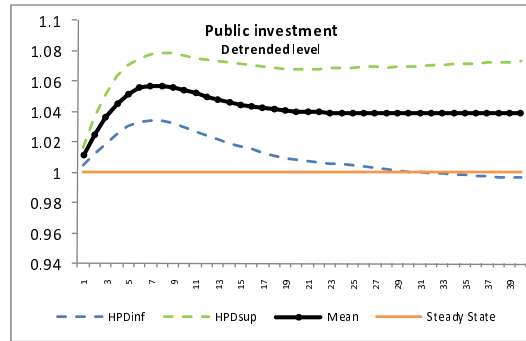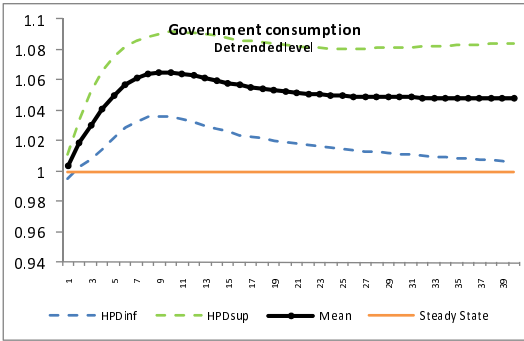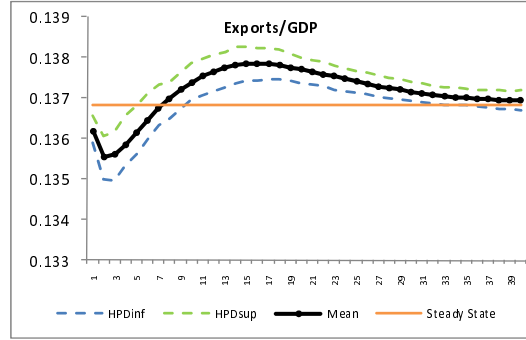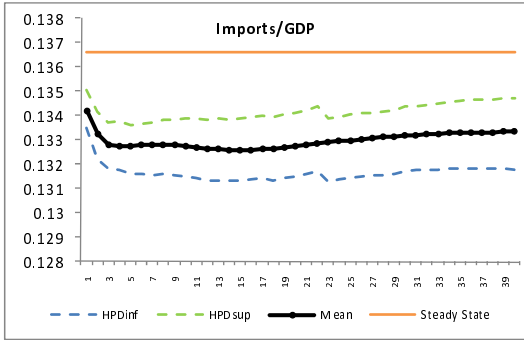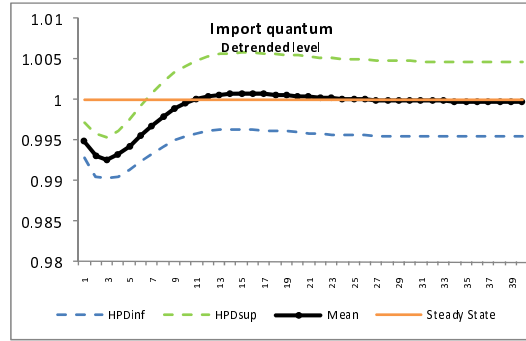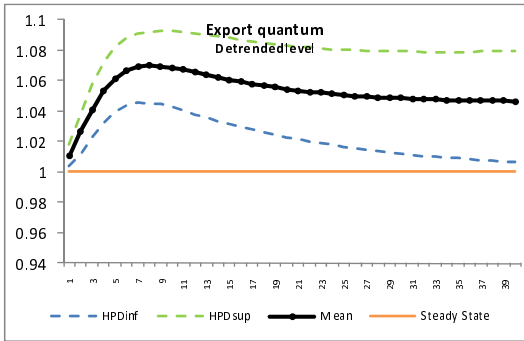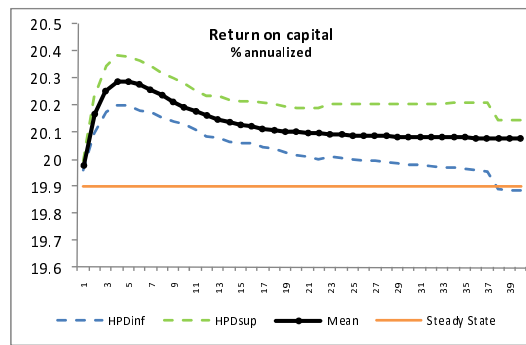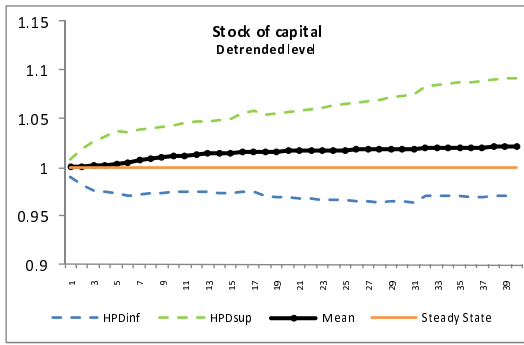
Figure 15: Impulse responses to a 1 s.d. permanent (labor-augmenting) productivity shock
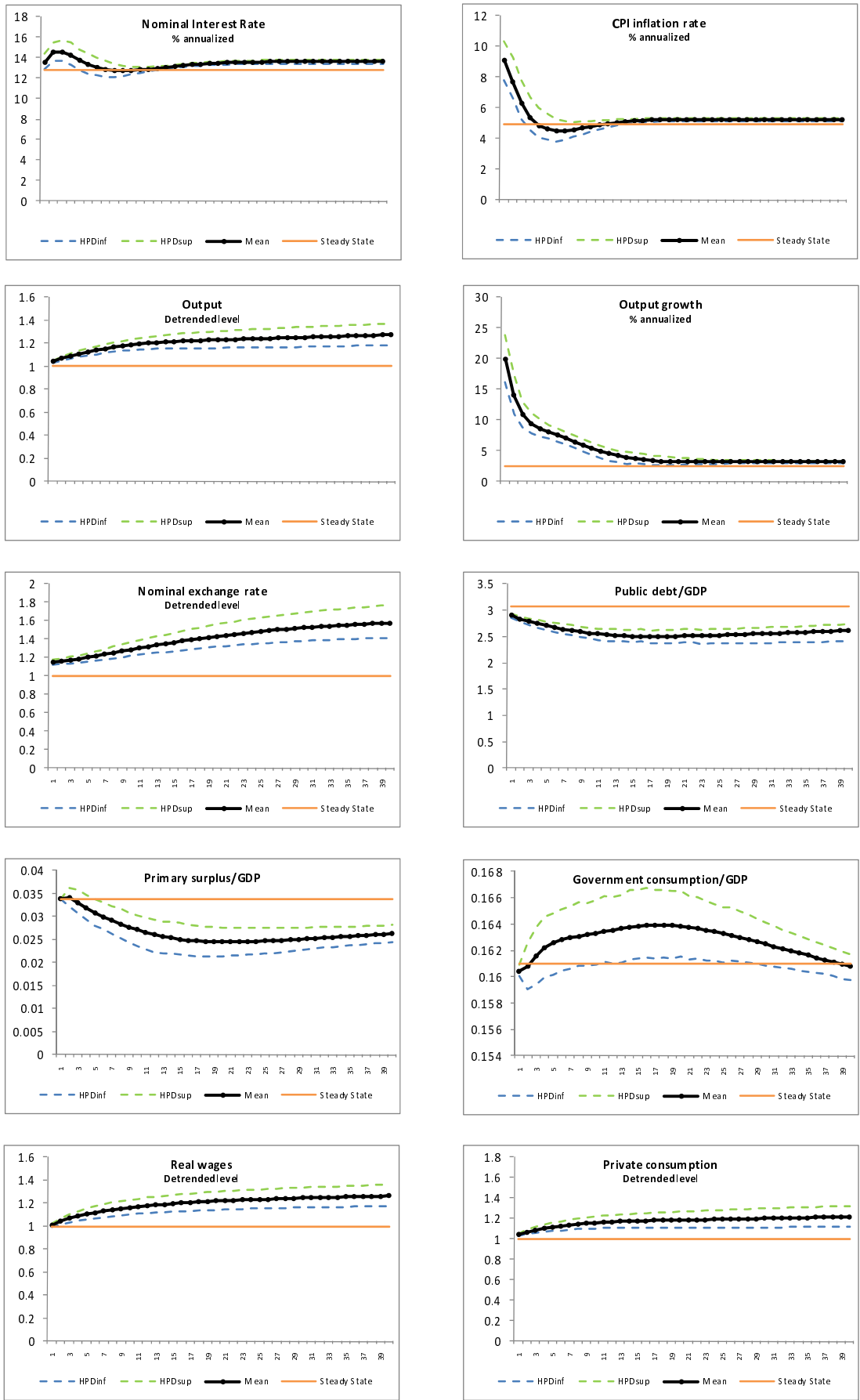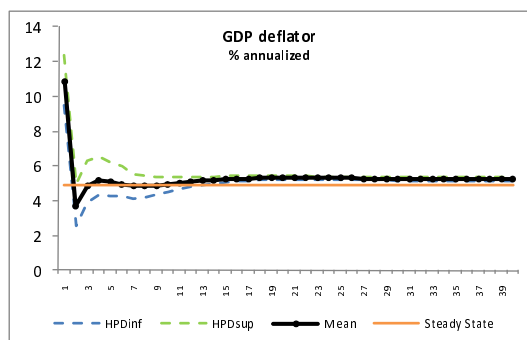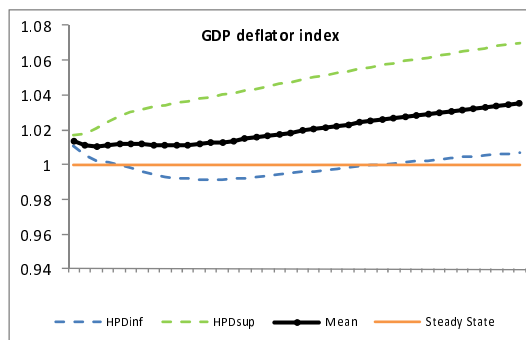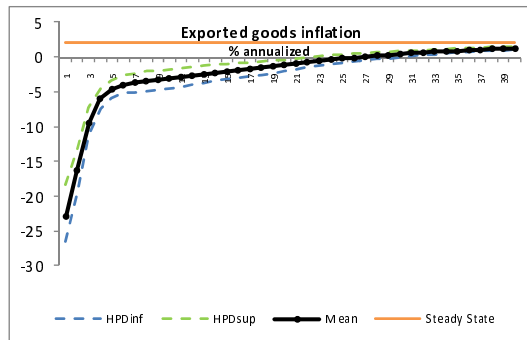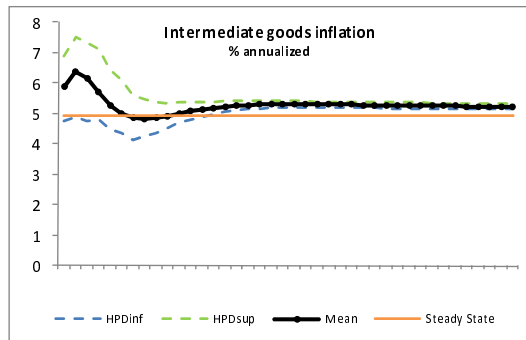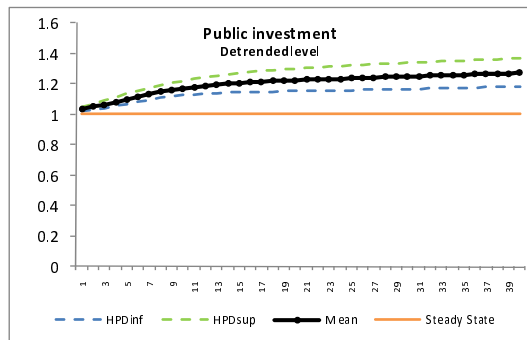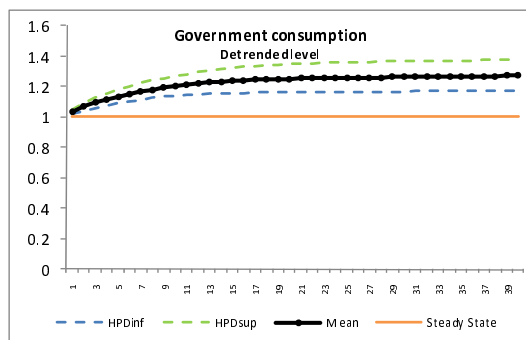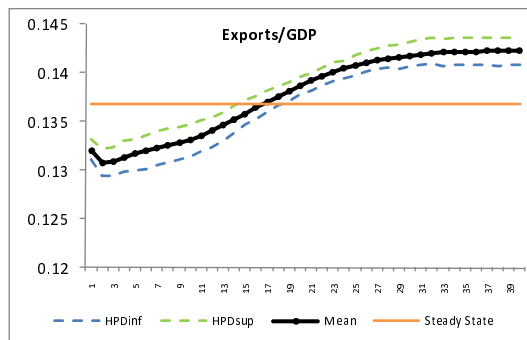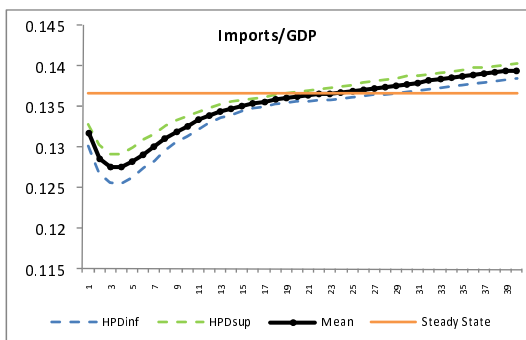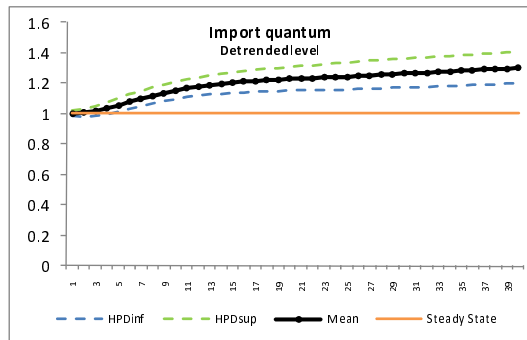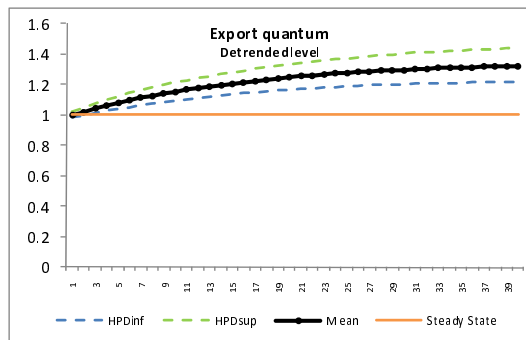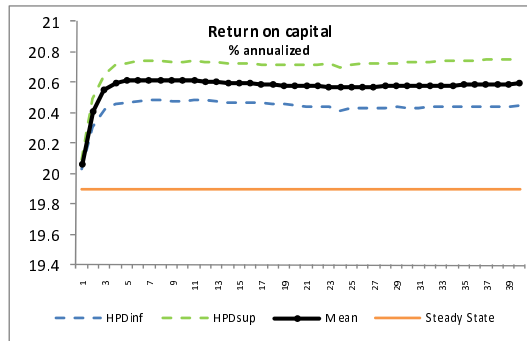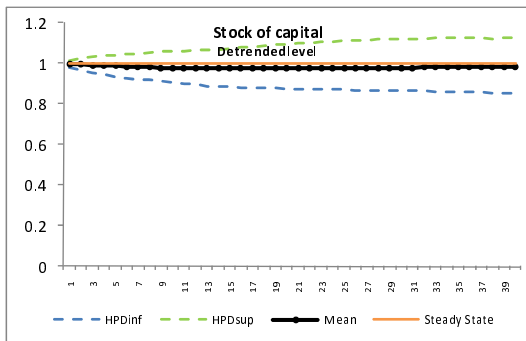
Figure 16: Historical Shock Decomposition (main shocks)

Primary Surplus/GDP

public investment

permanent (labor-augmenting) productivity

temporary productivity

domestic risk premium

primary-surplus shock

Legend: erp, eig, esp, ezn, ez

Consumption/GDP

public investment

public transfers

public transfers

permanent (labor-augmenting) productivity

temporary productivity

domestic risk premium

Legend: ez, ezn, etr, eig, erp

Figure 17: Policy Exercise – Changing the Primary Surplus Target: Shock to the Monetary Policy Rule
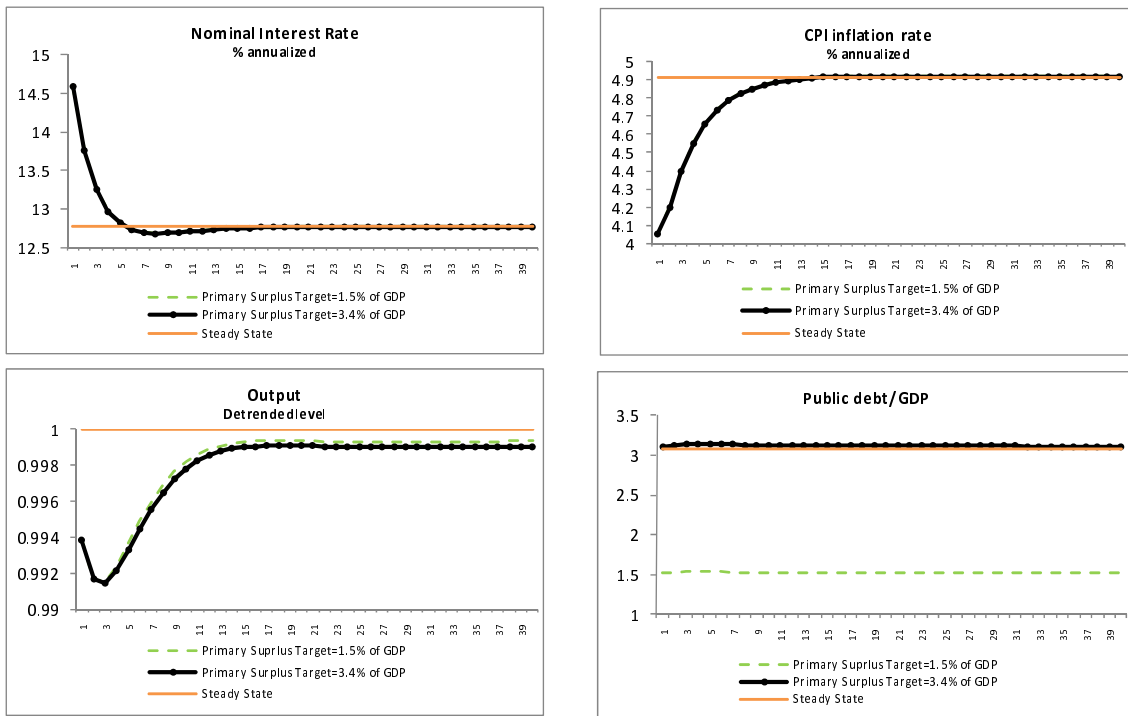
Figure 18: Policy Exercise – Changing the Reaction to the Debt-to-GDP Ratio in the Fiscal Rule for the Primary Surplus: Shock to the Primary Surplus Rule
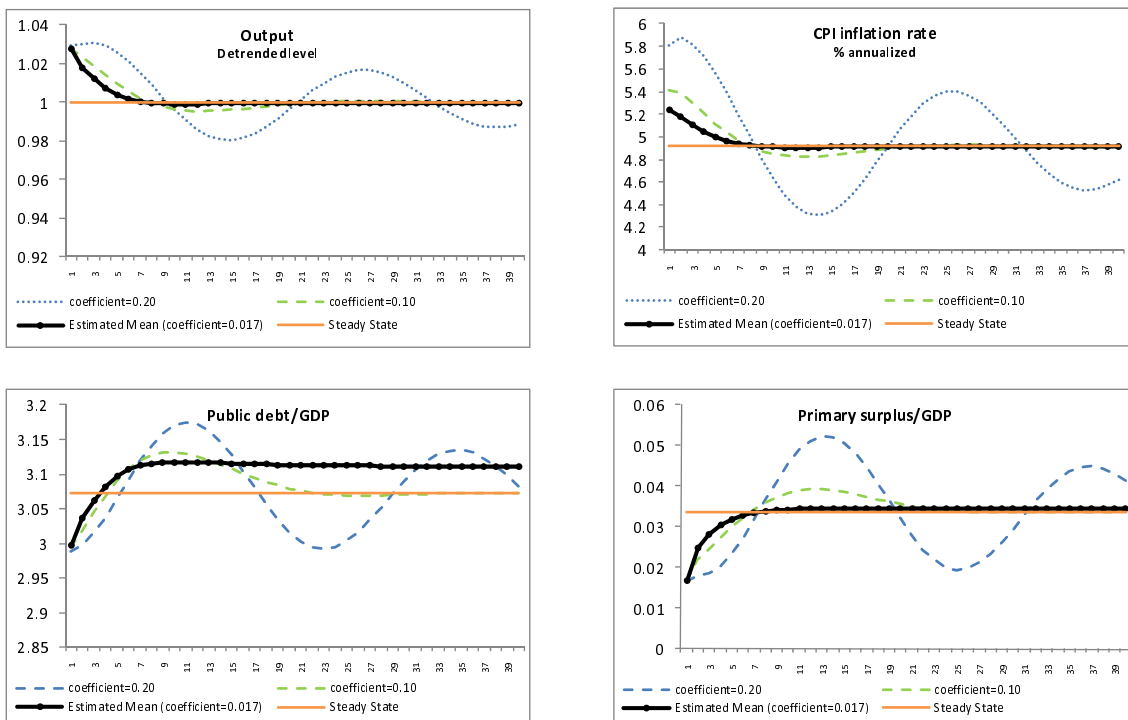
Figure 19: Policy Exercise – Changing the Reaction to GDP Growth in the Fiscal Rule for the Primary Surplus: Shock to the Primary Surplus Rule
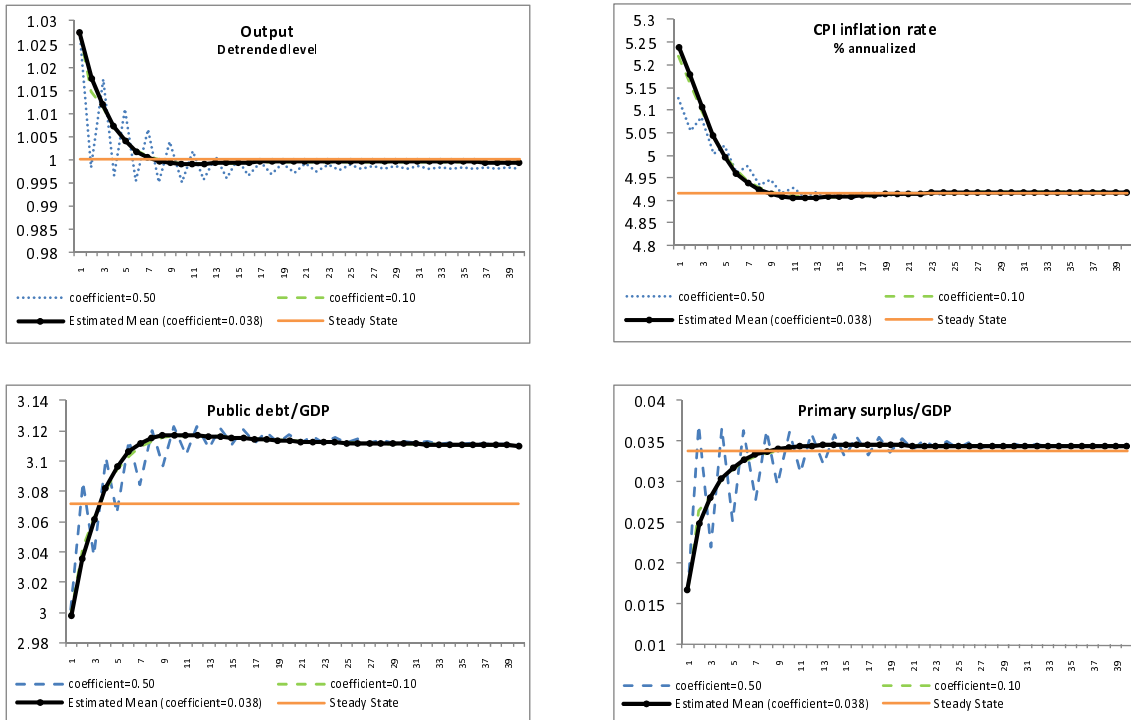
Figure 20: Policy Exercise – Changing the Reaction to GDP Growth in the Monetary Policy Rule: Shock to the Monetary Policy Rule
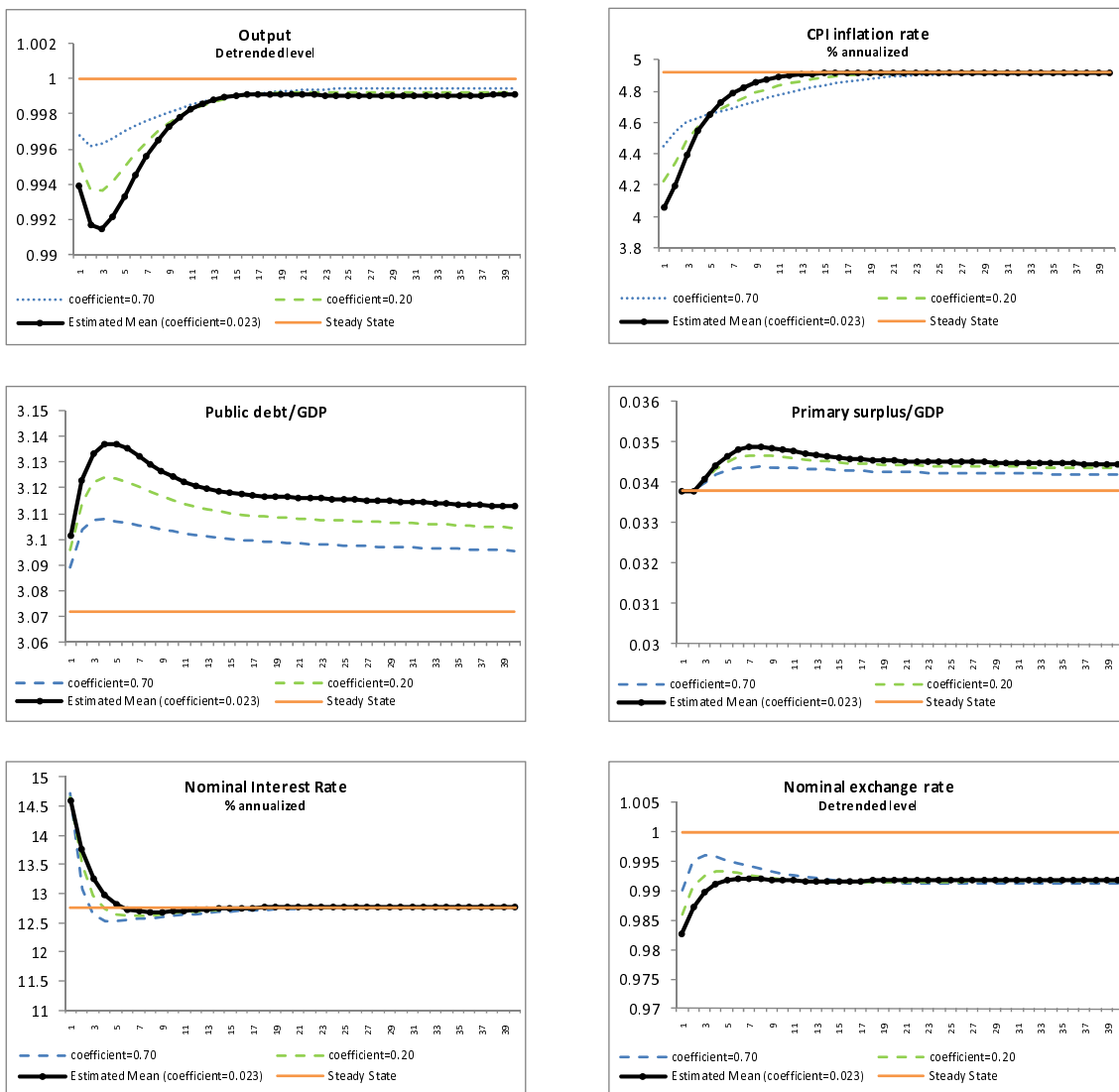
Figure 21: Policy Exercise – Changing the Size (ω) of the Worse-off Share of the Population: Shock to the Primary Surplus Rule
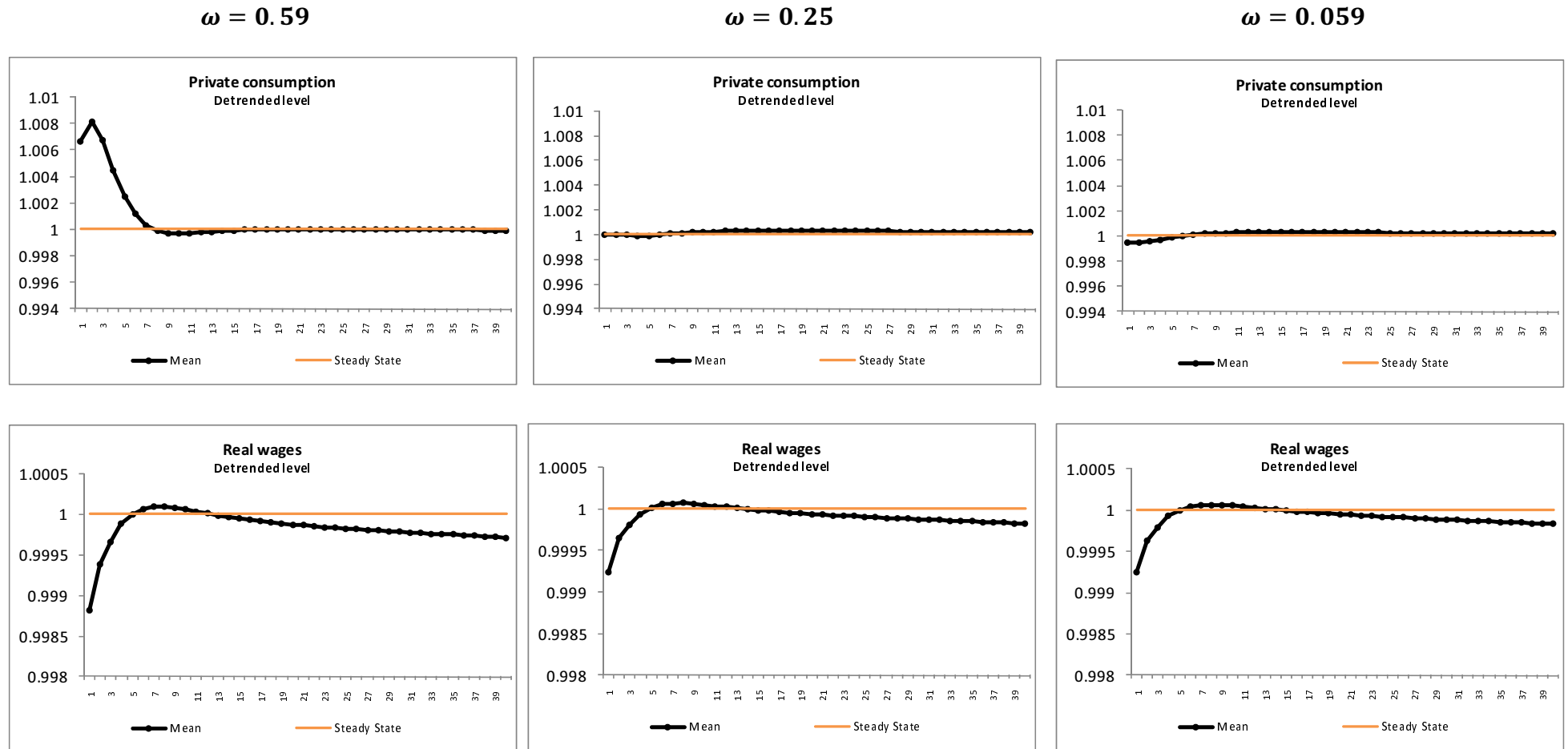
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