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A Macroeconomic Perspective on the Equivalence of Taxes Paid by Employers and Employees

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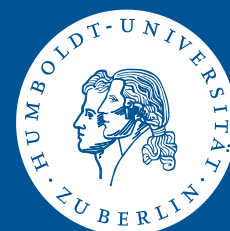


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A Macroeconomic Perspective on the Equivalence of Taxes Paid by Employers and Employees

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Abstract

Conventional wisdom states that the statutory split of labor taxes between firms and workers is of no macroeconomic relevance, because the tax incidence is fully determined by the market structure. This paper breaks with this view by establishing a theoretical link between the liability side of labor taxes and the business cycle volatility of prices and wages. It is shown that funding a social security system by a wage tax (paid by workers) significantly reduces the volatility in nominal variables relative to the volatility under a payroll tax (paid by firms). The gain in price and wage stability reduces inefficiencies in the equilibrium allocation of the stochastic model and thereby welfare costs of business cycle fluctuations. In a standard DSGE model calibrated for a European country, switching the liability side reduces welfare costs by 11.25%. Since the long-run income distribution is not affected, the finding points out room for Pareto improvement.

JEL classification: H55, H21, E30, E32, E60, D02.

Keywords: Labor taxes, social security, business cycles, automatic stabilizers, optimal taxation, liability side equivalence.

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1 Introduction

Economists have long understood that under price flexibility, the burden of a transaction tax will be shared according to the price elasticities of demand and supply. This insight, going back to Dalton (1922), is known as liquidity-side-equivalence (LSE) and is a standard component of economic training. In the context of the labor market, LSE implies that the liability side of a tax on labor is of no consequence for the distribution of the tax burden between employer and employees. Hence it does not matter to which share a tax is levied on the side of workers (as a 'wage tax') and on the side of firms (as a 'payroll tax'). This conclusion has been challenged from different perspectives. In labor economics, there is a strand of literature that examines whether LSE holds in the presence of market imperfections, i.e. 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) test for LSE in a non-experimental setup, while Weber and Schram (2013) conduct a laboratory experiment to analyze the implications of the liability side arising from bounded rationality.

This paper is the first to approach LSE of labor taxation from a general equilibrium perspective. Using a standard quantitative business cycle model, it establishes a link between the liability side of social security contributions (levied as a tax on labor) and welfare costs of business cycle fluctuations. This finding does not challenge the validity of LSE itself, since LSE holds in the model to the extent that prices and wages adjust. However, the finding contributes that, although the liability side is neutral for the distribution of the tax burden, it is *not* neutral for business cycle fluctuations. That is, the result does not challenge LSE in the 'classical sense', but it shows that the liability side of labor taxation is non-neutral in the broader sense that it matters for macroeconomic stability.

Establishing this role of the liability side of social security contributions relates the paper to two further strands of literature. The presented link is of relevance to the literature on public finance, as it points out a novel aspect of the design of labor taxation. Regarding the literature on automatic stabilizers, this paper contributes that the liability side matters for the degree of passive stabilization provided by the system. This literature fully neglects this design dimension and focuses on how taxes and transfers cushion disposable income over the cycle.¹

The theoretical finding of this paper states that if social contributions are levied as wage tax, business cycle volatility in nominal variables is lower relative to the volatility under the use of a payroll tax. As a result, welfare costs of business cycle fluctuations are lower if the system is funded by a wage tax. Quantitatively, a full shift of labor taxation from firms to workers reduces welfare costs by 11.25% in a standard New Keynesian business cycle model calibrated to a typical European country with a sizable welfare system.

¹See Furceri (2010) for a recent overview.

Before sketching the mechanism behind this result, I discuss the only non-standard assumption it requires. The finding rests on the assumption that the social contributions rate (SCR) is subject to adjustments in response to disturbances in the macroeconomic environment. These adjustments can have two different causes in the model. The first cause are fluctuations in outflows of the social system, to the extent that these fluctuations affect its financing needs and trigger adjustments in social security revenues that are implemented by changing the SCR. Cyclical fluctuations of outflows, especially from unemployment insurance schemes, is a standard result in the literature on automatic stabilizers. The second cause for adjustments in the SCR are fluctuations in total labor compensation, which is the tax base of social contributions levied as a tax on labor. If the SCR was not adjusted, cyclical movements in total labor compensation would translate into fluctuations in social security revenues. A government that seeks to maintain a given level of revenues therefore has to adjust the SCR to offset changes in the tax base. As a first assessment of the empirical plausibility of this assumption, the following graph shows the evolution of the statutory SCR in Germany. The mean deviation from the HP-filtered series amounts to 0.34%², which is shown to be sufficient to generate significant welfare implications of the liability side.

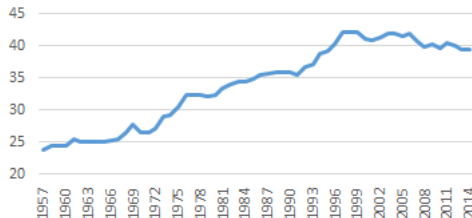


Figure 1: German statutory social contributions rate

Turning to the intuition of the result, I first establish that shifting the liability side from firms to workers implies that the change in the SCR that is required to bring about a given adjustment in revenues becomes smaller in magnitude. Since LSE holds in the model, shifting the taxation towards workers implies an increase of pre-tax wages in compensation of the additional nominal tax burden. In the aggregate, this implies a rise in (pre-tax) total labor compensation. The key insight is that if total labor compensation is higher, a given change in revenues (the product of tax base and tax rate) requires a smaller change in the SCR.

This observation intuitively implies that the volatility in the SCR required to bring about a given stochastic pattern of revenue adjustments becomes smaller. That is, adjusting revenues can be achieved with a more stable SCR if the system is funded by a wage tax. This implies a reduction in welfare costs of business cycle fluctuations, because it lowers the volatility in nominal variables and

²The smoothing parameter $\lambda = 6.25$ was applied as in Burda and Weder (2014). Data source: The German Council of Economic Experts.

thereby the degree of inefficiencies in the equilibrium allocation associated with price and wage dispersion. The reason why a more stable SCR implies more stable prices and wages is that changes in the SCR trigger nominal re-adjustments. Levied on the side of workers, changes in the SCR move after-tax real wages and thereby cause adjustments in nominal wages. On the side of firms, variations in the SCR move effective marginal costs and trigger price adjustments. It is well known that price and wage volatility contributes to the welfare costs of business cycle fluctuations. As e.g. described in Woodford (2003), nominal adjustments are associated with price and wage dispersion, which induces a resource cost as it lowers the efficiency of the equilibrium allocation. Hence, inducing a more stable SCR reduces nominal volatility and thereby the efficiency loss from this source, implying a reduction of the welfare costs of business cycle fluctuations.

Regarding the policy relevance of the finding, two remarks are in order. The first is that the mechanism presented in this paper is disconnected from the well understood Keynesian-type stabilization provided by social security systems. As the liability side does not affect the amount of generated revenues, it is neutral to the general financial stance of the system and thereby neutral to the means of the social system to stabilize income over the cycle. The liability side therefore constitutes a political control variable that is not in conflict with this desirable property of the welfare system. The second remark is that the liability side has, due to LSE, no long-run implications for the average ratio between profits and labor income. Hence, if a one-time shift of the statutory taxation towards workers is accompanied by a compensating rise in nominal wages, it is fully neutral to the income distribution in the economy. In this case changing the liability side induces a Pareto improvement, as it does not entail redistribution but all households benefit from the induced efficiency gain. Only then is it desirable from the perspective of the author. Since the statutory contribution to social security paid by workers is below 50% in vast majority of OECD countries, the findings imply substantial room for Pareto improvements.³

Section 2 lays out the model and discusses the calibration. Section 3 and 4 explain the findings in detail. Welfare results and robustness checks are reported in section 5, and the paper concludes with section 6.

2 The model

This paper employs a standard 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. Price and wage setting is staggered by Calvo mechanisms. The model features a social security system which is financed by a wage tax and/or a payroll tax, i.e. by a labor

³Table 5 in the appendix reports the statutory split for 21 OECD countries. From this sample, 19 countries have a statutory share of workers of below 50%.

tax that is levied on the side of workers and/or firms. Revenues are reimbursed as lump-sum transfers to households. 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 entering the production technology and demand shocks entering government spending. The remainder of this section presents the different building blocks of the model as well as its calibration.

2.1 Households

Each household on the continuum is indexed by $j \in [0, 1]$, but the index is suppressed in this section for ease of notation. Households choose consumption as to maximize their expected life-time utility. Hours worked are determined by labor demand because households reduce their labor supply below the competitive level to make use of their market power.

Life-time utility is given by:

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

where n_{t+k} are hours worked in period $t+k$ and c_{t+k} is the consumption of the final goods bundle in that period. The maximization is subject to a series of period budget constraints given by

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

P_t is the economy's price index defined below and i_t is the gross nominal interest rate on the one-period riskless nominal bond b_t assumed to mature at the beginning of period $t+1$. The portion of social security contributions levied as wage tax on the side of workers (rate τ_t^w) is deducted from nominal labor income $w_t \int_0^1 n_t(i) di$, where the integral constitutes the total remuneration the household receives from renting its differentiated type of labor to all firms on the continuum. ssb_t are 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 problem leads to a standard consumption Euler equation given by

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

The Dixit-Stiglitz aggregate c_t consumed by households consists of all varieties $c_t(i)$ produced by firms, each indexed by $i \in [0, 1]$. Aggregation into final goods c_t can be thought of as being conducted by a competitive final-goods firm with technology

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

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

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

The economy's aggregate price index is defined as

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

2.2 Firms and inflation dynamics

Since variations produced by different firms are imperfect substitutes in aggregator (2), firms possess market power which they use to extract profits. Assuming price stickiness à la Calvo (1983), only a random share $1 - \theta$ of firms is allowed to re-optimize prices in each period. Firms' production technologies are linear in a composite of all differentiated labor services supplied by households.

A firm i produces its good variation $y_t(i)$ with the linear production function

$$y_t(i) = A_t n_t(i) \quad (5)$$

where productivity is governed by $\log A_t = \rho^A \log A_{t-1} + \epsilon_t^A$ with $\epsilon_t^A \sim N(0, \sigma^A)$ allowing for aggregate productivity shocks. Firm i 's labor composite $n_t(i)$ contains labor-variations $n_t(i, j)$ supplied by all households on the continuum:

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

Analogous to demand equation (3), the cost-minimizing composition of different types of labor implies the following demand schedule for type- j labor:

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

where $w_t(j)$ is the wage charged by household j for its labor service and W_t is the aggregate wage index defined by

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

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

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

where τ_t^f governs the portion of social security contributions levied as payroll tax on the side of firms.

Since the government is assumed to consume the same final goods bundle as households do, total demand for the variety produced by firm i is given by

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

where $C_t = \int_0^1 c_t(j) dj$ is aggregate private consumption and G_t government consumption.

The price setting problem of a firm i allowed to re-optimize the price for its good variation $p_t(i)$ is

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

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

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

Optimal price setting subject to demand schedule (10) is governed by the FOC

$$\mathbb{E}_t \sum_{k=0}^{\infty} Q_{t,t+k} \theta^k y_{t+k|t} \left\{ p_t^* - \frac{\epsilon}{(\epsilon-1)} \left(1 + \tau_{t+k}^f \right) W_{t+k} A_{t+k}^{-1} \right\} = 0 \quad (11)$$

where p_t^* is the price set by all firms allowed to re-optimize in the current period. Combined with the definition of the aggregate price level (4), this FOC implies a standard New Keynesian Phillips Curve.

2.3 Wage setting

Nominal wage rigidity is introduced by using the apparatus of Erceg et al. (2000), which closely resembles the structure of the goods market. Households exert market power on the labor market because labor services supplied by different households are imperfect substitutes in aggregator (6). Each household is assumed to be represented by its own labor union which sets the household-specific wage rate subject to a Calvo-constraint, i.e. only a random share $1 - \theta_w$ of unions is allowed to adjust wages in each period.

The labor union operating on behalf of household j chooses this household's wage rate $w_t(j)$ as to maximize its expected present value of utility:

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

where $c_{t+k|t}(j)$ and $n_{t+k|t}(j)$ are period $t+k$ consumption and hours given that the newly set wage is in place up to that period. It can be shown that the optimal wage w_t^* satisfies the following FOC:

$$\mathbb{E}_t \sum_{k=0}^{\infty} (\beta\theta)^k MU_{t+k|t} n_{t+k|t} \left[\frac{(1 - \tau_{t+k}^w) w_t^*}{P_{t+k}} - \frac{\epsilon_w}{(\epsilon_w - 1)} MRS_{t+k|t} \right] = 0 \quad (12)$$

where $n_{t+k|t} = (w_t^*/W_{t+k})^{-\epsilon_w} (N_{t+k}/s_{t+k}^w)$ is period $t+k$ total demand for type- j labor, given that the wage rate is w_t^* .⁴ $MU_{t+k|t}$ and $MRS_{t+k|t}$ denote household j 's marginal utility and marginal rate of substitution in period $t+k$ under the same condition. Combined with the definition of the aggregate wage index (8), this FOC governs the evolution of aggregate wages. It implies that nominal wages are set such that the weighted average of future after-tax real wages is, in expectations, a mark-up over the weighted average of future marginal rates of substitution.

2.4 Social security

The social security system is modeled as simple redistribution device, reimbursing all revenues to households. Contributions are levied as wage tax and/or payroll tax. The statutory breakdown (i.e. the relative weight of τ_t^w and τ_t^f) is exogenously given and varied across different scenarios. The budget reads as:

$$\left(\tau_t^w + \tau_t^f \right) N_t W_t = \text{ssb}_t \quad (13)$$

where $N_t W_t$, the product of wage index (8) and employment index (15) defined below, is the tax base total labor compensation. In the following, the term 'SCR' refers to $\tau_t^w + \tau_t^f$. The system's outflows (social security benefits) ssb_t enter the household's budget (1) as lump-sum transfers and are determined by:

$$\text{ssb}_t = \overline{\text{ssb}} + \eta_t, \quad \eta_t = \rho^{ssb} \eta_{t-1} + \epsilon_t^{ssb} \quad (14)$$

with $\epsilon_t^{ssb} \sim N(0, \sigma^{ssb})$.

The specification implies that the social system runs a balanced budget as in Burda and Weder (2014). Since inflows are instantaneously reimbursed as lump-sum transfers, the amount of resources that the system redistributes is of no consequence for the income of households. The only effect of a change in ssb_t is therefore to raise the requirement of a SCR adjustment that induces a corresponding change in revenues.⁵ That is, apart from generating adjustments

⁴ N_t is the aggregate employment index (15) and is s_t^w a wage dispersion term, both introduced below. To obtain 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 $n_t(j) = \int_0^1 n_t(i, j) di = \left(\frac{w_t(j)}{W_t} \right)^{-\epsilon_w} \int_0^1 n_t(i) di$. Substituting the corollary $\int_0^1 n_t(i) di = \frac{N_t}{s_t^w}$ (see derivation of (16) in the appendix) yields the equation.

⁵ Variations in the degree of distortions in the economy can be neglected for small deviations.

in the SCR, the social system is irrelevant in the model. In the following I argue why this property is not only admissible but also favorable for this analysis.

To see why it is admissible, recall that this paper compares macroeconomic stability under different liability sides. As the SCR always adjusts as to raise the exogenously given amount of revenues ssb_t , the liability side is of no consequence for the budgetary stance of the system. Put differently, the liability side is disconnected from financial aspects of the system because it affects *how but not how much* revenue is generated. Hence, the liability side is also irrelevant for how much the system disburses and how the outflows are put to use. This disconnect allows to abstract from the expenditure side, i.e. from macroeconomic implications of the system's outflows (e.g. Keynesian-type stabilization) when comparing scenarios of different liability sides. The reason is that due to the disconnect, the implications of the expenditure side are in all scenarios identical and therefore drop out in a comparison. In other words, this paper looks at a property of the system that has no further implications for the system itself, which allows to abstract from the system's macroeconomic implications that are outside of the scope of this paper.

This property of the specification is favorable for this analysis as it implies that imposing a dynamic pattern on ssb_t has no other implications in the model than affecting the dynamic pattern of revenue adjustments (the driving force of the mechanism presented in this paper). It follows that one can freely choose a dynamic behavior of ssb_t such that it induces, jointly with the endogenous dynamic of the tax base, empirically plausible dynamic revenue adjustments. This raises the question of how to relate revenue adjustments to the data. The empirical strategy I pursue is to use the dynamic pattern of ssb_t to target empirically observed dynamics of the SCR. In particular, ρ^{ssb} and σ^{ssb} are chosen in the baseline calibration as to bring about endogenous SCR adjustments with $\sigma(\text{scr}_t) = 0.35\%$ and $\rho(\text{scr}_t, \text{gdp}_t) = -0.4$ under equal taxation of firms and workers. That is, under the statutory breakdown valid for Germany, the model endogenously generates moments of the SCR that are in line with empirical evidence for this country.⁶

The following consideration justifies this choice of an empirical counterpart and explains why assuming a balanced budget does not reduce the generality of the model.⁷ From the logic of the mechanism driving the results of this paper, the only requirement on an observed change in the SCR to qualify as counterpart to a revenue adjustment is that it is implemented with the aim to affect the amount of inflows. Since it does not matter how additionally

⁶In the baseline model, outflows ssb_t are assumed to fluctuate exogenously around their mean of \overline{ssb} . The model nevertheless generates the empirically plausible negative correlation between SCR and output. This is due to the fact that total labor compensation moves cyclical, so e.g. in a downturn, total labor compensation declines and lowers revenues for a given SCR. This requires an compensating upward-adjustment to keep revenues constant. Later on in this paper, the assumption of exogenous outflows is relaxed to account for a broader set of dynamic patterns of revenue adjustments.

⁷Social systems are in many countries allowed to run deficits. It is explained in the following why it would be pointless to take this explicitly into account by departing from the balanced budget assumption.

raised funds (induced by $\text{SCR}\uparrow$) are put to use or how a reduction in inflows (induced by $\text{SCR}\downarrow$) is financed, all changes in the statutory SCR naturally constitute valid empirical counterparts for revenue adjustments in the sense of the mechanism. This fact, together with the property of the model that fluctuations in outflows are irrelevant, allows to implicitly account for capital market access of social systems. The key insight is that the strategy to replicate empirically observed patterns in revenue adjustments is legitimate even if in reality, revenue adjustments were induced in order to affect some deficit/surplus. To see why, consider e.g. an observed revenue increase aimed at reducing a deficit. In the calibration strategy, this revenue adjustment is replicated in the model by a corresponding increase in ssb_t . This is inaccurate to the extent that the observed adjustment did not go along with an surge in outflows, as the additional funds were used repay some debt. However, as fluctuations in outflows are irrelevant, this inaccuracy is of no consequence in the model.

The fact that it is admissible to replicate adjustments that are in reality aimed at affecting a deficit/surplus allows to account for the implications that the possibility of accessing capital markets has for the finding of this paper. This is implicitly done in my calibration strategy, as the observed policy decisions that I use as empirical counterpart were decided on having the option to take on debt of the social system. Hence, the implications that this possibility has on the actual decision to affect revenues – the driving force of my results – is already incorporated in the data. Put differently, as the data I use is 'net of' having the option to access capital markets, I account for the implications that this option has on the effect I present in this paper.

2.5 Government and monetary policy

As widely done in the literature, exogenous disturbances in aggregate demand are modeled by introducing stochastic government spending in addition to the social security system. The government is assumed to consume the same final-goods bundle as households. Its consumption G_t is defined as plain waste and exogenously determined by

$$G_t = (1 - \rho^G) \bar{G} + \rho^G G_{t-1} + \epsilon_t^G$$

with $\epsilon_t^G \sim N(0, \sigma^G)$.⁸ I assume that expenditures are fully financed by lump-sum taxes in every period, so $G_t = tax_t$. Note that one could equally well combine government consumption and social security into one entity without changing the model.

Monetary policy is assumed to target zero inflation. Its policy is governed by the following standard Taylor rule:

$$i_t = \beta^{-1} + \alpha^\pi (\pi_{t+1} - 1)$$

⁸This specification of public spending is widely used in the literature, see e.g. Evers (2012).

where π_t denotes inflation. In a robustness check, the Taylor Rule is altered as to account for the monetary policy stance faced by a single member state of a monetary union.

2.6 Resource constraint

The resource constraint of the model economy has to account for resource costs resulting from inefficiencies in the equilibrium allocation that arise in the presence of price and wage dispersion. 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 performed by all households j in all firms i :

$$N_t = \int_0^1 \int_0^1 n_t(i, j) di dj \quad (15)$$

as shown in the appendix of this paper, it follows that

$$N_t = s_t^p s_t^w \frac{C_t + G_t}{A_t} \quad (16)$$

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

2.7 Calibration

In the baseline version, the model is calibrated for a typical member country of the European Union with a sizable welfare system. The Calvo probabilities for price and wage rigidity are chosen to match the empirical findings of Druant et al. (2009). In their recent study on the Euro Area, the authors report an average lifetime of prices and wages of 9.6 and 12.5 months respectively (excluding the outlier Italy). The elasticity of substitution between different variations of goods and types of labor match the respective mark-ups estimated in Basu and Kimball (1997) and Chari et al. (2002). Steady state government spending of $\bar{G} = 0.2$ is also used in Evers (2012). The steady state size of the social security system \bar{ssb} amounts to 14.2% GDP, which is lower than the figures observed in Austria, Belgium, the Czech Republic, France, Germany and the Netherlands (see table 5 in the appendix). Together with government consumption, this implies a public spending ratio of 36%.

Regarding the exogenous processes for productivity and government spending, I follow Evers (2012) in using the standard parameter of 0.95 for ρ^A while calibrating ρ^G , σ^A and σ^G as to match empirically observed moments of government spending and output in the Euro Area.⁹ The resulting parameters

⁹His sample covers nine European countries (Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal and Spain) over the sample period 1999Q1 to 2007Q4. The author applied an HP filter with smoothing parameter 1600 on the data in logs. He reports standard deviations of output and government spending of 0.87 and 0.83 percent respectively.

are roughly in line with the ones used in his study which employs a related model. Turning to the specification of the social system, parameters ρ^{ssb} and σ^{ssb} are, as outlined above, used to target empirical observations of $\sigma(scr_t)$ and $\rho(scr_t, gdp_t)$ for Germany. Choosing $\rho^{ssb} = 0.95$ and $\sigma^{ssb} = 0.0007$ (implying a mean deviation of ssb_t of half a percent of its steady state value), the model generates $\sigma(scr_t) = 0.35\%$ (as observed for the statutory rate in Germany, see introduction) and $\rho(scr_t, gdp_t) = -0.4$. While this figure is in line with the observation for Germany by Burda and Weder (2014)¹⁰ (see table 4 in the appendix), the baseline assumption of exogenously fluctuating outflows is generalized in section 4.2 to account for a broad set of dynamic patterns in revenue adjustments.

Table 1: Baseline calibration

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 labour 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 s. 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 s. expenditures	0.0007	} Matches data: $\sigma(scr_t) = 0.35\%$ and $\rho(scr_t, gdp_t) = -0.4$
ρ^{ssb} persistence social s. expenditures	0.95	

¹⁰One drawback of using this data is that the moments are reported for a constructed measure of the SCR that is computed as the ratio of social security revenues to total labor compensation. Movements in this 'effective SCR' do not necessarily reflect changes in the statutory SCR (and thereby policy decisions to adjust revenues), but can also be due to caps to social security contributions. Since total labor compensation varies over the cycle, the share of contracts for which caps are binding is also cyclical. This affects total revenues and thereby the descriptive statistics of the 'effective SCR'. However, the example of Germany suggests that movements due to caps are not necessarily of major relevance. Figure 7 in the appendix plots trend deviations of the statutory SCR (not picking up the effect of caps) with deviations of the 'effective' SCR (picking up the effects of caps), showing a very strong co-movement

3 Nominal volatility and the liability side

This section develops the main intuition for the results. As agents in the model are fully rational, LSE holds in the context of labor taxation to the extent that prices and wages adjust. Regarding tax incidence, levying social contributions as wage tax on the side of workers is equivalent in the long run to the use of a payroll tax on the firm's side. By implication, neutrality also holds for all intermediate distributions of statutory taxation between both sides. That is, the elasticities of demand and supply determine one unique level of long-run after-tax real wages (referred to as \overline{RW}) that holds for all intermediate distributions.¹¹ As the real allocation in the long run is decoupled from the distribution between both sides, the only role of the distribution is to pin down a level of pre-tax real wages that implies \overline{RW} for this particular tax structure. It follows that in the deterministic steady state of the model, in which the flexible price/wage allocation holds, the real allocation is fully independent of how social contributions are split between both sides, while the split maps into real wages RW in the set $\{(RW, \tau^w) \mid (1 - \tau^w) RW = \overline{RW}\}$.

To see how this property emerges from the model structure, consider a stylized example in which after tax real profits and after-tax real labor income are governed by $Y - (1 + \tau^f) \frac{W}{P} N$ and $(1 - \tau^w) \frac{W}{P} N$ respectively. In an initial steady state, prices and wages have fully adjusted such that \overline{RW} prevails. Now let the statutory taxation be surprisingly and permanently shifted towards workers, i.e. $\tau^w \uparrow$ and $\tau^f \downarrow$. This change in the tax structure instantaneously increases profits and reduces labor income, because prices and wages do not adjust in real time due to nominal rigidity. However, in this model, nominal variables start to gradually re-adjust with a decline in prices and an increase in wages.¹² Both adjustments lead to an increase in pre-tax real wages, thereby revoking the immediate redistribution towards profit income caused by the shift in the tax structure. This adjustment holds on until \overline{RW} (and with it the initial level of after-tax real profits) is restored. Hence, the shift of taxation towards workers is neutral in the long run apart from raising pre-tax real wages.

The remainder of this section explains how the statutory breakdown of social contributions between both sides is, despite its apparent disconnect from real allocation, relevant for the business cycle volatility of prices and wages. The link between nominal volatility and welfare is discussed in section 4.

Again note that the argument I present in the following rests on the assumption that a public authority dynamically adjusts the SCR with the aim of influencing the revenue position of the social system. Adjustments can either be driven by variations in the amount of revenues that the authority seeks to raise,

¹¹In a strict sense, the unconditional expectation of after-tax real wages in the ergodic distribution depends on the breakdown of social contributions between both sides. The reason is that, as shown later on, production efficiency depends on the latter. However, this is neglected in the discussion of why LSE in the 'classical sense' holds in the model.

¹²Prices decline because $\tau^f \downarrow$ enters marginal costs and therefore reduces the optimal price in FOC (11). Wages increase because optimal wage setting (12) schedules a stabilization of after-tax real wages, implying nominal wages to rise in compensation for $\tau^w \uparrow$.

or aimed at offsetting disturbances in revenues caused by cyclical fluctuations in total labor compensation, the tax base of social contributions. To measure the size of these adjustments, it will prove convenient to define the 'funding gap' as the difference between the amount of funds the authority seeks to raise and the amount of funds that it would raise, for the given tax base, *if the SCR was not adjusted*. That is, the funding gap measures the absolute size of a revenue adjustment that is required to raise the desired amount of tax revenues for the given tax base. Using this measure, the assumption of this paper is that the funding gap is volatile.

The core finding of this paper is that shifting the statutory taxation towards workers lowers the volatility in the SCR that is implied by a given stochastic structure of revenue adjustments, i.e. of the funding gap. To illustrate this result, I first establish that the absolute size of a SCR adjustment that mirrors a given funding gap is declining in the steady state tax base. To this aim, the budget equation (13) is rewritten by splitting the variables into their steady state components (denoted by a bar) and deviations (denoted by a delta):

$$(\overline{scr} + \Delta scr_t) * (\overline{NW} + \Delta(NW)_t) = \overline{ssb} + \Delta ssb_t$$

where scr is $\tau_t^w + \tau_t^f$, with weights varying over different scenarios. The funding gap reads as $gap_t \equiv \Delta ssb_t - \overline{scr} * \Delta(NW)_t$, summarizing the two sources of adjustment.¹³ Subtracting the steady state relationship $\overline{scr} * \overline{NW} = \overline{ssb}$ and substituting the definition of gap_t yields

$$\Delta scr_t = gap_t [\overline{NW} + \Delta(NW)]^{-1}$$

which shows that the required adjustment Δscr_t mirroring a given funding gap gap_t is declining in steady state total labor compensation \overline{NW} .

This intuitively implies that a given dynamic structure in revenue adjustments can be brought about by smaller dynamic adjustments in the SCR if steady state total labor compensation is higher. That is, a given volatility in the funding gap translates into a smaller volatility in the SCR. This insight, combined with the fact that a shift of statutory taxation towards workers is neutral apart from inducing an offsetting rise in \overline{NW} , establishes the main intuition of this paper: Levying social contributions to a higher share on the side of workers has no long-run distributional consequences because of LSE, but implies that given revenue adjustments can be achieved with a more stable SCR.

To complete the link between the liability side and volatility of prices and wages, note that social contributions are part of effective production costs (as payroll tax), and determine after-tax wages for given pre-tax wages (as wage tax). As a result, fluctuations in the SCR trigger nominal re-adjustments, since they affect effective marginal costs in firms' FOC (11) (on the firms' side) as well as after-tax real wages in labor unions' FOC (12) (on the workers' side).

¹³Under a balanced budget, scheduled revenues are equal to outflows, so Δssb_t accounts for the first reason for a nonzero funding gap. $\overline{scr} * \Delta(NW)_t$ accounts for the second reason: Fluctuations in revenues due to disturbances in the tax base, given that the SCR is constant.

Shifting the statutory taxation towards workers therefore has two implications. It reduces the size of SCR fluctuations and thereby overall nominal volatility, while it also shifts the side where SCR fluctuations induce nominal readjustments towards wages.

So far, this section provided a simplified account of the mechanism to explain the intuition. However, a thorough quantitative analysis has to be conducting in a general equilibrium framework. The remainder of this section presents impulse response functions to shed light on the link between the liability side and volatility of prices and wages, accounting for general equilibrium repercussions.

General equilibrium analysis

This subsection contains three exercises, each contrasting the adjustment to an exogenous shock if the social system is funded by a wage tax (circled lines) with the adjustment occurring if it is funded by a payroll tax (solid lines). The first exercise is a reduction in social security revenues, proving the claim that a given revenue adjustment induces less movement in nominal variables if contributions are levied on the side of workers. The second and the third exercise shows the adjustment to a productivity and a demand shock respectively. All descriptions focus on fluctuations in nominal variables, since the link between the liability side and nominal volatility constitutes the predominant driver for the welfare results presented in the next section.

Exogenous change in social security benefits

The figure below shows the adjustment to an exogenous reduction of social security benefits in the magnitude of 1% GDP. Due to the balanced budget assumption, the negative realization of ϵ_t^{ssb} ceteris paribus causes a revenue adjustment in equal magnitude.

Before turning to the differences in the adjustment in both scenarios, notice that for the reason outlined above, the decline in the SCR required to lower revenues by 1% GDP is substantially weaker if they are collected from workers. We begin by examining the scenario of payroll taxes (no markers). The decline of the SCR directly reduces effective marginal costs, which leads firms to reduce prices and the central bank to respond by implementing a negative deviation of the real interest rate. Consumption and output surge as a result. Regarding the evolution of wages, we observe a decline in wage inflation but an increase in after-tax real wages. To understand this adjustment, recall that labor unions' FOC (12) schedules a stabilization of future after-tax real wages around a mark-up over future marginal rates of substitution. Since the strong decline in prices elevates after-tax real wages on a level above the one which is optimal for the equilibrium path of the MRS, labor unions reduce nominal wages. The adjustment of wage inflation has a hump-shaped form because this downward pressure on wages is at the beginning of the adjustment offset by the

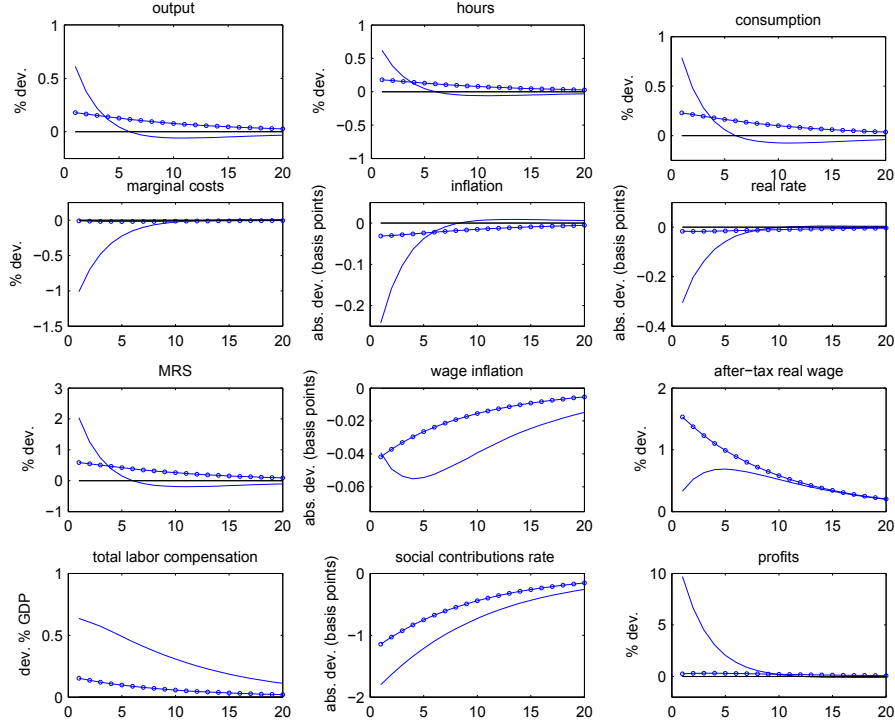


Figure 2: Reduction of social security benefits in the magnitude of 1% GDP. Solid lines: taxing firms vs. marked lines: taxing workers.

Turning to the adjustment under a wage tax (marked lines), we observe that the surge in output and hours is roughly one third of the magnitude as in the opposed scenario. This is because the reduction in the real rate is many times weaker, due to the fact that real marginal costs and prices do not decline nearly as much as in the adjustment under a payroll tax. This is for two reasons. The first is that a given decline in the SCR has a weaker effect on marginal costs if taxes are collected from workers. In this case, the reduction in the SCR does not directly enter marginal costs – as it is the case in under payroll taxes – but only affects marginal costs indirectly via slowly adjusting nominal wages. The second reason is that the magnitude of the decline in the SCR itself is smaller, from the reasoning outlined at the beginning of this section.

Concerning the adjustment of wages, we again observe a decline in newly set nominal wages but a rise in after-tax real wages. The explanation is similar to the one in the scenario of taxing firms: The reduction of payroll taxes (instead of a reduction of prices) pushes after-tax wages on a level exceeding the optimal one for the given path of the MRS. As a result, newly set wages are reduced to compensate for the reduction in the SCR.

Concluding with a comparison of the adjustment of nominal variables in both scenarios, we observe that the decline in prices is many times stronger under a payroll tax. Regarding wages, we also observe a larger negative deviation if taxes are collected from firms, although the difference between both scenarios is not nearly as great as for price inflation.¹⁴ The explanation why the decline in

¹⁴Accordingly, the implications of the statutory split for mean price dispersion are more

wage inflation is stronger under a payroll tax lies in the equilibrium path of the MRS. Only in this scenario it deviates negatively in the medium run, leading labor unions to adjust nominal wages downwards.¹⁵

Productivity disturbances

The next figure shows the adjustment to a positive productivity shock in the magnitude of one standard deviation.

Before discussing the implications of the liability side, we briefly discuss the economy's general adjustment to the shock. The reduction in marginal costs from the gain in productivity leads firms to lower prices, which in turn causes the central bank to implement a decline in the real interest rate. This causes households to increase consumption. Regarding output and hours, we observe that labor demand, and with it hours, decline despite the surge in production because the gain in productivity reduces the amount of hours required per unit of output. The MRS deviates positively for about 1.5 years because the decline in marginal utility overcompensates the decline in the disutility of labor. In their decision on newly set wages, labor unions take into account this increase in the MRS as well as the decline in consumer prices. As the latter dominates, we observe a decline in wage inflation. Regarding real wages, the drop in prices overcompensates the gradual decline of nominal wages, implying a positive deviation.

With increasing total labor compensation, the SCR has to decline to maintain a balanced budget for constant outflows of security program. In line with the explanation at the beginning of this section, holding revenues constant requires the SCR to drop by more under the taxation of firms, because the steady state tax base is smaller. Notice that the effect on nominal variables originating from the productivity shock and from the resulting adjustment in the SCR have the same sign, i.e. they complement each other. In accordance with the discussion of the previous exercise, the decline in prices is significantly stronger under a payroll tax, while the implication of the liability side for wage inflation has the same direction but is smaller in magnitude.

important in the welfare analysis than its implications for mean wage dispersion.

¹⁵In explaining this path of the MRS, we start with the observation that price inflation deviates positively from period 7 on. This inflation leads the central bank to raise the real interest rate and thereby to lower consumption and output, which drags the MRS below its steady state value during the late phase of the adjustment.

The positive deviation of inflation from period 7 has to be due to an increase in marginal costs (barely visible in the plot), which constitute pre-tax real wages since the firm pays no taxes in this scenario. The reason why we only observe a sustained increase in pre-tax real wages under the collection of taxes from firm is the strong initial deflationary impulse occurring in this case. This short-lived impulse pushing up real wages has a sustained impact because nominal wages do only adjust sluggishly. Hence, in the late stage of the adjustment, the remaining positive deviation of real wages is gradually dismantled by negative wage inflation and positive price inflation. In the opposed scenario of a wage tax, the deflationary impulse is comparably negligible while the initial decline in the SCR pushing up the after-tax real wage has no direct effect on marginal costs.

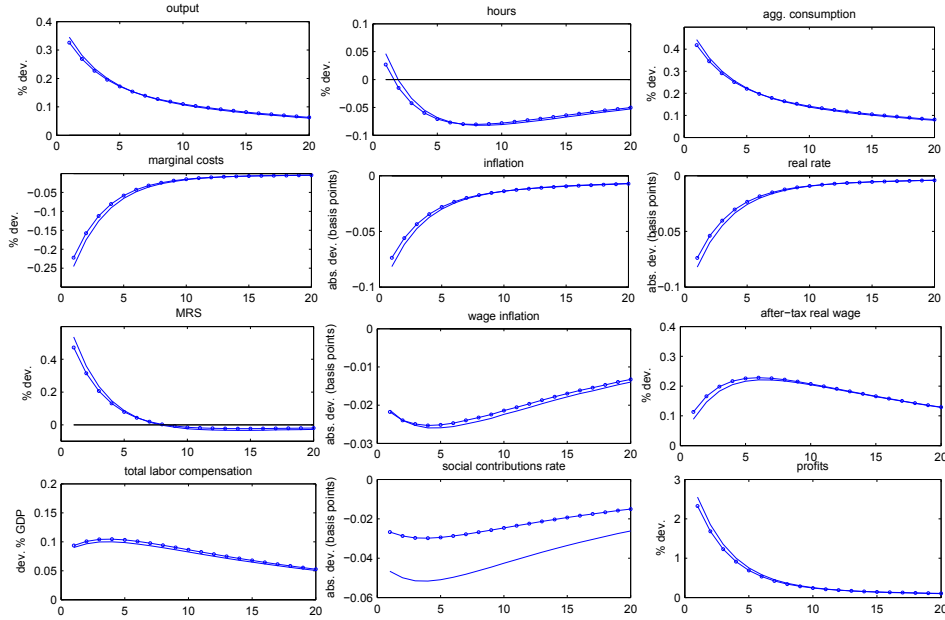


Figure 3: Positive one STD productivity shock.
 Solid lines: taxing firms vs. marked lines: taxing workers.

Demand disturbances

The next figure shows the adjustment to a positive government spending shock in the magnitude of one standard deviation. Regarding the general adjustment, we observe that the bulk of additional government consumption is covered by a surge in output, which implies a very mild consumption crowding out. This is due to wage rigidity: As nominal wages slowly adjust 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 reduces the strength of the resulting contractionary monetary policy stance, i.e. of the driving force of consumption crowding out. The output expansion implies an increase in total labor compensation which requires a downward adjustment of the SCR.

Under taxation of workers, marginal costs are only affected by the growth in nominal wages resulting from the surge in disutility of labor. The emerging inflationary pressure leads the central bank to implement a rise in the real rate, causing consumption to decline. The adjustment of real marginal costs is substantially different if social contributions are collected as a payroll tax. In this case, the reduction in the SCR overcompensates the rise in nominal wages at the beginning of the adjustment, leading to the hump-shaped path of inflation. The resulting monetary policy causes consumption to decline in a hump-shaped

manner as well.

In the context of demand disturbances, no clear-cut picture arises on which liability side is more favorable in terms of reducing nominal volatility. The welfare analysis will show that using a wage tax slightly reduces the volatility of prices and wages, but in an insignificant magnitude.

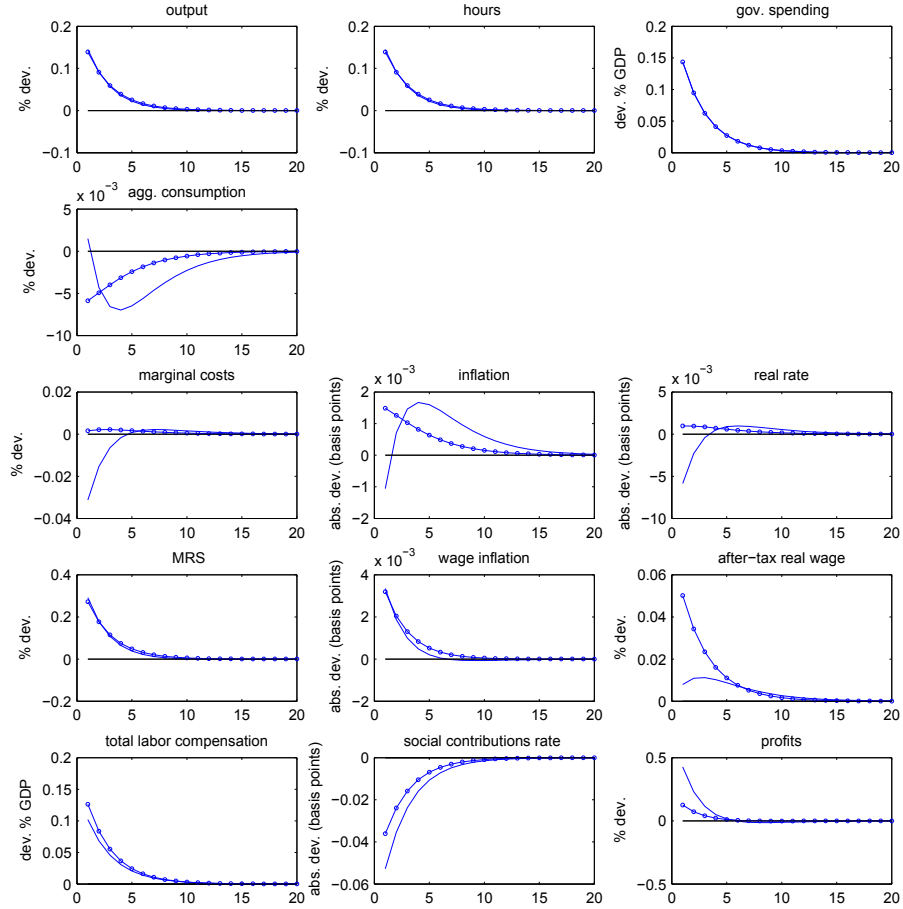


Figure 4: Positive one STD government spending shock.
Solid lines: taxing firms vs. marked lines: taxing workers.

4 Welfare analysis

This section compares welfare costs of business cycle fluctuations arising if social contributions are levied from workers with the costs arising if they are levied from firms. Welfare costs are measured by ν , the consumption compensation for business cycle fluctuations. If consumption in the deterministic steady state is changed by ν percent, the agent is as well off in the deterministic steady state as in the ergodic distribution of the model.¹⁶ This commonly applied measure goes back to Lucas (1987) and Lucas (2003). Welfare is defined as the discounted sum of future and present flow utility, so it holds that

$$\mathbb{E} \sum_{t=0}^{\infty} \beta^t U(c_t, n_t) = \sum_{t=0}^{\infty} \beta^t U((1 + \nu) \bar{c}, \bar{n}) \quad . \quad (17)$$

That is, the unconditional expectation of the agent's welfare in the ergodic distribution of the model (LHS) equals his/her welfare in the deterministic steady state of the model, given that consumption is scaled down by ν (RHS).

Following Evers (2012), Taylor-Approximations are applied on both sides to express ν as a function of first and second moments of the ergodic distribution. This allows to decompose the total welfare loss arising from business cycle fluctuations into its components.¹⁷ That is, it is dismantled into the contributions of volatility effects (volatility in consumption and hours in the ergodic distribution) and level effects (unconditional expectations of consumption and hours in the ergodic distribution differ from their deterministic steady state values).

As shown by Kim and Kim (2003), meaningful welfare analyses require a second-order accurate approximation to the system of equations. To obtain second-order accurate population moments that I use for the welfare function, the equilibrium conditions are not linearized but written in a recursive form as in Schmitt-Grohé and Uribe (2007). Then, Dynare is used to apply a second-order accurate perturbation method. Since welfare analyses require a high degree of accuracy, I do not conducting simulations but apply the nonlinear moving average method by Lan and Meyer-Gohde (2013) to obtain population moments analytically.¹⁸

In the following, I compute consumption compensations $\nu^{\text{wage tax}}$ and $\nu^{\text{payroll tax}}$ that arise if social contributions are fully levied as wage tax respectively as payroll tax. Comparing welfare costs arising under both liability sides is only meaningful if the welfare in both ergodic distributions is compared to the same level of welfare in the deterministic steady state. That is, $\nu^{\text{wage tax}}$ and $\nu^{\text{payroll tax}}$ can only be compared if they are computed with the same deterministic steady state as reference point. This is given for exercise at hand because LSE holds

¹⁶As the agent suffers from stochastic in the model, consumption in the deterministic environment has to be scaled down, so the sign of ν is negative.

¹⁷The functions and details on their derivation are provided in the appendix.

¹⁸The Dynare add-on provided by the authors does not directly report variances around deterministic steady state values, as required to compute consumption compensations. The required statistics can easily be recovered from the output of the software. Details are available upon request.

in the model and implies that the flexible-price allocation prevailing in the deterministic steady state is identical under both liability sides.

4.1 Welfare results for the baseline model

This subsection reports welfare results for the baseline model with exogenously fluctuating social security benefits. The table shows welfare costs of fluctuations and moments of selected macro aggregates in dependency of the liability side. Columns labeled 'workers' ('firms') report figures arising if social contributions take the form of a wage tax (payroll tax). In addition to the full stochastic setup, the results are also reported for productivity and demand disturbances in isolation.

Table 2: Welfare costs of fluctuations, baseline model

	Both shocks			Only productivity shocks			Only Demand 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:									
mean cons.:	-0.1458	-0.1582	-15.58	-0.1455	-0.1580	-15.64	-0.0016	-0.0039	-246.70
mean 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 ^X	0.2720	0.3054	12.29	0.2720	0.3053	12.27	0.0008	0.0100	1229.78
Mean disp. labor types ^X	0.1453	0.1537	5.78	0.1452	0.1536	5.79	0.0011	0.0031	175.54

*Changes are reported in units per mill.
^XDispersion terms are reported as deviations from one in units per mill.

Before turning to the implications of the liability side, this section makes two general observations, one regarding the predominant source of the welfare losses and one regarding how they originate from the model structure. Concerning the source, first notice the relative importance of volatility and level effects. As apparent in the welfare decomposition, the contributions of volatility in consumption and hours to total business cycle costs are negligible compared to the contributions of the level effects. Next notice that the welfare costs originating from demand shocks are negligible relative to the costs stemming from productivity shocks.¹⁹ This allows us to focus in the following discussion

¹⁹This is well compatible with the arguing provided in this section, which ultimately at-

on the level effects brought about by productivity disturbances.

Regarding these level effects, we observe that stochastics in the model cause the household to consume less and work fewer hours, resulting in a welfare reduction (the loss from consuming less is roughly twice as large as the gain from reducing working hours). This is due to a decline in productivity in the stochastic environment, which can be traced back to volatility in price and wages. The well-known chain of reasoning starts with the observation that nominal re-adjustment, on the side of good producers and labor unions, is accompanied by dispersion among prices and wages. Since under Calvo rigidity only a random share of firms and unions is allowed to re-adjust prices and wages in a given period, the willingness to do so causes newly set prices and wages to differ from non-adjusted ones. While price dispersion causes households to consume differing quantities of different good variations, wage dispersion leads firms to employ varying amounts of different types of labor. As a result, Jensen's Inequality applies for aggregators (2) and (6). This implies an efficiency loss, as a higher amount of good variations is required to bundle one unit of the final good, and more total labor is required to bundle one unit of the labor composite. The loss in efficiency manifests itself in the emergence of resource costs in the aggregate resource constraint (16).

Now we turn to the discussion of the main result of this paper, the implications of the liability side for welfare costs of business cycle fluctuations. If the social system is financed by a payroll tax, these costs are by 11.25% higher than if the system is funded by a wage tax. To understand this finding, first note that the results validate the intuition that a wage tax implies a more stable SCR, which in turn leads to more stable prices and wages: Under the use of a wage tax, the volatility in the SCR is by 35.78% smaller, leading to a reduction of the standard deviations of price and wage inflation by 5.99% and 2.87% respectively.²⁰ In accordance with the explanation above, a decline in price and wage volatility reduces the expected magnitudes of price and wage dispersion by 12.29% and 5.78%. As dispersion among prices and wages was shown to be the main driver for the welfare loss of business cycle fluctuations, the latter are smaller if the social system is funded by a wage tax.

Up to this point, I have compared the use of a wage tax with the use of a payroll tax. Figure 7 in the appendix considers intermediate cases by plotting the total welfare loss and the standard deviation of the SCR in dependency of the statutory breakdown of social contributions between firms and workers. It shows that both variables depend almost linearly on the statutory breakdown.

tributes the welfare loss to nominal volatility. Comparing the IRFs of productivity and demand shocks shows that the movement in prices and wages induced by productivity shocks is at least ten times larger.

²⁰The fact that price volatility declines by more than wage volatility is in line with the IRFs presented in section 3.

4.2 Generalizing the dynamics of the funding gap

While the dynamic pattern of revenues adjustments in the baseline calibration is empirically plausible for Germany, this subsection generalizes the analysis by considering a broad set of dynamics. This allows to build additional intuition for the result, and to relate the quantitative findings also to different countries.

As described in section 2.4, dynamic patterns of revenue adjustments are generated by modeling variability in outflows ssb_t , which has otherwise no consequence in the model. To be able to generate a broad set of patterns of revenues adjustments (along the dimensions of volatility and correlation with output), this section abandons the assumption of exogenously fluctuating outflows and instead establishes an ad-hoc link between ssb_t and output.²¹ To this aim, η_t (the time-variant component of ssb_t in equation (14)) is governed by

$$\eta_t = \rho^{ssb} \eta_{t-1} + \alpha \epsilon_t^{ssb} + \beta \epsilon_t^A \quad (18)$$

where ϵ_t^A is the innovation of the process for technology entering production function (5). Since productivity disturbances are the predominant driver for business cycle fluctuations in the model, α and β govern the sign and the strength of the dynamic link between outflows and output. Varying the two parameters therefore allows to cover a broad set of dynamic patterns in revenue adjustments.²²

The plot below shows welfare results (i.e. the percentage reduction in welfare costs resulting from a full shift of taxation from firms to workers) in dependency of the dynamic pattern of revenue adjustments, characterized by their volatility and their correlation with output. For the reasons outlined in section 2.4, dynamic patterns are identified by the moments $\sigma(scr_t)$ and $\rho(scr_t, gdp_t)$ of SCR adjustments that arise under equal taxation of both sides.²³

²¹From the reasoning of section 2.4, the ad-hoc nature of the dependency is of no consequence for the results, as outflows have no role in the model.

²²To shed light into how this specification of η_t allows to determine the correlation of the revenue gap and output, this footnote contrasts the cases of $\beta > 0$ and $\beta < 0$. $\beta > 0$ links output fluctuations to rectified fluctuations in social security benefits (ϵ_t^A causes output and ssb_t to move in the same direction). This reduces the cyclical surplus of the system that is implied by the cyclical surplus of the tax base, and thereby the resulting negative correlation between SCR and output. E.g. in a recession, output and the tax base decline, implying *ceteris paribus* an upward-adjustment in revenues. The size of this adjustment is smaller if ssb_t drops at the same time. In contrast, $\beta < 0$ strengthens the cyclical surplus of the system, since ϵ_t^A moves output and outflows in opposed directions. E.g. in a recession, the decline in the tax base is accompanied by an increase in outflows, which requires a stronger upwards-adjustment in revenues. This elevates the negative correlation between output and the SCR stemming from the cyclical surplus of the tax base.

Hence, α and β govern the direction of the co-movement of ssb_t and outflows, as well as the relative weight of independent variations (via ϵ_t^{ssb}) and variations linked to the cycle (via ϵ_t^A). This allows to determine the dynamic pattern of revenue adjustments along the dimensions of their volatility as well as their correlation to output fluctuations.

²³The plot does not consider positive correlations between SCR and output because they are of minor empirical relevance according to the findings of Burda and Weder (2014).

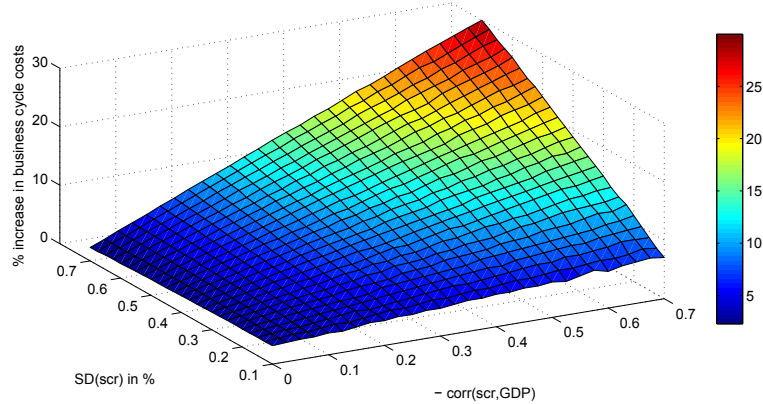


Figure 5: %-increase in welfare costs of business cycle fluctuations from full shift of taxation from workers towards firms.

The dynamic patterns of revenue adjustments observed in specific countries correspond to positions on the grid. Using the data from table 4 and 6 for observed SCR dynamics (mirroring revenue adjustments) and data from table 5 for the statutory breakdown of payroll taxation indicates that there is room for substantial welfare gains in many OECD countries. For example, the feasible reduction of business cycle costs in Germany, France, Belgium and Austria amount to roughly 7%, 6%, 8% and 5% respectively.

The plot also allows to build additional intuition for the mechanism driving the results. The two observations that I explain in the following are firstly that the welfare gain increases in $\sigma(scr_t)$ (i.e. in the volatility of the underlying funding gap) for a given $\rho(scr_t, Y_t)$, and secondly that the gain increases in $-\rho(scr_t, Y_t)$ for a given $\sigma(scr_t)$. The first observation is straightforward to explain. If required adjustments in the SCR are stronger, the contribution of SCR adjustments to total nominal volatility is higher. It follows that a proportionate reduction of nominal volatility stemming from this source (induced by shifting the taxation) has a stronger impact on overall nominal volatility and thereby welfare costs.

To understand the second observation, it is useful to distinguish between the following two driving forces of movement in nominal variables: While most of the movement is driven by exogenous disturbances (predominantly productivity shocks), another portion of movement in prices and wages is due to adjustments of the SCR. Now reconsider the IRFs presented in section 3 to learn about how the impulses on prices and wages originating from both sources are related. Figure 3 shows that productivity disturbances push output in the opposed direction than prices and wages,²⁴ while figure 2 shows that movements in the SCR exert, independently of the liability side, a rectified impulse on prices and wages.

²⁴In this figure, the adjustment to the shock is accompanied by an adjustment in the SCR. However, the SCR change has a small influence on the overall adjustment relative to the productivity shock and can be neglected in the context of the statement.

This observation allows to understand why the welfare gain increases in the direction of $-\rho(\text{scr}_t, Y_t)$. Consider first the limiting case of $\rho(\text{scr}_t, \text{gdp}_t) = 0$. This implies that the impulse on nominal variables resulting from productivity shocks (assumed to be the online driver of output fluctuations for the sake of the argument) is not correlated with the impulse stemming from SCR adjustments. Hence, both impulses are as likely to cancel each other out as they are likely to complement each other. Reducing the magnitude of impulses from SCR changes (by changing the liability side) does therefore also reduce the magnitude of offset if both impulses happen oppose each other. This undesirable side effect reduces the reduction in total nominal volatility that can be achieved by switching the liability side. That does not apply in the other limiting case of $\rho(\text{scr}_t, \text{gdp}_t) = -1$. As we know from the inspection of the IRF, if productivity shocks (driving GDP) and SCR adjustments are negatively correlated, the associated impulses on nominal variables are positively correlated. It follows that offset between both impulses has a probability of zero. Hence, limiting the size of impulses originating from SCR changes does not entail a reduction in the degree of possible offset. Inspecting the two extreme cases shows that the reduction in nominal volatility (and thereby the welfare gain) that can be induced by shifting taxation is larger the less likely it is for both impulses to oppose each other, i.e. the higher the negative correlation between SCR and output.

5 Robustness analysis

This section examines the sensibility of the results to parameter choices. While table A replicates the results from the baseline calibration depicted in figure 5 above, the remaining tables report the results for modifications of the model.

Table 3: Robustness exercises

		Baseline calibration								A: Avg. lifetime prices and wages of one year							
		SD(scr_t)								SD(scr_t)							
		0.1	0.2	0.3	0.4	0.5	0.6	0.7			0.1	0.2	0.3	0.4	0.5	0.6	0.7
$-\text{corr}(\text{scr}_t, \text{GDP}_t)$	0.1	3.7	4.2	4.7	5.2	5.6	6.0	6.3	$-\text{corr}(\text{scr}_t, \text{GDP}_t)$	0.1	3.2	3.8	4.4	4.8	5.4	5.6	6.2
	0.2	4.2	5.2	6.7	7.5	8.5	9.5	10.4		0.2	3.7	4.6	6.2	7.0	8.2	9.0	10.2
	0.3	4.7	6.2	8.3	9.9	11.5	12.9	14.5		0.3	4.2	6.5	7.6	9.4	10.9	12.4	13.9
	0.4	4.6	7.9	9.5	11.6	14.3	16.5	18.1		0.4	5.3	7.3	9.7	12.0	13.7	15.8	17.9
	0.5	6.3	8.8	11.6	14.0	16.9	19.6	22.5		0.5	5.2	8.2	11.0	14.2	16.2	18.8	21.7
	0.6	6.3	9.8	12.9	16.4	20.1	22.8	25.9		0.6	6.3	9.7	12.8	16.2	19.3	21.9	25.6
	0.7	7.3	11.3	15.4	18.5	22.4	26.5	28.9		0.7	6.2	11.2	14.1	18.3	21.5	25.6	27.1
		B: Less responsive monetary policy								C: Smaller social security system							
		SD(scr_t)								SD(scr_t)							
		0.1	0.2	0.3	0.4	0.5	0.6	0.7			0.1	0.2	0.3	0.4	0.5	0.6	0.7
$-\text{corr}(\text{scr}_t, \text{GDP}_t)$	0.1	3.8	4.3	4.7	5.0	5.3	5.6	5.8	$-\text{corr}(\text{scr}_t, \text{GDP}_t)$	0.1	3.2	3.7	4.1	4.6	4.9	5.4	5.7
	0.2	4.2	4.8	6.0	6.5	7.4	8.1	8.8		0.2	3.6	4.6	5.7	6.9	8.0	9.0	9.6
	0.3	4.6	6.2	7.0	8.3	9.4	10.5	11.7		0.3	4.1	5.5	7.5	9.2	10.9	12.5	13.3
	0.4	5.4	6.8	8.5	10.1	11.4	13.0	14.5		0.4	4.6	7.1	9.5	11.6	14.1	15.9	17.5
	0.5	5.3	7.5	9.4	11.7	13.7	15.5	17.1		0.5	5.1	8.6	11.4	13.7	16.5	19.8	22.2
	0.6	6.1	8.6	10.8	13.2	15.3	17.7	19.9		0.6	5.6	9.5	12.5	16.5	19.5	22.8	26.6
	0.7	6.0	8.8	12.1	15.1	17.4	19.7	19.7		0.7	6.1	11.5	14.3	18.5	22.3	25.0	25.0

Exercise A: Avg. lifetime of prices and wages of one year

Calvo-Probabilities of price and wage adjustments are set to $\theta = \theta_w = 0.75$, implying an average lifetime of prices and wages of one year. Relative to the baseline calibration prices are more sticky, whereas wage rigidity is almost identical. The welfare difference between the outcomes under the taxation of firms and workers shrinks to a small extent, not qualitatively changing the results. The reason is that the difference whether changes in the SCR enter marginal costs directly (if firms are taxed) or via slowly adjusting wages (if workers are taxed) matters less for the volatility of inflation if prices are more sticky.

Exercise B: Less active monetary policy

The assumption of independent monetary policy maintained in the baseline version of the model is odd for countries belonging to the European Monetary Union. While a thorough analysis requires an open-economy setup – which is a promising direction for further research – this robustness exercise seeks to draw near this analysis by reducing the responsiveness of monetary policy. In this exercise the model represents a country of the EMU core region defined as Germany, France, Austria, Belgium and the Netherlands. As the size of the social system exceeds 14% GDP in all of these countries (see table 5 in the appendix), they well match the calibration for sizable welfare states. With a total population of 183.12 million, this set covers more than half of the population in the Eurozone and has, according to the ECB’s 2014 HICP country weights, a weight of 60.2% in the average inflation measure.

From the perspective of an individual Eurozone country, the responsiveness of monetary policy to the domestic macroeconomic environment does not only depend on the size of this country, but also on the synchronization between this country’s and other Eurozone countries’ business cycles.²⁵ A large majority of the studies on European business cycle synchronization (surveyed e.g. by de Haan (2008) and Jones et al. (2012)) find a high degree of synchronization across the EMU core counties, which in all studies include Germany, France and Austria.²⁶ On the background of these empirical findings, this robustness exercise treats the EMU core as one country entering the measure of union-wide inflation with a weight of 60.2%.²⁷ The adjustment in this exercise consists of adapting the active portion of monetary policy (i.e. the change of the nominal interest rate exceeding the inflation rate) to the weight of the EMU core. Given

²⁵In the limiting case of perfect synchronization between all member countries, a union-wide monetary policy could not be distinguished from the individual conduct of monetary policy in all member countries.

²⁶This is in line with the classic study of Bayoumi and Eichengreen (1994) who found that the set defined as EMU core in this exercise is a suitable candidate for a currency area because of the high correlation of supply shocks across these countries.

²⁷Equivalently, one can think of the model to represent one country belonging to the set under the assumption of perfect correlation of inflation rates.

that the baseline calibration features the standard inflation coefficient of 1.5, the responsiveness of monetary policy to inflation in the EMU core amounts to $\alpha_{core}^{\pi} = 1 + 0.5 * 0.602 = 1.301$. Panel C shows that the results become slightly weaker, but do not change qualitatively.

Exercise C: Smaller social security system

Reducing the steady state size of the social security system to 10% GDP (i.e. $\overline{ssb} = 0.09$) only causes a slight reduction of the relevance of the liability side. However, notice that the dynamic properties of the SCR were held constant in this exercise.

6 Conclusion

This paper is the first to examine LSE of labor taxation in a general equilibrium model. It augments the 'classic' notion of LSE by the insight that the liability side of labor taxation matters for the volatility of prices and wages and thereby for the welfare costs of business cycle fluctuations. It employs a standard DSGE model calibrated for a member state of the Eurozone featuring empirically plausible SCR dynamics to quantify this finding. The result is that a full shift of social contribution from firms to workers reduces the standard deviation of prices and wages by 5.99% and 2.87%, implying a reduction in the welfare loss of 11.25%. Improving the design of a social system along this dimension constitutes a Pareto improvement, given that the one-time change in the tax structure is accompanied by a compensating rise in wages. From the perspective of a policymaker, this result is of relevance since the implementation of the Pareto improvement does not require to dispose public funds, and does not interfere with the property of social systems to provide stabilization in a Keynesian fashion.

Regarding real-world applicability, the findings of this study have to be taken with a grain of salt. While the structure of the model is sufficiently rich to allow for the mechanism that gives rise to the macroeconomic relevance of the statutory split, it is hardly encompassing enough to provide a realistic account of European economies. There are several modeling dimensions which are presumably relevant for the results, and therefore constitute a promising direction for further research. Introducing credit constrained Rule-of-Thumb consumers who do not earn profit income as in Galí et al. (2004) would allow to account for short-term redistribution in the course of unanticipated SCR changes. This would affect aggregate demand via the different propensities to consume between both groups. Further extensions of potential interest are the inclusion of capital, as well as allowing for trade in an open economy setup. The latter generalization is especially interesting if the model represents a member country of a monetary union. Since the literature on optimal currency areas identifies price stickiness as the root for the costs of belonging to a union, the liability side with its impact on price setting is of potential relevance in this context.

7 Appendix

Derivation of (16):

Starting with

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

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

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

since 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

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

Derivation of welfare Functions:

The sum on the LHS of equation (17) 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, (17) can be written as

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

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

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

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

where the bar denotes variables of 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

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

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

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

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
United Kingdom	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:

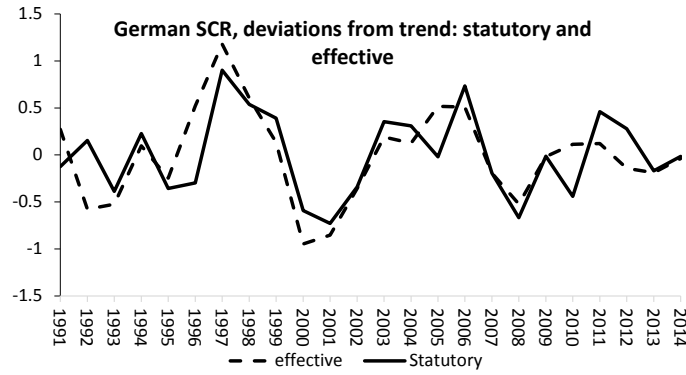


Figure 6: German SCR, statutory and 'effective' as computed in Burda and Weder (2014), deviations from trend.

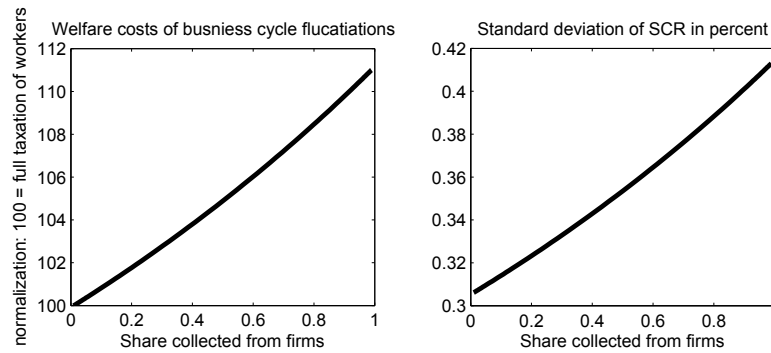


Figure 7: Functional form of the dependency of welfare costs and $\sigma(\text{scr})$.

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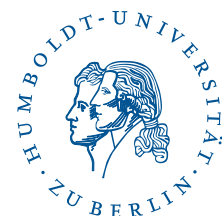
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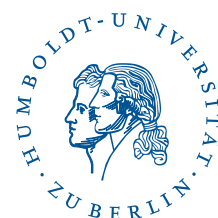
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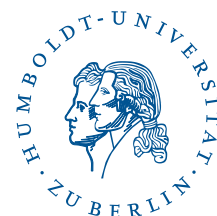
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