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**Was Anna Schwartz right?  
The role of government size and the exchange  
rate regime for macroeconomic stability**

Philipp Wegmueller

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**DISCUSSION PAPERS**

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# Was Anna Schwartz right?

*The role of government size and the exchange rate regime for macroeconomic stability*

Philipp Wegmueller\*

July 2, 2014

## **Abstract**

I contribute to the resurging debate on the reform of the international monetary system by asking: How does the size of the public sector under different exchange rate regimes affect macroeconomic stability and welfare? In response to a meeting of the Bretton Woods Commission in 1993, renowned economist Anna Schwartz (2000) claimed providently that the increasing size of the public sector impedes the viability of an exchange rate regime with a fixed rule for convertibility. I study her line of reasoning using a new Keynesian small open economy framework. One important feature of the paper is to bridge the literature on the choice of the exchange rate regime with the literature on the effects of government size for macroeconomic stability. The main findings are threefold: First, output is stabilized by the share of the public sector and destabilized by the tax rate, irrespective of the exchange rate regime in place. Second, inflation is destabilized by the level of income taxes under flexible prices but stabilized under sticky prices. Finally, irrespective of the model specification, an exchange rate peg exhibits the largest macroeconomic volatility and highest welfare losses.

*Preliminary and incomplete  
Comments are greatly appreciated*

**JEL class:** E32, E52, E63, F33

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*“The growth of government itself has destroyed the viability of a gold standard. A real gold standard was feasible in a world in which government spent 10 percent of national income, as in Britain and the United States pre-World War I. It is not feasible in a world in which governments spend half or more of national income. Why is this so?*

*A country that adopts a gold standard and observes the convertibility rule at times will be compelled to implement contractionary monetary policy. A balance of payments deficit will lead to a loss of gold reserves. A loss of gold reserves will enforce a reduction in domestic money supply. That reduction will impose price reductions and employment losses. The government share of national income is unaffected by the contraction in money, but the private sector bears its brunt. The government will not be constrained, as the private sector is, to lay off workers and cut the price of its services.*

*When government’s share is half of national income, the burden on the private sector is magnified. That is why the appeal of the gold standard has declined as the leviathan government has grown (Schwartz, 2000).”*

# 1 Introduction

The idea of a reform of the international monetary system has recently experienced upwind, with former Federal Reserve Chairman Paul Volcker calling for a new exchange rate regime in the style of Bretton Woods.<sup>1</sup> Already in 1993, the so-called Bretton Woods Commission proposed a new framework for foreign exchange rates, with the aim of ending their market fluctuations and substituting the management of their movements by monetary authorities. In response to this proposition, renowned economic historian Anna Schwartz laid out a balance-sheet for the Bretton Woods regime, asking if there is need for a reform of the international monetary system. Regarding the vision of the reform, she said that “[...] for some, the reform would be a return to the gold standard, domestic currencies convertible into gold, and fixed exchange rates among national currencies (Schwartz, 2000).”

She claims that the durability and viability of the gold standard in the late 19th and early 20th century is attributed on the one hand to the small share of government spending in total output, facilitating the adjustment to idiosyncratic shocks, and on the other hand to the role of the pegged exchange rate, where gold served as a nominal anchor, thereby enforcing price stability (Tavlas, 2013). She concludes her discussion asserting that “[...] the appeal of the gold standard has declined as the leviathan government has grown (Schwartz, 2000).”

This paper asks the question: *Was Anna Schwartz right?* Following the reasoning of Anna Schwartz (2000) gives rise to the question, whether a large government in combination with a fixed exchange rate regime is harmful for macroeconomic stability. It is the aim of this paper to provide a study of how alternative exchange rate regimes and the size of the public sector affect macroeconomic conditions, thereby contributing to the current debate over the implementation of a new international monetary system.

In a wide range of countries the public sector experienced a substantial increase during the 20th century. As documented by Tanzi and Schuknecht (2000), the government size of a selection of developed economies increased from an average level of about 10% general government expenditures in GDP in the late 19th century to 45% by the end of the 20th century. Public employment rose from below 5% percent to 15-20% in the same time interval. Quadrini and Trigari (2007) show that the number of employees and their compensation is significantly less cyclical in the public sector, leading to an amplification of the macroeconomic impact of shocks. By logic we can argue, that if employment and wages in the public sector are more rigid than in the private sector, then the private sector will be forced to absorb proportionally more of the adjustments to shocks.

This argument is linked to a broad literature examining the role of government size, on macroeconomic stability, essentially output variability. Government size is usually defined by the amount of total government expenditures, therefore including the public wage bill. These studies report that in the data there appears a strong negative correlation between government size and output volatility. It is argued that this finding is mainly due to the working of government purchases as an automatic

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<sup>1</sup><http://on.wsj.com/1ogdaYC> Downloaded June 19, 2014

stabilizer.<sup>2</sup> Nevertheless, in the context of standard RBC and new Keynesian models, there appears no clear connection between government size and output volatility and results are dependent on the model specification. While most of the literature lays its focus on the stabilization properties of the public sector for output, the present paper takes a wider perspective and also considers its role for inflation and real exchange rate stabilization.

Apart from the role of government size on output volatility, the choice of the exchange rate regime plays a fundamental role for macroeconomic stability. In the words of Anna Schwartz: The gold standard (i.e. a fixed exchange rate regime) “[...] is not feasible in a world in which governments spend half or more of national income (Schwartz, 2000).” It is therefore natural to ask, if a floating exchange rate regime would be a valuable alternative? There is a vast literature that examines the performance of alternative open economy monetary policy rules and its macroeconomic implications as well as their welfare properties.<sup>3</sup> Empirically it has been shown, that changing the exchange rate regime from a float to a peg has no effect on the volatility of real variables, while the nominal and real exchange rate are significantly more volatile under a floating regime. This is related to the fact, that in the 90’s the desire of some exponents to establish a new international monetary framework ensuring more financial stability arose. On theoretical grounds, the value emerging from the choice of exchange rate regime is mixed. The results depend on the structure of the asset markets, the degree and source of nominal frictions and the type of policy rule conducted.

What has not been investigated so far, is how the government size can affect the macroeconomic stability and welfare properties of different exchange rate regimes. This is a question, which is both relevant and current, since several countries pertaining to the European union have large public sectors and had to face strong adjustments during the financial crisis of 2008. Adjustments which were mostly absorbed by the private sector, causing skyrocketing unemployment rates and calling for austerity plans aiming at constraining the public sector to lay off workers and cut down services. Could some of this burden have been prevented under flexible exchange rates?

The value added of the present paper relative to the existing literature on the choice of the exchange rate regime and the impact of government size for macroeconomic stability contains several elements. First, the paper picks up a resurging debate on the reform of the international financial system and contributes to it with a theoretical equilibrium model, using as basis a statement containing a contentious hypothesis. Second, it analyzes the role of government size adding thereby to an ongoing discussion with new insights and extensions (such as the role of the public sector on price stability). Third, it allows for different exchange rate regimes and compares their implications under different sizes of the public sector, a contribution which matters greatly for the conduct of monetary policy in countries with fixed exchange rates. Finally, the paper is able to bridge a gap in the macroeconomic literature by combining two strands of literature, using a quote which was such prescient,

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<sup>2</sup>Prominent work addressing the question of how the size of the government affects output volatility are among others Gali (1994), Guo and Harrison (2006), Fatás and Mihov (2001), Andrés and Doménech (2006) and Andrés, Doménech, and Fatas (2008)

<sup>3</sup>For instance Baxter and Stockman (1989), Backus, Kehoe, and Kydland (1992), Collard and Dellas (2002), Dedola and Leduc (2001), Kollmann (2002), Clarida, Gali, and Gertler (2001) and Gali and Monacelli (2005)

original and challenging.

The objective of this paper is to address the question, if Anna Schwartz was right by claiming that the size of the public sector causes exchange rate pegs to be less long lasting than floating exchange rate regimes. It is addressed by using a fully specified small open economy, stochastic general equilibrium model. The model incorporates a government, which gets revenue from distortionary income taxes and seigniorage. The role of nominal rigidities is crucial for the exchange rate regime in place to affect households decisions and therefore have real effects.

The main channel through which the choice of exchange rate regime affects real variables in the presented model is through price stickiness. With nominal rigidities in place, we observe that qualitatively it does not make a difference whether the government levies distortionary or lump-sum taxes. Income taxes are necessary in the flexible price world to distort the labor supply decision and thereby obtaining that the exchange rate regime matters, although only by little. Under sticky prices, the Taylor rule with floating exchange rates has the best welfare properties and the exchange rate peg fares worst. This result is robust for the model with lump-sum taxation and also under the assumption of a positive inflation steady-state. The impact of seigniorage revenues entering the consolidated government budget constraint is although minor and does not have significant effects on the welfare properties of the model. Under flexible prices, all the monetary policy rules exhibit welfare losses, while the exchange rate peg fares worst and the money supply rule fares best.

In the light of these findings, the statement by [Schwartz \(2000\)](#) has to be mitigated. Concerning the stability of output, the answer to the guiding question whether Anna Schwartz was right is mixed. The paper shows that output volatility is significantly higher under an exchange rate peg, but government size can have stabilizing or destabilizing effects, depending on the expenditure or revenue side. When looking at price stability, Anna Schwartz was right. Here, a monetary system imposing an exchange rate peg and a large government is undoubtedly harmful. While the share of public spending destabilizes inflation under either exchange rate regime, the income tax rate can have slightly stabilizing effects on inflation under a peg.

The paper is organized as follows. The next section presents the baseline small open economy model. Section 3 presents the model calibration and the computational details. Focusing on the stabilization properties of government size and the exchange rate regime, section 4 analyzes dynamic responses, second moments and the welfare properties generated by the proposed model. Sections 5 and 6 test the model for robustness and consider some simple extensions. Section 7 concludes.

## 2 The model

The following section outlines a standard small open economy model in the lines of [Gali and Monacelli \(2005\)](#). The domestic economy is assumed to be infinitesimally small and to consist of three building blocks. First there is an utility maximizing representative agent who can buy goods that are traded internationally and who has access to domestic and foreign bonds. The household works in the private sector producing a homogeneous intermediate good. The only input for production

is labor. There is monopolistic competition in the intermediate goods market and perfect competition in the market for final goods. Intermediate goods producer face nominal rigidities in the form of price adjustment costs. The third building block is represented by the government, which has to fulfill a balanced budget. In order to finance a given level of public expenditures, the government creates revenues from the collection of lump-sum and distortionary taxes from households and from seigniorage. The foreign economy is assumed to be exogenous. The role of the central bank is to ensure inflation and output stability and to assess a role to the exchange rate regime in place.<sup>4</sup>

## 2.1 Households

The domestic household chooses a bundle of consumption goods  $c_t$ , real money balances  $\frac{M_t}{P_t}$  and labor supply  $n_t$  to the private sector, such to maximize the expected present discounted value of utility,

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U \left( c_t, \frac{M_t}{P_t}, l_t \right),$$

subject to the budget constraint

$$\begin{aligned} P_t c_t + B_{H,t} + S_t B_{F,t} + M_t \\ \leq (1 - \tau_t^D) W_t n_t + R_{t-1} B_{H,t-1} + S_t R_{t-1}^* B_{F,t-1} - \phi_B(B_{F,t}) + M_{t-1} + \Pi_t - P_{H,t} \tau_t^L. \end{aligned}$$

$B_{H,t}$  is a one-period domestic bond, which is not traded internationally and in zero net supply at the domestic household level. The domestic bond returns a gross nominal interest of  $R_t$ .  $B_{F,t}$  is a traded one-period foreign bond denominated in the foreign currency with an exogenous gross nominal return of  $R_t^*$ . It is costly to hold a quantity of foreign assets in the portfolio which is away from some long-run level  $\bar{B}_F$ . The convex portfolio adjustment cost function<sup>5</sup>  $\phi_B(B_{F,t})$  is borrowed from [Schmitt-Grohé and Uribe \(2003\)](#) and serves to induce stationarity into the debt process and close the small open economy model.  $M_{t-1}$  is the amount of money that households bring into period  $t$  and  $M_t$  is the end of period money stock of the agent.  $\Pi_t$  is the dividend payment the household gets from the domestic competitive firms. The household has to pay a time-varying distortionary income tax  $\tau^D$  and pays (receives)  $\tau_t^L$  as a lump-sum tax (transfer) to (from) the government.<sup>6</sup> All these variables are denominated in domestic currency,  $P_t$ , being the nominal price of the final domestic consumption good.  $S_t$  is the nominal exchange rate defined such that an increase in  $S_t$  implies a depreciation of the domestic currency.<sup>7</sup>

<sup>4</sup>Examples of similar models include [Clarida, Gali, and Gertler \(2001\)](#), [McCallum and Nelson \(2000\)](#) and [Lim and McNelis \(2008\)](#).

<sup>5</sup> $\phi_B'(B_{F,t}) > 0$ ,  $\phi_B''(B_{F,t}) > 0$ . Note that  $\phi_B(\bar{B}_F) = \phi_B'(\bar{B}_F) = 0$  and  $\phi_B''(\bar{B}_F) = \phi$

<sup>6</sup>From here on I will refer to  $\tau^L$  as a lump-sum tax, irrespective of its sign.

<sup>7</sup>The nominal exchange rate is defined as domestic currency per units of foreign currency.  $\Delta S_t = \frac{S_t}{S_{t-1}}$ , where  $\Delta S_t > 1$  implies that the domestic currency depreciates. That is, domestic households have to pay more for foreign currency in period  $t$  than in period  $t - 1$ .



The total time endowment is normalized to unity and the household is subject to the time constraint

$$l_t = 1 - n_t.$$

The first order conditions are given by the following five equations, taking into account that the necessary transversality conditions hold<sup>8</sup>:

$$c_t : \quad U_{c,t}(\cdot) = \Lambda_t P_t \quad (2.1)$$

$$\frac{M_t}{P_t} : \quad U_{\frac{M}{P},t}(\cdot) + \beta \mathbb{E}_t [\Lambda_{t+1}] = \Lambda_t \quad (2.2)$$

$$n_t : \quad -U_{n,t}(\cdot) = \Lambda_t (1 - \tau_t^D) W_t \quad (2.3)$$

$$B_{H,t} : \quad \Lambda_t = \beta R_t \mathbb{E}_t [\Lambda_{t+1}] \quad (2.4)$$

$$B_{F,t} : \quad \Lambda_t (1 + \phi'_B(B_{F,t})) = \beta R_t^* \mathbb{E}_t [\Lambda_{t+1} \Delta S_{t+1}] \quad (2.5)$$

where  $\Lambda_t$  is the Lagrange multiplier attached to the budget constraint of the household. Equation (2.1) is the optimal choice of the consumption good  $c_t$ , while (2.2) states the opportunity cost of holding money balances relative to consumption. Equation (2.3) is the labor supply schedule of the household, which equates the amount of hours worked by the households to the after tax nominal wage rate. The Euler equations of the household are given by equations (2.4) and (2.5). The combination of these two equations yields a form of interest parity condition:

$$R_t (1 + \phi'_B(B_{F,t})) = R_t^* \mathbb{E}_t [\Delta S_{t+1}], \quad (2.6)$$

which relates the domestic interest rate to the foreign interest rate. In the long run, the domestic interest rate equals the foreign interest rate, while in the short run, deviations in the interest rates are captured by the expected change in the nominal exchange rate. Note here that the portfolio adjustment costs alter the uncovered interest parity condition from the one given by complete financial markets.<sup>9</sup>

The consumption bundle  $c_t$  is comprised of domestic and foreign goods, summarized in a CES aggregation function, formally

$$c_t = \left[ (1 - \gamma)^{\frac{1}{\eta}} c_{H,t}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} c_{F,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \quad (2.7)$$

where  $c_{H,t}$  is the domestic consumption good and  $c_{F,t}$  is the good coming from the foreign economy. The parameter  $\eta > 0$  measures the elasticity of substitution between these two goods.<sup>10</sup> The

<sup>8</sup>The transversality conditions are given by  $\lim_{t \rightarrow \infty} \beta^t B_{H,t+1} \Lambda_t = 0$ ,  $\lim_{t \rightarrow \infty} \beta^t B_{F,t+1} \Lambda_t = 0$

<sup>9</sup>See Gali and Monacelli (2005) for details. It can be shown that the standard uncovered interest parity relationship can be derived by log-linearization.

<sup>10</sup>A special case arises when the elasticity of substitution is equal to unity, then we have the case of a Cobb-Douglas consumption aggregate, represented by  $C_t = C_{H,t}^{1-\gamma} C_{F,t}^\gamma$ .

degree of value the household attributes to the good from the Foreign economy is indexed by the parameter  $\gamma \in [0, 1]$ . In the open economy literature,  $\gamma$  is referred to as a natural measure of openness.

The consumer price index (CPI) is a weighted average of the price level in the domestic economy and the price level in the Foreign economy, given by

$$P_t = \left[ (1 - \gamma)P_{H,t}^{1-\eta} + \gamma P_{F,t}^{1-\eta} \right]^{\frac{1}{1-\eta}}. \quad (2.8)$$

Solving the optimal expenditure allocation problem of the household, the demand equations for the Home and Foreign good are

$$c_{H,t} = (1 - \gamma) \left( \frac{P_{H,t}}{P_t} \right)^{-\eta} c_t \quad (2.9)$$

$$c_{F,t} = \gamma \left( \frac{P_{F,t}}{P_t} \right)^{-\eta} c_t. \quad (2.10)$$

Combining the two demand functions yields the relative consumption plan of the household as a function of the relative price of the domestic and foreign good.

$$\frac{c_{H,t}}{c_{F,t}} = \frac{1 - \gamma}{\gamma} \left[ \frac{P_{H,t}}{P_{F,t}} \right]^{-\eta},$$

where the relative price  $\frac{P_{H,t}}{P_{F,t}}$  is equal to the bilateral terms of trade.

Summarizing, total household consumption expenditures are the sum of goods stemming from domestic production of the final good firm and the goods which are imported from the foreign economy:

$$P_t c_t = P_{H,t} c_{H,t} + P_{F,t} c_{F,t}.$$

## 2.2 Private sector

In the domestic production sector, we have a competitive firm that aggregates intermediate inputs from monopolistically competitive firms into a final good.

### Final good firm

The competitive final good firm uses the following constant returns to scale technology:

$$y_t = \left[ \int_0^1 y_t(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}},$$

where  $\epsilon > 1$  is the constant elasticity of substitution between differentiated intermediate inputs. Hence, demand faced by each individual domestic good,  $j$ , is

$$y_t(j) = \left[ \frac{P_{H,t}(j)}{P_{H,t}} \right]^{-\epsilon} y_t, \quad (2.11)$$

where  $\frac{P_{H,t}(j)}{P_{H,t}}$  is the relative price of each variety with respect to the aggregate domestic price level,  $P_{H,t}$ , which is given by

$$y_t = \left[ \int_0^1 P_{H,t}(j)^{1-\epsilon} dj \right]^{\frac{1}{1-\epsilon}}.$$

Total domestic demand amounts to the consumption demand arising from domestic households,  $c_{H,t}$ , the demand for the final good coming from the foreign economy, and in addition the amount of goods demanded by the government for public purchases,

$$y_t = c_{H,t} + c_t^* + g_t. \quad (2.12)$$

### Intermediate goods producer

There is a continuum of intermediate goods producing firms in the  $(0, 1)$  interval. Each intermediate firm  $j$  produces output using labor as the only productive input,

$$y_t(j) = a_t n_t(j),$$

given an AR(1)-process for technology level  $a_t$ . In the input markets there is perfect competition, meaning that firms minimize their production costs by choosing optimally the amount of labor, taking wages as given. Since firms are identical, they all choose the same amount of private inputs. Cost minimization thus implies that common real marginal costs are

$$mc_t = \zeta \frac{W_t}{P_{H,t}} \frac{n_t}{y_t}, \quad (2.13)$$

where  $\zeta = \frac{\epsilon-1}{\epsilon}$ , being the standard employment subsidy which is necessary to ensure that the optimality of the flexible price equilibrium is guaranteed.<sup>11</sup>

Firms are monopolistically competitive in the intermediate goods market. Firms in the monopolistic sector face quadratic price-adjustment costs as proposed by [Rotemberg \(1982\)](#). The mechanism is as follows: Each intermediate goods producing firm pays an increasing and convex cost measured in terms of aggregate private sector output when the size of its price increase deviates from the steady state domestic inflation rate,  $\bar{\pi}_H$ .

The cost function is given by

$$\frac{\kappa}{2} \left( \frac{P_{H,t}(j)}{P_{H,t-1}(j)} - \bar{\pi}_H \right)^2 y_t.$$

The intermediate goods producing firm maximizes its expected future discounted real value of profits

$$\mathbb{E}_t \left[ \sum_{\tau=0}^{\infty} \Phi_{t+\tau,t} \frac{\Pi_{t+\tau}(j)}{P_{H,t+\tau}} \right],$$

<sup>11</sup>See [Gali and Monacelli \(2005\)](#) for a detailed derivation and explanation.

with  $\Phi_{t+i,t}$  is an appropriate stochastic discount factor given by  $\beta^i \mathbb{E}_t \left[ \frac{\Lambda_{t+i}}{\Lambda_t} \right]$  and  $\frac{\Pi_{t+i}(j)}{P_{H,t+i}}$  the real value of intermediate goods firm's profits. The intermediate goods producing firm maximizes expected future discounted profits subject to the demand equation for good  $j$ , given by equation (2.11), which by substituting in is given by the following expression:

$$E_t \left[ \sum_{i=0}^{\infty} \Phi_{t+i,t} y_{t+i} \left( \left[ \frac{P_{H,t+i}(j)}{P_{H,t+i}} \right]^{1-\epsilon} - mc_{t+i} \left[ \frac{P_{H,t+i}(j)}{P_{H,t+i}} \right]^{-\epsilon} - \frac{\kappa}{2} \left( \frac{P_{H,t+i}(j)}{P_{H,t+i-1}(j)} - \bar{\pi}_H \right)^2 \right) \right].$$

Firms optimize with respect to the price set by firm  $j$  in period  $t$ ,  $P_{H,t}(j)$ . In a symmetric equilibrium we have that all firms choose the same price  $P_{H,t}(j) = P_{H,t}(j') = P_{H,t}$  and also  $\frac{P_{H,t}}{P_{H,t-1}} = \pi_{H,t}$ , hence

$$\frac{(\epsilon - 1)}{\epsilon} = mc_t - \frac{\kappa}{\epsilon} \left\{ (\pi_{H,t} - \bar{\pi}_H) \pi_{H,t} + \beta \mathbb{E}_t \left[ (\pi_{H,t+1} - \bar{\pi}_H) \pi_{H,t+1} \left( \frac{y_{t+1}}{y_t} \right) \left( \frac{\lambda_{t+1}}{\lambda_t} \right) \right] \right\}. \quad (2.14)$$

In the case where  $\kappa = 0$ , we have that prices are fully flexible and the markup is constant equal to  $\frac{\epsilon-1}{\epsilon}$ . For the case where  $\epsilon \rightarrow \infty$ , the real marginal cost will converge to one.

A first order linear approximation of equation (2.14) around its non-stochastic steady state yields the inflation equation

$$\hat{\pi}_{H,t} = \frac{\epsilon - 1}{\kappa \bar{\pi}_H} \hat{m}c_t + \beta \mathbb{E}_t \hat{\pi}_{H,t+1}, \quad (2.15)$$

which is identical to the one obtained using a pricing mechanism as suggested by Calvo (1983). Notice that domestic inflation is dependent on the price elasticity of demand,  $\epsilon$ , and the level of price adjustment cost,  $\kappa$ .

### 2.3 Government

A central role in the present model is the role of the public sector. In order to keep the model tractable and simple, the focus for government size is laid essentially on the amount of public consumption expenditures. It is abstracted from giving a special role to public employment and wages, as the public wage bill is included in the government consumption expenditures and the rigidity of the public sector is resembled by fixing the total amount of public spending.

The government finances purchases of goods and services from the private sector,  $g_t$ , through time varying distortionary income taxes  $\tau_t^D$  and a lump sum tax  $\tau_t^L$ . Total tax revenue is then defined by

$$\tau_t = \tau_t^L + \tau_t^D y_t. \quad (2.16)$$

Besides collecting tax revenues, the government also gets revenue from money creation. The government prints money  $M_t$  and pays increases in the money stock out to the government in the form of transfers,  $RCB_t$ . As an example for the direct receipts of the government from the central

bank may be mentioned the interest earnings on the portfolio the US FED makes and passes on to the Treasury. The budget identity for the central bank is given through

$$RCB_t = M_t - M_{t-1}. \quad (2.17)$$

The fiscal branch of the government has a budget constraint with revenues on the right hand side and expenditures on the left hand side, everything denoted in nominal terms:

$$P_{H,t}g_t = P_{H,t}\tau_t + RCB_t. \quad (2.18)$$

The budget constraint of the government can be combined with the one of the central bank to yield the consolidated period-by-period budget constraint<sup>12</sup>,

$$P_{H,t}g_t = P_{H,t}(\tau_t^L + \tau_t^D y_t) + M_t - M_{t-1}. \quad (2.19)$$

The amount of government purchases is fixed at a level of  $\bar{g}$ . In the baseline simulation, the government collects revenues from exhibiting a constant amount of lump-sum taxes, setting  $\hat{\tau}_t^L = 0$ , a time varying amount of distortionary income taxes and the seigniorage revenues.<sup>13</sup>

Government size is measured by two parameters, namely on the one hand by the share of government spending on total GDP, denoted by  $s_g$ . On the other hand, I will use the level of distortionary taxes,  $\tau^D$ , as a measure for the size of government, by inspecting the revenue side of the government's budget constraint. Further note that in steady state we have that lump-sum taxes (transfers) are used to balance the budget when  $s_g$  and  $\tau^D$  are varied in size to investigate their impact on macroeconomic volatility.

## 2.4 Monetary Policy

Besides studying the role of government size on macroeconomic volatility, the goal of this paper is to study the business-cycle implications of the exchange rate policy in place. At center stage is the case of a regime that resembles closely the Gold standard, which abstracting from revenues of the gold reserves can be characterized by a perfectly credible peg of the devaluation rate. The domestic economy is a follower of the foreign economy, namely the one that is either pegging the nominal exchange rate to the currency of the leader or letting the exchange rate float.

The central bank of the domestic economy is supposed to follow a Taylor-type interest rate rule with full commitment, which takes on the following form

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[ \left(\frac{\pi_t}{\bar{\pi}}\right)^{\phi_\pi} \left(\frac{y_t}{y}\right)^{\phi_y} (\Delta S_t)^{\phi_{\Delta S}} \right]^{1-\rho_R}, \quad (2.20)$$

with  $\phi_x$  being the weights in the rule controlling for inflation, output and exchange rate movements. Two extreme cases will be under investigation. First, a freely floating exchange rate regime,

<sup>12</sup>It can be pointed out that the government has no interest bearing liability (money bears no interest).

<sup>13</sup>A version of Ricardian equivalence holds as mentioned in (Gali, 1994, pp. 120), which allows for a balanced-budget requirement, and lets us set  $B_{H,t} = 0$ .

given when the weight  $\phi_{\Delta S}$  equals zero (FLEX-T). Second, a strict peg is achieved when the weight converges to infinity (FIX-T).

In addition to the monetary policy conducted with a Taylor rule, two alternative specifications of exchange rate policy will be considered. In the first case, the central bank lets the nominal exchange rate float freely, targeting the monetary base, that is, the central bank controls the growth rate of money supply  $\mu_t$  exogenously, given by an AR(1) process (FLEX-M).

In the other case, the monetary authority imposes a strictly fixed exchange rate regime, meaning that the central bank sets

$$\Delta S_t = 1, \quad (2.21)$$

where the monetary authority sets the change in the nominal exchange rate equal to unity, but also reacts to changes in the foreign interest rate by adjusting the money supply endogenously, determined by equation (2.22).

In all cases, I assume that the supply of money evolves according to

$$M_t = \mu_t M_{t-1}, \quad (2.22)$$

with  $\mu_t$  being the gross rate of growth of the money stock in the economy.

## 2.5 Foreign Economy

The foreign economy is large relative to the home country. It is therefore unnecessary to distinguish between consumer price inflation and domestic inflation in the foreign country. This implies that  $P_{F,t} = P_t^*$ . Foreign prices  $P_t^*$ , foreign output  $y_t^*$  and the foreign interest rate,  $R_t^*$ , are considered to be independent exogenous AR(1)-processes,

$$\log(x_t^*) = \rho_x \log(x_{t-1}^*) + (1 - \rho_x)\bar{x} + \epsilon_{x,t}^*, \quad \text{for } x = R, y, P. \quad (2.23)$$

As the countries are symmetric in their consumption preferences, the demand of the foreign economy for the domestic good, that is exports of the domestic economy, can be characterized by the following expression:

$$c_t^* = \gamma \left( \frac{P_{H,t}}{S_t P_t^*} \right)^{-\eta} y_t^*. \quad (2.24)$$

## 2.6 Equilibrium

In the equilibrium, all domestic households are identical and we have that domestic bonds are in zero net supply,  $B_{H,t} = 0$ .

The evolution of foreign debt is given by the aggregate budget constraint of the domestic residents and evolves according to

$$S_t B_{F,t} = R_{t-1}^* S_t B_{F,t-1} + NX_t, \quad (2.25)$$

where the net exports  $NX_t$  are equal to exports minus imports,

$$NX_t = P_{H,t} c_t^* - P_{F,t} c_{F,t}. \quad (2.26)$$

Labor market clearing requires that aggregate employment is a continuum of the labor types, such that

$$n_t = \int_0^1 n_t(j) dj. \quad (2.27)$$

Finally, goods market clearing in the domestic economy yields the aggregate resource constraint:

$$P_t c_t + P_{H,t} g_t + NX_t + \phi_B(B_{F,t}) + \frac{\kappa}{2} \left( \frac{P_{H,t}}{P_{H,t-1}} - \bar{\pi}_H \right)^2 y_t = P_{H,t} y_t. \quad (2.28)$$

A competitive general equilibrium is defined as follows<sup>14</sup>:

**Definition.** *Given the sequence of stochastic shocks*

$$\mathcal{Z}_{t=0}^\infty = \{a_t, \pi_t^*, R_t^*, y_t^*, \mu_t\}_{t=0}^\infty,$$

*an equilibrium allocation of this economy is a sequence of prices*

$$\mathcal{P}_{t=0}^\infty = \{P_t, P_{H,t}, P_{F,t}, P_t^*, S_t, R_t, W_t\}_{t=0}^\infty,$$

*and quantities*

$$\mathcal{Q}_{t=0}^\infty = \{\Lambda_t, c_t, n_t, M_t, B_{F,t}, B_{H,t}, mc_t, c_{H,t}, c_{F,t}, c_t^*, g_t, \tau_t^L, \tau_t^D\}_{t=0}^\infty$$

*such that the following conditions are satisfied:*

- i. the household's allocations solve their optimization problem.*
- ii. the prices of intermediate goods producers solve their maximization problem.*
- iii. the final goods producer's allocations solve their problem.*
- iv. the market-clearing conditions hold.*
- v. the government chooses a tax policy.*
- vi. the monetary authority chooses an exchange rate policy.*

The remaining part of the paper will discuss the set-up of the baseline economy, the calibration of the model and its steady-state results, to then turn to the qualitative implications of the presented framework.

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<sup>14</sup>The model equations are listed in appendix A.

### 3 Calibration, steady state and welfare measure

In order to solve the nonlinear stochastic general equilibrium model, a second-order log-linear approximation around the (zero-inflation) non-stochastic steady state is performed.

#### 3.1 Calibration and model parametrization

For the baseline simulation, following functional forms are assumed:

$$U(\cdot) = \frac{c_t^{1-\sigma} - 1}{1-\sigma} + \frac{\vartheta}{1-b} \left( \frac{M_t}{P_t} \right)^{1-b} - \chi \frac{n_t^{1+\nu}}{1+\nu}, \quad 0 < \nu, b \quad 0 \leq \sigma, \chi, \vartheta,$$

$$U_{c,t}(\cdot) = c_t^{-\sigma}; \quad U_{\frac{M}{P},t}(\cdot) = \vartheta \left( \frac{M_t}{P_t} \right)^{-b}; \quad U_{n,t}(\cdot) = -\chi n_t^\nu,$$

$$\phi_B(B_{F,t}) = \frac{\phi_B}{2} (B_{F,t} - \bar{B}_F)^2,$$

The paper follows the suggested parametrization of the business cycle literature, whereas the values of the deep structural parameters<sup>15</sup> are set as given in table 1. The discount factor  $\beta$  is calibrated such that the annual steady state world interest rate is 4%. The preference parameters are set as  $\sigma = \nu = b = 2$ , which are parameter values for the labor supply elasticity and the intertemporal elasticity of substitution for consumption and real money balances that are in line with the literature. The elasticity of substitution among the different varieties of goods in the domestic economy is chosen to be 6, which implies a steady state markup of 20%, a value also used in [Gali and Monacelli \(2005\)](#). The price adjustment cost parameter is usually calibrated within the range of 20 to 50, in this paper  $\kappa = 30$  for the benchmark simulation. The elasticity of substitution between domestic and foreign goods is chosen to be 1.5. A baseline value for openness, measured by  $\gamma$  is set at 0.2.

For the public sector values which are roughly representing the mean values of several OECD countries are chosen as steady state. In order to have a balanced budget, neglecting seigniorage, the income tax rate equals the share of public spending, set  $\tau^D = s_g = 0.25$ , implying that government consumes 25% of total GDP. Steady state labor is normalized to 1. When the monetary authority follows an interest rate rule, the coefficient on inflation stabilization takes on a value of 1.5, which is in accordance with the original Taylor calibration. Output is stabilized with  $\phi_y = 0.125$ .

The stochastic components of the model are calibrated to the Canadian economy, which is considered to fulfill the criteria of a small open economy. The time unit is of one quarter. For the monetary policy variant, where the central bank uses a simple money growth rule, the following process is assumed:

$$\log(\mu_t) = \rho_\mu \log(\mu_{t-1}) + \epsilon_{\mu,t}, \quad (3.1)$$

where  $\epsilon_{\mu,t}$  is a normally distributed mean zero shock. We use Canadian data for M1 from 1960Q1 to 2013Q4 and run a regression<sup>16</sup> of the form given in (3.1) to estimate the persistence and the stan-

<sup>15</sup>The parameter values are to be viewed as rather suggestive than as values to fit the model to specific empirical regularities.

<sup>16</sup>The data series is in logs and hp-filtered with  $\lambda = 1600$



Table 1: Benchmark Parameters

Parameter	Value	Description
<i>Preferences</i>		
$\beta$	$1.04^{-0.25}$	Subjective discount factor (quarterly)
$\sigma$	2.000	Risk aversion
$\nu$	2.000	Inverse Frish labor supply elasticity
$\vartheta$	$1 * 10^{-6}$	Utility weight on money balances
$b$	2.000	Intertemporal Elasticity of substitution of money balances
$\eta$	1.500	Elasticity of substitution between Domestic and Foreign Consumption
$\phi_{BF}$	0.500	Portfolio adjustment cost
$\gamma$	0.200	Share of Foreign good in the consumption basket
$\epsilon$	6.000	Elasticity of substitution between differentiated goods
$\kappa$	30.000	Price adjustment cost parameter
<i>Government size</i>		
$s_g$	0.250	Output share of public expenditures
$\tau^D$	0.250	Distortionary taxes
<i>Steady State values</i>		
$\bar{n}$	1.000	Steady state labor supply
$\bar{\pi}$	1.000	Steady state inflation
<i>Monetary Policy</i>		
$\phi_\pi$	1.500	Taylor Rule coefficient on inflation
$\phi_y$	0.1250	Taylor Rule coefficient on output
$\phi_{\Delta S}$	0 or $10^7$	Taylor Rule coefficient on exchange rate (float or peg)
<i>Forcing Processes</i>		
$\rho_a, \sigma_{\epsilon^a}$	0.6944, 0.0066	Technology shock
$\rho_{y^*}, \sigma_{\epsilon_{y^*}}$	0.8604, 0.0075	Foreign output shock
$\rho_{\pi^*}, \sigma_{\epsilon_{\pi^*}}$	0.8903, 0.0027	Foreign inflation shock
$\rho_{R^*}, \sigma_{\epsilon_{R^*}}$	0.9630, 0.0093	Foreign interest rate shock

standard deviation of the shock process. The serial correlation of the process is 0.8703 while the standard deviation  $\sigma_{\epsilon^\mu}$  equals 0.0128. For the exogenous process of productivity, an AR(1) process is fit to (log) labor productivity in Canada, as done in [Gali and Monacelli \(2005\)](#), obtaining the following estimates

$$\log(a_t) = 0.6944 \log(a_{t-1}) + \epsilon_{a,t}, \quad \sigma_{\epsilon^a} = 0.0066. \quad (3.2)$$

In order to calibrate the sources of stochastic volatility in the rest of the world, US quarterly data on output, the consumer price index CPI and the Federal Funds Rate is used. To seek for innovations in output we estimate an AR(1)-process and obtain  $\rho_{y^*} = 0.8604$  and  $\sigma_{\epsilon_{y^*}} = 0.0075$ . A fitted AR(1)-process for inflation yields

$$\log(\pi_t^*) = 0.8903 \log(\pi_{t-1}^*) + \epsilon_{\pi^*,t}, \quad \sigma_{\epsilon^\pi} = 0.0027. \quad (3.3)$$

Finally, as it is done in [Monacelli \(2004\)](#), we can rewrite the (log) world interest rate as

$$\log(R_t^*) = \log(1 + i_t^*) - \log(\pi_{t+1}^*) = \log(1 + i_t^*) - 0.8903 \log(\pi_t^*), \quad (3.4)$$

where  $i_t^*$  is the Federal Funds Rate, and estimate the stochastic process for the constructed series:

$$\log(R_t^*) = 0.9630 \log(R_{t-1}^*) + \epsilon_{R^*,t}, \quad (3.5)$$

with  $\sigma_{\epsilon_{R^*}} = 0.0093$ .

### 3.1.1 Steady State Analysis

In the steady state we have no changes in the nominal exchange rate, thus  $\Delta S = 1$ . The money supply equation pins down the steady state level of money growth,  $\mu$ . In a zero inflation steady state we have that  $\bar{\pi} = \bar{\pi}^* = 1$ , implying that real marginal costs are constant and equal to  $mc = \frac{\epsilon-1}{\epsilon}$ . From the Euler equations we know that  $R = R^* = \frac{\bar{\pi}}{\beta}$ . The supply side pins down the steady state level of output which is  $\bar{y} = \bar{n}$ . In the flexible price world, the real wage equals the marginal product of labor, which is equal to the level of productivity, normalized to unity ( $\bar{w} = \bar{a} = 1$ ). Under sticky prices, we have that the real wage equals the marginal cost times an employment subsidy  $\zeta$ . In order to achieve the flexible price allocation, we set  $\zeta$  equal to the inverse of the steady state mark-up. Prices in the domestic economy equal the real exchange rate and are normalized to one,  $P_H = rer = 1$ . The money demand equation pins down the steady state level of money holdings, the demand equations for domestic and foreign consumption as well as exports pin down the consumption levels and the aggregate resource constraint yields aggregate consumption. In the steady state, trade is balanced,  $nx = 0$ , and foreign bonds are in zero net supply,  $\bar{B}_F = 0$ . From the equation for money creation we get the level of money transfers from the central bank to the government, and from the government budget constraint we can derive the steady state level of taxes. As the share of government spending  $s_g$  and the level of distortionary taxes  $\tau^D$  are the parameters of interest, we calibrate the level of lump-sum transfers (taxes) such that the government runs a balanced budget. The following equation has to be satisfied in the long run,

$$\tau^L = \bar{g} - \tau^D \bar{y} - \bar{m} \left( \frac{\bar{\pi} - 1}{\bar{\pi}} \right).$$

For the case of zero steady state inflation, we have that lump-sum taxes (transfers) have to be equal to the size of government spending minus the level of government revenue arising from the distortionary income taxes. In order to have a well defined steady state, we finally pin down the value of  $\chi$  such that  $\bar{n}$  is equal to 1:

$$\chi = (1 - \tau^D) \bar{w} \bar{\lambda} \bar{n}^{-\nu} = (1 - \tau^D) \bar{w} (1 - s_g)^{-\sigma} \bar{n}^{-(\sigma+\nu)}.$$

Given the parametrization in table 1, we have that  $\chi$  is equal to 4/3.

In the experiments that follow we will vary the size of the public sector by imposing different sizes of  $s_g$  and  $\tau^D$ . Note that in order to maintain the deep parameters fixed, a change in the respective parameters  $s_g$  and  $\tau^d$  will cause a change in the level of steady state employment. A change in  $\bar{n}$  implies changes in  $\bar{c}$ ,  $\bar{y}$  and consequently in the other steady state values.<sup>17</sup>

<sup>17</sup>A change in  $\bar{n}$  implies changes in

$$\begin{aligned} y^* &= \bar{c} = (1 - s_g) \bar{y} = (1 - s_g) \bar{n} \\ c_F &= c^* = \gamma \bar{c} \\ \bar{\lambda} &= \bar{c}^{-\sigma} = ((1 - s_g) \bar{n})^{-\sigma} \\ \bar{m} &= \left( \frac{R-1}{R} \frac{c^{-\sigma}}{\theta} \right)^{-\frac{1}{b}} = \left( \frac{\bar{\pi} - \beta}{\bar{\pi} \theta} \right)^{-\frac{1}{b}} (1 - s_g)^{\frac{\sigma}{b}} \bar{n}^{\frac{\sigma}{b}} \end{aligned}$$

### 3.2 Welfare measure

The different monetary rules and the effect of government size are evaluated based on the welfare compensation of a permanent change in consumption relative to the steady state allocation. The paper follows the approach proposed by Lucas (1987), by calculating the unconditional expected utility of the fluctuating consumption process and equate it to the utility that is obtained in a deterministic steady-state. Although it has been shown that welfare costs of removing business cycle fluctuations are only about 0.1% of the level of consumption in each period, it is worthwhile to study the welfare implications of the different exchange rate regimes and government sizes in order to have a relative measure and being able to make a qualitative statement about the welfare ranking of regimes.

Home welfare is defined as

$$U = \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t U(c_t, m_t, n_t), \quad (3.6)$$

with  $U(c_t, m_t, n_t)$  being the instantaneous household's utility and  $\mathbb{E}_t$  the unconditional expectations operator. It refers to  $\zeta^A > 0$  as the welfare gain ( $\zeta^A < 0$  as the welfare cost) of the associated exchange rate regime  $A$ , defined as the fraction of non-stochastic steady-state consumption the household would be willing to pay in order to be indifferent between the corresponding constant sequences of consumption, money balances and hours and the equilibrium stochastic processes for these three variables with the monetary policy under consideration.<sup>18</sup> Formally, the measure is

$$U(\bar{c}, \bar{m}, \bar{n}) = \mathbb{E} \sum_{t=0}^{\infty} \beta^t U((1 - \zeta^A)c_t, m_t, n_t).$$

We approximate  $\zeta^A$  by taking a second-order Taylor expansion of the above expression with respect to  $\log x_t$  for  $x = c, m, n$  around  $\bar{x}$ . In addition, we use the fact that  $\mathbb{E}_t[\hat{x}_t] = 0$ . Then, by using the utility function specified in equation (3.1),  $\zeta^A$  is given by

$$\zeta^A = \left[ 1 + \frac{(1 - \sigma)^2}{2} \text{Var}[\hat{c}_t] + \vartheta \frac{\bar{m}^{1-b} (1 - \sigma)(1 - b)}{\bar{c}^{1-\sigma}} \text{Var}[\hat{m}_t] - \chi \frac{\bar{n}^{1+\nu} (1 - \sigma)(1 + \nu)}{\bar{c}^{1-\sigma}} \text{Var}[\hat{n}_t] \right]^{\frac{1}{1-\sigma}} - 1,$$

where a hat on a variable denotes its log-deviation from the nonstochastic steady state and  $\text{Var}[\hat{x}_t]$  is the unconditional variance of  $\hat{x}_t$ .

## 4 Macroeconomic stability, government size and the exchange rate regime

The analysis of the given hypothesis is based on the comparison of dynamic impulse responses generated by the proposed model, on the resulting theoretical second moments, conditional on the size of the public sector and the different exchange rate policies conducted, and on the welfare implications resulting thereof. This section first presents some selected simulations of the log-linearized version

<sup>18</sup>See Kollmann (2002), Schmitt-Grohé and Uribe (2007) and Evers (2006) for the same approach to related questions.

of the model, then discusses the different channels and the implications of the exchange rate regime in place and the role of government size. The benchmark simulations conducted assume that prices adjustments are costly and the government levies distortionary taxes to finance its expenditures.

#### **4.1 The transmission of shocks**

Before turning to the evaluation of the impact of government size on macroeconomic volatility, it is instructive to characterize the transmission mechanism in our model and to investigate the role of the exchange rate regime in place. I do so by analyzing the impulse response functions of selected variables to a 1% shock to each of the exogenous processes. In a first step, I start by examining the short run dynamics of selected variables in a world where the central bank conducts a Taylor rule and lets the nominal exchange rate float freely. These dynamics are presented in figure 1. Second, I will compare the dynamics of a domestic technology shock under the four exchange rate regimes considered, which is given by figure 2.

##### **Domestic technology shock**

A domestic technology shock (i.e. supply shock) *ceteris paribus* raises domestic production directly through the production function. The increase in household income leads to an increased demand for consumption and leisure. In our model, the labor-leisure *substitution effect* is dominated by the consumption-labor *wealth effect*, causing hours worked to fall. The monopolistically competitive intermediate goods producer faces lower real marginal costs and would like to adjust its prices. As the price adjustment is costly, the firms decrease their prices only slightly, consequently lowering the nominal wage.

The improvement in technology is partly accommodated by the central bank, which lowers the nominal interest rate, while increasing the quantity of money in circulation. This is due to the fact, that the central bank reacts to the fall in the domestic CPI inflation and the increase in domestic output, in response to an increase in domestic technology.

Given that the foreign interest rate is unchanged, the interest parity condition implies that the nominal exchange rate depreciates. This depreciation is supported by the central bank's increase in money supply. The fall in prices is smaller than the adjustment in the nominal exchange rate, which implies that the real exchange rate appreciates on impact. The real exchange rate appreciation leads to a decrease of exports to the foreign economy, which is captured by the decrease on impact of the net-exports.

##### **Foreign interest rate shock**

A shock to the foreign interest rate raises the cost of borrowing from the foreign economy and causes agents to reallocate their portfolio, which is costly due to the portfolio adjustment cost. The tightening of the budget constraint leads agents to reduce their consumption and to work more. As productivity remains unchanged, output reacts equally to the labor supply.

The increase in aggregate demand causes prices to increase on instant. The nominal exchange rate appreciates in response to the reaction in prices. The central bank stabilizes output and inflation by raising the domestic nominal interest rate. The real exchange rate appreciates, as the nominal exchange rate adjusts less than the domestic CPI inflation. In order to sustain the nominal appreciation, the monetary authority is forced to reduce the domestic money supply.<sup>19</sup>

### **Foreign inflation shock**

A foreign inflation shock has similar but opposite effects as the foreign interest rate shock. An increase in foreign prices causes the domestic currency to depreciate relative to the foreign currency, making imports more costly. The nominal exchange rate depreciates, which given the interest parity condition, causes domestic prices to fall. The domestic deflation together with the strongly depreciating domestic currency implies a depreciation of the real exchange rate. The impact effect on net exports is therefore negative and outweighs the positive impact effect on aggregate consumption, causing output and labor supply to fall on impact. The fall in prices and output demands a reaction of the central bank which lowers the nominal interest rate and increases domestic money supply.

### **Foreign output shock**

When foreign demand increases, then this gives raise for more exports of the domestically produced goods. The impact effect on net exports is thus positive. The shock to foreign demand causes ceteris paribus foreign prices to go up, inducing the nominal exchange rate in the domestic economy to appreciate. The domestic price level reacts only slightly positively, implying that the real interest rate appreciates on impact. The monetary authority raises the nominal interest rate in order to react to the inflation pressure. The raise in the domestic prices causes an overall decrease in consumption, output and hours worked.

## **4.2 The role of the exchange rate regime**

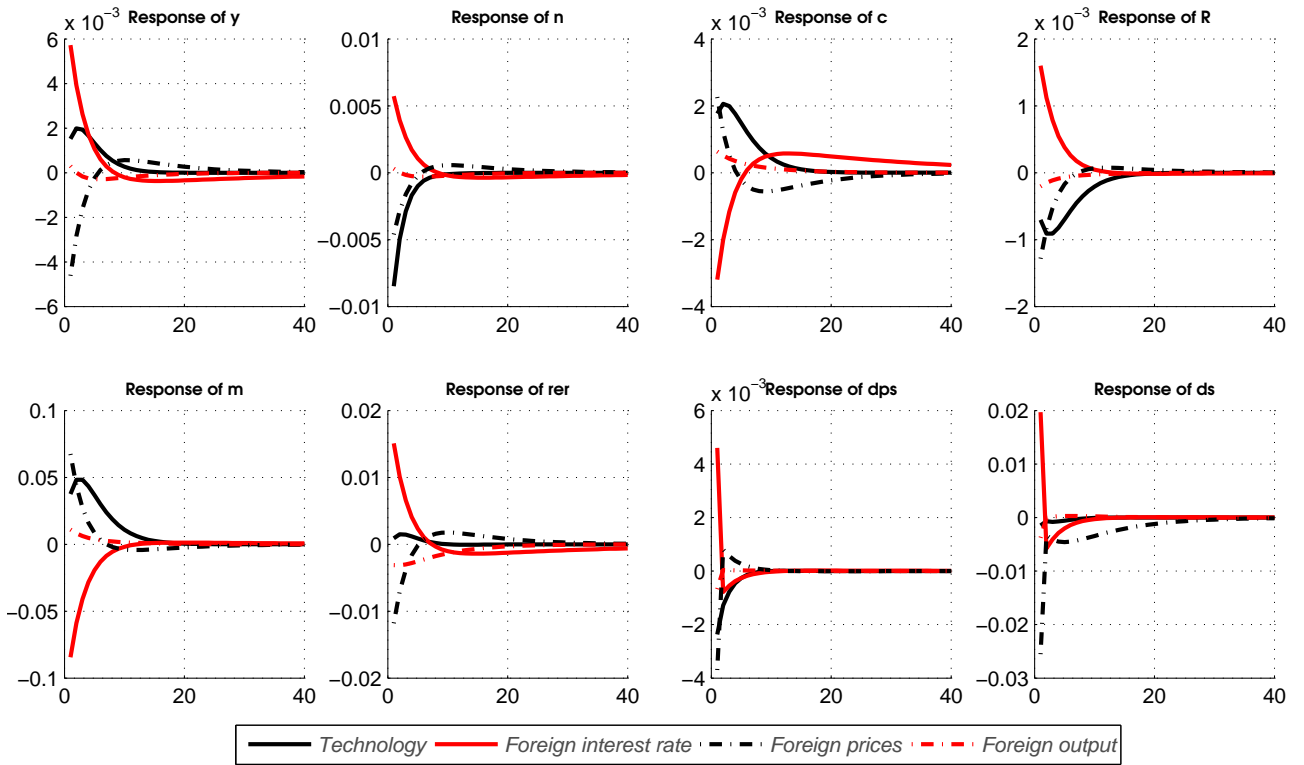
In order to compare the implications of the exchange rate regime in place, I focus for the sake of the argument on a 1% technology shock in the domestic economy and analyze the impulse responses generated by the baseline model. The results are given in figure 2 and in table 2. I will compare the two cases of flexible exchange rates, one where the central bank conducts a *Taylor rule*, and the other when the monetary authority controls the *Money supply* directly, with the case of pegging the nominal exchange rate. It should be emphasized here that a Taylor rule with infinite weight on exchange rate stabilization yields quantitatively and qualitatively the same results as when the exchange rate is strictly pegged ( $\Delta S = 1$ ). To this end, I only report the results for a Taylor rule which pegs the exchange rate completely.

Under the Taylor rule with a floating exchange rate, the impact effect on inflation and the nominal exchange rate is smaller than under the money supply rule. When the monetary authority conducts

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<sup>19</sup>To validate my results it can be pointed out that they are in line with [Kollmann \(2002\)](#).

Figure 1: Comparing the shocks – Taylor Rule float



Response to a 1% shock to  $a, y^*, R^*, \pi^*$ , Exchange rate regime is a Taylor rule with float. Units are in percentage deviations from steady state values.

Table 2: Impact elasticities to 1% technology shock

Variable	$\pi$	$\pi_H$	$\Delta S$	$m$	$R$
Taylor rule float	-0.24	-0.26	-0.15	3.76	-0.07
Taylor rule peg	-0.17	-0.21	0.00	0.36	-0.00
Money supply float	-0.27	-0.27	-0.26	0.27	-0.00
Strict Peg	-0.17	-0.21	0.00	0.36	-0.00

Impact elasticities to a 1% technology shock for CPI inflation  $\pi$ , domestic inflation  $\pi_H$ , the change in the nominal exchange rate  $\Delta S$ , real money balances  $m$  and the nominal interest rate  $R$ .

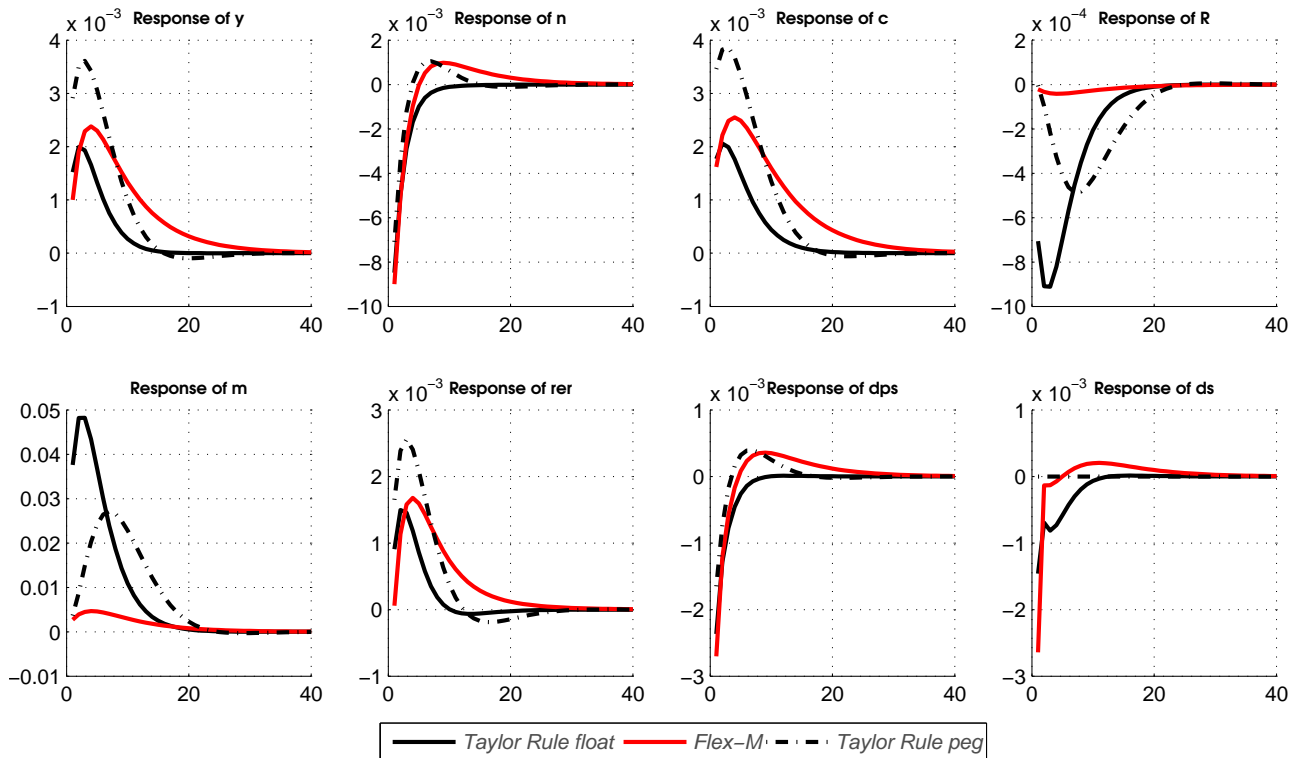
a Taylor rule, then money growth ( $\mu$ ) is endogenous and the nominal interest rate adjusts in order to close the output and the inflation gap. This is reflected in the stronger reaction of the nominal interest rate under the Taylor rule regime. Under the money supply rule and the strict exchange rate peg, the domestic nominal interest rate follows the foreign nominal interest rate to balance the interest parity condition.<sup>20</sup> In order to maintain the interest parity condition under a Taylor rule regime, the central bank will raise the money supply and the nominal exchange rate will depreciate. As can be seen in figure 2, the cumulative depreciation is larger under the Taylor rule regime than under the money supply rule. Although the nominal interest rate reacts to stabilize prices and output, the increase in money supply leads to a stronger depreciation over all.

When the nominal exchange rate is pegged, the monetary authority has to adjust money growth

<sup>20</sup>  $\hat{R}_t + \phi_B B_F \hat{b}_{F,t} = \hat{R}_t^* + \mathbb{E}_t[\Delta \hat{S}_{t+1}]$

in order to maintain the convertibility rule. From table 2 it can be deduced that the impact on money growth is higher under a peg than under the float with a money supply rule. Yet, inflation reacts less than under either of the floating exchange rate regimes. Under the Taylor rule, the impact effect of inflation is smaller than under the money supply rule because the interest rate is adjusted and this dampens the negative effect. Under the peg we observe that money balances increase more than under the money supply rule, creating thereby inflationary pressures, mitigating the negative impact effect of inflation.

Figure 2: Comparing the rules – Technology shock



Response to a 1% domestic technology shock under different exchange rate regimes. Units are in percentage deviations from steady state values.

This paper asks, if the exchange rate regime in place together with the size of the public sector affects macroeconomic stability. One natural question that arises thereof is, how the exchange rate affects households decisions and therefore real variables? Starting point to answer this question is to consider the log-linearized government budget constraint in real terms<sup>21</sup>

$$0 = \underbrace{\tau^D y(\hat{\tau}_t^D + \hat{y}_t)}_{\text{tax revenue}} + \underbrace{m(\mu_t)}_{\text{seigniorage}}, \quad (4.1)$$

Then we can observe that seigniorage affects the government budget.<sup>22</sup> The intuition for the

<sup>21</sup>The government sets deviations of lump-sum taxes to zero,  $\hat{\tau}^L = 0$ , note further that in the baseline model we are at the zero inflation steady state. I can then substitute in the government budget equation for the growth rate of money balances,  $\hat{m}_t = \hat{\mu}_t + \hat{m}_{t-1} - \hat{\pi}_t$ .

<sup>22</sup>It is important to mention here that, as it is standard in low-inflation developed countries, seigniorage adds little to total government revenues. The steady state level of  $\frac{\hat{m}}{\hat{y}}$  is equal to 0.4%, a value also observed in the data.

*exchange rate channel* is as follows: A positive technology shock lowers domestic prices, inducing a depreciation of the domestic currency. This depreciation is sustained by an increase in money supply, causing money balances to grow (i.e.  $\mu > 0$ ). The revenue from money creation is passed on to the government in terms of seigniorage revenues, entering the government's budget constraint. All else equal, a raise in seigniorage revenue will be followed by a decrease in income taxes. If we turn to the labor supply decision, given by the following equation,

$$v\hat{n}_t = -\sigma\hat{c}_t + \hat{w}_t + \frac{\tau^D}{1-\tau^D}\hat{\tau}_t^D, \quad (4.2)$$

then it follows immediately that a decrease in income taxes will *ceteris paribus* cause a fall in the amount of hours worked. The observed hump-shaped response of hours worked to a technology shock is due to the fact, that consumption strongly increases as the real exchange rate appreciates. This effect is especially pronounced in the case of fixed exchange rates under a Taylor rule. Pegging the exchange rate causes CPI inflation to react more strongly, implying that imports become cheaper and households will consume more.

To sum up, the nominal exchange rate affects real variables through seigniorage via the consolidated budget constraint of the government, causing distortionary income taxes to adjust and hence affecting the labor supply decision of the households. Importantly and consistently with the data it has to be noticed that this effect is small. The main driver in the labor market decision comes from the fact, that the exchange rate regime affects essentially the behavior of the real exchange rate and therefor consumption. A positive technology shock induces a fall in domestic prices and hence a depreciation of the nominal exchange rate. The real exchange rate appreciates, encouraging households to import and consume more. As labor demand goes down, hours worked decrease.

### 4.3 The role of government size

The finding that the nominal exchange rate affects real variables<sup>23</sup> leads directly to the second natural question arising from the hypothesis stated at the beginning: How is government size related to macroeconomic stability?

To answer this question, we first observe, that  $s_g$  and  $\tau^D$  affect the steady state level of labor in the economy. By changing either of the two parameters, we have to adjust the amount of steady state labor  $\bar{n}$ , such to hold the deep parameter  $\chi$  constant. To this end, we derive an expression for  $\bar{n}$ , given by equation (4.3):

$$\bar{n} = \left[ \frac{(1-s_g)^{-\sigma}(1-\tau^D)}{\chi} \right]^{\frac{1}{\sigma+v}}, \quad \frac{\partial \bar{n}}{\partial s_g} > 0, \quad \frac{\partial \bar{n}}{\partial \tau^D} < 0. \quad (4.3)$$

Holding all else constant, a positive change in the share of government spending in GDP raises the amount of steady state labor, while the contrary happens when the amount of distortionary taxes

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<sup>23</sup>In an economy where prices are perfectly flexible, this means that money is not super-neutral.



is increased. I will refer to this feature of the model as the *employment effect*.<sup>24</sup> In contrast to Gali (1994) and Guo and Harrison (2006), the inverse Frish labor supply elasticity for the utility function assumed in the baseline model is  $\frac{1}{\nu}$  and therefore independent of  $\bar{n}$ . This implies that my results are not driven by the fact observed in the mentioned papers, where a change in  $\tau^D$  affects the labor supply elasticity and hence changes the impulse response and volatility of employment to a given shock.

Apart from affecting the steady state amount of labor, the government share and the distortionary taxes affect the economy through the *wealth effect*. An increase in  $s_g$  means taking resources away from the households which could be used for consumption, reducing thereby private wealth. A lower steady state value for consumption implies lower steady state values for all the other real variables. An increase in  $\tau^D$  reduces directly after tax income, tightening the household's budget constraint and therefore reducing the consumption schedule. Besides changing the steady state value of labor, a change in  $\tau^D$  has no direct effect on the steady state level of any other real variable.

By inspecting equation (4.1) we can see that an increase in the level of distortionary taxes changes the elasticity of government revenues from tax collection  $\tau^D \bar{y}$  and therefore untightens the government budget constraint. The elasticity of tax revenue is affected directly through  $\tau^D$  and also indirectly through  $\bar{y}$ . An example helps to illustrate: An increase in  $\tau^D$  from its benchmark value at 0.25 to a value of 0.3 increases the elasticity by 17% (from 0.25 to 0.29), which is less than one-by-one, as the amount of labor is decreasing in the level of taxes. The income tax rate also affects the labor supply equation (4.2), as the elasticity of distortionary taxes  $\frac{\tau^D}{1-\tau^D}$  increases with  $\tau^D$ . This means that the impact effect on the amount of labor supplied after a technology shock is amplified with an increase in the level of the tax distortion.

With the transmission mechanism in mind and understanding how the exchange rate regime in place and the two measures of government size affect the baseline economy, we will now turn to the analysis of macroeconomic stability.

#### 4.4 Business cycle stability

In the following I will address the main question of the paper by inspecting the volatility of selected macroeconomic variables by varying the government size, represented by  $s_g$  and  $\tau^D$ , and by contrasting the different monetary policy regimes.

Similar to the procedure in Andrés, Doménech, and Fatas (2008), I have simulated the model under different configurations of parameters, to assess how the size of the public sector affects macroeconomic stability. In contrast to related papers studying the effect of government size on output<sup>25</sup>, I widen the perspective and lay my focus on a broader range of variables, especially because I am interested in the monetary policy dimension of macroeconomic stability. Parameters for the share

<sup>24</sup>The employment effect found in this paper can be qualitatively compared to the findings in Guo and Harrison (2006). But it is important to stress, that in contrast to their findings, identical changes in  $s_g$  and  $\tau^D$  affect  $\bar{n}$  differently, depending on the size of the intertemporal elasticity of consumption  $\sigma$ . For the case where  $\sigma = 1$ , identical changes do not affect the steady state of hours worked.

<sup>25</sup>See for example Andrés, Doménech, and Fatas (2008), Gali (1994) and Guo and Harrison (2006).

of government consumption and the tax rate are a transformation to those of the benchmark model, where the range is  $s_g, \tau^D \in [0.1, 0.6]$ . The steady state budget remains balanced even when  $s_g$  and  $\tau^D$  are not changed by equal amounts, because the residual is captured by the amount of lump-sum transfers (taxes).

Table 3: Volatilities of selected variables, all shocks

	Government shares $s_g = [0.1, 0.6]$			Tax rate $\tau^D = [0.1, 0.6]$		
	Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T
$y$	0.87	1.03	2.09	0.77	0.89	1.78
	0.66	0.72	1.43	0.90	1.04	2.18
$n$	1.05	1.15	2.05	1.00	1.07	1.78
	0.97	1.01	1.50	1.09	1.18	2.15
$rer$	1.95	2.05	1.54	2.02	2.11	1.58
	2.42	2.50	1.85	2.25	2.35	1.77
$\pi$	0.48	0.56	0.65	0.49	0.57	0.66
	0.52	0.59	0.66	0.50	0.56	0.64
$\Delta S$	2.07	2.31	–	2.12	2.35	–
	2.36	2.59	–	2.24	2.47	–

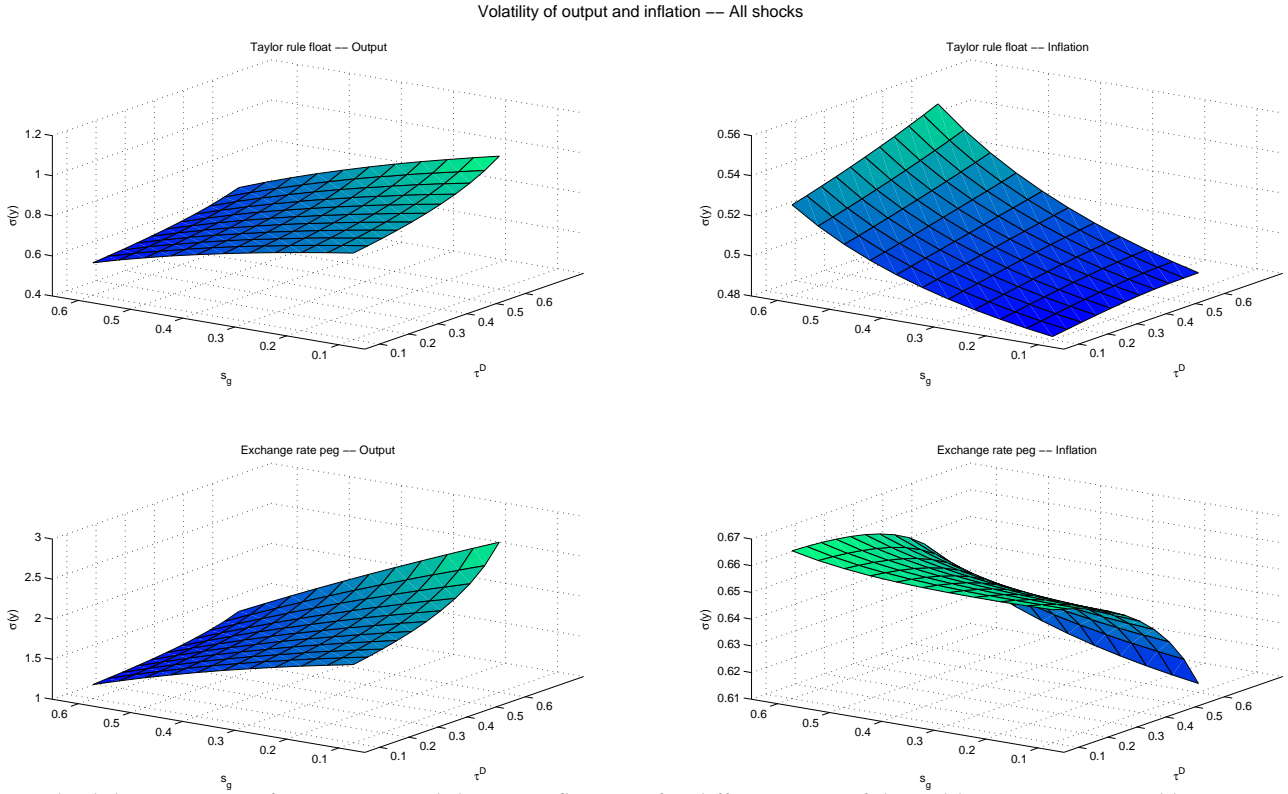
Standard deviation in % for output  $y$ , hours worked  $n$ , the real exchange rate  $rer$ , the CPI inflation  $\pi$  and the change in the nominal exchange rate  $\Delta S$ .

A summary of the results from the benchmark experiment is presented in table 3. It is worthwhile to highlight the contrary effect of the government share and the tax rate on output and labor volatility. It can be seen that first the volatility range for varying taxes is lower than for varying the government share, and second that the tax rate is more destabilizing than the government share is stabilizing. When turning to the real exchange rate, we see that it is destabilized for positive changes both in the tax rate and in the share of the public sector, yet the latter is more destabilizing. An inspection of figure 3 shows that qualitatively the picture for output is the same for the two exchange rate regimes considered. Notwithstanding, output and hours worked show a significantly higher volatility under a peg than under the floating regimes. By contrast, the volatility pattern of inflation shows significant differences to the one of output, stressing thereby the importance of the role of the monetary policy regime: For inflation, the difference in volatilities across regimes is small. The share of government spending is destabilizing under either regime, while the tax rate is destabilizing under a float, but stabilizing under a peg.

For the real exchange rate, we observe that the ranking of exchange rate regimes regarding their volatility differs from the rest of the variables. For output, employment and inflation, the exchange rate peg fares worse than a floating exchange rate regime. Moreover, a Taylor rule has better stabilization properties than a money supply rule. For the real exchange rate, we see that the money supply rule exhibits the largest volatility. The volatility under a float is higher for the real exchange rate, because its volatility is closely linked to the volatility of the nominal exchange rate. This finding is consistent with the observations in the data reported by several studies, such as Monacelli (2004) and Dedola and Leduc (2001), and relates to the Mussa-Puzzle<sup>26</sup>.

<sup>26</sup>The Mussa-Puzzle is one of six puzzles in international economics relating to the fact that the real exchange rate is significantly more volatile when the exchange rate regime is in a float than when the exchange rate regime is pegged (Mussa (1986)).

Figure 3: Comparing the volatilities of output and inflation – All shocks



Standard deviation in % for output  $y$  and the CPI inflation  $\pi$  for different sizes of the public sector, measured by government spending share  $s_g$  and income taxes  $\tau^D$ . All shocks simulated.

It is natural to ask to what extent the results displayed in figure 3 and table 3 depends upon the choice of the underlying stochastic force in the system. Therefore, I allow the model to be driven only by one selected disturbance at a time. In all cases, the qualitative implications reported above remain unchanged. The relationship between government size, the exchange rate regime and business cycle stability emerges independently of the source of shock.

Table 4: Volatilities of selected variables, each shock, varying  $s_g$

		Technology shock			Foreign R shock			Foreign $\pi$ shock			Foreign $y$ shock		
		Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T
y	$s_g = 0.1$	0.30	0.48	0.64	0.79	0.89	1.14	0.18	0.20	1.58	0.07	0.05	0.40
	$s_g = 0.6$	0.20	0.31	0.42	0.61	0.64	0.81	0.13	0.14	1.07	0.05	0.03	0.25
n	$s_g = 0.1$	0.66	0.71	0.51	0.79	0.89	1.14	0.18	0.20	1.58	0.07	0.05	0.40
	$s_g = 0.6$	0.75	0.77	0.63	0.61	0.64	0.81	0.13	0.14	1.07	0.05	0.03	0.25
rer	$s_g = 0.1$	0.17	0.25	0.35	1.80	1.90	1.18	0.39	0.41	0.74	0.61	0.61	0.56
	$s_g = 0.6$	0.21	0.29	0.42	2.29	2.36	1.46	0.48	0.49	0.91	0.60	0.60	0.54
$\pi$	$s_g = 0.1$	0.17	0.21	0.13	0.43	0.51	0.34	0.10	0.12	0.53	0.05	0.06	0.10
	$s_g = 0.6$	0.21	0.22	0.14	0.46	0.53	0.37	0.11	0.12	0.52	0.05	0.06	0.09
$\Delta S$	$s_g = 0.1$	0.19	0.18	–	1.89	2.13	–	0.78	0.80	–	0.29	0.33	–
	$s_g = 0.6$	0.19	0.19	–	2.19	2.42	–	0.82	0.84	–	0.28	0.31	–

Standard deviation in % for output  $y$ , hours worked  $n$ , the real exchange rate  $rer$ , the CPI inflation  $\pi$  and the change in the nominal exchange rate  $\Delta S$ .

The first row in tables 4 and 5 reports the standard deviation of output in percent after each of the four shocks and for the three different monetary policies. It can be seen that in all of the cases output volatility is decreasing with the size of the government share and increasing with the tax

rate. This replicates qualitatively the results found in the study by [Gali \(1994\)](#). The intuition for this first result is as follows: On the one hand, there is the negative employment effect, which says that by lowering the share of the public sector under its baseline calibration, the steady state amount of labor is reduced. On the other hand, we have a positive wealth effect. Over all, the wealth effect dominates for the given calibration and therefore government spending stabilizes output. By the reverse argument, we have that income taxes are destabilizing. Furthermore, as taxes also affect the labor supply decision we do not only observe that taxes are destabilizing output, but also that taxes are destabilizing employment under all the shocks. When focusing on the volatility of labor, we see that government spending is destabilizing under the technology shock but stabilizing under the three foreign shocks. In contrast to the foreign shocks, where the standard deviation of labor equals the one of output, the domestic technology shock implies that real wages will adjust, which affects the labor supply decision in addition to the channels already observed. The additional volatility of real wages affects the volatility of labor positively, which is not mitigated by the share of the public sector.

The share of government spending destabilizes the real exchange rate under all the shocks considered but the foreign output shock. When the shock is to foreign output the effect of government size is negligibly small on the real exchange rate and also on the rest of the variables under consideration. The volatility of the real exchange rate is linked to the volatility of inflation and the nominal exchange rate. For a domestic technology shock we observe that the size of the public sector destabilizes inflation and the nominal exchange rate, which also leads to an increasing volatility of the real exchange rate. However, for the foreign interest rate shock and the foreign inflation shock, this is not the case. Here it is important to have a look at the role of the conducted exchange rate regime.

By considering the standard deviation of output, it can be inspected that the exchange rate regime has a significant impact on its volatility. We can observe that the fixed exchange rate regime exhibits the highest volatility, whilst the lowest volatility is provided by the Taylor rule with floating exchange rates. For hours worked and the real exchange rate, the volatility ranking depends on the source of shocks. This is a finding, which stands in contrast to the observations made by [Baxter and Stockman \(1989\)](#). Using a postwar sample of 49 countries, the authors show, that apart from greater volatility of the real exchange rate under a floating exchange rate regime, there is little evidence of systematic differences in the behavior of macroeconomic aggregates under alternative exchange rate regimes.<sup>27</sup>

The choice of exchange rate regime has important consequences for the stabilization properties of inflation and the nominal exchange rate. It is evident from column 1 of table 4 that an exchange rate peg is stabilizing for inflation. Furthermore, government size destabilizes inflation under any monetary policy regime and irrespective of the source of the shock. The exchange rate peg exhibits significantly higher inflation volatility than the floating exchange rate regimes, when the economy is hit by a foreign price shock. This interesting result is linked to the volatility of the nominal exchange

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<sup>27</sup>The finding by [Baxter and Stockman \(1989\)](#) is closely linked to the aforementioned *Mussa-Puzzle*, and gave rise to a large literature investigating the role of exchange rate regimes for the behavior of the real exchange rate, see for example [Monacelli \(2004\)](#), [Dedola and Leduc \(2001\)](#) and [Chari, Kehoe, and McGrattan \(2002\)](#).

rate. Under a float, the domestic currency can appreciate (depreciate) if necessary to adjust for the terms of trade imbalances, reducing the inflation pressure. If this adjustment cannot be done, prices will have to adjust more strongly in reaction to the change in money supply to maintain the exchange rate peg.

The role of distortionary taxes for macroeconomics stability is similar but opposite to the role of government share. The tax rate destabilizes output, labor and the real exchange rate under all the exchange rate regimes and for all the shocks. It also destabilizes inflation for a technology shock. Interestingly, inflation is stabilized for the foreign shocks no matter which exchange rate regime is conducted, and inflation volatility is significantly lower under a peg than under a float.

Table 5: Volatilities of selected variables, each shock, varying  $\tau^D$

		Technology shock			Foreign R shock			Foreign $\pi$ shock			Foreign y shock		
		Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T
y	$\tau^D = 0.1$	0.26	0.41	0.54	0.70	0.77	0.97	0.16	0.17	1.35	0.06	0.04	0.34
	$\tau^D = 0.6$	0.29	0.48	0.65	0.83	0.90	1.21	0.18	0.19	1.65	0.07	0.05	0.39
n	$\tau^D = 0.1$	0.69	0.72	0.55	0.70	0.77	0.97	0.16	0.17	1.35	0.06	0.04	0.34
	$\tau^D = 0.6$	0.68	0.74	0.55	0.83	0.90	1.21	0.18	0.19	1.65	0.07	0.05	0.39
rer	$\tau^D = 0.1$	0.18	0.26	0.35	1.88	1.96	1.23	0.40	0.42	0.76	0.61	0.60	0.55
	$\tau^D = 0.6$	0.20	0.30	0.42	2.11	2.20	1.33	0.45	0.46	0.94	0.60	0.60	0.54
$\pi$	$\tau^D = 0.1$	0.19	0.21	0.13	0.44	0.51	0.35	0.10	0.12	0.53	0.05	0.06	0.10
	$\tau^D = 0.6$	0.20	0.22	0.14	0.44	0.50	0.33	0.10	0.11	0.52	0.05	0.06	0.09
$\Delta S$	$\tau^D = 0.1$	0.14	0.18	–	1.94	2.18	–	0.78	0.80	0.00	0.29	0.33	–
	$\tau^D = 0.6$	0.15	0.19	–	2.07	2.30	–	0.80	0.82	0.00	0.29	0.32	–

Standard deviation in % for output  $y$ , hours worked  $n$ , the real exchange rate  $rer$ , the CPI inflation  $\pi$  and the change in the nominal exchange rate  $\Delta S$ .

## 4.5 Welfare

Next we investigate the impact of government size and the exchange rate regime on the welfare implications. Table 6 presents the results. For the benchmark model, flexible exchange rates lead to welfare gains and the exchange rate peg leads to significant welfare losses. Under the exchange rate peg, the foreign shocks contribute the most to the welfare loss. As seen in figure reffig:IRFS2, consumption increases are highest under a peg, leading to higher consumption volatility and therefore higher welfare costs. The Taylor rule with a floating exchange rate has a higher welfare gain than the money supply rule, which is particularly notable when looking at the technology shock.

In a next step, I contrast the benchmark case to two cases of a large public sector, one where the share of public spending is raised to 0.6 and another where the level of distortionary taxes is raised to 0.6. It can be immediately seen that qualitatively the ranking of monetary policies remains the same, with the exchange rate peg exhibiting welfare costs and the floating regimes yielding small gains. An increase in income taxes leads to lower gains when the exchange rate is left to float and induces a higher welfare cost of pegging the exchange rate. For the share of public expenditures, the gains are amplified under floating exchange rates but also the costs are larger when there is a pegged regime.

Table 6: Welfare comparison, each shock

Shock	Benchmark model			$\tau^D = 0.6, s_g = 0.25$			$\tau^D = 0.25, s_g = 0.6$		
	<i>Flex-T</i>	<i>Flex-M</i>	<i>Fix-T</i>	<i>Flex-T</i>	<i>Flex-M</i>	<i>Fix-T</i>	<i>Flex-T</i>	<i>Flex-M</i>	<i>Fix-T</i>
Technology shock	0.019	0.012	0.003	0.010	-0.000	-0.012	0.036	0.027	0.016
Foreign $R$ shock	0.017	0.017	-0.111	0.012	0.015	-0.156	0.018	0.018	-0.155
Foreign $\pi$ shock	0.001	0.001	-0.147	0.001	0.001	-0.199	0.001	0.001	-0.189
Foreign $y$ shock	-0.000	-0.000	-0.007	-0.000	-0.000	-0.009	-0.000	-0.000	-0.008
All shocks	0.036	0.029	-0.262	0.023	0.015	-0.375	0.054	0.045	-0.335

Note: Each entry gives the level of Welfare for each shock in terms of the corresponding steady-state consumption equivalent in per-mill. Flex-T is a Taylor rule with floating exchange rate, Flex-M is the money supply rule and Fix-T corresponds to the exchange rate peg.

## 5 The role of nominal rigidities

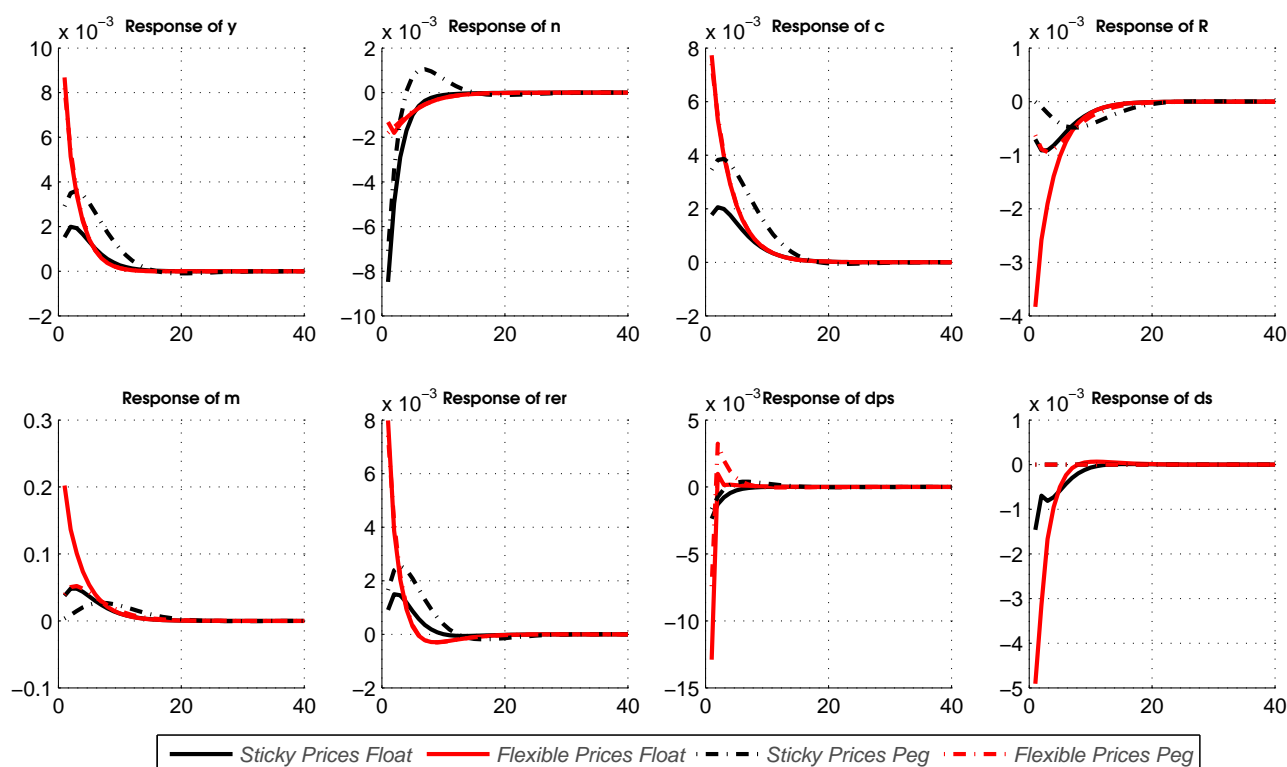
In this section I will compare the findings of the baseline simulation with a model economy where no nominal price rigidities are present. To this end, I set the parameter in the price adjustment cost function,  $\kappa$ , equal to zero. The resulting impulse response functions together with those for the sticky price variant are displayed in figure 4. Under sticky prices, the response of output exhibits a hump-shaped response and hours worked fall strongly on impact. In the absence of price rigidities, hours worked fall by less, increasing thereby the positive effect on output. Without nominal rigidities, we have that the real wage equals the marginal product of labor, and hence increases one-to-one with the technology shock, causing household wealth to increase and thus stimulating consumption. Under flexible prices, the inflation rate falls much more than under sticky prices, causing the real exchange rate to appreciate more strongly also.

A comparison of the exchange rate regimes brings to light that under flexible prices the impulse response functions do not vary much quantitatively. Although the nominal exchange rate is pegged, we observe a large real exchange rate appreciation, as inflation falls less than under a float. The response of hours worked does not feature a negative spike under an exchange rate peg, as the seigniorage falls out shorter (money balances react less).

When turning to the evaluation of volatilities, given in table 7, we observe that volatility of output and inflation are lower under sticky prices than under flexible prices. For hours worked, the contrary is true. When looking at the real exchange rate, we observe that volatility is higher under sticky prices when the exchange rate policy is conducted by a float but lower in the flexible price world where the exchange rate is pegged.

Government size stabilizes output under sticky as well as under flexible prices. In contrast to the sticky price variant, hours worked are destabilized by the share of public spending under flexible prices, although having reduced its volatility by 50% under the floating regime and by four times under an exchange rate peg. The reduction in employment volatility comes at the expense of more inflation volatility. It is further important to note that under flexible prices we observe the fact that the volatility of output and hours worked does not vary much across the exchange rate regimes in place. Yet, this is also the case for the real exchange rate, standing in contrast with the empirical literature around the Mussa-Puzzle.

Figure 4: The effect of nominal rigidities – Technology shock, Taylor rule with float and peg



Response to a 1% domestic technology shock under different exchange rate regimes and nominal rigidities. Units are in percentage deviations from steady state values.

Lastly, let us turn to the welfare properties related to the nominal rigidities. As the non-stochastic steady state is the same under both model economies, we can directly compare their implications. Note first, that under flexible prices all the monetary policies exhibit a welfare loss, whilst the loss is highest for the pegged exchange rate, it is smallest under the money supply rule. The welfare loss is decreasing in the share of government consumption and increasing in the level of the income tax rate. We observed that under sticky prices the exchange rate peg exhibits large welfare losses, these are mitigated under flexible prices.

## 6 Taxation and Seigniorage

So far I have assumed that the government fixed its amount of government spending at  $\bar{g}$  and had a time varying income tax, reacting counter cyclically to output and seigniorage. The amount of transfers (lump-sum taxes) was set such that the government budget was balanced. As comparative exercises, I will now consider two cases and compare their stabilization properties with those of the benchmark simulation. First, I will assume that the government fixes the level of distortionary taxes, setting their time variation to zero and letting instead the lump-sum tax vary. Second, I will assume that the economy is in a non-zero steady state, inspecting thereby the role of seigniorage for macroeconomic stability.

Table 7: Volatilities of selected variables, all shocks, sticky prices vs flexible prices

	Government shares $s_g = [0.1, 0.6]$						Tax rate $\tau^D = [0.1, 0.6]$					
	Sticky prices			Flexible prices			Sticky prices			Flexible prices		
	Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T
$y$	0.87 0.66	1.03 0.72	2.09 1.43	0.96 0.73	0.95 0.73	0.93 0.72	0.77 0.90	0.89 1.04	1.78 2.18	0.83 1.12	0.82 1.10	0.81 1.08
$n$	1.05 0.97	1.15 1.01	2.05 1.50	0.54 0.58	0.56 0.59	0.52 0.57	1.00 1.09	1.07 1.18	1.78 2.15	0.53 0.67	0.54 0.68	0.51 0.63
$rer$	1.95 2.42	2.05 2.50	1.54 1.85	1.84 2.34	1.85 2.34	1.80 2.31	2.02 2.25	2.11 2.35	1.58 1.77	1.90 2.23	1.91 2.24	1.88 2.17
$\pi$	0.48 0.52	0.56 0.59	0.65 0.66	1.13 1.19	1.39 1.53	1.43 1.79	0.49 0.50	0.57 0.56	0.66 0.64	1.11 1.32	1.41 1.52	1.50 1.63
$\Delta S$	2.07 2.36	2.31 2.59	– –	2.19 2.45	2.50 2.77	– –	2.12 2.24	2.35 2.47	– –	2.23 2.34	2.54 2.64	– –
<i>Welfare</i>	0.030 0.054	0.024 0.045	-0.230 -0.335	-0.037 -0.036	-0.035 -0.035	-0.039 -0.037	0.045 0.023	0.037 0.015	-0.227 -0.375	-0.034 -0.048	-0.032 -0.044	-0.035 -0.050

Standard deviation in % for output  $y$ , hours worked  $n$ , the real exchange rate  $rer$ , the CPI inflation  $\pi$  and the change in the nominal exchange rate  $\Delta S$ . Flex-T: Taylor rule, flexible exchange rate; Flex-M: Money supply rule, flexible ER; Fix-T: Taylor rule, pegged ER. Top row: small government, Bottom row: Large government; Reading example for output. The standard deviation for a calibration  $s_g = 0.1$ ,  $\tau^D = 0.25$  under sticky prices and a Taylor rule with a float is 0.87.

### The case of lump-sum taxation

By setting the income tax to its long-run value and letting the lump-sum tax vary, the government budget constraints then reads

$$0 = \tau^L \hat{\tau}_t^L + \tau^D y(\hat{y}_t) + m(\mu_t). \quad (6.1)$$

Note here that government revenue from tax collection is now a combination of the income and lump-sum tax (if  $\tau^L$  is positive, otherwise it would be a transfer, i.e. government spending). Most importantly, the tax rate no longer affects the labor supply decision of households, as we now have

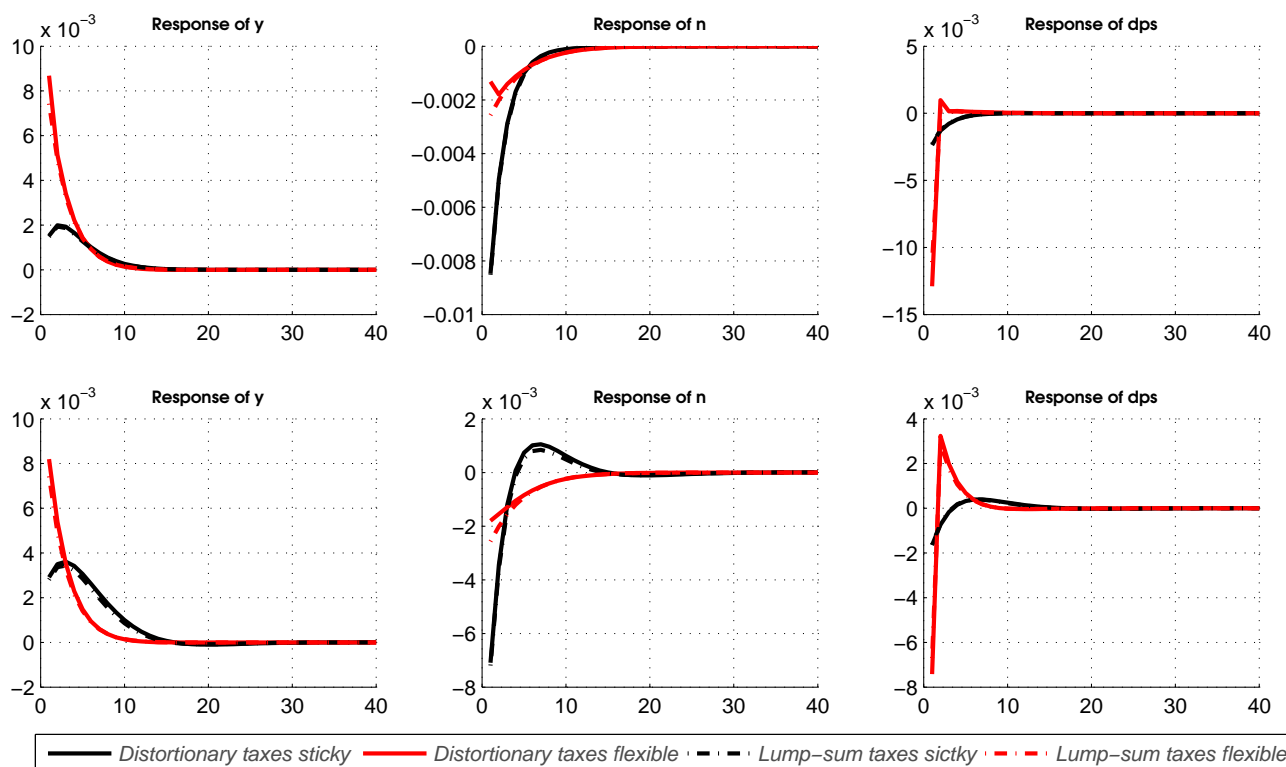
$$v \hat{n}_t = \hat{\lambda}_t + \hat{w}_t. \quad (6.2)$$

By means of example, I will analyze the role of time varying distortionary taxation first by inspecting the impulse response functions to a domestic technology shock, where monetary policy is conducted via a Taylor rule, the exchange rate is either pegged or left to float freely and prices are either flexible or sticky. As a first result, we can observe in figure 5, that the transmission mechanism of shocks is not fundamentally altered when the tax regime changes. Notably, the largest difference can be found for the case of flexible prices in the impact elasticity of labor, which is due to the fact that labor supply is not anymore affected by the distortionary tax rate and wages are set equal to the marginal product of labor (see equation (6.2)). In the top panel of figure 5 we have the case with flexible exchange rates, and in the bottom panel the pegged exchange rate regime. Differences between the two can only be found when inspecting the shape of the response of output and hours worked, which displays a more hump-shaped response under a peg than a float.

In the case of flexible prices and with lump-sum taxation, the distortionary tax no longer affects the transmission mechanism through the labor supply equation. Further, as prices can adjust instantaneously, we have that seigniorage revenues, and therefore the choice of exchange rate regime, will no



Figure 5: Comparing the tax policies – Technology shock  
 Top row: Taylor rule with float, Bottom row: Taylor rule with peg



Response to a 1% domestic technology shock under different exchange rate regimes, nominal rigidities and tax regimes. Units are in percentage deviations from steady state values. Top row: Taylor rule with floating exchange rates; Bottom row: Taylor rule with pegged exchange rate.

longer affect the households choices and hence the volatility of real variables. This finding is shown in the last column of table 8, where I contrast the two tax policies when all the shocks are present and where I compare the volatilities resulting under the various exchange rate policies. In a recent study by Andrés and Doménech (2006) on the effect of the fiscal structure upon the trade-off between inflation and output stabilization, the authors show that the supply side effects of distortionary taxes, what I call the employment effect, are crucial for the results in an economy with flexible prices. In their economy with sticky prices, distortionary income taxes yield lower output volatility than under lump-sum taxes, as the steady state level of employment is reduced by the tax distortion. It is interesting to see, how the nominal rigidities play an important role in the choice of the exchange rate regime. While under sticky prices the form of taxation does not have a significant effect on volatilities and the impact of government size is qualitatively similar under both tax regimes, in the flexible price economy we observe that distortionary taxes drive a small wedge between the different exchange rate regimes. This important finding relates to the fact, that under flexible prices the real wage is set according to its marginal product of labor and in the sticky price case we have that firms take wages as given and optimize their cost function setting domestic prices.

From table 8 it can be seen, that volatilities for output, labor and the real exchange rate are slightly higher under distortionary taxes than under the lump-sum tax policy. The finding prevails that

Table 8: Volatilities of selected variables, all shocks, distortionary vs lump-sum taxes

		Sticky prices						Flexible prices					
		Distortionary			Lump-sum			Distortionary			Lump-sum		
		Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T
y	$s_g = 0.1$	0.87	1.03	2.09	0.85	1.00	1.92	0.96	0.95	0.93	0.87	0.87	0.87
	$s_g = 0.6$	0.66	0.72	1.43	0.65	0.71	1.35	0.73	0.73	0.72	0.68	0.68	0.68
n	$s_g = 0.1$	1.05	1.15	2.05	1.04	1.13	1.90	0.54	0.56	0.52	0.53	0.53	0.53
	$s_g = 0.6$	0.97	1.01	1.50	0.97	1.00	1.44	0.58	0.59	0.57	0.59	0.59	0.59
rer	$s_g = 0.1$	1.95	2.05	1.54	1.94	2.03	1.53	1.84	1.85	1.80	1.80	1.80	1.80
	$s_g = 0.6$	2.42	2.50	1.85	2.41	2.48	1.84	2.34	2.34	2.31	2.29	2.29	2.29
$\pi$	$s_g = 0.1$	0.48	0.56	0.65	0.48	0.58	0.68	1.13	1.39	1.43	1.03	1.38	1.52
	$s_g = 0.6$	0.52	0.59	0.66	0.51	0.60	0.68	1.19	1.53	1.79	1.11	1.51	1.84
$\Delta S$	$s_g = 0.1$	2.07	2.31	-	2.07	2.32	-	2.19	2.50	-	2.19	2.51	-
	$s_g = 0.6$	2.36	2.59	-	2.36	2.60	-	2.45	2.77	-	2.45	2.78	-
Welfare	$s_g = 0.1$	0.030	0.024	-0.230	0.030	0.023	-0.193	-0.037	-0.035	-0.039	-0.034	-0.034	-0.034
	$s_g = 0.6$	0.054	0.045	-0.335	0.053	0.045	-0.300	-0.036	-0.035	-0.037	-0.033	-0.033	-0.033

Standard deviation in % for output  $y$ , hours worked  $n$ , the real exchange rate  $rer$ , the CPI inflation  $\pi$  and the change in the nominal exchange rate  $\Delta S$ . Flex-T: Taylor rule, flexible exchange rate; Flex-M: Money supply rule, flexible ER; Fix-T: Taylor rule, pegged ER.

distortionary taxes are destabilizing and the share of government purchases is stabilizing, reinforcing the results obtained in the baseline model.<sup>28</sup> Under the lump-sum tax schedule we observe that volatilities for output, labor and the real exchange rate are the same for the money supply rule and the exchange rate peg. This is the result of money neutrality, that is the seigniorage revenues do not affect the household decisions through the labor supply equation and the inflation tax.

In terms of welfare it can be pointed out that there is no difference in losses when prices are perfectly flexible and the government's tax policy is via lump-sum taxation. When instead prices are sticky, the Taylor rule with floating exchange rates has the highest welfare gain and the peg fares worst. When the exchange rate is pegged, the welfare cost is lower when lump-sum taxes are implemented. Overall, it remains to be mentioned that the highest welfare gains are achieved by implementing a Taylor rule and having distortionary income taxes.

### The role of seigniorage

So far I considered a model in which steady state inflation was zero and seigniorage revenues entered the government budget only through the contemporaneous growth rate of money balances,  $\mu_t$ . In a world where inflation is greater than zero, suppose at a central bank target of 2% (that is  $\bar{\pi} = 1.02$ ), the government revenue from seigniorage will be larger and the inflation tax will have stronger budgetary implications for the government. A positive inflation steady state has the consequence, that the government budget constraint combined with the money growth equation reads

$$\left(1 - \frac{1}{\pi}\right) m \hat{p}_{H,t} = \tau^D y (\hat{\tau}_t^D + \hat{y}_t) + \underbrace{m \left( \frac{\bar{\pi} - 1}{\bar{\pi}} \hat{m}_t - \frac{1}{\bar{\pi}} \hat{p}_t \right)}_{\text{Seigniorage revenues}}.$$

It is straightforward to see that the monetary policy regime in place now affects seigniorage revenues such through the growth rate in money balances as well as through the stock of money bal-

<sup>28</sup>See in the appendix for a table with different values for  $\tau^D$ , the results are qualitatively similar.

ances, therefore amplifying seigniorage revenues. For the government budget to be balanced, the tax rate will react less counter-cyclically when the government raises more revenue from seigniorage. A comparison of the baseline model specification with the model where steady state inflation is calibrated at 2% shows that there is no significant difference in impulse responses to a 1% shock to technology in the domestic economy (see figure 7 in the appendix).

By inspecting the role of the level of steady state inflation on the volatility of the selected variables I observe that the impact on real variables is negligibly small, a result given in table 9. More importantly, inflation is slightly less volatile under positive steady state inflation when the exchange rate is left to float freely, but more volatile under an exchange rate peg. The result that government spending is stabilizing for output, hours worked and the real exchange rate whereas distortionary income taxes are destabilizing remains stable under this specification (see table 9 for varying the income tax). Under flexible prices, inflation is more volatile than under sticky prices and a positive inflation steady-state amplifies its volatility even further. The welfare rankings remain the same as above and the impact of seigniorage is negligibly small.

Table 9: Volatilities of selected variables, all shocks, zero inflation vs 2% inflation

		Sticky Prices						Flexible Prices					
		Zero Inflation			2% inflation			Zero Inflation			2% inflation		
		Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T
$y$	$s_g = 0.1$	0.87	1.03	2.09	0.88	1.02	2.12	0.96	0.95	0.93	0.95	0.95	0.94
	$s_g = 0.1$	0.66	0.72	1.43	0.66	0.71	1.45	0.73	0.73	0.72	0.73	0.73	0.72
$n$	$s_g = 0.1$	1.05	1.15	2.05	1.06	1.12	2.09	0.54	0.56	0.52	0.56	0.56	0.55
	$s_g = 0.1$	0.97	1.01	1.50	0.98	0.99	1.53	0.58	0.59	0.57	0.59	0.59	0.59
$rer$	$s_g = 0.1$	1.95	2.05	1.54	1.96	2.03	1.56	1.84	1.85	1.80	1.84	1.85	1.84
	$s_g = 0.1$	2.42	2.50	1.85	2.43	2.48	1.87	2.34	2.34	2.31	2.34	2.34	2.33
$\pi$	$s_g = 0.1$	0.48	0.56	0.65	0.47	0.54	0.66	1.13	1.39	1.43	1.06	1.32	1.53
	$s_g = 0.1$	0.52	0.59	0.66	0.51	0.57	0.66	1.19	1.53	1.79	1.14	1.45	1.87
$\Delta S$	$s_g = 0.1$	2.07	2.31	-	2.07	2.27	-	2.19	2.50	-	2.18	2.45	-
	$s_g = 0.1$	2.36	2.59	-	2.36	2.56	-	2.45	2.77	-	2.44	2.71	-
Welfare	$s_g = 0.1$	0.030	0.024	-0.230	0.033	0.025	-0.232	-0.037	-0.035	-0.039	-0.032	-0.032	-0.032
	$s_g = 0.6$	0.054	0.045	-0.335	0.057	0.046	-0.346	-0.036	-0.035	-0.037	-0.031	-0.031	-0.031

Standard deviation in % for output  $y$ , hours worked  $n$ , the real exchange rate  $rer$ , the CPI inflation  $\pi$  and the change in the nominal exchange rate  $\Delta S$ . Flex-T: Taylor rule, flexible exchange rate; Flex-M: Money supply rule, flexible ER; Fix-T: Taylor rule, pegged ER.

Summarizing, the main channel through which the choice of exchange rate regime affects real variables is through the nominal rigidities in the model. The impact of seigniorage revenues entering the consolidated government budget constraint is minor and does not have a significant effect on the welfare properties of the model. Income taxes are necessary in the flexible price world to distort the labor supply decision and thereby causing that the exchange rate regime matters, although only by little. With nominal rigidities in place, we observe that qualitatively it does not make a difference whether the government levies distortionary or lump-sum taxes. Under sticky prices, the Taylor rule with floating exchange rates has the best welfare properties and the exchange rate peg fares worst. This result is robust for the model with lump-sum taxation and also under the assumption of a positive inflation steady-state. Under flexible prices, all the monetary policy rules exhibit welfare losses, while the exchange rate peg fares worst and the money supply rule fare best.

## 7 Conclusion

At the beginning of the paper the question is asked: *Was Anna Schwartz right?* Is it the case that the combination of a large public sector with a fixed exchange rate regime yields higher macroeconomic volatility than when the exchange rate is left to float freely, the public sector is small, or both? My analysis starts by investigating from a theoretical point of view, how the exchange rate regime in place and the government size, measured on the revenue and expenditure side, affect macroeconomic conditions. Understanding how the fiscal and monetary policies interact with the business cycle in my model is crucial to derive conclusions with respect to the question at hand.

In the analysis, it is found that the nominal price rigidities are essential for the exchange rate regime to affect households decisions. Since under monopolistic competition the intermediate goods producing firm takes wages as given and sets domestic prices, the labor supply equation changes with respect to the flexible price variant, thereby affecting hours worked, consumption and output. As the exchange rate regime affects the dynamics of prices, it therefore has important implications for the macroeconomic stability and welfare properties of the economy. The paper shows that monetary policy conducted by a Taylor rule and letting the exchange rate float fares best in terms of welfare, and that an exchange rate peg exhibits the largest welfare losses. A robust outcome of the paper is that the share of government spending is stabilizing output and destabilizing inflation, irrespective of the exchange rate regime. The tax rate destabilizes output under either float or peg, but stabilizes inflation under an exchange rate peg.

The model is tested for different tax policies and also for the importance of seigniorage revenues. It is showed that the above results are robust, as such the model with lump-sum taxation as well as under the assumption of a positive inflation steady-state exhibits the same stabilization properties of the government size. Under flexible prices, all the monetary policy rules exhibit welfare losses, while the exchange rate peg fares worst and the money supply rule fare best.

The statement by Anna Schwartz lead to the hypothesis, that exchange rate regimes are less long lasting when the government is large, as the private sector is more exposed to the adjustment of shocks. Given the results of the presented model it can be concluded, that a strict exchange rate peg combined with a large public sector, as it is observed in several countries of the European Union, is harmful for price and output stability. In this point, Anna Schwartz *is* right. A caveat of the results is that depending on the size of government revenues and expenditures, it can have mixed implications for output and inflation volatility. Increasing the amount of expenditures is destabilizing, while an increase in revenues can stabilize inflation, depending on the exchange rate policy. These results have to be taken with caution, as the present model does not include real rigidities like capital adjustment costs, besides the characterization of the public sector and the labor market are rudimentary and left to be further developed.

## A Model outline

### A.1 General equilibrium (Nominal)

Marginal utility of c	$U_{c,t}(\cdot) = \Lambda_t P_t$
Marginal utility of m/p	$U_{\frac{M}{P},t}(\cdot) = \Lambda_t - \beta \mathbb{E}_t [\Lambda_{t+1}]$
Marginal utility of n	$-U_{n,t}(\cdot) = \Lambda_t (1 - \tau_t^D) W_t$
Domestic bond holdings	$\Lambda_t = \beta R_t \mathbb{E}_t [\Lambda_{t+1}]$
Foreign bond holdings	$\Lambda_t S_t (1 + \phi'_B(B_{F,t})) = \beta R_t^* \mathbb{E}_t [\Lambda_{t+1} S_{t+1}]$
CPI	$P_t = \left[ (1 - \gamma) P_{H,t}^{1-\eta} + \gamma P_{F,t}^{1-\eta} \right]^{\frac{1}{1-\eta}}$
Domestic good	$c_{H,t} = (1 - \gamma) \left( \frac{P_{H,t}}{P_t} \right)^{-\eta} c_t$
Imports	$c_{F,t} = \gamma \left( \frac{P_{F,t}}{P_t} \right)^{-\eta} c_t$
Aggregate resources	$P_{H,t} y_t = P_t c_t + P_{H,t} g_t + NX_t + \phi_B(B_{F,t}) + \frac{\kappa}{2} \left( \frac{P_{H,t}}{P_{H,t-1}} - \bar{\pi}_H \right)^2 y_t$
Domestic prices	$\frac{(\epsilon - 1)}{\epsilon} = mc_t - \frac{\kappa}{\epsilon} \left\{ \left( \frac{P_{H,t}}{P_{H,t-1}} - \bar{\pi}_H \right) \pi_{H,t} + \beta \mathbb{E}_t \left[ \left( \frac{P_{H,t+1}}{P_{H,t}} - \bar{\pi}_H \right) \pi_{H,t+1} \left( \frac{y_{t+1}}{y_t} \right) \left( \frac{\Lambda_{t+1}}{\Lambda_t} \right) \right] \right\}$
Domestic production	$y_t = a_t n_t$
Labor demand	$mc_t = \xi \frac{W_t}{P_{H,t}} \frac{n_t}{y_t}$
Government budget	$P_{H,t} g_t = P_{H,t} (\tau_t^L + \tau_t^D y_t) + M_t - M_{t-1}$
Exports	$c_t^* = \gamma \left( \frac{P_{H,t}}{S_t P_t^*} \right)^{-\eta} y_t^*$
Money supply	$M_t = \mu_t M_{t-1}$
<b>either</b> Fixed Regime	$S_t = \bar{S}$
<b>or</b> Flexible/Crawl Regime	$\frac{R_t}{R} = \left( \frac{R_{t-1}}{R} \right)^{\rho_R} \left[ \left( \frac{\pi_t}{\bar{\pi}} \right)^{\phi_\pi} \left( \frac{y_t}{y} \right)^{\phi_y} (\Delta S_t)^{\phi_{\Delta S}} \right]^{1-\rho_R},$
Net foreign assets	$S_t B_{F,t} = R_{t-1}^* S_t B_{F,t-1} + NX_t$
Net exports	$NX_t = P_{H,t} c_t^* - P_{F,t} c_{F,t}$
Law of one Price	$P_{F,t} = S_t P_t^*$
	$\log(z_t) = \rho_z \log(z_{t-1}) + (1 - \rho_z) \bar{z} + \epsilon_{z,t}$
	for $z = y^*, R^*, a, p^*, \mu$

Define the following for deflating the model:

$$\lambda_t = \Lambda_t P_t; \quad p_{H,t} = \frac{P_{H,t}}{P_t}; \quad P_{F,t} = P_t^*; \quad rer_t = \frac{S_t P_t^*}{P_t};$$

$$\Delta S_t = \frac{S_t}{S_{t-1}}; \quad \pi_t = \frac{P_t}{P_{t-1}}; \quad \pi_{H,t} = \frac{P_{H,t}}{P_{H,t-1}}; \quad w_t = \frac{W_t}{P_t}; \quad m_t = \frac{M_t}{P_t}.$$

## A.2 General equilibrium (Deflated)

Marginal utility of c	$U_{c,t}(\cdot) = \lambda_t$
Marginal utility of m/p	$U_{\frac{M}{P},t}(\cdot) = \lambda_t - \beta \mathbb{E}_t \left[ \frac{\lambda_{t+1}}{\pi_{t+1}} \right]$
Marginal utility of n	$-U_{n,t}(\cdot) = \lambda_t(1 - \tau_t^D)w_t$
Domestic bond holdings	$\lambda_t = \beta R_t \mathbb{E}_t \left[ \frac{\lambda_{t+1}}{\pi_{t+1}} \right]$
Foreign bond holdings	$\lambda_t(1 + \phi'_B(B_{F,t})) = \beta R_t^* \mathbb{E}_t \left[ \frac{\lambda_{t+1} \Delta S_{t+1}}{\pi_{t+1}} \right]$
CPI	$1 = (1 - \gamma)p_{H,t}^{1-\eta} + \gamma rer_t^{1-\eta}$
Domestic good	$c_{H,t} = (1 - \gamma)p_{H,t}^{-\eta} c_t$
Imports	$c_{F,t} = \gamma rer_t^{-\eta} c_t$
Aggregate resources	$p_{H,t} y_t = c_t + p_{H,t} g_t + n x_t + \frac{\phi_B}{2} (b_{F,t} - \bar{b}_F)^2 + \frac{\kappa}{2} (\pi_{H,t} - \bar{\pi}_H)^2 y_t$
Domestic prices	$\frac{(\epsilon - 1)}{\epsilon} = m c_t - \frac{\kappa}{\epsilon} \left\{ (\pi_{H,t} - \bar{\pi}_H) \pi_{H,t} + \beta \mathbb{E}_t \left[ (\pi_{H,t+1} - \bar{\pi}_H) \pi_{H,t+1} \left( \frac{y_{t+1}}{y_t} \right) \left( \frac{\lambda_{t+1}}{\lambda_t} \right) \right] \right\}$
Domestic production	$y_t = a_t n_t$
Labor demand	$m c_t = \zeta \frac{w_t}{p_{H,t}} \frac{n_t}{y_t}$
Government budget	$p_{H,t} g_t = p_{H,t} (\tau_t^L + \tau_t^D y_t) + m_t - \frac{m_{t-1}}{\pi_t}$
Exports	$c_t^* = \gamma \left( \frac{p_{H,t}}{rer_t} \right)^{-\eta} y_t^*$
Money supply	$m_t = \mu_t \frac{m_{t-1}}{\pi_t}$
<b>either</b> Fixed Regime	$\Delta S_t = 1$
<b>or</b> Flexible/Crawl Regime	$\frac{R_t}{R} = \left( \frac{R_{t-1}}{R} \right)^{\rho_R} \left[ \left( \frac{\pi_t}{\bar{\pi}} \right)^{\phi_\pi} \left( \frac{y_t}{y} \right)^{\phi_y} (\Delta S_t)^{\phi_{\Delta S}} \right]^{1-\rho_R},$
Net foreign assets	$b_{F,t} = R_{t-1}^* \frac{\Delta S_t b_{F,t-1}}{\pi_t} + n x_t$
Net exports	$n x_t = p_{H,t} c_t^* - rer_t c_{F,t}$
Real Exchange Rate	$rer_t = \frac{\Delta S_t \pi_t^*}{\pi_t} rer_{t-1}$
Domestic Price Inflation	$p_{H,t} = \frac{\pi_{H,t}}{\pi_t} p_{H,t-1}$
	$\log(z_t) = \rho_z \log(z_{t-1}) + (1 - \rho_z) \bar{z} + \epsilon_{z,t}$
	for $z = y^*, R^*, \pi^*, a, \mu$

### A.3 Linearized Equilibrium Conditions

$$-\sigma \hat{c}_t = \hat{\lambda}_t \quad (\text{A.1})$$

$$-b \hat{m}_t = \frac{\pi}{\pi - \beta} \hat{\lambda}_t - \frac{\beta}{\pi - \beta} \mathbb{E}_t [\hat{\lambda}_{t+1} - \hat{\pi}_{t+1}] \quad (\text{A.2})$$

$$v \hat{n}_t = \hat{\lambda}_t + \hat{w}_t + \frac{\tau^D}{1 - \tau^D} \hat{\tau}_t^D \quad (\text{A.3})$$

$$\hat{\lambda}_t = \hat{R}_t + \mathbb{E}_t [\hat{\lambda}_{t+1} - \hat{\pi}_{t+1}] \quad (\text{A.4})$$

$$\hat{\lambda}_t + \phi_B B_F \hat{b}_{F,t} = \hat{R}_t^* + \mathbb{E}_t [\hat{\lambda}_{t+1} + \Delta \hat{S}_{t+1} - \hat{\pi}_{t+1}] \quad (\text{A.5})$$

$$0 = (1 - \eta) \hat{p}_{H,t} + (1 - \eta) r \hat{e}r_t \quad (\text{A.6})$$

$$\hat{c}_{H,t} = -\eta \hat{p}_{H,t} + \hat{c}_t \quad (\text{A.7})$$

$$\hat{c}_{F,t} = -\eta r \hat{e}r_t + \hat{c}_t \quad (\text{A.8})$$

$$\hat{y}_t = \frac{c}{y} \hat{c}_t + \left( \frac{g}{y} - 1 \right) \hat{p}_{H,t} + \frac{nx}{y} \hat{n}x_t \quad (\text{A.9})$$

$$\hat{y}_t = \hat{a}_t + \hat{n}_t \quad (\text{A.10})$$

$$\hat{\pi}_{H,t} = \frac{\epsilon - 1}{\kappa \bar{\pi}_H} \hat{m}c_t + \beta \mathbb{E}_t \hat{\pi}_{H,t+1} \quad (\text{A.11})$$

$$\hat{m}c_t = \hat{w}_t - \hat{p}_{H,t} + \hat{n}_t - \hat{y}_t \quad (\text{A.12})$$

$$\left( 1 - \frac{1}{\bar{\pi}} \right) m \hat{p}_{H,t} = \tau^L \hat{\tau}_t^L + \tau^D y (\hat{\tau}_t^D + \hat{y}_t) + m \left( \hat{m}_t - \frac{1}{\bar{\pi}} (\hat{m}_{t-1} - \hat{\pi}_t) \right) \quad (\text{A.13})$$

$$\hat{a}_t = \hat{w}_t \quad (\text{A.14})$$

$$\hat{c}_t^* = -\eta (\hat{p}_{H,t} - r \hat{e}r_t) + \hat{y}_t^* \quad (\text{A.15})$$

$$\hat{m}_t = \hat{\mu}_t + \hat{m}_{t-1} - \hat{\pi}_t \quad (\text{A.16})$$

$$B_F \hat{b}_{F,t} = \frac{R^*}{\pi} B_F (\hat{R}_t^* + \Delta \hat{S}_t + \hat{b}_{F,t-1} - \hat{\pi}_t) + \gamma c_y y (\hat{p}_{H,t} + \hat{c}_t^* - (r \hat{e}r_t + \hat{c}_{F,t})) \quad (\text{A.17})$$

$$r \hat{e}r_t = \Delta \hat{S}_t + \hat{\pi}_t^* - \hat{\pi}_t + r \hat{e}r_{t-1} \quad (\text{A.18})$$

$$\hat{p}_{H,t} = \hat{\pi}_{H,t} - \hat{\pi}_t + \hat{p}_{H,t-1} \quad (\text{A.19})$$

Tax policies:

$$\hat{\tau}^L = 0 \quad (\text{A.20})$$

$$\hat{\tau}^D = 0 \quad (\text{A.21})$$

Monetary policies:

$$\Delta \hat{S}_t = 0 \quad (\text{A.22})$$

$$\hat{R}_t = \rho_R \hat{R}_{t-1} + (1 - \rho_R) (\phi_\pi \hat{\pi}_t + \phi_y \hat{y}_t + \phi_{\Delta S} \Delta \hat{S}_t) + \hat{v}_t \quad (\text{A.23})$$

$$\hat{\mu}_t = \rho_\mu \hat{\mu}_{t-1} + (1 - \rho_\mu) \bar{\mu} + \epsilon_\mu \quad (\text{A.24})$$

Shocks:

$$\hat{z}_t = \rho_z \hat{z}_{t-1} + \epsilon_{z,t} \quad (\text{A.25})$$

$$\text{for } z = y^*, R^*, \pi^*, a, \mu \quad (\text{A.26})$$

Table 10: Volatilities of selected variables, all shocks, distortionary vs lump-sum taxes

		Sticky prices						Flexible prices					
		Distortionary			Lump-sum			Distortionary			Lump-sum		
		Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T
y	$\tau^D = 0.1$	0.77	0.89	1.78	0.77	0.88	1.72	0.83	0.82	0.81	0.80	0.80	0.80
	$\tau^D = 0.6$	0.90	1.04	2.18	0.83	0.95	1.76	1.12	1.10	1.08	0.83	0.83	0.83
n	$\tau^D = 0.1$	1.00	1.07	1.78	1.00	1.07	1.73	0.53	0.54	0.51	0.54	0.54	0.54
	$\tau^D = 0.6$	1.09	1.18	2.15	1.05	1.12	1.77	0.67	0.68	0.63	0.58	0.58	0.58
rer	$\tau^D = 0.1$	2.02	2.11	1.58	2.02	2.10	1.59	1.90	1.91	1.88	1.89	1.89	1.89
	$\tau^D = 0.6$	2.25	2.35	1.77	2.21	2.30	1.70	2.23	2.24	2.17	2.06	2.06	2.06
$\pi$	$\tau^D = 0.1$	0.49	0.57	0.66	0.48	0.58	0.67	1.11	1.41	1.50	1.05	1.40	1.59
	$\tau^D = 0.6$	0.50	0.56	0.64	0.51	0.61	0.69	1.32	1.52	1.63	1.08	1.46	1.68
$\Delta S$	$\tau^D = 0.1$	2.12	2.35	-	2.12	2.35	-	2.23	2.54	-	2.23	2.55	-
	$\tau^D = 0.6$	2.24	2.47	-	2.25	2.52	-	2.34	2.64	-	2.36	2.71	-
Welfare	$\tau^D = 0.1$	0.045	0.037	-0.227	0.045	0.037	-0.210	-0.034	-0.032	-0.035	-0.031	-0.031	-0.031
	$\tau^D = 0.6$	0.023	0.015	-0.375	0.019	0.011	-0.254	-0.048	-0.044	-0.050	-0.042	-0.042	-0.042

Standard deviation in % for output  $y$ , hours worked  $n$ , the real exchange rate  $rer$ , the CPI inflation  $\pi$  and the change in the nominal exchange rate  $\Delta S$ . Flex-T: Taylor rule, flexible exchange rate; Flex-M: Money supply rule, flexible ER; Fix-T: Taylor rule, pegged ER.

Table 11: Volatilities of selected variables, all shocks, zero inflation vs 2% inflation

		Sticky Prices						Flexible Prices					
		Zero Inflation			2% inflation			Zero Inflation			2% inflation		
		Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T	Flex-T	Flex-M	Fix-T
y	$\tau^D = 0.1$	0.77	0.89	1.78	0.77	0.88	1.81	0.83	0.82	0.81	0.82	0.82	0.82
	$\tau^D = 0.1$	0.90	1.04	2.18	0.91	1.03	2.20	1.12	1.10	1.08	1.10	1.10	1.09
n	$\tau^D = 0.1$	1.00	1.07	1.78	1.01	1.04	1.81	0.53	0.54	0.51	0.54	0.54	0.53
	$\tau^D = 0.1$	1.09	1.18	2.15	1.10	1.15	2.18	0.67	0.68	0.63	0.68	0.68	0.66
rer	$\tau^D = 0.1$	2.02	2.11	1.58	2.03	2.10	1.60	1.90	1.91	1.88	1.91	1.91	1.90
	$\tau^D = 0.1$	2.25	2.35	1.77	2.26	2.34	1.80	2.23	2.24	2.17	2.23	2.24	2.22
$\pi$	$\tau^D = 0.1$	0.49	0.57	0.66	0.48	0.55	0.66	1.11	1.41	1.50	1.06	1.33	1.58
	$\tau^D = 0.1$	0.50	0.56	0.64	0.48	0.54	0.64	1.32	1.52	1.63	1.17	1.44	1.79
$\Delta S$	$\tau^D = 0.1$	2.12	2.35	-	2.12	2.32	-	2.23	2.54	-	2.23	2.49	-
	$\tau^D = 0.1$	2.24	2.47	-	2.24	2.44	-	2.34	2.64	-	2.33	2.59	-
Welfare	$\tau^D = 0.1$	0.045	0.037	-0.227	0.047	0.039	-0.232	-0.034	-0.032	-0.035	-0.029	-0.029	-0.029
	$\tau^D = 0.1$	0.023	0.015	-0.375	0.025	0.016	-0.377	-0.048	-0.044	-0.050	-0.041	-0.040	-0.041

Standard deviation in % for output  $y$ , hours worked  $n$ , the real exchange rate  $rer$ , the CPI inflation  $\pi$  and the change in the nominal exchange rate  $\Delta S$ . Flex-T: Taylor rule, flexible exchange rate; Flex-M: Money supply rule, flexible ER; Fix-T: Taylor rule, pegged ER.



Figure 6: Volatility of output – All shocks

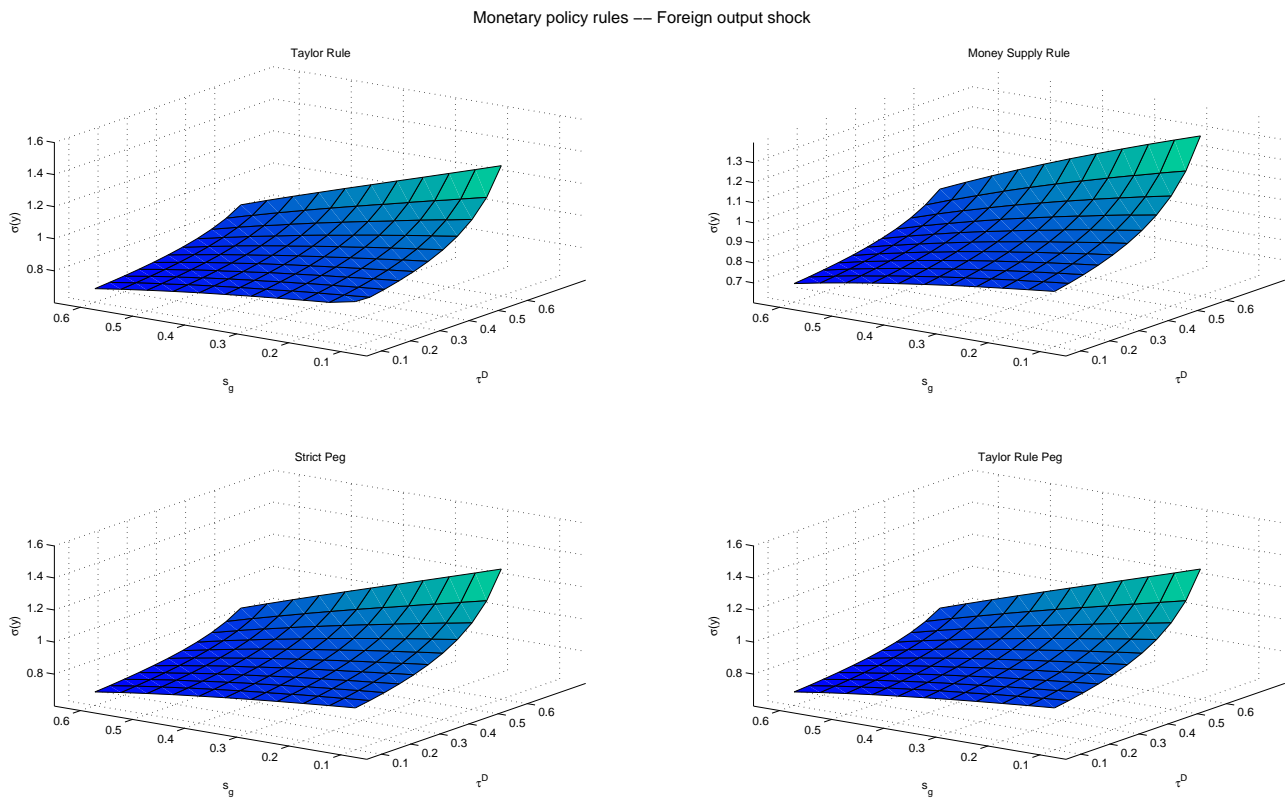
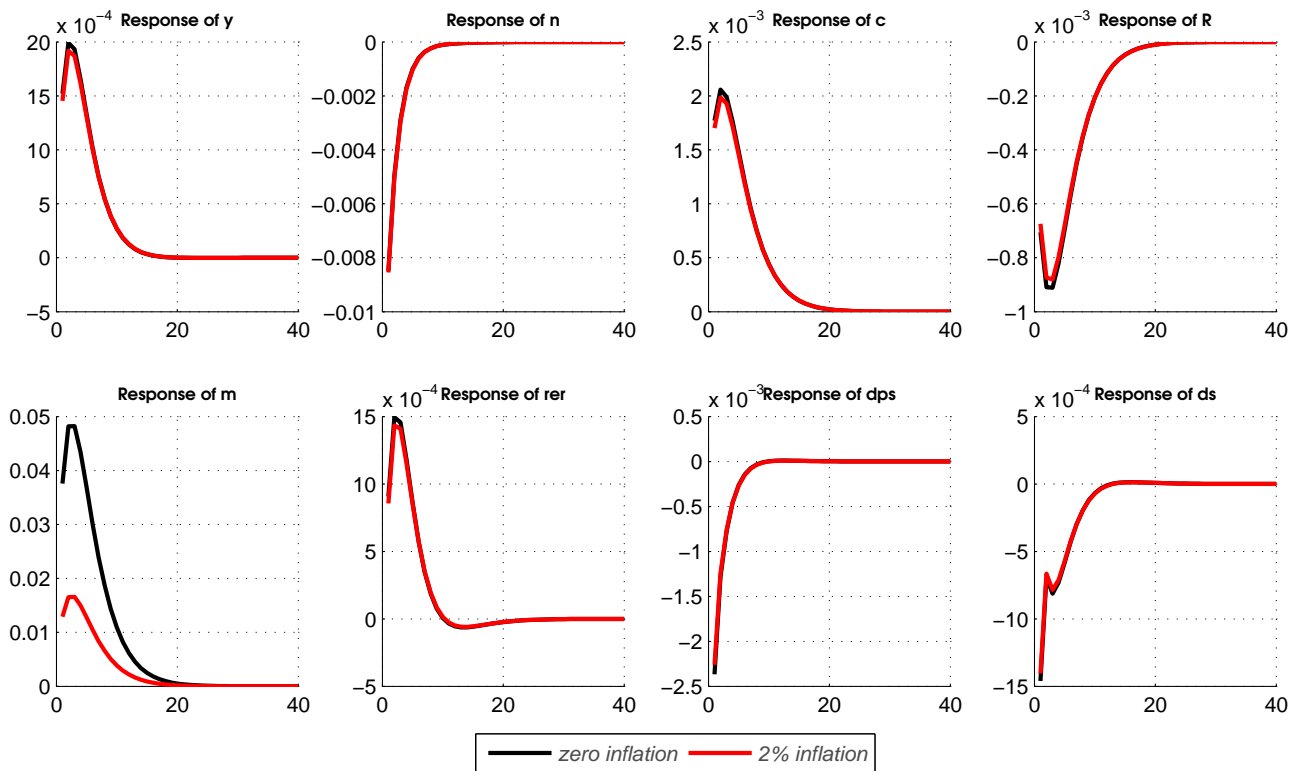


Figure 7: Effect of seigniorage revenues – Technology shock, Taylor rule with float



## References

- ANDRÉS, J., AND R. DOMÉNECH (2006): "Automatic stabilizers, fiscal rules and macroeconomic stability," *European Economic Review*, 50(6), 1487–1506.
- ANDRÉS, J., R. DOMÉNECH, AND A. FATAS (2008): "The stabilizing role of government size," *Journal of Economic Dynamics and Control*, 32(2), 571–593.
- BACKUS, D. K., P. J. KEHOE, AND F. E. KYDLAND (1992): "International real business cycles," *Journal of political Economy*, pp. 745–775.
- BAXTER, M., AND A. C. STOCKMAN (1989): "Business cycles and the exchange-rate regime: some international evidence," *Journal of monetary Economics*, 23(3), 377–400.
- CALVO, G. A. (1983): "Staggered prices in a utility-maximizing framework," *Journal of monetary Economics*, 12(3), 383–398.
- CHARI, V. V., P. J. KEHOE, AND E. R. MCGRATTAN (2002): "Can sticky price models generate volatile and persistent real exchange rates?," *The Review of Economic Studies*, 69(3), 533–563.
- CLARIDA, R., J. GALI, AND M. GERTLER (2001): "Optimal Monetary Policy in Open versus Closed Economies: An Integrated Approach," *American Economic Review*, 91(2), 248–252.
- COLLARD, F., AND H. DELLAS (2002): "Exchange rate systems and macroeconomic stability," *Journal of Monetary Economics*, 49(3), 571–599.
- DEDOLA, L., AND S. LEDUC (2001): "Why is the business-cycle behaviour of fundamentals alike across exchange-rate regimes?," *International Journal of Finance & Economics*, 6(4), 401–419.
- EVERS, M. P. (2006): "Federal fiscal transfers in monetary unions: a NOEM approach," *International Tax and Public Finance*, 13(4), 463–488.
- FATÁS, A., AND I. MIHOV (2001): "Government size and automatic stabilizers: international and intranational evidence," *Journal of International Economics*, 55(1), 3–28.
- GALI, J. (1994): "Government size and macroeconomic stability," *European Economic Review*, 38(1), 117–132.
- GALI, J., AND T. MONACELLI (2005): "Monetary policy and exchange rate volatility in a small open economy," *The Review of Economic Studies*, 72(3), 707–734.
- GUO, J.-T., AND S. G. HARRISON (2006): "Government size and macroeconomic stability: A comment," *European Economic Review*, 50(5), 1339–1346.
- KOLLMANN, R. (2002): "Monetary policy rules in the open economy: effects on welfare and business cycles," *Journal of Monetary Economics*, 49(5), 989–1015.
- LIM, G. C., AND P. D. MCNELIS (2008): *Computational macroeconomics for the open economy*. MIT press Cambridge, MA.
- LUCAS, R. (1987): *Models of business cycles*, Yrjö Jahnsson lectures. Blackwell.
- MCCALLUM, B., AND E. NELSON (2000): "Monetary policy for an open economy: an alternative framework with optimizing agents and sticky prices," *Oxford Review of Economic Policy*, 16(4), 74–91.

- MONACELLI, T. (2004): "Into the Mussa puzzle: monetary policy regimes and the real exchange rate in a small open economy," *Journal of International Economics*, 62(1), 191–217.
- MUSSA, M. (1986): "Nominal exchange rate regimes and the behavior of real exchange rates: Evidence and implications," in *Carnegie-Rochester Conference Series on Public Policy*, vol. 25, pp. 117–214. North-Holland.
- QUADRINI, V., AND A. TRIGARI (2007): "Public Employment and the Business Cycle," *The Scandinavian Journal of Economics*, 109(4), 723–742.
- ROTEMBERG, J. J. (1982): "Monopolistic price adjustment and aggregate output," *The Review of Economic Studies*, 49(4), 517–531.
- SCHMITT-GROHÉ, S., AND M. URIBE (2003): "Closing small open economy models," *Journal of international Economics*, 61(1), 163–185.
- SCHMITT-GROHÉ, S., AND M. URIBE (2007): "Optimal simple and implementable monetary and fiscal rules," *Journal of monetary Economics*, 54(6), 1702–1725.
- SCHWARTZ, A. J. (2000): "Do we need a new Bretton Woods," *Cato J.*, 20, 21.
- TANZI, V., AND L. SCHUKNECHT (2000): *Public spending in the 20th century: A global perspective*. Cambridge University Press.
- TAVLAS, G. S. (2013): "Anna Jacobson Schwartz: In Memoriam," *Cato Journal*, 33(3).