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The statutory breakdown of payroll taxes between firms and workers and the business

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Abstract

According to conventional wisdom, the statutory split of payroll taxes between firms and workers is irrelevant for the real allocation in the long run, as tax incidence is fully determined by the market structure when prices and wages adjust. This paper breaks with this view, by showing that if payroll taxes are levied on workers, business cycle fluctuations of prices and wages are smaller than under the formal taxation of firms. Lower nominal volatility mitigates price and wage dispersion, and thereby the proclivity loss from business cycles. In a standard DSGE model calibrated to a typical European country, a full shift of contributions from firms to workers reduces the welfare costs of the business cycle 11.25%.

JEL classification: H55, H20, E30, E60.
Keywords: Labor taxes, social security, business cycles, automatic stabilizers, liability side equivalence.

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1 Introduction

It is well known that in a market setting with flexible prices, the breakdown of the burden of a transaction tax between buyer and seller is fully determined by the price elasticties of demand and supply. This insight, which goes back at least to Dalton (1922), is known as "liability side equivalence" or "tax incidence equivalence" and is a standard principle of public finance (see Stiglitz (2000), for example). In the context of the labor market, the principle implies that the liability side of a payroll tax – i.e., whether it is imposed on employers or employees – is irrelevant for the distribution of the tax burden.[1] The study at hand shows in a New Keynesian model that liability side equivalence holds in the long run, but that the liability side nevertheless matters for welfare costs of business cycle fluctuations. In a model calibrated to a representative European country, a full shift of payroll taxation from firms to workers reduces the welfare loss from business cycle fluctuations by 11.25%.

The otherwise standard DSGE model features a social security system that is funded by a payroll tax (social security contributions). The tax rate is assumed to be time variant because the government adjusts the rate in order to stabilize social security contributions over the cycle. When the tax base (gross total labor compensation) declines in a recession, the government ceteris paribus has to increase the tax rate to sustain constant revenues. Vice versa, a surging tax base during upswings has to be compensated by a tax rate reduction.[2] This assumption is also made by Burda and Weder (2014), who also provide empirical evidence. Cyclical adjustments in the tax rate contribute to price and wage volatility, because changes in the tax rate lead firms and labor unions to adjust prices and wages. In a Calvo-setup, nominal volatility gives rise to price and wage dispersion, which impedes an efficient allocation of resources and reduces the economy's productive capacity. This productivity loss counts towards welfare costs of business cycles. Its emergence is summarized in Figure 1.

[1] If a payroll tax is imposed on workers, it is a labor income tax that lowers the net wage for a given gross wage. Imposed on firms, payroll taxes scale up the effective wage bill for a given gross wage bill. In this paper, this distinction is made for the employer's portion and the employee's portion of social security contributions. Formally, firms pay the entire tax burden of both sides. However, because firms and workers usually negotiate over a gross wage that includes the worker contribution but excludes the firm contribution, the nominal tax burden is nevertheless split between both sides. Consider for example a German hourly minimum wage of 8.50€, and a contributions rate of 40% split equally between both sides. The firm pays a total of 8.50€*1.2=10.20€ per hour, of which 3.40€ (2*1.70€, the sum of the contributions of both sides) are paid to the government, and 6.80€ are paid to the worker. Since the worker contribution of 1.70€ is deducted from the paycheck and paid to the government on her or his behalf, while the wage agreed upon is 8.50€, the worker portion of contributions is economically a labor income tax.

[2] In reality, social security expenditures tend to move against the cycle, as e.g. unemployment insurance requires more funding in downturns than in expansions (see Dolls et al. (2012), for example). This puts further pressure on a government to adjust the tax rate in a counter cyclical manner. This observation is neglected in the baseline model for the sake of tractability. However, it is accounted for in a robustness check, and shown to quantitatively strengthen the results of the paper.

Business cycles cause fluctuations in tax base	⇒	Tax rate adjustments to maintain constant revenues	⇒	Changes in tax rate trigger nominal adjustments	⇒	Price and wage dispersion lower productivity

Figure 1: The role of the social security system in nominal volatility.

The paper shows that the liability side of social security contributions affects the size of tax rate adjustments that are necessary to stabilize revenues over the cycle. If contributions are levied on workers, stabilizing revenues requires smaller adjustments in the tax rate than in the case when contributions are levied on firms. In Figure 1, this corresponds to a weaker link from business cycles (first item) to tax rate adjustments (second item). As a result, given business cycle dynamics cause less volatility in the tax rate, which reduces the size of the productivity loss and thereby welfare costs. The explanation of this result is split into two steps: The next paragraph argues that taxing workers implies a larger tax base (relative to firm taxation), while the subsequent paragraph explains why this mitigates the productivity loss.

The fact that gross total labor compensation is larger under worker taxation is a corollary of liability side equivalence. Because the split of the tax incidence between both sides is the same under worker taxation and firm taxation, after-tax real wages have to be the same as well. This implies that pre-tax wages are higher if contributions are levied on workers, because they have to compensate for a nominal tax burden that is absent under the taxation of firms. With higher nominal wages, gross total labor compensation ($wage * hours$) is larger as well, since hours worked are virtually identical under both liability sides.

The larger tax base has two implications. First, a given level of social security revenues is generated by a smaller tax rate τ. This does not affect the real allocation, because social security revenues – and thereby the real tax burden – is assumed to be the same in both cases. Second, the government has to adjust the tax rate by less in order to stabilize revenues in the face of a given fluctuation in the tax base. To see why, denote revenues by $\tau * tax\, base$, and note that deviations from the steady state can be decomposed into $\Delta revenues = \Delta\tau * \overline{tax\, base} + \overline{\tau} * \Delta tax\, base$, where bars denote steady state values and Deltas deviations. Maintaining constant revenues (i.e. $\Delta revenues = 0$) requires to adjust the tax rate by $\Delta\tau = -(\overline{\tau}/\overline{tax\, base}) * \Delta tax\, base$ in response to some fluctuation $\Delta taxbase$. As explained above, taxing workers implies a larger (smaller) steady state tax base (tax rate), so $(\overline{\tau}/\overline{tax\, base})$ is smaller in magnitude. In Figure 1, this corresponds to a weakening of the mechanism symbolized by the first arrow, and consequently reduces business cycle costs.

Payroll taxation represents a large component of public finance in developed nations, especially in Europe. In 2013, the total of employee and employer social security contributions exceeded a third of total labor costs in eight OECD countries.[3] These large figures result from a rapid growth of payroll tax rates that started in 1960 (see Gruber (1997), for example). In the vast majority of European OECD countries, social contributions are not primarily levied on

[3] Austria, Belgium, the Czech Republic, France, Germany, Greece, Hungary and the Slovak Republic. See OECD Taxing Wages 2013.

workers (see Table 5 in the Appendix). In the light of the model, this suggests substantial scope to reduce business cycle costs.

There is a broad body of literature on liability side equivalence, with contributions from the fields of public finance, labor economics and behavioral economics. Mieszkowski (1967) provides a unified treatment of classic theoretical tax analysis. In labor economics, a strand of literature examines whether liability side equivalence holds in the presence of market imperfections, that is, in the context of efficiency-wage and wage-bargaining models (see, among others, Picard and Toulemonde (2001), Rasmussen (1998) or Koskela and Schöb (1999)). Regarding empirical work, Lehmann et al. (2011) and Gruber (1997) are recent studies on the principle's validity. Weber and Schram (2013) conduct a laboratory experiment to analyze the implications of the liability side of payroll taxation under bounded rationality. The paper at hand is also loosely related to the literature on automatic stabilizers (see Furceri (2010) for a recent overview), as the liability side in the model passively affects nominal volatility caused by business cycles.

Section 2 lays out the model and discusses the calibration. Section 3 analyzes the implications of the liability side for the adjustment to exogenous shocks, which explain the welfare results presented in section 4. Section 5 provides robustness checks. The paper concludes with section 6.

2 The model

In the closed-economy New Keynesian DSGE model, the economy is populated by a continuum of firms and a continuum of infinitely-lived households. Firms produce differentiated intermediate goods, which are aggregated into a final goods bundle consumed by households. Likewise, households supply differentiated types of labor, which enter the production function subject to aggregation into a composite of labor services. Since different intermediate goods and different labor types are imperfect substitutes, firms and workers have market power. Price and wage setting are staggered by Calvo mechanisms. A social security system is financed by payroll taxes and reimburses revenues as lump-sum transfers to households. Depending on the scenario, contributions are either levied on firms or on workers. A government consumes according to an exogenous process, with public consumption defined as plain waste. Its expenditures are fully financed by lump-sum taxes in every period. Monetary policy is governed by a standard Taylor rule. There are two sources of uncertainty in the economy: productivity shocks and demand shocks that affect government spending.

2.1 Households

The index $j \in [0, 1]$ for households is suppressed for ease of notation. While the consumption decision results from intertemporal optimization, hours worked are determined by labor demand as workers reduce their labor supply below the competitive level. Lifetime utility is given by:

$$U_t = \mathbb{E}_t \sum_{k=0}^{\infty} \beta^k \left(\frac{c_{t+k}^{1-\gamma}}{1-\gamma} - \frac{n_{t+k}^{1+\phi}}{1+\phi} \right) \quad ,$$

where n_{t+k} and c_{t+k} are hours worked and consumption in period $t+k$. Maximization is subject to the series of period budget constraints for $t \geq 0$:

$$P_t c_t + (1/R_t) b_t \leq b_{t-1} + (1-\tau_t^w)\, w_t \int_0^1 n_t(i)\, di + ssb_t - tax_t + \Pi_t \quad , \tag{1}$$

where P_t is the economy's price index (defined below) and R_t is the gross nominal interest rate on a one-period risk-free nominal bond b_t maturing at the beginning of $t+1$. τ_t^w is the rate of employee's social security contributions, which are deducted from nominal labor income $w_t \int_0^1 n_t(i)\, di$ (the household earns the same wage for its work at all different firms on the continuum, each indexed by i.). Note that τ_t^w is zero in the scenario of taxing firms. The term ssb_t denotes lump-sum social security benefits, tax_t are lump-sum taxes levied by the government and Π_t denotes nominal profits from the ownership of firms. The resulting Euler equation is:

$$R_t = \beta \mathbb{E}_t \left(\frac{c_t}{c_{t+k}} \right)^{\gamma} \frac{P_t}{P_{t+1}} \quad .$$

The Dixit-Stiglitz aggregate c_t consists of all varieties $c_t(i)$ produced by firms on the continuum $[0,1]$. Aggregation is undertaken by a competitive final-goods firm using technology

$$c_t \equiv \left(\int_0^1 c_t(i)^{1-\frac{1}{\epsilon}}\, di \right)^{\frac{\epsilon}{\epsilon-1}} . \tag{2}$$

Cost-efficient composition of c_t implies the following household demand for the variation produced by firm i, where $p_t(i)$ denotes its price:

$$c_t(i) = \left(\frac{p_t(i)}{P_t} \right)^{-\epsilon} c_t \quad . \tag{3}$$

The economy's aggregate price index is defined as:

$$P_t \equiv \left(\int_0^1 p_t(i)^{1-\epsilon}\, di \right)^{\frac{1}{1-\epsilon}} \quad . \tag{4}$$

2.2 Firms and price setting

Firm i produces its goods variation $y_t(i)$ with a linear production function:

$$y_t(i) = A_t n_t(i) \quad , \tag{5}$$

where productivity is governed by $\log A_t = \rho^A \log A_{t-1} + \epsilon_t^A$ with $\epsilon_t^A \sim N\left(0, \sigma^A\right)$ allowing for aggregate productivity shocks. The input is a labor composite $n_t(i)$ that contains differentiated labor variations $n_t(i,j)$ of all households j:

$$n_t(i) \equiv \left(\int_0^1 n_t(i,j)^{1-\frac{1}{\epsilon_w}} dj \right)^{\frac{\epsilon_w}{\epsilon_w - 1}} \quad . \tag{6}$$

Analogous to (3), cost-minimizing composition of $n_t(i)$ implies the following demand schedule for type-j labor:

$$n_t(i,j) = \left(\frac{w_t(j)}{W_t} \right)^{-\epsilon_w} n_t(i) \quad , \tag{7}$$

where $w_t(j)$ is the wage for type-j labor and W_t is the aggregate wage index:

$$W_t \equiv \left(\int_0^1 w_t(j)^{1-\epsilon_w} dj \right)^{\frac{1}{1-\epsilon_w}} . \tag{8}$$

Using (7) and (8), firm i's total wage bill can be expressed as:

$$\int_0^1 \left(1 + \tau_t^f\right) w_t(j)\, n_t(i,j)\, dj = \left(1 + \tau_t^f\right) W_t n_t(i) \quad , \tag{9}$$

where τ_t^f is the rate of employers' social contributions (set to zero in the scenario of taxing workers).

Total demand for the variety produced by firm i is given by

$$y_t(i) = \left(\frac{p_t(i)}{P_t} \right)^{-\epsilon} (C_t + G_t) \tag{10}$$

where $C_t = \int_0^1 c_t(j)\, dj$ is aggregate private consumption and G_t is public consumption. The government consumes the same final goods as households.

The price setting problem of a firm i allowed to re-optimize its price $p_t(i)$ is:

$$\max_{p_t(i)} \mathbb{E}_t \sum_{k=0}^{\infty} Q_{t,t+k} \theta^k \left[y_{t+k|t}(i)\, p_t(i) - \Psi_{t+k}\left(y_{t+k|t}(i)\right) \right] \quad ,$$

where $y_{t+k|t}(i)$ is period $t+k$ output if the price set today remains valid up to this period, which has probability θ^k. The stochastic discount factor is $Q_{t,t+k} \equiv \beta^k \left(c_{t+k}/c_t\right)^{-\gamma} \left(P_t/P_{t+k}\right)$. The cost function $\Psi_t(.)$ represents the firm's total wage bill (9), which under the use of (5) can be written as:

$$\Psi_{t+k}\left(y_{t+k|t}(i)\right) = \left(1 + \tau_{t+k}^f\right) W_{t+k} \frac{y_{t+k|t}(i)}{A_{t+k}} \quad . \tag{11}$$

Optimal price setting (subject to demand schedule (10)) is governed by the following FOC that (jointly with (4)) implies a standard NKPC:

$$\mathbb{E}_t \sum_{k=0}^{\infty} Q_{t,t+k} \theta^k y_{t+k|t} \left[p_t^\star - \frac{\epsilon}{(\epsilon - 1)} (1 + \tau_{t+k}^f) W_{t+k} A_{t+k}^{-1} \right] = 0 \quad . \tag{12}$$

The optimal new price $p_t^\star$ is a markup over an expected weighted average of effective marginal costs including the employer's portion of social security contributions. A change in τ_t^f ceteris paribus moves $p_t^\star$ and leads some firms to re-adjust prices, which is symbolized by the second arrow in Figure 1.

2.3 Unions and wage setting

Nominal wage rigidity follows Erceg et al. (2000). Households exert market power on the labor market because differentiated labor services are imperfect substitutes in (6). Each household j is represented by its own labor union that sets the household-specific wage rate $w_t(j)$ subject to a Calvo constraint, so only a random share $1-\theta_w$ of unions can readjust each period. A union maximizes the expected present value of utility perceived by the household it represents:

$$\max_{w_t(j)} \mathbb{E}_t \left[\sum_{k=0}^{\infty} (\beta\theta_w)^k U\left(c_{t+k|t}(j), n_{t+k|t}(j)\right) \right] \quad ,$$

where $c_{t+k|t}(j)$ and $n_{t+k|t}(j)$ are period $t+k$ consumption and hours, if the newly set wage is still valid. The optimal wage $w_t^\star$ satisfies the following FOC, that (jointly with (8)) governs the evolution of aggregate wages:

$$\mathbb{E}_t \sum_{k=0}^{\infty} (\beta\theta_w)^k MU_{t+k|t} n_{t+k|t} \left[\left(1-\tau_{t+k}^w\right) \frac{w_t^\star}{P_{t+k}} - \frac{\epsilon_w}{(\epsilon_w - 1)} MRS_{t+k|t} \right] = 0 \quad (13)$$

where $n_{t+k|t} = \left(w_t^\star / W_{t+k}\right)^{-\epsilon_w} \left(N_{t+k}/s_{t+k}^w\right)$ is period $t+k$ total demand for type-j labor, given that w_t^* is valid.[4] $MU_{t+k|t}$ and $MRS_{t+k|t}$ denote household j's period $t+k$ marginal utility and marginal rate of substitution, also conditional on w_t^*. For $w_t^\star$, it holds that after-tax real wages are a mark-up over an expected weighted average of marginal rates of substitution. Note that because unions take after-tax wages into account, they effectively negotiate over the wage inclusive of the employee's portion of social security contributions. A change in τ_t^w ceteris paribus affects $w_t^\star$. The resulting wage re-adjustments are also symbolized by the second arrow in Figure 1.

2.4 Social security system

Following Burda and Weder (2014), the social security system is funded by payroll taxes and runs a balanced budget. The model allows contributions to be levied on firms or workers (rate τ_t^w or τ_t^f). The budget reads as

$$\left(\tau_t^w + \tau_t^f\right) N_t W_t = ssb_t \quad . \quad (14)$$

[4] N_t is the aggregate employment index (18) and s_t^w is a wage dispersion term, both introduced below. To derive this demand schedule, notice that a household charges the same wage to all firms renting its labor service, so (7) implies that total demand for type-j labor is given by $n_t(j) = \int_0^1 n_t(i,j)\,di = \left[w_t(j)/W_t\right]^{-\epsilon_w} \int_0^1 n_t(i)\,di$. From the derivation of (19) (see the Appendix) we know that $\int_0^1 n_t(i)\,di = N_t/s_t^w$. Substitution yields the equation.

The tax base is gross total labor compensation $N_t W_t$, regardless of whether taxes are levied on firms or workers. ssb_t denotes the system's expenditures, which are reimbursed to households as lump-sum transfers. In the baseline model, ssb_t is assumed to fluctuate exogenously, and is governed by

$$ssb_t = \overline{ssb} + \eta_t \quad \text{with} \quad \eta_t = \rho^{ssb}\eta_{t-1} + \epsilon_t^{ssb} \quad . \tag{15}$$

The term $\overline{ssb}$ denotes steady state expenditures and $\epsilon_t^{ssb} \sim N\left(0, \sigma^{ssb}\right)$ induces innovations to the stochastic component η_t. Depending on whether the scenario is the taxation of firms or workers, one tax rate is set to zero:

$$\tau^w = 0 \text{ (if taxing firms)} \quad \text{or} \quad \tau^f = 0 \text{ (if taxing workers)} \tag{16}$$

For given tax base and given expenditures, (14) determines $(\tau_t^w + \tau_t^f)$ such that the budget is balanced. Since one of the two rates is set zero by (16), both rates are determined. The non-zero tax rate is referred to as social contributions rate or SCR. (14) and (16) jointly govern how the SCR adjusts in order to stabilize revenues in the face of fluctuations in the tax base. These adjustments are counter cyclical because the tax base tends to move with output, so upswings ceteris paribus require a downward-adjustment of the SCR to keep revenues constant (and the other way round in downturns). In Figure 1, this is symbolized by the first arrow.

Shocks to expenditures ssb_t (induced by η_t) are an additional source of variation in the SCR, as they ceteris paribus require revenues to move accordingly under a balanced budget. Since ssb_t is exogenous in the baseline model, SCR changes from this source are not correlated with output.[5] Hence, a higher volatility of sbb_t means that independent SCR fluctuations are stronger, so the SCR's negative correlation with output – induced by tax base movements – becomes weaker. This is exploited in the calibration of the model. As discussed later on, the dynamics of independent fluctuations (governed by ρ^{ssb} and σ^{ssb}) is chosen such that resulting SCR dynamics resemble an empirically plausible pattern in a "calibration-scenario" of equal taxation of both sides.

Irrelevance of the social security system for household income

Equations (14)-(16) are irrelevant for the income of the representative household, because social security contributions – which either reduce the representative household's profit income or labor income – are fully reimbursed as lump-sum transfers. Hence, if we abstract from distortions (which is admissible for this exercise since distortions are the same under both liability sides), the only implication of (14)-(16) is to govern above-mentioned dynamic adjustments in the SCR, which in turn cause re-adjustments of prices or wages (see (12) and (13)).

The model specification thus abstracts from all macroeconomic implications of the social system beyond its relevance for price and wage adjustments. This

[5]As a robustness check, ssb_t is assumed to move counter cyclical, to account for the observed behavior of unemployment benefits (see the literature on automatic stabilizers). It is shown to strengthen the results of this paper.

property is suitable for the exercise, as explained in the following. The two scenarios under comparison only differ with regard to the liability side, and the liability side does not affect the level of social security contributions – it determines *how*, but not *how much* of the latter are raised. The amount of resources available to the social system is therefore identical in both scenarios, and the way they are spend is also the same. Hence, only the implications of the social system for price and wage adjustments differ across both scenarios. This allows us to abstract from all other implications, since they are constant across scenarios and therefore drop out in the comparison of the model distributions under both liability sides. This model property rationalizes the calibration strategy for the dynamics of ssb_t in (15). Since changes in ssb_t are meaningless in the model apart from triggering SCR adjustments, their dynamics do not affect other variables and can be freely used to generate empirically plausible SCR-dynamics in the calibration-scenario.

With this calibration strategy – which is discussed in detail in section 2.7 – the analysis can also be applied to countries that do not adhere to a balanced budget rule. Abandoning this rule means that when revenues and expenditures would ceteris paribus diverge, only a portion of the distance between the two variables is covered by adjusting revenues (i.e. by changing the SCR), while the remainder of the difference is covered by borrowing or lending. Empirically observed changes in the SCR reflect only the use of the first policy option to counteract an emerging divergence between revenues and expenditures. Calibrating (15) as to match observed SCR dynamics in the calibration-scenario therefore means that the model replicates only the portion of cyclical budgetary pressure that results in SCR adjustments. However, only this portion is relevant for the mechanism presented in this paper, since the latter is based on the use of SCR adjustments to balance the budget.

2.5 Fiscal and Monetary Policy

As common in the literature, exogenous disturbances in aggregate demand are introduced by stochastic government spending. G_t is defined as plain waste and exogenously determined by:

$$G_t = \left(1 - \rho^G\right) \overline{G} + \rho^G G_{t-1} + \epsilon_t^G \quad , \tag{17}$$

with $\epsilon_t^G \sim N\left(0, \sigma^G\right)$.[6] Expenditures are fully financed by lump-sum taxes in every period, so $G_t = tax_t$. Note that combining government consumption and social security into one entity would not change the model.

Monetary policy is assumed to target zero inflation. Its policy is governed by the following standard Taylor rule, where $\pi_{t+1} = P_{t+1}/P_t$:

$$R_t = \beta^{-1} + \alpha^\pi \left(\pi_{t+1} - 1\right) \quad .$$

[6]This specification of public spending is widely used in the literature, such as Evers (2012), for example.

2.6 Resource constraint

The constraint accounts for resource costs resulting from inefficiencies in the equilibrium allocation due to price and wage dispersion, which is symbolized by the third arrow in Figure 1. Closely related to Schmitt-Grohé and Uribe (2007), the relation between output of the final consumption good and the required amount of labor is established by defining aggregate employment N_t as total labor of all households j at all firms i:

$$N_t = \int_0^1 \int_0^1 n_t(i,j)\, di dj \quad . \tag{18}$$

As shown in the Appendix of this paper, it follows that:

$$N_t = s_t^p s_t^w \frac{C_t + G_t}{A_t} \quad , \tag{19}$$

where $s_t^p \equiv \int_0^1 (p_t(i)/p_t)^{-\epsilon}\, di$ and $s_t^w \equiv \int_0^1 (w_t(j)/w_t)^{-\epsilon_w}\, dj$ are dispersion terms, which are equal to their lower bound of 1 in the absence of dispersion.

2.7 Calibration

Table 1 shows the baseline calibration for a typical member country of the European Union. It largely follows Evers (2012), who calibrates a related model to members of the EMU. Calvo probabilities for price and wage rigidity are chosen to match the empirical findings of Druant et al. (2009). In their study on the Euro Area, they report an average lifetime of prices and wages of 9.6 and 12.5 months respectively (excluding the outlier Italy). Elasticities of substitution between different good variations and labor types match 11% price mark-up and 15% wage mark-up, as estimated in Basu and Kimball (1997) and Chari et al. (2002). Steady state government consumption $\overline{G} = 0.2$ (22% of GDP) is also used in Evers (2012). The size of the social system in the steady state $\overline{ssb}$ is 14.2% GDP. This figure is at the higher end of the observed spectrum (see Table 5 in the Appendix), but well below the values observed in Austria, Belgium, the Czech Republic, France, Germany and the Netherlands.

For the stochastic component of social security expenditures, we use $\sigma^{ssb} = 0.0007$ (corresponding to a SD of 0.5% of steady state expenditures) and $\rho^{ssb} = 0.95$. This calibration is chosen because the model then generates moments $sd(scr) = 0.35\%$ and $corr(scr, gdp) = -0.4$ in the calibration-scenario of equal taxation of firms and workers, i.e. when using $\tau_t^w = \tau_t^f \ \forall\, t$ instead of (16). On the background of the empirical observations of $corr(scr, gdp)$ from Burda and Weder (2014) and analogously computed observations of $sd(scr)$ (see Tables 4 and 6 in the Appendix), this can be regarded as a typical dynamic pattern.[7] The reason to target these moments under equal taxation of both sides is that they are shown to depend on the liability side, and are thus generated by different parameter depending on whether the tax is levied on firms or workers. Table 5

[7]Different dynamics are examined as a robustness check.

in the Appendix shows that the statutory breakdown of contributions between firms and workers varies widely across EU countries. Targeting the moments of the SCR under equal taxation of both sides constitutes an agnostic approach.

The calibration strategy for the exogenous processes of productivity and government spending is the same as in Evers (2012). The standard value of $\rho^A = 0.95$ is used for productivity shocks, while the remaining parameters ρ^G, σ^A and σ^G are calibrated as to match observed moments of government spending and output in the Euro Area.[8]

Table 1: Baseline calibriation

Parameter		Value	Motivation / Target
β	Discount factor	0.99	Annual risk-free rate of 4%
γ	Relative risk aversion	1	Log-utility
ϕ^{-1}	Frisch elasticity of labor supply	1	Kimball and Shapiro (2008)
ϵ	Elasticity of substitution goods variations	10	11% price mark-up, Basu and Kimball (1997)
ϵ_w	Elasticity of substitution types of labor	7.4	15% wage mark-up, Chari et al. (2002)
θ	Calvo probability firms	0.6875	Avg. lifetime 9.6 months, Druant et al. (2009)
θ_w	Calvo probability unions	0.76	Avg. lifetime 12.5 months, Druant et al. (2009)
α^π	Inflation coefficient in Taylor rule	1.5	Standard
$\overline{G}$	Steady state government spending	0.2	Evers (2012)
$\overline{ssb}$	Steady state social sec. expenditures	0.13	14.2% of steady state GDP
Shock processes			
σ^A	Std. innovations of technology process	0.0044	Matches *std(gdp)* in the data
ρ^A	Persistence technology shock	0.95	Chari et al. (2002)
σ^G	Std. innovations of gov't spending process	0.0013	Matches *std(G)* in the data
ρ^G	Persistence gov't spending shock	0.66	Matches *std(G)/std(gdp)* in the data
σ^{ssb}	Std. innovations of social sec. expenditures	0.0007	} Matches data: $\sigma(scr_t) = 0.35\%$
ρ^{ssb}	Persistence social sec. expenditures	0.95	} and $\rho(scr_t, gdp_t) = -0.4$

3 Shock adjustment under different liablity sides

This section contrast the model adjustment to exogenous shocks under the taxation of firms and workers. In particular, we study deviations of social security expenditures (η_t in (15)), of productivity (A_t in (5)) and of government spending (ϵ_t^G in (17)). Throughout this section, lines without markers depict deviations in the scenario of the taxation of firms, while marked lines show the adjustment under the statutory taxation of workers.

[8]His sample covers nine European countries (Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal and Spain) over the period 1999Q1 to 2007Q4. Applying an HP filter with smoothing parameter 1600 on data in logs, he reports standard deviations of output and government spending of 0.87% and 0.83% respectively. Targeting both moments as well as their ratio yields values of ρ^G, σ^A and σ^G that are roughly in line with his calibration.

3.1 Exogenous variation of expenditures

Figure 2 shows the adjustment to a reduction in social security expenditures ssb_t by 1% of steady state GDP. As outlined in section 2.4, the reduction in ssb_t itself is without consequence in the model, since it does not affect household income. However, the associated SCR-reduction – which is required under a balanced budget to lower revenues in line with expenditures – affects prices and wages, and thereby all other variables in general equilibrium. This SCR-adjustment is smaller under the taxation of workers (4th row, 2nd column), because the steady state tax base is larger in this case (as explained in the introduction), so a given SCR adjustment has a stronger impact on revenues.

Under the taxation of firms, the decline of the SCR directly reduces effective marginal costs (which include contributions), so firms reduce prices and the central bank responds by lowering the real interest rate. Consumption and output surge as a result. Regarding wages, we observe a decline in wage inflation but an increase in after-tax real wages. To see why, recall that labor unions' FOC (13) schedules a stabilization of expected after-tax real wages around a mark-up over expected marginal rates of substitution. The strong decline in prices elevates after-tax real wages above the level that is optimal for the equilibrium path of the MRS, so labor unions reduce nominal wages. The adjustment of wage inflation has a hump-shaped form because at the beginning of the adjustment, the downward pressure on wages is offset by the initial jump of the MRS, which in turn results from the initial surge in hours.

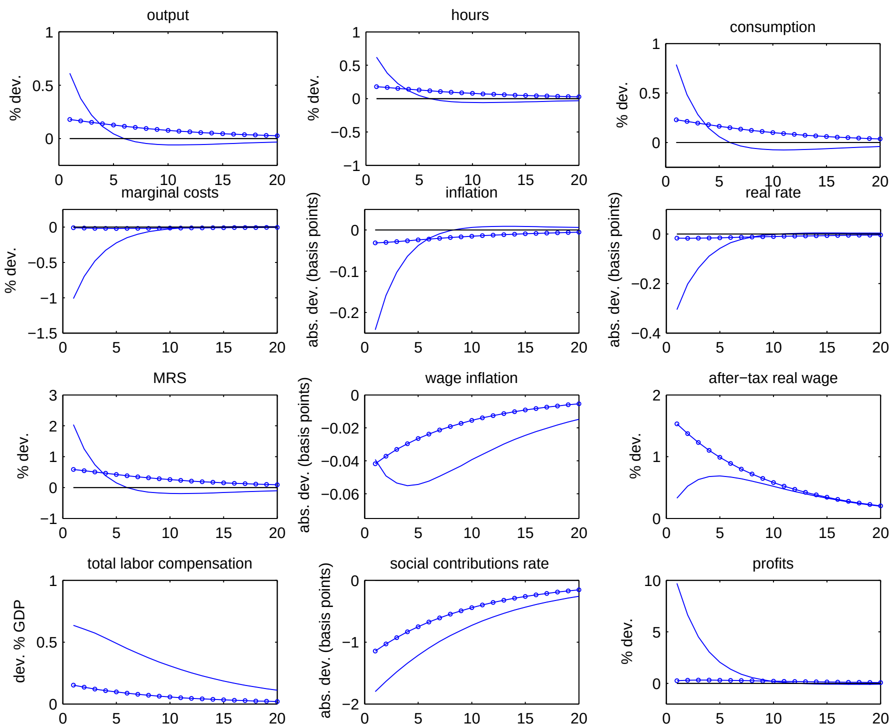


Figure 2: Reduction of social security benefits in the magnitude of 1% GDP; Taxing firms (solid lines) vs. taxing workers (marked lines)

Turning to the taxation of workers (marked lines), we observe that the initial surge in output and hours has roughly one third of its magnitude under firm taxation. The reason is that the initial reduction in marginal costs is almost negligible in comparison to its adjustment under firm taxation, which implies a dramatically weaker decline in prices, leading the central bank to implement a more timid reduction in the real rate. The weaker decline in marginal costs is for two reasons. First, the SCR reduction does not directly affect marginal costs, as it is the case under firm taxation. Instead, a lower contributions rate only affects marginal costs to the extent that it leads to a staggered downward-adjustment of wages. Second, the decline in the SCR itself is weaker, as the steady state tax base is larger (see above). Regarding wages, we again observe a decline in newly set nominal wages but a rise in after-tax real wages. The reduction of social contributions paid by workers pushes after-tax wages on a level above the optimal one for the given path of the MRS, so newly set wages are lowered.

To conclude this exercise, note that under worker taxation, the reduction in social security expenditures causes a smaller deviation of output, consumption, prices and wages. While it is not surprising that prices are more stable – the SCR change is smaller and affects them only indirectly – it is noteworthy that also wages adjust by less under worker taxation, although the SCR change directly affect them in this case. This is due to the smaller size of the SCR adjustment, as well as to the negative deviation of the MRS after period 7, which lowers the optimal wage that unions seek to implement.

3.2 Productivity shocks

Figure 3 shows that the adjustment to a productivity shock is mildly different in both scenarios. In either case, the positive deviation of productivity (one SD of ϵ_t^A in (5)) reduces marginal costs and with it prices. This leads the central bank to lower the real interest rate, in turn causing households to increase consumption. Since the shock reduces the amount of hours required per unit of output, labor demand and hours decline despite the surge in GDP. The MRS deviates positively because the decline in marginal utility overcompensates the decline in the disutility of labor. In the wage setting decision of unions, the higher MRS is weighted against the decline in consumer prices that pushes up real wages. As the latter dominates, unions lower wages. Regarding the social security system, the shock raises total labor compensation, which would ceteris paribus cause a surge in revenues. Since expenditures remain unchanged, the balanced budget requires to lower the SCR in order to hold revenues constant as well. This SCR adjustment is smaller if contributions are levied on workers because the steady state tax base is higher (as discussed in the introduction).

All differences between the adjustment to the productivity shock in both scenarios originate from the different impact of the SCR-reduction, because the liability side is irrelevant for the shock adjustment if the SCR were constant. This allows us to explain the differences in the adjustment under both scenarios on the basis of the results from the previous exercise. Since the change in ssb_t is irrelevant for household income, the economy's adjustment in the precious exercise is fully attributed to the associated SCR-reduction. Because the SCR is also lowered in the course of the productivity shock, the adjustment discussed in the previous subsection is also present in this exercise – in addition to the impact of the productivity shock. For example, we observe that the adjustment path of wage inflation is lower under firm taxation. The reason is that the downward-adjustment of the SCR then exerts stronger downward-pressure on this variable, as shown in the previous exercise.

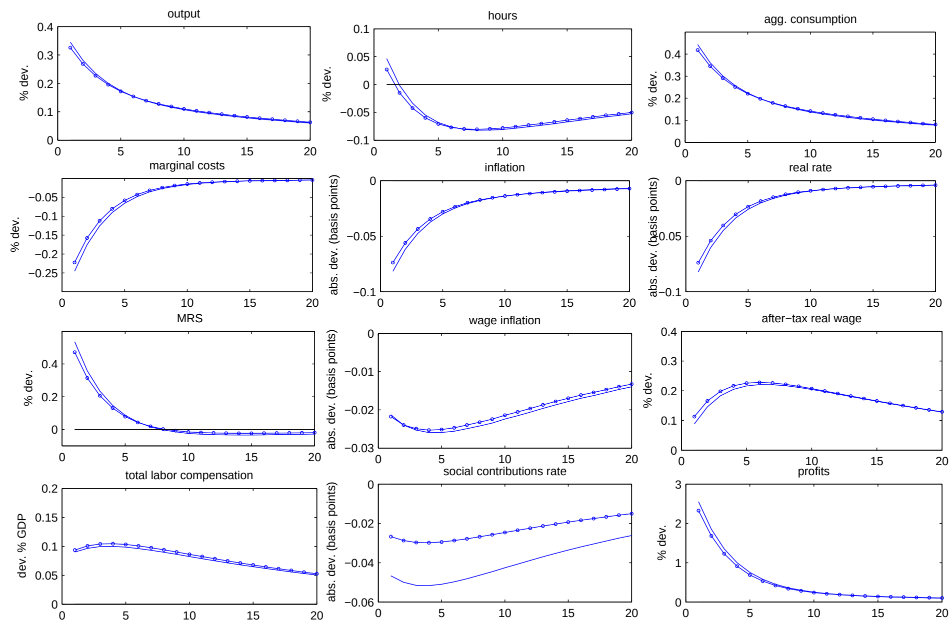


Figure 3: Positive one SD productivity shock;
Taxing firms (solid lines) vs. taxing workers (marked lines)

3.3 Demand shocks

Figure 6 in the Appendix shows the impact of a positive innovation in ϵ_t^G (equation (17)) in the magnitude of one standard deviation. Regarding the general adjustment, most of the additional government consumption is covered by a surge in output, implying a very mild consumption crowding out. This is due to wage rigidity: As nominal wages adjust slowly to the increment in disutility of labor, the rise in output only causes a moderate hike in marginal costs. This limits the induced inflation and thereby the strength of the resulting contractionary monetary policy stance. The output expansion implies an increase in total labor compensation, which requires a downward adjustment of the SCR. Unlike in the previous two exercises, there is no clear-cut picture on which liability side is favorable in terms of reducing fluctuations in macroeconomic aggregates. The welfare analysis will show that the taxation of workers reduces price and wage volatility, but only to a negligible extent.

4 Welfare analysis

This section compares the welfare costs of business cycle fluctuations – measured by consumption compensation – under both liability sides. The consumption compensation ν is defined as the percentage reduction of consumption in the deterministic steady state for which an agent is equally well off in the deterministic steady state and in the stochastic environment.[9] It is determined by:

$$\begin{aligned} \mathbb{E}\sum_{t=0}^{\infty}\beta^t U\left(c_t,n_t\right) &= \sum_{t=0}^{\infty}\beta^t U\left(\left(1+\nu^f\right)\bar{c},\bar{n}\right) \quad \text{(if taxing firms)} \\ \mathbb{E}\sum_{t=0}^{\infty}\beta^t U\left(c_t,n_t\right) &= \sum_{t=0}^{\infty}\beta^t U\left(\left(1+\nu^w\right)\bar{c},\bar{n}\right) \quad \text{(if taxing workers)} \end{aligned} \tag{20}$$

The LHS denotes the unconditional expectation of household welfare in the ergodic distribution of the model with social contributions fully levied on the respectively side. The model distribution is different under both liability sides because the latter affects the adjustment to shocks. The RHS is household welfare in the deterministic steady state, given that consumption is reduced by the respective consumption compensation ν^f or ν^w (which are negative). The allocation in the deterministic steady state is independent from the liability side because liability side equivalence holds in the flexible-price allocation. $\bar{c}$ and $\bar{n}$ are thus the same under both liability sides, so differences in the LHS between both scenarios translate into differences between ν^f and ν^w.

Following Evers (2012), both sides of (20) are approximated to express ν^f and ν^w as a function of first and second moments of the ergodic distribution. This allows us to decompose the total welfare loss into the following four components: The contributions of volatility in consumption and hours and the contributions of level effects in these two variables (defined as differences between the variables' unconditional expectations in the ergodic distribution and their value in the deterministic steady).[10] To obtain the moments used in the welfare function, the model is written recursively as in Schmitt-Grohé and Uribe (2007) and solved in Dynare by a second-order accurate perturbation method. To eliminate the inaccuracy involved in simulating the model, population moments are computed analytically by applying the nonlinear moving average method of Lan and Meyer-Gohde (2013). This approach withstands the critique of Kim and Kim (2003), who show that meaningful welfare analyses require at least a second-order accurate approximation to the system of equations.

4.1 Welfare results

Table 2 presents the results of the welfare analysis and moments of selected variables. Labels "Workers" and "Firms" indicate that the tax is levied on the respective side. The figures are reported for the full stochastic setup (labeled "All shocks"), as well as for two setups in which either demand shocks or productivity shocks are deactivated. For the reported moments, columns labeled "%-diff" show their difference under both liability sides, as a percentage share of the value under worker taxation. The same holds for the total welfare loss, where a positive value indicates that the loss becomes more severe under firm taxation (the negative compensation becomes larger). For the four components of the

[9] This commonly applied measure goes back to Lucas (1987) and Lucas (2003).
[10] Details on the functions and their derivation are provided in the Appendix.

welfare loss, "%-diff" also presents differences between both scenarios, but as a share of the total loss under worker taxation. Here, a positive value indicates that the respective component contributes to a worsening of the welfare loss under firm taxation, while a negative value means that the component mitigates the loss.[11]

Before we compare the outcomes under both liability sides, we make two general observations that hold in either scenario. First, in each of the three stochastic setups, level effects greatly dominate volatility effects in the decomposition of the welfare loss.[12] Second, the total welfare loss if there are no productivity shocks is insignificant compared to the loss that arises if there are no demand shocks.[13] Hence, since demand shocks and volatility effects are of secondary importance, we can focus on level effects caused by productivity shocks to explain the total welfare loss in the full stochastic setup.

These level effects arise because productivity is lower in the stochastic environment, which leads households to work fewer hours and consume less (which lowers welfare since the loss from forgone consumption is roughly three times as large as the gain from more leisure). The source of the productivity loss is price and wage volatility, which is under Calvo-rigidity accompanied by dispersion among prices and wages.[14] Price dispersion leads households to consume different quantities of different good variations, while wage dispersion leads firms to employ different amounts of different types of labor. As a result, Jensen's Inequality applies in aggregators (2) and (6) and raises the total amount of good variations required to bundle one unit of the final good, as well as the amount of total labor required to bundle one unit of the labor composite. Less output of the final good for given labor input means that productivity is lower, which manifests in the aggregate resource constraint (19) as resource costs.

Finally turning to the comparison of model distributions under both liability sides, we observe that in the full stochastic setup, total welfare costs are by 11.25% higher under firm taxation. The reason is that SCR-adjustments are dramatically larger, implying that the SCR's standard deviation is by 35.78% higher than under worker taxation – in line with the shock adjustments shown in Figures 2 and 3. Larger SCR-adjustments lead to stronger adjustments in prices and wages, so the standard deviations of price and wage inflation are by

[11]For example, in the full stochastic setup, lower mean consumption under firm taxation increases this component of the welfare loss, in a magnitude that corresponds to 15.58% of the total loss under worker taxation. In contrast, fewer hours worked under firm taxation mitigate the welfare loss by 4.31% of the total loss under worker taxation.

[12]Consider for example the full stochastic setup and the taxation of workers. Summing up over consumption and hours, level effects cause a welfare loss of -0.1458 + 0.0735 = -0.0723 units, while volatility effects lead to a loss of -0.0061 - 0.0016 = -0.0077 units.

[13]This observation fits the explanation of Figure 1, which attributes the welfare loss to nominal volatility. Comparing the adjustment to productivity and demand shocks (Figures 3 and 6) shows that a productivity shock induces about ten times stronger deviations of price and wage inflation, although the impact on output only differs by the factor two. Productivity disturbances are thus substantially more relevant for nominal volatility.

[14]Whenever the optimal price (wage) changes, entities that are allowed to re-adjust set a price (wage) different from the price (wage) that remains valid for the non-adjusting entities.

Table 2: Welfare costs of fluctuations, baseline model

	All shocks			No demand shocks			No productivity shocks		
	Workers	Firms	%-diff.	Workers	Firms	%-diff.	Workers	Firms	%-diff.
Welfare loss of fluctuations	-0.0800	-0.0890	11.25	-0.0797	-0.0887	11.29	-0.0009	-0.0025	171.10
Decomposition:									
Level cons.:	-0.1458	-0.1582	15.58	-0.1455	-0.1580	15.64	-0.0016	-0.0039	246.70
Level hours:	0.0735	0.0770	-4.31	0.0734	0.0768	-4.35	0.0010	0.0017	-71.07
Volatility cons.:	-0.0061	-0.0061	-0.02	-0.0061	-0.0061	-0.03	-0.0001	-0.0001	-2.53
Volatility hours:	-0.0016	-0.0016	0.01	-0.0015	-0.0015	0.02	-0.0002	-0.0002	-1.99
Moments									
Mean output⋆	0.9165	0.9164	-0.08	0.9165	0.9164	-0.08	0.9176	0.9176	-0.02
Mean consumption⋆	0.7166	0.7165	-0.12	0.7166	0.7165	-0.12	0.7176	0.7176	-0.02
Mean hours⋆	0.9169	0.9168	-0.04	0.9169	0.9168	-0.04	0.9176	0.9176	-0.01
Std. dev. consumption	0.0079	0.0078	-0.32	0.0079	0.0078	-0.32	0.0010	0.0008	-13.54
Std. dev. hours	0.0056	0.0056	2.26	0.0053	0.0054	4.60	0.0020	0.0019	-48.77
Std. dev. SCR	0.0031	0.0041	35.78	0.0030	0.0041	35.88	0.0029	0.0039	35.57
Std. dev. inflation	0.0028	0.0029	5.99	0.0028	0.0029	5.98	0.0001	0.0005	264.66
Std. dev. wage inflation	0.0017	0.0018	2.87	0.0017	0.0018	2.87	0.0001	0.0002	66.00
Mean disp. good variations⋆⋆	0.2720	0.3054	12.29	0.2720	0.3053	12.27	0.0008	0.0100	1229.78
Mean disp. labor types⋆⋆	0.1453	0.1537	5.78	0.1452	0.1536	5.79	0.0011	0.0031	175.54

⋆Differences are reported in units per mill.

⋆⋆Dispersion terms are reported as deviations from one in units per mill.

5.99% respectively 2.87% higher than under worker taxation.[15] Higher nominal volatility increases mean price and wage dispersion by 12.29% and 5.78% respectively, implying a stronger productivity loss. The latter leads to lower output, consumption and hours worked. This increases the welfare loss, because the gain from working fewer hours (4.31% of the total loss under worker taxation) is dominated by the loss from lower consumption (15.58% of the total loss under worker taxation).

Up to this point, model distributions under the exclusive taxation of firms respectively workers were compared. Figure 5 in the Appendix considers intermediate cases, by plotting the welfare loss as a function of the statutory share of contributions levied on firms. The loss depends almost perfectly linear on the statutory breakdown of social contributions between firms and workers.

5 Robustness analysis

Before we consider variations of key parameter values, we first modify the dynamics of social security expenditures (ssb_t in (15)) in order to generate different SCR-dynamics in the calibration-scenario of equal taxation of firms and workers. Again note that changes in ssb_t only affect other variables via the associated SCR-adjustments (see section 2.4), so the dynamics of ssb_t are a suitable de-

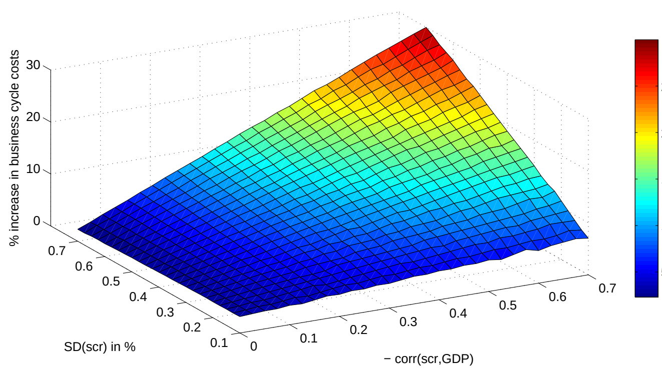
[15]This is also in line with Figures 2 and 3.

vice to introduce different SCR-dynamics. In order to allow for a broad set of dynamics in ssb_t, an ad-hoc dependency of ssb_t on output fluctuations is introduced. To this aim, the time-variant component of ssb_t in equation (15) is governed by

$$\eta_t = \rho^{\text{ssb}} \eta_{t-1} + \epsilon_t^{ssb} + \alpha \epsilon_t^A \quad , \tag{21}$$

where $\epsilon_t^{ssb} \sim N\left(0, \sigma^{ssb}\right)$ induces independent fluctuations, ϵ_t^A is the stochastic innovation of productivity shocks (see (5)), and α is an exogenous weight. The dependency of η_t (and thereby of ssb_t) on ϵ_t^A allows us to adjust the strength of the cyclical behavior of the SCR. A negative value of α strengthens the countercyclicality of the SCR, because in this case, a positive technology shock ($\epsilon_t^A > 0$) does not only cause a surge in the tax base (see Figure 3), but also an reduction in ssb_t. Hence, the downward-adjustment that is required to offset the raising tax base is reinforced by the need to lower revenues in line with declining expenditures. Vice versa, $\alpha > 0$ weakens the countercyclicality of the SCR: a positive technology shock then leads to higher social security expenditures, which counteracts the downward-adjustment in the SCR that stems from the surging tax base.

Figure 4 shows the percentage increase in welfare costs under firm taxation relative to worker taxation – derived in the same way as in Table 2 – as a function of SCR-dynamics in the calibration-scenario (summarized by $sd(scr)$ and $corr(scr, gdp)$).[16] The figure reported in Table 2 is found at $sd(scr) = 0.35\%$ and $-corr(scr, gdp) = 0.4$. The table next to the figure contains the same information as the plot.



sd(scr) -corr(scr,gdp)	0.1	0.2	0.3	0.4	0.5	0.6	0.7
0.1	3.7	4.2	4.7	5.2	5.6	6.0	6.3
0.2	4.2	5.2	6.7	7.5	8.5	9.5	10.4
0.3	4.7	6.2	8.3	9.9	11.5	12.9	14.5
0.4	4.6	7.9	9.5	11.6	14.3	16.5	18.1
0.5	6.3	8.8	11.6	14.0	16.9	19.6	22.5
0.6	6.3	9.8	12.9	16.4	20.1	22.8	25.9
0.7	7.3	11.3	15.4	18.5	22.4	26.5	28.9

Figure 4: Welfare results in dependency of baseline SCR-dynamics

The difference in welfare costs between both scenarios increases in $sd(scr)$ and in $-corr(scr, gpd)$. The increment in $sd(scr)$ is straightforward to explain: Under worker taxation, a given adjustment in revenues can be implemented by a smaller change in the contributions rate. However, a low value of $sd(scr)$ in

[16] For each point on the $sd(scr)$-$corr(scr, gdp)$ plane, α and σ^{ssb} are adjusted such that the respective moments are generated by the model under equal taxation of firms and workers. Then, for each point, the difference in the welfare loss under worker and firm taxation computed and plotted.

the calibration-scenario means that required adjustments in revenues are small on average, so the liability side makes less of a difference for SCR-volatility and thereby for welfare. To explain why the welfare difference increases in $-corr(scr, gpd)$, first note that SCR-adjustments can offset some of the adjustment pressure on prices and wages that results from shocks driving business cycle fluctuations. This occurs whenever the adjustment pressure on nominal variables resulting from an SCR-adjustment has the opposite direction than the adjustment pressure from a business cycle shock. Such an offset leads to a reduction in the overall size of price and wage adjustments. The higher the probability of an offset, the lower is the reduction in nominal volatility that can be achieved by reducing the average size of SCR-adjustments. The reason is that by downsizing SCR-adjustments, one also mitigates the size of the reduction in nominal adjustments that results from an offset. In the extreme case of $corr(scr, gdp) = 0$, SCR-adjustments are independent from shocks that drive business cycle fluctuations of output, so the probability of an offset is 50%. In this case, lowering the expected size of SCR-adjustments by taxing workers instead of firms leads to virtually no reduction in nominal volatility and welfare costs. The reason is that the mitigation of the consequences of an offset balances out with the reduction in nominal adjustment from SCR-adjustments when there is no offset. With higher values of $-corr(scr, gdp)$, the likelihood of an offset is declining, because an offset typically occurs when an output deviation and an SCR-adjustment have the same direction.[17] This means that the adverse side effect of having smaller SCR-adjustments under worker taxation – i.e. to limit the impact of offsets – becomes less important. As a result, taxing workers causes a stronger reduction of nominal volatility and welfare costs.

Quantitatively, the welfare implications of the liability side are significant already for a mild countercyclicality and a mild volatility of the SCR – which is in general the case, given the observed dynamics reported in Table 4 and 6.

5.1 Sensitivity to model parameters

Table 3 shows welfare results and moments of selected variables in the same way as Table 2, but for several parameter variations. For each parameter variation, the calibration of expenditures (21) is adjusted such that $sd(scr) = 0.35\%$ and $corr(scr, gdp) = -0.4$ are valid in the calibration-scenario of equal taxation of both sides. Without these adjustments, SCR-dynamics in the calibration-scenario would differ across parameter variations because the latter affect the dynamics of total labor compensation (the tax base), and thereby of social security revenues.

[17] Since most of the variation in GDP stems from productivity shocks, GDP tends to move in the opposite direction than prices and wages (see Figure 3). In contrast, SCR-adjustments drag prices and wages in their own direction (see Figure 2). Hence, when a productivity-induced output deviation and a SCR-adjustment have the opposite direction, the adjustment pressure on nominal variables from both sources has the same direction.

Table 3: Robustness exercises

	Total Loss	Level Cons.	Level Hours	Vola. Cons.	Vola. Hours	$\mathbb{E}$(output)	$\mathbb{E}$(cons.)	$\mathbb{E}$(hours)	SD(cons.)	SD(hours)	SD(SCR)	SD(inflation)	SD(wage infl.)	$\mathbb{E}$(good disp.)	$\mathbb{E}$(labor disp.)
Baseline calibration															
Workers	-0.0800	-0.1458	0.0735	-0.0061	-0.0016	0.9165	0.7166	0.9169	0.0079	0.0056	0.0031	0.0028	0.0017	0.2720	0.1453
Firms	-0.0890	-0.1582	0.0770	-0.0061	-0.0016	0.9164	0.7165	0.9168	0.0078	0.0056	0.0041	0.0029	0.0018	0.3054	0.1537
%-diff.	11.25	15.58	-4.31	-0.02	0.01	-0.08	-0.12	-0.04	-0.32	2.26	35.78	5.99	2.87	12.29	5.78
Exercise A: $\alpha^{\pi} = 1.301$ Less responsive monetary policy															
Workers	-0.1178	-0.2331	0.1220	-0.0042	-0.0025	0.9158	0.7160	0.9163	0.0064	0.0069	0.0030	0.0031	0.0021	0.3483	0.2304
Firms	-0.1286	-0.2478	0.1259	-0.0042	-0.0025	0.9157	0.7159	0.9163	0.0063	0.0069	0.0041	0.0033	0.0022	0.3822	0.2393
%-diff.	9.22	12.50	-3.28	-0.02	0.02	-0.09	-0.15	-0.05	-0.78	3.43	35.76	4.77	1.93	9.72	3.84
Exercise B1: $\theta = \theta_w = 0.75$ Prices and wages equally rigid															
Workers	-0.0842	-0.1349	0.0589	-0.0068	-0.0014	0.9166	0.7167	0.9170	0.0083	0.0052	0.0030	0.0025	0.0017	0.3698	0.1257
Firms	-0.0931	-0.1458	0.0610	-0.0068	-0.0014	0.9165	0.7166	0.9170	0.0083	0.0052	0.0041	0.0026	0.0017	0.4109	0.1323
%-diff.	10.53	13.00	-2.51	0.04	0.00	-0.07	-0.11	-0.03	0.16	0.02	35.17	5.44	2.57	11.12	5.18
Exercise B2: $\theta = 0.8$, $\theta_w = 0.667$ Prices more rigid than wages															
Workers	-0.0798	-0.0892	0.0195	-0.0094	-0.0008	0.9170	0.7170	0.9174	0.0098	0.0039	0.0030	0.0023	0.0017	0.5091	0.0655
Firms	-0.0865	-0.0955	0.0192	-0.0095	-0.0007	0.9169	0.7170	0.9174	0.0099	0.0039	0.0041	0.0024	0.0017	0.5530	0.0679
%-diff.	8.42	7.87	0.42	0.14	-0.01	-0.04	-0.06	0.00	0.55	-2.95	35.34	4.24	1.79	8.62	3.59
Exercise B3: $\theta = 0.667$, $\theta_w = 0.8$ Wages more rigid than prices															
Workers	-0.0857	-0.1706	0.0915	-0.0041	-0.0025	0.9163	0.7164	0.9167	0.0064	0.0070	0.0030	0.0027	0.0015	0.2266	0.1757
Firms	-0.0954	-0.1850	0.0961	-0.0040	-0.0026	0.9162	0.7163	0.9166	0.0063	0.0071	0.0041	0.0029	0.0016	0.2556	0.1861
%-diff.	11.35	16.81	-5.42	-0.08	0.05	-0.10	-0.14	-0.06	-1.19	6.79	35.13	6.23	2.92	12.80	5.90
Exercise C: $\overline{ssb} = 0.09$ Smaller social security system															
Workers	-0.0739	-0.1409	0.0748	-0.0060	-0.0017	0.9400	0.7402	0.9404	0.0081	0.0057	0.0032	0.0028	0.0017	0.2714	0.1444
Firms	-0.0817	-0.1520	0.0780	-0.0060	-0.0017	0.9400	0.7401	0.9404	0.0081	0.0058	0.0039	0.0029	0.0017	0.3058	0.1526
%-diff.	10.54	14.94	-4.37	-0.05	0.02	-0.08	-0.11	-0.04	-0.43	3.93	22.57	6.16	2.81	12.67	5.66
Exercise D: $\phi = 2$ Increased curvature of labor disutility															
Workers taxed	-0.1186	-0.2567	0.1475	-0.0053	-0.0040	0.9415	0.7416	0.9419	0.0074	0.0063	0.0030	0.0027	0.0016	0.2640	0.1322
Firms taxed	-0.1301	-0.2765	0.1558	-0.0053	-0.0041	0.9414	0.7415	0.9418	0.0074	0.0064	0.0041	0.0029	0.0017	0.3001	0.1403
%-diff.	9.77	16.70	-7.00	-0.01	0.08	-0.14	-0.20	-0.10	-0.64	8.79	34.13	6.66	3.06	13.71	6.13

Differences in means are reported in units per mill, and dispersion terms as deviations from one in units per mill.

Exercise A: Less responsive monetary policy

$\alpha^{\pi} = 1.301$ reduces the responsiveness of monetary policy relative to the baseline calibration. This parameter approximates the monetary policy stance faced by a member country of the Euro Zone "core region" defined as Germany, France, Austria, Belgium and the Netherlands. A large body of literature reports a high degree of business cycle synchronization among these counties.[18] Under the simplifying assumption of perfect synchronization, monetary policy reacts to inflation in a "core region"-country with the same strength as to inflation in a hypothetical country that has the size of the entire "core region" taken together.[19] The "core region" covers more than half of the population of the

[18] See e.g. de Haan (2008) and Jones et al. (2012), or the classic study of Bayoumi and Eichengreen (1994), who report a high synchronization of supply shocks.

[19] Under perfect synchronization, inflation rates are perfectly correlated across "core region" countries, so each country has effectively the same weight in the ECB's Taylor rule as the

Euro Zone, and has a weight of 60.2% in the ECB's average inflation measure (using 2014 HICP country weights). In order to adjust the responsiveness of the real interest rate accordingly, the active portion of monetary policy (i.e., the change of the nominal interest rate in excess of the inflation rate) is weighted by 0.602. This yields a Taylor coefficient of $\alpha^{\pi} = 1 + 0.5 * 0.602 = 1.301$. For this calibration, the welfare loss is by 9.22% higher under firm taxation, which is a slight reduction of the liability side's welfare implications relative to the main calibration.

Exercises B1, B2 and B3: Varying price and wage rigidity

Exercises B1, B2 and B3 investigate the role of nominal rigidity of prices and wages. B1 considers the case of symmetric price and wage rigidity. It sets $\theta = \theta_w = 0.75$ (implying a one-year expected lifetime of prices and wages), which increases price rigidity relative to the baseline calibration, but leaves wage rigidity almost unchanged. With a difference in the welfare loss of 10.53%, the results do not change significantly. B2 and B3 consider non-symmetric rigidity: In B2, prices are expected to last for 5 quarters ($\theta = 0.8$), while wages are significantly more flexible and have a lifetime of only 3 quarters ($\theta_w = 0.667$). B3 considers the opposite case, in which prices are expected to last for only 3 quarters, but wages for 5 quarters ($\theta = 0.667$ and $\theta_w = 0.8$). The results show that when prices are more rigid than wages, the welfare implication of the liability side decreases to 8.42%. However, in the more plausible case of higher wage rigidity (which closely resembles the baseline calibration), the figure is 11.35%.

Exercise C: Smaller social security system

This exercise sets $\overline{ssb} = 0.09$, which implies a steady state size of the social security system of 10% GDP (compared to 14.2% in the baseline calibration). This value is at the lower end of the range observed in OECD countries: Only Denmark, Ireland, Norway, Portugal and the UK have smaller social systems. Under this calibration, the difference between the welfare loss under both liability sides is 10.54%, a slight reduction compared to the main calibration.

Exercise D: Increased curvature of labor disutility

The baseline-parameter for the Frisch elasticity of labor supply $1/\phi = 1$ is common in the New Keynesian literature. To check the robustness with regard to this parameter, exercise D considers the value $\phi = 2$, which implies a Frisch elasticity of 0.5. The results show that the effect on the difference between the welfare loss under both liability sides is weak: Business cycle costs are by 9.77% higher if contributions are levied on firms.

entire "core region" as a whole.

6 Conclusion

This paper shows that the liability side of social security contributions matters in a New-Keynesian DSGE model for the volatility of prices and wages, and thereby for the welfare loss of business cycle fluctuations. Calibrating the model to a typical Eurozone country with a sizable welfare system, taxing workers lowers price and wage volatility by 5.99% and 2.87% relative to the taxation of firms, which implies a reduction of the welfare loss by 11.25%.

In the unconditional mean of the model distribution, all agents are better off under worker taxation, while the ratio between after-tax profits and after-tax labor income is independent from the liability side due to liability side equivalence. However, a regime switch towards worker taxation causes transitory redistribution of labor income towards firm profits. The reason is that nominal rigidity prevents wages to adjust instantaneously when the nominal tax burden is shifted towards workers. Hence, the initial ratio between after-tax firm profits and after-tax labor income is only restored – and the transitory redistribution undone – when the nominal adjustment to the tax shift is completed. This has to be taken into account in a normative evaluation of the policy.

The structure of the model is rich enough to generate the role of the liability side, but abstracts from features that are potentially relevant for the finding. The introduction of credit-constrained households that do not earn profit income (Galí et al. (2004)) constitutes a promising extension of the model. With this feature, above mentioned transitory fluctuations in the ratio between labor income and profits imply redistribution between the two groups of households. This in turn affects aggregate demand because credit-constrained households have a propensity to consume of one. Since the liability side would determine the direction of the cyclical redistribution, it would have further implications for the business cycle. Other promising directions for future research are the inclusion of capital and allowing for trade in an open economy setup. The latter is especially interesting in the context of a monetary union. The literature on optimum currency areas identifies price stickiness as the root cause for the costs of belonging to a union.[20] The liability side, with its impact on cyclical price setting, could be of relevance for these costs.

[20] See Mundell (1961), McKinnon (1963) and Kenen (1969) for classic contributions.

7 Appendix

Derivation of (19):
Starting with

$$N_t = \int_0^1 \int_0^1 n_t(i,j)\,didj = \int_0^1 \int_0^1 \frac{n_t(i,j)}{n_t(i)} n_t(i)\,didj \quad ,$$

one can use (7) to substitute for the fraction:

$$= \int_0^1 \int_0^1 \left(\frac{w_t(j)}{W_t}\right)^{-\epsilon_w} n_t(i)\,didj = \int_0^1 \left(\frac{w_t(j)}{W_t}\right)^{-\epsilon_w} \int_0^1 n_t(i)\,didj$$

as the inner integral is constant in j,

$$= \int_0^1 \left(\frac{w_t(j)}{W_t}\right)^{-\epsilon_w} dj \int_0^1 n_t(i)\,di = s_t^w \int_0^1 n_t(i)\,di.$$

Equating the production function (5) with firm-specific total demand (10) to evoke market clearing on the firm level, one obtains $n_t(i) = \left(\frac{p_t(i)}{P_t}\right)^{-\epsilon} \frac{C_t+G_t}{A_t}$. Substituting yields:

$$= s_t^w \int_0^1 \left(\frac{p_t(i)}{P_t}\right)^{-\epsilon} di \frac{C_t+G_t}{A_t} = s_t^w s_t^p \frac{C_t+G_t}{A_t} \quad .$$

Derivation of welfare functions:
The sum on the LHS of equation (20) comprises unconditional expectations of utility on the ergodic distribution, while the sum on the RHS comprises utility in the deterministic steady state. As neither quantity depends on time, and they are therefore constant in the sum, equation (20) can be written as:

$$\frac{1}{1-\beta}\mathbb{E}U(c_t, n_t) = \frac{1}{1-\beta}U((1+\nu)\,\overline{c}, \overline{n})$$

$$\Leftrightarrow$$

$$\mathbb{E}[U(c_t, n_t)] = U((1+\nu)\,\overline{c}, \overline{n}) \quad .$$

On the LHS, applying a second-order Taylor approximation in c_t and n_t around the deterministic steady state yields:

$$\overline{U} + \overline{U}_C \mathbb{E}[c_t - \overline{c}] + \frac{\overline{U}_{CC}}{2}\mathbb{E}[c_t - \overline{c}]^2 + \overline{U}_N \mathbb{E}[n_t - \overline{n}] + \frac{\overline{U}_{NN}}{2}\mathbb{E}[n_t - \overline{n}]^2$$

where the bar denotes variables in the deterministic steady state and the cross term is neglected, as commonly done in the literature. On the RHS, applying a first-order Taylor approximation in ν around the deterministic steady state yields:

$$\overline{U} + \frac{\delta \overline{U}}{\delta \nu} \nu \quad .$$

It follows that the total consumption compensation for business cycle fluctuations is a sum of the following components of the total welfare loss:

$$\nu_{\text{mean C}} = \left(\partial \overline{U} / \partial \nu\right)^{-1} \overline{U}_C \mathbb{E}\left[c_t - \overline{c}\right]$$
$$\nu_{\text{mean N}} = \left(\partial \overline{U} / \partial \nu\right)^{-1} \overline{U}_N \mathbb{E}\left[n_t - \overline{n}\right]$$
$$\nu_{\text{volatility C}} = \left(\partial \overline{U} / \partial \nu\right)^{-1} 0.5 \overline{U}_{CC} \mathbb{E}\left[c_t - \overline{c}\right]^2$$
$$\nu_{\text{volatility N}} = \left(\partial \overline{U} / \partial \nu\right)^{-1} 0.5 \overline{U}_{NN} \mathbb{E}\left[n_t - \overline{n}\right]^2$$

Tables:

Table 4: Payroll taxes over time, correlation between SCR and GDP

	Ratio of payroll taxes to total compensation		Correlation of annual payroll payroll tax rate with GDP*		
	1970-89	1990-2012	1970-1989	1990-2012	1970-2012
Germany	0.28	0.34	-0.48	-0.56	-0.51
Sweden	0.24	0.29	-0.56	0.41	0.13
France	0.37	0.41	-0.19	-0.34	-0.28
Netherlands	0.31	0.29	-0.47	0.19	-0.01
UK	0.22	0.26	0.29	0.12	0.22
Denmark	0.09	0.16	-0.04	0.20	0.15
Finland	0.14	0.15	-0.47	-0.15	-0.22
Japan	0.17	0.25	-0.45	-0.05	-0.24
Belgium	0.32	0.39	-0.69	-0.57	-0.63
Italy	0.36	0.38	-0.30	-0.04	-0.10
Austria	0.30	0.35	-0.41	-0.58	-0.50
Australia	0.01	0.01	-0.34	0.04	-0.23
Norway	0.23	0.21	0.21	-0.07	0.14
Canada	0.07	0.09	-0.30	-0.33	-0.32
New Zealand		0.10		0.33	0.25
South Korea	0.10	0.18	-0.44	-0.43	-0.39
Spain	0.25	0.30	-0.65	-0.24	-0.38
US	0.10	0.12	0.29	-0.48	-0.02

Source: Burda and Weder (2014), data from OECD.
*Tax rates and log real GDP are HP-filtered with a smoothing parameter $\lambda = 6.25$.

Table 5: Social security systems in the EU, 2012

	Social security contributions, % of GDP	Employee's share in %
Austria	14.5	40
Belgium	14.2	30
Czech Republic	15.4	20
Denmark	1.0	95
Estonia	11.9	7
Finland	12.6	22
France	16.7	24
Germany	14.2	44
Greece	10.6	39
Hungary	12.9	60
Ireland	4.6	23
Italy	13.4	18
Luxembourg	11.0	46
Netherlands	14.8	43
Norway	9.5	33
Poland	11.4	40
Portugal	9.3	39
Slovak Republic	12.3	24
Spain	12.1	16
Sweden	10.1	26
UK	6.7	40

Source: OECD Revenue Statistics 2012.

Table 6: Volatility of social contributions rate

Country	Std. dev. SCR in %	Sample
Austria	0.21	76-13
Belgium	0.19	95-13
Cyprus	0.42	95-13
Germany	0.38	91-13
Estonia	0.46	95-14
Spain	0.13	95-13
Finland	0.73	75-13
France	0.32	74-14
Greece	0.75	00-13
Italy	0.65	92-14
Luxembourg	0.24	85-14
Latvia	0.86	92-13
Malta	0.16	95-13
Netherlands	0.83	71-13
Portugal	0.22	95-13
Slovenia	0.20	91-13
Slovakia	1.19	95-14

SCR constructed as social contributions divided by compensation of employees. Std. dev. reports the expected deviation from HP-filtered series ($\lambda = 6.25$). The approach is analogous to Burda and Weder (2014). Source: Eurostat government statistics.

Graphs:

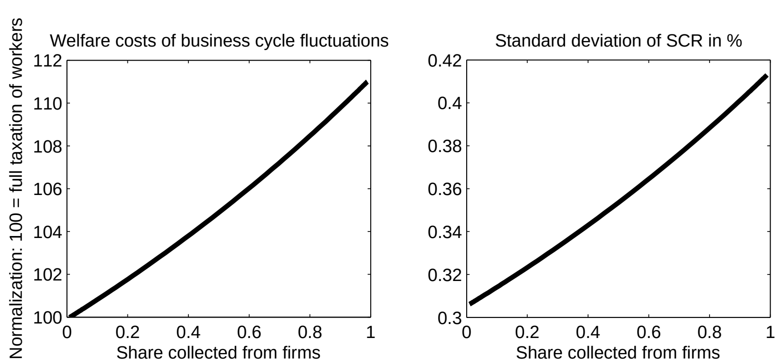


Figure 5: Functional form of the dependency of welfare costs and $\sigma(scr)$

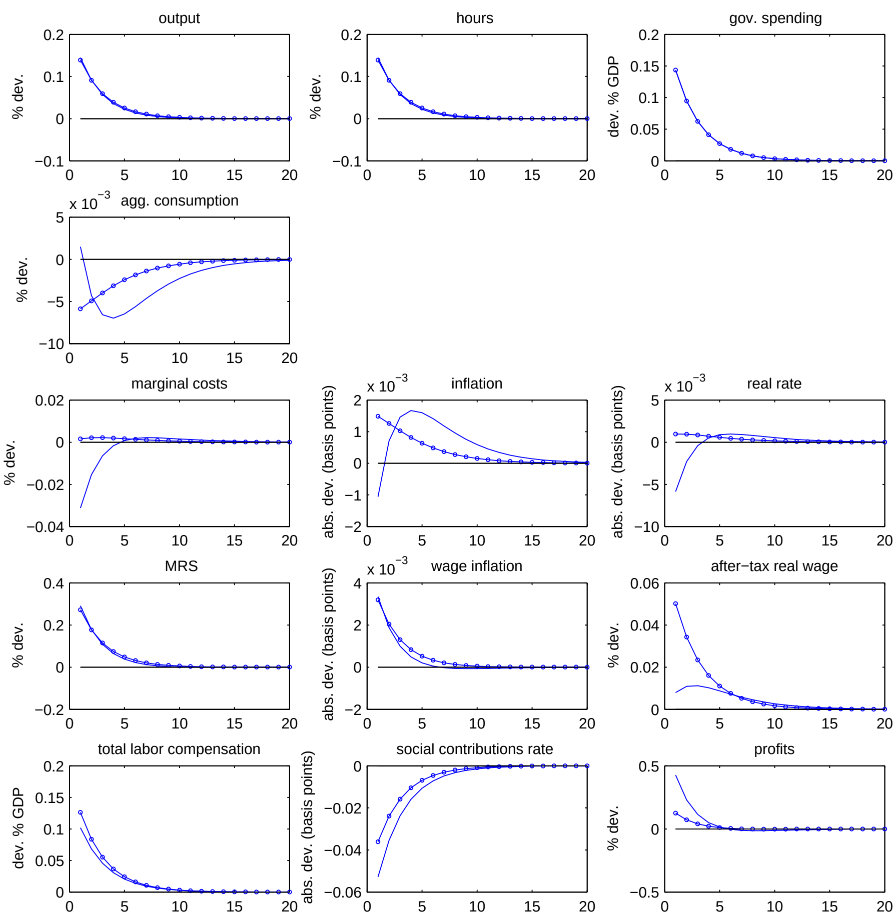


Figure 6: Positive one SD government spending shock;
Taxing firms (no markers) vs. taxing workers (markers)

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