# Payroll Taxes, Social Insurance and Business Cycles

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November 18, 2014

*Keywords*: business cycles, payroll taxes, consumption-tightness puzzle, unemployment, labor market wedge. *JEL Classification*: E24, J64, E32. We are grateful to the editor Marios Angeletos and four referees of this journal, Robert Barro, Monique Ebell, Chris Edmond, Francisco Gonzalez, Bob Gregory, Dan Hamermesh, Tom Krebs, Nir Jaimovich, François Langot, Ian McLean, Christian Merkl, Alex Meyer-Gohde, Javier Perez, Bruce Preston, Dennis Snower, Lutz Weinke, Jake Wong, Randall Wright as well as seminar participants at Adelaide, ANU, Bonn, CEMFI, Cologne, Deakin, Humboldt, Kiel, Leipzig, Mannheim, McGill, Melbourne, Milwaukee, Tübingen, Utrecht, EALE/SOLE, MMF, Search and Matching Network Conference in Glasgow, and SWIM for useful comments and discussions. Anna Almosova, Patrick Bunk, Hong Lan, Femke Schmarbek and Susanne Schöneberg provided excellent research assistance. The authors acknowledge generous support from the Alexander von Humboldt Foundation (AUS/1132996), the Australian Research Council (DP1096358), the Netherlands Institute of Advanced Study, and the Collaborative Research Center 649 of the German Science Foundation.

## Abstract

Payroll taxes represent a major distortionary influence of governments on labor markets. This paper examines the role of time-varying payroll taxes and the social safety net for cyclical fluctuations in a non-monetary economy with labor market frictions and unemployment insurance, when the latter is only imperfectly related to search effort. A balanced social insurance budget induces countercyclical payroll taxation, renders gross wages more rigid over the cycle and strengthens the model's endogenous propagation mechanism. For conventional calibrations, the model generates a negatively-sloped Beveridge curve and countercyclical unemployment as well as substantial volatility and persistence of vacancies and unemployment.

# 1 Introduction

Payroll taxes represent a major influence of governments on labor markets. In 2011, OECD member governments collected about \$3.8 trillion from employers and employees, representing 9.1% of GDP and, given a wage share of two-thirds, roughly 15% of the total wage bill. In some European countries, the share of "contributions to social insurance" in total compensation is as high as 40%-45% percent.[1] Payroll taxes drive a wedge between hiring decisions of firms and labor supply decisions of households, and are likely to spur the untaxed, informal economy. A less-studied aspect is the effect of time-varying labor taxation on intertemporal decisions of employers and employees. Not only do payroll taxes impact the long-run functioning of labor markets and the macroeconomy, but they may also affect the magnitude and persistence of business cycle fluctuations.

This paper investigates the interaction of payroll taxes, the social insurance system and the business cycle. We begin with an empirical examination of the cyclical behavior of payroll taxation in advanced economies. We find that the payroll tax burden is countercyclical in a number of countries: employer and employee contributions to social insurance, measured relative to the total wage bill, tend to fall in recoveries and rise in recessions. This countercyclical labor tax burden arises for at least two reasons. First, most OECD governments rely on payroll taxation to fund their social welfare systems, in particular unemployment insurance, and this is frequently done on a near-balanced budget basis. Second, payroll taxation is usually capped, implying a relatively higher effective rate of taxation for low-productivity workers.

We study the effects of countercyclical payroll taxation in an equilibrium

[1] Source: OECD Revenue Statistics 2013 and OECD Factbook 2011-2012.

business cycle model with labor market frictions. We show that in this class of models, the elasticity of search activity on both sides of the market is influenced by the intertemporal path of the wedge between labor costs paid by firms and income received by households. The sensitivity of the tax burden to cyclical conditions reinforces the intertemporal response of labor market activity and increases the endogenous propagation of shocks in the model economy. By distinguishing between search and leisure, we break the link between non-working time and active search and create an additional margin for time use. There are two other features central to the model: unemployment benefits are financed by payroll taxation on a balanced budget basis and unemployment benefit provision is only imperfectly related to search effort.[2] This latter is due to social welfare payments in the model economy, which can also be thought of as "Type II" classification error – paying unemployment benefits to individuals who are in fact enjoying leisure. Combined with the endogeneity of labor taxation, these effects significantly distort the labor-search-leisure decision and increase the internal propagation of the model economy.

Models with labor market frictions have proliferated in recent years, but exhibit shortcomings in matching real data. Tripier (2003), Veracierto (2008), and Ravn (2008) show that with endogenous participation, the search model predicts a counterfactually positively-sloped Beveridge relation and procyclical unemployment. Shimer (2005) and Hall (2005) showed that such models generally do not generate sufficient volatility and persistence of labor market quantities, i.e. vacancies and unemployment.[3] Gartner, Merkl and Rothe

[2] Tripier (2003), Ravn (2008) and Ebell (2009) examine similar setups, but they do not examine the impact of unemployment benefit on the search-leisure margin and do not consider unemployment benefits financed by distortionary payroll taxation.

[3] Wage rigidity, high fallback positions, low workers' bargaining power and overlapping Nash-bargained wage contracts have been proposed to solve the puzzle (see Hagedorn and Manovskii, 2008, Cole and Rogerson, 1999, and Gertler and Trigari, 2009). However,

(2012) point out that for Western European economies, in particular Germany, the "Hall-Shimer puzzle" is even more pronounced than in the US. The central finding of this paper is that the interaction of endogenous payroll taxation with the social insurance system increases the stability of gross labor costs in a real equilibrium business cycle model, thereby better matching key macro stylized facts, which include high cyclical volatility of labor market quantities, persistence in vacancies and unemployment, and negative correlation of vacancies and unemployment (the Beveridge curve). Time-varying payroll tax burdens affect the both cost of labor and the value of vacancies to the firm, as well as the value of time spent by workers in search. This intertemporal effect of payroll taxation on equilibrium models of unemployment is also a novel finding. Furthermore, when the time intensity of search is endogenous, booms lead to more participation, more matches, more employment and lower payroll burdens than in the case of a fixed search intensity. This complementarity is an important feature which enables our model to account better for various labor market puzzles than the standard setup with endogenous taxation alone.

In Section 2, we document the level and intertemporal behavior of payroll taxation in the major OECD countries. For most Western European economies, effective payroll taxes are significantly countercyclical; in the United States, a similar pattern has emerged since the late 1980s. Section 3 presents and studies a nonmonetary dynamic stochastic general equilibrium economy with a social insurance system, unemployment benefits and endogenous search. In Section 4, we calibrate the model and present our central finding: a productivity-driven real equilibrium economy with search frictions can account for key labor market facts and generate a pattern of counter-

Hornstein, Krusell and Violante (2005) and Costain and Reiter (2008) show that despite their successes, these models continue to exhibit a number of undesirable properties.

cyclical payroll tax burdens observed in many OECD countries. Robustness checks and more detailed interpretation of the results are laid out in Sections 5 and 6. Section 7 concludes.

# 2 Payroll Taxes in the OECD

## 2.1 Magnitude of payroll taxes

Payroll taxation represents a significant, yet frequently overlooked intervention in labor markets in developed economies. The first two columns of Table 1 provide a longer-term perspective. The payroll tax rate $\tau$ is defined as the ratio of "contributions to social insurance" divided by total compensation of employees, and represents the average burden posed by payroll taxes and similar payments as a fraction of total labor costs paid by firms. Contributions to social insurance consist of payments by firms or employees for pension, health, unemployment and disability insurance, and related programs. Total compensation is the sum of gross wages, salaries and contributions to social insurance. Our data are taken from the OECD Economic Outlook and Main Economic Indicators databases.

The average effective payroll tax rate varies widely in OECD countries, ranging from 5-15% of the wage bill in Australia, Canada, Finland and the US to 30% or more in Belgium, France, Germany, Italy and Spain. Over the four decades of data available, they have risen secularly in almost all countries. At the same time, they fluctuate around their respective trends, with standard deviations of less than 0.2-0.3 percentage points in the US, Austria and Canada to 0.4% in France, Germany, and Spain, and more than 0.5% in Greece, Italy, Sweden and the Netherlands. Such fluctuations of tax burdens are likely to be important for labor markets, not only in continental Europe, but also in the United States.

| **Table 1:** Payroll taxes in OECD countries, 1970-2012 | | | | | |
|---|---|---|---|---|---|
| *Country* | Ratio of payroll taxes to total compensation, $\tau$ | | Correlation of annual payroll tax rate with GDP* | | |
| | 1970-89 | 1990-2012 | 1970-1989 | 1990-2012 | 1970-2012 |
| Germany | 0.28 | 0.34 | -0.59 | -0.48 | -0.52 |
| Sweden | 0.24 | 0.29 | -0.47 | 0.42 | 0.15 |
| France | 0.37 | 0.41 | -0.14 | -0.33 | -0.26 |
| Netherlands | 0.31 | 0.29 | -0.20 | 0.14 | 0.02 |
| UK | 0.22 | 0.26 | 0.29 | 0.10 | 0.20 |
| Denmark | 0.09 | 0.16 | -0.04 | 0.21 | 0.15 |
| Finland | 0.14 | 0.15 | -0.63 | -0.15 | -0.25 |
| Japan | 0.17 | 0.25 | -0.26 | -0.07 | -0.16 |
| Belgium | 0.32 | 0.39 | -0.70 | -0.57 | -0.63 |
| Italy | 0.36 | 0.38 | -0.29 | -0.02 | -0.08 |
| Austria | 0.30 | 0.35 | -0.41 | -0.56 | -0.48 |
| Australia | 0.01 | 0.01 | -0.36 | -0.26 | -0.32 |
| Norway | 0.23 | 0.21 | 0.23 | -0.07 | 0.16 |
| Canada | 0.07 | 0.09 | -0.28 | -0.35 | -0.32 |
| New Zealand | NA | 0.10 | NA | 0.39 | 0.36 |
| South Korea | 0.14 | 0.19 | -0.44 | -0.43 | -0.40 |
| Spain | 0.25 | 0.30 | -0.65 | -0.24 | -0.38 |
| US | 0.10 | 0.12 | 0.32 | -0.48 | 0.00 |

Source: OECD, authors' calculations on annual data
Note: Data from Denmark, Finland, Italy, New Zealand and South Korea start in 1981, 1975, 1980, 1986, and 1975, respectively.
*Tax rates and log real GDP are HP-filtered with smoothing parameter $\lambda$= 6.25.

Payroll taxes are primarily used to fund social insurance systems.[4] Social insurance dates back to reforms in late-nineteenth century Germany, which served as a model for many industrial countries, including the United States. "Bismarckian" social insurance systems are characterized by a relatively low

[4]In Germany about two-thirds of all social transfers in 2008 were financed by social contributions (payroll taxes); the corresponding figure in the United States was about one-half (OECD National Accounts, General Government Accounts, 2010).

level of explicit redistribution; health, pension, and unemployment insurance programs honor entitlements based on past service or accrued eligibility.[5] Contributions by workers and firms fund programs on a balanced budget basis, at least at the margin. Budgets of such programs are susceptible to business cycle fluctuations, with cyclical adjustments often required to bring contributions in line with outlays. In contrast, Beveridge's notion of social insurance was based on a notion of minimum benefit funded in part or entirely by the general public budget. In many European countries, deficits in social security programs are regularly covered by budgetary transfers. The social security system of old-age benefits in the United States combines Bismarckian and Beveridgean elements. It is funded by payroll taxes, with employers withholding 6.2% of employee gross wages and matching that amount in employer social security taxes until total earnings reach a fixed earnings base (ceiling) for the year, above which no further tax is levied.

**Figures 1 and 2 about here**

## 2.2 Cyclical behavior of payroll taxes

For at least two reasons, the average payroll tax rate $\tau$, and thus the tax burden for the representative worker moving from unemployment into employment, is likely to be countercyclical. In recessions, budget shortfalls are difficult to close, especially when social expenditures involve entitlements. As

[5] In an effort to deflect criticism of rising inequality in a time of rapid economic growth, the German chancellor Bismarck initiated wide-reaching reforms in the 1880s, in particular the Health Insurance Act of 1883 (*Gesetz betreffend die Krankenversicherung der Arbeiter*), the Accident Insurance Act of 1884 (*Unfallversicherungsgesetz*) and the Old Age and Disability Insurance Act of 1889 (*Gesetz betreffend der Invaliditäts- und Altersversicherung*). These were important first pillars of the current German social insurance system, which were augmented in 1927 by the Law on Employment and Unemployment Insurance (*Gesetz über Arbeitsvermittlung und Arbeitslosenversicherung*).

a result, tax rates may be raised in recessions and cut in expansions. While we focus on unemployment insurance and welfare benefits, countercyclical funding issues arise in systems of health services, public pensions and social programs in general. A second reason for countercyclical effective payroll tax rates is the cap on contributions in most OECD countries, which limits total annual tax liability of employers for a given employee.[6] In expansions, when overall wages and productivity are rising, more workers will earn gross pay exceeding the contributions cap, exempting a larger fraction of pay from tax. In recessions, new jobs tend to pay less, raising the effective tax burden on new employer-employee matches.

The first two columns of Table 1 document that the average effective payroll tax rate is subject to long-run trends. Figures 1 and 2 show more detail for quarterly data from the US and Germany. To remove low frequency movements in the data, we applied the HP-filter to the payroll tax and real GDP series. The correlations for data are displayed in the right-hand columns of Table 1; quarterly data are plotted for the US and Germany in Figures 3 and 4. The overall contemporaneous correlation of payroll tax rate and the business cycle in annual data for the period 1990-2012 is $-0.51$ in Germany (which coincides with results for quarterly data, $\rho = -0.49$). While payroll taxation in the US is less cyclical over the longer sample period, it has become increasingly countercyclical since 1990, consistent with the narrative provided by Romer and Romer (2009).[7] Our finding for the US is consistent with the

[6]In the United States, annual contributions to old age, survivors and disability insurance are capped (an exception is the hospital insurance program, which is unlimited). The ceiling on social security contributions, which is linked to a wage index, was $102,100 in 2012. This represents the roughly the 85th percentile of the annual gross household income distribution in the US. In Germany, the annual ceiling was roughly €67,000.

[7]This finding is not an artifact of the detrending procedure. With first-differenced annual data, the correlation in the US declines over the two respective subperiods from 0.46 to -0.25.

business cycle accounting literature and its concept of the "labor wedge" (see Chari, Kehoe and McGrattan, 2008), which tends to stress distortions originating in government regulation and market imperfections. Rogerson and Shimer (2010) and Shimer (2009) argue that the labor wedge moves countercyclically, that is, in the same direction as our payroll tax measure.[8]

**Figures 3, and 4 about here**

Policy can influence the sign of this correlation by breaking the link between payroll taxation and the business cycle which results from balanced budget policies. Already in the 1930s, Kaldor (1936) and Meade (1938) proposed setting payroll taxes to covary positively with the state of the economy, and their ideas were endorsed by Keynes (1942) and Beveridge (1944). In smaller, open economies such as the Netherlands and Sweden, discretionary policy seems to have reduced the countercyclicality of the payroll tax rate or even rendered it procyclical. The increasing countercyclical behavior of the US payroll tax rate may also be due to increasing procyclicality in both levels and variance of wages, given the contributions cap.[9] In the next section, we study the effects of time-varying, distortionary payroll taxation in a dynamic stochastic general equilibrium model of the business cycle.

[8]The correlation between HP-detrended versions of Shimer's (2009) wedge measure for the US and the average payroll tax rate is 0.52 for the period 1990-2006 (for the period 1970-2006 it is only 0.10).

[9]See Gali and van Rens (2010) for recent evidence on the United States.

# 3 An equilibrium business cycle model with payroll taxation

## 3.1 Labor market search

Subscripts refer to periods of discrete time indexed by $t$. The economy is populated by a large number of identical, infinitely-lived consumer-worker households of measure one. Each household consists of a large number of individuals who derive utility from consumption and leisure. Workers (or family members) can spend their nonworking time in active unemployment (i.e., searching) or in leisure. If non-sleeping time is normalized to unity, the representative agent-household faces the following time constraint:

$$h_t + s_t + \ell_t = 1 \tag{1}$$

where $h_t$, $s_t$, and $\ell_t$ are measures of the household's working time, search time, and leisure (which could include home production). The threefold use of time reflects our interest in the distinction between search and voluntary unemployment and its interaction with payroll taxes and social insurance.[10]

Workers and jobs search for each other in a decentralized labor market.[11] Matching is the result of workers' search activities, $s_t$, and firms' posted vacancies, $v_t$, and takes the form of a constant returns matching function, $M(s_t, v_t) = s_t^{\eta} v_t^{1-\eta}$. At the same time, filled jobs are broken up each period at an exogenous rate, $\delta^h$, with $0 < \delta^h < 1$.[12] In the absence of on-the-job search, the vacancy-unemployment ratio $\theta_t \equiv v_t/s_t$ is a sufficient statistic of market tightness. The vacancy placement rate $q_t$, is linked to the job-finding

[10]Without loss of generality it is possible to modify this model to reflect more standard time use assumptions as well as costly labor market state switching.

[11]See Merz (1995) and Andolfatto (1996) for the seminal contributions to this literature.

[12]Shimer (2005) and Hall (2005b) argue that the cyclical variability of separations is dominated by that of outflows from unemployment.

rate among the searching unemployed $f_t$, by the relation $q_t = \frac{M(s_t,v_t)}{v_t} = M(\frac{s_t}{v_t}, 1) = \frac{M(1,\theta_t^{-1})}{\theta_t} = \frac{f_t}{\theta_t}$. Employment at the beginning of period $t$, $h_t$, is a state variable for the household. From the perspective of the individual searcher, $f_t$ is the probability that a match will occur. For the aggregate economy, employment obeys

$$h_{t+1} = s_t f_t + (1 - \delta^h) h_t. \tag{2}$$

Similarly, $q_t$ is the probability that an open vacancy will be matched in a period (the job matching rate per vacancy posted) so the following aggregate relationship also holds:

$$h_{t+1} = v_t q_t + (1 - \delta^h) h_t. \tag{3}$$

## 3.2 Government and social insurance

The government collects social security contributions (payroll taxes) in this one-good economy from gross factor payments to labor, $w_t h_t$, at rate $\tau_t$. Revenues from payroll taxes are used to finance unemployment benefits $b$ paid to $s_t$ unemployed engaged in search, and $\varepsilon b$ paid to $(1 - s_t - h_t)$ household members enjoying leisure (social welfare payments), and finance an exogenous component $g_s$ of total government purchases $g$, which is discussed in more detail below.[13] The parameter $\varepsilon \in (0, 1)$ can be interpreted alternatively as a measure of "classification error", malfeasance in the unemployment system, or overall generosity of the welfare state.[14] A positive $\varepsilon$ means that household members not actively searching still receive some level of government transfers, a characteristic of many OECD social security systems. The government adjusts the payroll tax rate $\tau_t$ in each period to respect the budget

[13] Government purchases of goods and services include health care expenditures (excluding sick pay) and the overhead adminstration costs of the welfare, pension, and disability systems.

[14] See Burda and Weder (2002) for a similar formulation.

constraint

$$bs_t + \varepsilon b(1 - s_t - h_t) + g_s = \tau_t w_t h_t. \tag{4}$$

As $\varepsilon$ approaches 1, search time and leisure are rewarded equally by the social insurance systemd; as $\varepsilon$ approaches zero, the system resembles the standard model. Writing the budget constraint (4) as

$$\tau_t = \frac{(1-\varepsilon)\, bs_t + \varepsilon b(1 - h_t) + g_s}{w_t h_t}, \tag{5}$$

we see that a sufficient condition for countercyclical $\tau_t$ is for $w_t$ and $h_t$ to be procyclical and $s_t$ countercyclical. The payroll tax rate and thus the level of distortion in the economy is driven by the generosity of unemployment insurance, $b$, and welfare benefits, $\varepsilon$, as well as endogenous labor market outcomes ($h_t$ and $s_t$). While the financing of social security in this parsimonious model excludes many aspects of the social security net, it sufficient to replicate countercyclical patterns of payroll taxation in the data.

## 3.3 Household behavior

A representative household chooses labor and capital market activities to maximize expected discounted utility. Labor services $h_t$ are compensated at net rate $(1-\tau_t)w_t$. The household owns the capital stock used in production, $k_t$, and sells capital services deriving from it, $\kappa_t$, to firms in a competitive market. These capital services consist of the product of the capital stock and its utilization rate, $u_t$, i.e. $\kappa_t = u_t k_t$. Since $k_t$ is a state variable in $t$, the household chooses $\kappa_t$ by varying utilization, which affects depreciation according to

$$\delta_t^k = \frac{\Psi}{\omega} u_t^{\omega} \tag{6}$$

where $\Psi > 0, \omega > 1$.[15] Given sequences of market real wages, $\{w_t\}$, and rental rates for capital services, $\{r_t\}$, the household at $t = 0$ chooses sequences of consumption $\{c_t\}$, leisure $\{\ell_t\}$, search time $\{s_t\}$, employment tomorrow $\{h_{t+1}\}$, capital tomorrow $\{k_{t+1}\}$ and capital utilization $\{u_t\}$ to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[ \ln c_t + A \frac{(1 - s_t - h_t)_t^{1+\chi}}{1+\chi} \right],$$

subject to the time constraint (1), the period-by-period budget constraint for $t = 0$, 1,..:

$$k_{t+1} + c_t = (1 - \tau_t) w_t h_t + (1 + u_t r_t - \delta_t^k) k_t + b s_t + \epsilon b (1 - s_t - h_t) - T, \tag{7}$$

the evolution of employment (2) and the dependence of depreciation on utilization (6), and taking initial capital ($k_0$) and employment ($h_0$) as given. It is assumed that $A > 0$, $0 < \beta < 1$, and $\chi \leq 0$. $T$ are lump-sum taxes imposed by the government so $T = g - g_s$.

Let $z_t$ stand for an exogenous stationary stochastic process which describes the state of productivity in the economy, to be made more precise below. The maximized value of expected utility given current employment, capital stock and the state of the economy, $V(h_t, k_t; z_t)$, is governed by the Bellman equation for $t = 0$, 1, ..

$$V(h_t, k_t; z_t) = \max_{c_t, s_t, u_t, h_{t+1}, k_{t+1}} \ln c_t + A \frac{(1 - s_t - h_t)^{1+\chi}}{1+\chi} + \beta E_t V(h_{t+1}, k_{t+1}; z_{t+1})$$

subject to (2), (6) and (7), taking initial levels of employment and capital as given. Optimality is characterized by the following first-order necessary conditions:

$$\frac{1}{c_t} = \beta E_t \left[ \frac{1 + u_{t+1} r_{t+1} - \delta_{t+1}^k}{c_{t+1}} \right] \tag{8}$$

[15] Modeling depreciation as a convex function of capacity utilization is common and follows Greenwood, Hercowitz and Huffman (1988) among others. This feature is included to match GDP behavior more closely and is not essential for generating our findings.

$$r_t = \Psi u_t^{\omega - 1} \tag{9}$$

and

$$A\left(1 - s_t - h_t\right)^{\chi} - \frac{b}{c_t}(1 - \epsilon) = \beta f_t E_t \frac{w_{t+1}(1 - \tau_{t+1}) - \epsilon b}{c_{t+1}} \tag{10}$$
$$+\beta f_t E_t f_{t+1}^{-1} \left[ \left(1 - \delta^h - f_{t+1}\right) A\left(1 - s_{t+1} - h_{t+1}\right)^{\chi} - \frac{b\left(1 - \delta^h\right)(1 - \epsilon)}{c_{t+1}} \right].$$

Equation (8) is a typical consumption Euler equation while (9) sets the marginal return from renting capital services to firms equal to marginal cost. Equation (10) characterizes the optimal intertemporal search-labor supply sequence. The left-hand side denotes the net marginal utility of leisure time lost from shifting time from leisure to search activities today. The right-hand side is the net expected discounted marginal utility from search, which consists of the expected utility of earning net wage $w_{t+1}(1 - \tau_{t+1})$ tomorrow minus $\epsilon b$, the financial benefit from spending that time in leisure instead (note if $\epsilon = 0$, leisure is not subsidized), plus the net utility gain from not having to search tomorrow. Search activity today is also influenced by future taxes; higher expected taxes tomorrow reduces the net return from work and thus the incentive to search today.

## 3.4 Firms

Firms maximize expected profits on behalf of their owners, the households. They produce output $y_t$ using a constant returns production technology

$$y_t = z_t \kappa_t^{\alpha} h_t^{1-\alpha}. \tag{11}$$

Periodic profits, $\Pi_t$, are given by

$$\Pi_t = y_t - w_t h_t - r_t \kappa_t - a v_t. \tag{12}$$

We now assume that the logarithm of total factor productivity, $\ln z_t$, follows a stationary, first-order autoregressive stochastic process. Firms maximize the expected discounted value of profits, computed using the stochastic discount factor $\rho_{t+1} = \beta\lambda_{t+1}/\lambda_t$, by hiring capital services $\kappa_t$ from households, posting vacancies at $v_t$ at cost $a$ and, given (3), choosing the volume of employment at the beginning of the next period, $h_{t+1}$. The maximized value of the firm given current employment and the state of the economy, $W(h_t; z_t)$, solves the Bellman equation

$$W(h_t; z_t) = \max_{\{\kappa_t, v_t, h_{t+1}\}} \Pi_t + E_t \left[\rho_{t+1} W(h_{t+1}; z_{t+1})\right]$$

subject to (12), the transition equation for employment from the firm's perspective (3), and given the current state variables $h_t$ and $z_t$.

First-order conditions for the firm for $t = 0, 1, ..$ can be expressed as follows. Optimal capital service input equates marginal product with the rental price:

$$\alpha \frac{y_t}{\kappa_t} = r_t. \tag{13}$$

Optimal vacancy decisions are governed by

$$\frac{a}{q_t} = E_t \rho_{t+1} \left[ (1-\alpha) \frac{y_{t+1}}{h_{t+1}} - w_{t+1} + (1-\delta^h) \frac{a}{q_{t+1}} \right] \tag{14}$$

which equates expected costs of posting a vacancy to the expected discounted value of profits of filling it (recursively, the marginal surplus of a match today plus vacancy costs saved if it survives to the next period).

## 3.5 Wage bargaining

The two surpluses derived above determine the joint surplus from a match between a worker and a firm. The surplus to a matched worker is $V_{h_t} - V_{s_t}$, since the fallback position of a worker is to resume search or spend time in leisure. At the optimum, these two alternatives yield equal utility. For firms, the surplus of an additional employed worker is $W_{h_t} - W_{v_t}$; we will study free-entry equilibria with respect to vacancies, so $W_{v_t} = 0$. The wage divides match surplus between worker and firm and is determined at the individual level (we abstract from collective bargaining). Individual workers are hired by a representative firm, which employs many workers. Labor's bargaining power is summarized by $\mu \in [0, 1]$, the Nash bargaining parameter which determines the split of the match surplus going to the worker. As the solution to a standard Nash bargaining problem, the gross (before tax) wage is continuously renegotiated and there are no *ad hoc* real rigidities. In each period, it solves

$$\max_{w_t} \mu \ln \left[ (V_{h_t} - V_{s_t}) / \lambda_t \right] + (1 - \mu) \ln W_{h_t}$$

subject to the definitions of $V_{h_t}$, $V_{s_t}$ and $W_{h_t}$ and taking the marginal utility of output $\lambda_t$ as given. In the Appendix, we show that the wage which solves this problem is given by:

$$w_t = \frac{(1-\mu)\,b}{1-\tau_t} + \mu\,(1-\alpha)\,\frac{y_t}{h_t} + \mu(1-\delta^n)\frac{a}{q_t} - \mu(1-\delta^n - f_t)\frac{a}{q_t}\frac{E_t\,(1-\tau_{t+1})}{1-\tau_t}. \tag{15}$$

Three features of the wage equation (15) are noteworthy. First, a novel and central aspect is the explicit role of payroll taxation, and in particular, its intertemporal path. Ceteris paribus, expectations of higher future payroll taxes will raise the bargained gross-of-tax wage today. Similarly, falling expected payroll taxes tomorrow will cause the bargained gross wage to decline today. If taxes are constant ($\tau_t = \tau_{t+1} = \tau$), the wage equation reduces to

$$w_t = \frac{(1-\mu)\,b}{1-\tau} + \mu\,(1-\alpha)\,\frac{y_t}{h_t} + \mu\theta_t a, \tag{16}$$

and if $\tau = 0$, (15) collapses to a wage equation found in, for example, Ebell (2011) or Ravn (2008). The intertemporal path of taxes opens up the possibility of endogenous gross wage rigidity or persistence. In an expanding economy, payroll tax rates are expected to fall in the future, and the Nash bargain results in lower gross wages today. Conversely, a shrinking economy implies higher future expected tax rates, and will moderate gross wage reductions today. A second noteworthy aspect of (15) is the interaction of payroll taxation with worker bargaining power, parametrized by $\mu$. The gross Nash-bargained wage depends positively on the tax rate, but the extent of the intertemporal effect depends on $\mu$; more bargaining power of workers will be more persistent, ceteris paribus. As worker bargaining power approaches zero, the gross wage reflects only indifference with the unemployment benefit paid to searchers i.e., $w_t(1 - \tau_t) \longrightarrow b$.

While the wage is influenced by the unemployment benefit paid to searching unemployed, it is independent of the social safety net parameter $\epsilon$, holding constant the marginal product of labor $(1 - \alpha)\frac{y_t}{h_t}$, market conditions ($f_t$ and $q_t$), and the expected intertemporal path of taxes $\frac{E_t(1-\tau_{t+1})}{1-\tau_t}$. The parameter $\epsilon$ does however play a central role by determining the size of the social safety net, the level and intertemporal nature of search intensity by workers ($s_t$) and firms ($v_t$), and the volatility of $\tau_t$ in general equilibrium. From (10), as $\epsilon$ approaches 1, search today is less attractive and the gains from intertemporal reallocation of search activity increase. The net effect of these forces on labor market quantities and prices can only be studied in dynamic general equilibrium.

# 4 Properties of the artificial economy

## 4.1 Equilibrium and benchmark calibration

An equilibrium in this decentralized economy is defined as a set of sequences of prices, quantities and payroll tax rates $\{w_t\}$, $\{r_t\}$, $\{\kappa_t\}$, $\{k_t\}$, $\{u_t\}$, $\{h_t\}$, $\{s_t\}$, $\{v_t\}$, $\{y_t\}$, $\{c_t\}$, and $\{\tau_t\}$ which satisfy optimality conditions of households and firms, resource and budget constraints as well as a transversality condition for the capital stock, given the current state variables: employment, technology, and capital stock.

We calibrate our model to quarterly data from the German economy in the period 1970-2008. The parameter values underlying the non-stochastic stationary state of this economy can be found in Table 2.[16] While most parameter values are standard, our baseline calibration and the implied steady state require more detailed discussion. To focus discussion on the role of payroll taxes, we begin with a calibration in which $g_s = g = T = 0$ (lump-sum taxes are zero). In the steady state of this economy, the labor share is 67% and costs of posting vacancies, $av$, are half a percent of output; higher values of the vacancy share had no significant implications for our results.[17] Our choice of $\beta$ implies an annual risk free rate of about four percent; physical capital depreciates at 2.5% per quarter. By setting $\chi = -5$, we make individual labor supply less elastic than usually assumed in real business cycle models.[18] The model is calibrated to match the replacement rate, $b/w$, at

[16] See Cooley (1997) for a more detailed description of calibration methods. We used West German data for the period 1970:1-1990:4 and chained them with unified German data from 1991:1-2008:4.

[17] In comparison, Hagedorn and Manovskii (2008) estimate the labor costs of posting a vacancy at 11% of labor productivity. In the steady state of our benchmark calibration with $g_s > 0$, a=0.304 and y/h=2.904, implying a comparable statistic of 10.4%.

[18] This value is in line with micro studies of labor supply and deflects the usual criticism of the labor market in real business cycle models. We will show below that a high labor supply elasticity is not needed to induce high employment volatility.

60 percent. This value is significantly lower than that assumed by Hagedorn and Manovskii (2008) and it corresponds to values found in Western Europe. Steady state nonsleeping leisure time $1-h-s$ is set to $1/2$ (Burda, Hamermesh, and Weil, 2008). The steady state unemployment rate is seven percent and $\tau$ is equated to the average rate in Germany (30%).[19] The government's steady state financing constraint pins down the "misclassification rate" at

$$\varepsilon = \frac{\tau\frac{h}{b/w} - s}{1-s-h} = 0.395$$

| **Table 2:** Parameter values, baseline quarterly calibration | |
|---|---|
| *Postulated/assumed:* | |
| Discount factor, $\beta$ | 0.99 |
| Steady state capital depreciation rate, $\delta^k$ | 0.025 |
| Job separation rate, $\delta^h$ | 0.06 |
| Frisch supply elasticity of nonleisure time, $-1/\chi$ | 0.20 |
| Matching function elasticity, $\eta$ | 0.50 |
| AR coefficient of log TFP process $\rho$ | 0.95 |
| Vacancy cost share $av/y$ | 0.005 |
| | |
| *Calibrated/matched to data:* | |
| Labor share, $wh/y$ | 0.67 |
| Replacement rate, $b/w$ | 0.60 |
| Unemployment rate $s/(s+h)$ | 0.07 |
| Time working and searching, $h+s$ | 0.50 |
| Labor taxation rate, $\tau$ | 0.30 |
| | |
| *Calculated:* | |
| Elasticity of output to capital, $\alpha$ | 0.324 |
| Elasticity of depreciation to utilization, $\omega$ | 1.404 |
| Social transfer (misclassification) rate, $\epsilon$ | 0.395 |
| Bargaining power of workers, $\mu$ | 0.569 |

[19]While payroll taxation has increased in all countries over the sample period, this secular increase was relatively modest with the exception of Germany, which we address below. Table 1 suggests that most changes occured with regards to payroll tax volatility. We therefore calibrate our model economy as if the steady state $\tau$ did not change.

The elasticity of the matching function with respect to searching unemployed is set to 0.5. In the steady state, optimal search by households and the wage equation simultaneously determine the periodic utility parameter $A$ and bargaining power $\mu$.[20] The elasticity parameter $\omega$ relating depreciation to capacity utilization is pinned down by the first order conditions for the household (8) and (9): $\omega = \left(1/\beta - 1 + \delta^k\right)/\delta^k$.

## 4.2 Cyclical properties of the artificial economy

We now examine the central predictions of the model for macroeconomic and labor market variables. In particular, we are interested in artificial economies that exhibit cyclical behavior of payroll taxation as in Table 1. To this end, we simulate the artificial economy and compare the outcome to data from Germany. We begin by presenting key facts regarding the correlations of vacancies, unemployment, labor market tightness and labor productivity for the German economy in Table 3. All data are quarterly, Hodrick-Prescott detrended for the period 1970:1 to 2008:4.

We focus attention on three important empirical regularities in Table 3. The most well-known is the Beveridge curve, the empirical negative correlation between vacancies and unemployment. Second, the table features the inverse relationship of unemployment and labor market tightness, which is measured by $\theta$, the ratio of vacancies to unemployment. This measure of tightness rises in booms and declines in recessions. Third, unemployment and labor productivity, $p$, are slightly negatively correlated; booms tend to be periods of higher labor productivity.

[20]Because the bargaining parameter does not coincide with the elasticity of the matching function, the Hosios (1990) condition is not generally satisfied. Given the severe tax and other distortions present in this model, it seems inappropriate to assume the efficient outcome of the search process.

**Table 3:** Correlation of labor market indicators and labor productivity, Germany, 1970:1 - 2008:4

| | $v$ | $s$ | $\theta$ | $p$ |
|---|---|---|---|---|
| $v$ | 1.00 | -0.81 | 0.96 | 0.30 |
| $s$ | | 1.00 | -0.94 | -0.24 |
| $\theta$ | | | 1.00 | 0.29 |
| $p$ | | | | 1.00 |

*Note*: $p$ denotes labor productivity $(y/h)$; $\theta$ denotes labor market tightness $(v/s)$

We first characterize the dynamics of our artificial economy in the absence of payroll taxes and thus in the absence of government spending financed by those taxes. Table 4 shows that our artificial economy - which is driven by a single technology shock - displays a counterfactual property in the absence of a social-security system and payroll taxation. The economy fails to replicate the Beveridge curve relationship, instead generating a $s - v$ correlation of 0.85. While this version of the model predicts a positive correlation between productivity and market tightness, it is considerably stronger than in the data (model: 0.99, Germany: 0.29). Furthermore, it cannot generate the observed negative correlations between labor market tightness and labor productivity with unemployment.[21]

**Table 4** Correlation of labor market indicators and labor productivity, artificial economy

| | $v$ | $s$ | $\theta$ | $p$ |
|---|---|---|---|---|
| $v$ | 1.00 | 0.85 | 0.66 | 0.74 |
| $s$ | | 1.00 | 0.17 | 0.28 |
| $\theta$ | | | 1.00 | 0.99 |
| $p$ | | | | 1.00 |

A key finding of this paper is that central correlations in the data can be reproduced in the presence of payroll taxes and a self-financing social

[21] Ravn (2008) described these results as a "consumption-tightness puzzle."

security system. Tables 5-9 document these results. In Table 5 we report the same labor market correlations for the calibrated economy with a positive and endogenous payroll tax rate and a social safety net of calibrated size. The calibrated model is qualitatively and quantitatively more consistent with correlations from the German economy. First, the Beveridge curve is restored, with a correlation of $-0.79$, essentially the value for the German economy. Second, the model economy produces a significant increase in the volatility of vacancies and unemployment (Table 6). Furthermore, unemployment and tightness are negatively correlated: the correlation reverses sign from 0.17 to $-0.92$, a value which is almost identical to the correlation in the German data. Theory can now also account for a weak correlation between unemployment and productivity. Overall, the model resolves the puzzles put forward by Ravn (2008).

**Table 5:** Correlation of labor market indicators and labor productivity, artificial economy with payroll tax

| | $v$ | $s$ | $\theta$ | $p$ |
|---|---|---|---|---|
| $v$ | 1.00 | -0.79 | 0.97 | 0.58 |
| $s$ | | 1.00 | -0.92 | 0.04 |
| $\theta$ | | | 1.00 | 0.36 |
| $p$ | | | | 1.00 |

In Tables 6 and 7 we consider other attributes of the artificial economy and show that the introduction of payroll taxation generates unemployment that not only moves countercyclically, but is also volatile and serially correlated, in line with German data. Likewise, vacancies are strongly cyclical. The "Shimer statistic" $\sigma_\theta/\sigma_p$, which measures the volatility of labor market tightness relative to labor productivity, increases in the artificial economy by about thirtyfold, also taking on a value similar to that in the data. Employment volatility also rises with procyclical payroll taxes. This is noteworthy since labor supply is relatively inelastic. The model also can track the pattern of other GDP aggregates. Finally, Table 7 suggests that the intertemporal effects of taxes on search and vacancy choice as well as on wage setting creates labor market persistence commonly observed in data; in our artificial economy, vacancies and unemployment exhibit autocorrelations much more consistent with empirical observation than in the model without payroll taxation.

**Table 6:** Macro moment comparisons, data and model

| | Germany | Model without payroll tax | Model with payroll tax |
|---|---|---|---|
| $\sigma_v/\sigma_y$ | 13.24 | 1.66 | 13.31 |
| $\sigma_s/\sigma_y$ | 11.41 | 1.27 | 8.53 |
| $\sigma_h/\sigma_y$ | 0.64 | 0.15 | 0.85 |
| $\sigma_c/\sigma_y$ | 0.83 | 0.27 | 0.71 |
| $\sigma_i/\sigma_y$ | 2.64 | 2.27 | 2.48 |
| $\rho(v, y)$ | 0.67 | 0.66 | 0.99 |
| $\rho(s, y)$ | -0.74 | 0.16 | -0.82 |
| $\rho(h, y)$ | 0.55 | 0.75 | 0.70 |
| $\rho(h, p)$ | 0.04 | 0.66 | -0.21 |
| $\rho(c, y)$ | 0.64 | 0.97 | 0.81 |
| $\rho(c, \theta)$ | 0.66 | 0.98 | 0.68 |
| $\rho(i, y)$ | 0.82 | 0.99 | 0.34 |

*Note*: $i$ denotes gross fixed domestic capital formation (investment expenditures).

**Table 7:** Labor market tightness and persistence

| | Germany | Model without payroll tax | Model with payroll tax |
|---|---|---|---|
| $\sigma_\theta/\sigma_p$ | 34.52 | 1.00 | 28.65 |
| $\rho(\theta, p)$ | 0.29 | 0.99 | 0.36 |
| $\rho(v, v_{-1})$ | 0.95 | 0.30 | 0.83 |
| $\rho(s, s_{-1})$ | 0.95 | 0.25 | 0.89 |

The model's superior ability to replicate business cycle facts originates in the countercyclical behavior of payroll taxation, which follows directly from the balanced budget restriction and its effect on the wage bargain. Table 8 displays the cyclical behavior of real product wages in the artificial economy and Germany, 1970-2008. Real wages are computed as the ratio of total labor compensation to total employees divided by the GDP deflator, with West German data chained with unified German data in 1991:1. The table shows that the introduction of taxes reduces pre-tax wage volatility significantly, with the relative standard deviation of wages declining by almost 50%. The wage rises less during booms, and the correlation with output is also cut by half. The effect of the tax system is to induce rigidity in gross wages paid by employers, even though gross and net wages are perfectly flexible.

| **Table 8:** Wages (total compensation per employee) | | | |
|---|---|---|---|
| | Germany | Model without payroll tax | Model with payroll tax |
| $\sigma_w/\sigma_y$ | 0.83 | 0.87 | 0.66 |
| $\rho(w,y)$ | 0.38 | 0.99 | 0.54 |

# 5 Dissecting and interpreting the mechanism

Our central finding is that a calibrated RBC model with labor market frictions combined with an endogenous payroll tax and a distortion of the search-leisure decision can significantly increase endogenous propagation, restore the Beveridge curve, and significantly increase the volatility of labor market quantities. Our model achieves this without ad hoc assumptions regarding sticky wages, extreme fallback positions or low worker bargaining power. In this section, we examine the roles of countercyclical payroll taxes and the participation margin in more detail, and show that both are necessary for our results.

## 5.1 The role of countercyclical payroll taxation

We first show that time-varying payroll taxation is central for generating our results. Table 9 verifies that the payroll tax in the artificial economy with a fully-funded social insurance scheme exhibits relative volatility and countercyclical behavior consistent with the overall intertemporal pattern of average payroll tax rates in the data noted in Section 2. While $\tau_t$ is more strongly correlated with output than in the data, it is important to keep in mind that our model is driven by a single shock. Overall, the general mechanism of tax fluctuations that we have uncovered in this paper is both qualitatively and quantitatively relevant.

Formally, countercyclical taxation contributes directly to the elasticity of labor market tightness to labor productivity $p$.[22] Intuitively, countercyclical payroll taxes dampen the volatility of gross wages in response to a shock. Firms will post more vacancies in response and, while workers will see their net wages increase and increase participation, job finding rises faster, leading to lower unemployment, more matches, more output, and lower tax rates.

[22]Log differentiation of the steady state vacancy condition after substitution for the steady state wage yields

$$\begin{aligned} \frac{d\ln\theta}{d\ln p} &= \left[\frac{(1-\mu)(1-\alpha)p}{\eta(1-\mu)\left((1-\alpha)p-\frac{b}{1-\tau}\right)+(1-\eta)\mu a\theta}\right] \\ &\quad - \left[\frac{(1-\mu)b}{\eta(1-\mu)\left((1-\alpha)p-\frac{b}{1-\tau}\right)+(1-\eta)\mu a\theta}\right]\frac{\tau}{(1-\tau)^2}\frac{d\ln\tau}{d\ln p}, \end{aligned}$$

so if $d\ln\tau/d\ln p<0$, the elasticity of $\theta$ to labor productivity will be greater than in the standard case, in which $d\ln\tau/d\ln p=0$.

| **Table 9:** Behavior of payroll tax rate | | |
|---|---|---|
| | Model without payroll tax | Model with payroll tax |
| $\sigma_\tau/\sigma_y$ | 1.57 | 2.23 |
| $\rho(\tau, y)$ | -0.51 | -0.89 |

To demonstrate the importance of the countercyclical aspect of the distortionary payroll tax channel, we examine the behavior of our model economy under an alternative financing regime consisting of a constant payroll tax rate $\tau$ and variable lump sum taxes, $T_t$, adjusted each period to obey the government funding constraint

$$bs_t + \varepsilon b(1 - s_t - h_t) = \tau w_t h_t + T_t. \quad (17)$$

To maintain the comparability of both models and to isolate the level effect, we impose $T = 0$ in the steady state, so $\tau$ assumes the same long-run value as in our baseline calibration and the steady state payroll tax distortion is unchanged. While the model performs better than the version without distortionary taxation, the slope of the Beveridge curve remains counterfactually positive ($\rho(v, s) = 0.99$), and unemployment is procylical ($\rho(s, y) = 0.33$). Under the alternative financing arrangement, the correlation of the wage with output rises to close to one and its relative volatility nearly doubles.

## 5.2 The roles of the participation margin and the level of time-varying taxation

The natural issue arises: how much of the above results is dependent on the labor market participation channel and how much comes from payroll taxation? To investigate this aspect, we contrast our model with those in which participation is constant, i.e. the agents either work or are searching while unemployed, e.g. Merz (1995) and Andolfatto (1996). Expected lifetime utility in this "two-state model" is now

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[ \ln c_t + A \frac{(1-h_t)^{1+\chi}}{1+\chi} \right]$$

which is maximized subject to the time constraint

$$1 = h_t + s_t.$$

and the periodic budget constraint of the household

$$k_{t+1} + c_t = (1-\tau_t) w_t h_t + (1 + u_t r_t - \delta_t^k) k_t + b(1-h_t).$$

The social insurance budget constraint becomes

$$\tau_t w_t h_t = g_s + b s_t,$$

where social security expenditures on output $g_s$ (in excess of unemployment benefit payments) are set to target the same steady state payroll tax rate in the original calibration, i.e. $\tau = 0.3$. The firm's side of the model is unaffected by these changes. Payroll taxes in this simulated economy are countercyclical, with $\rho(\tau, y) = -0.98$. The model predicts $\rho(s, y) = -0.81$, and a negatively sloped Beveridge curve. $\sigma_\theta/\sigma_p$ at 12.07, closing a large part of the Shimer puzzle; in the absence of the tax channel, $\sigma_\theta/\sigma_p$ declines to roughly 2.5 and the Beveridge curve's correlation approaches zero as in Merz (1995).

What is the quantitative prediction of the model of the link between the volatility of labor market tightness and the level of payroll taxes in this model? To study this, we continue to shut down the labor participation margin and examine the implied volatility as a function of the steady state payroll tax rate. This is done by comparing volatilities across different levels of social insurance expenditures $g_s$. The results, displayed in Figure 5, show that a higher tax rate implies higher volatility of labor market quantities.[23] Decreasing the variable payroll tax rate from 30% to 15% - while holding $b/w$ constant and setting $\varepsilon = 0.1625$ to respect the government budget constraint - reduces $\sigma_\theta/\sigma_p$ to 9.8 and increases $\rho(s, y)$ to 0.43. Because steady-state $\tau$ appears in coefficients of the log-linear model, it affects the economy's dynamics directly, in particular the variability of $\tau_t$. Empirical support for this theoretical prediction can be found in Section 6 below.

**Figure 5 about here**

## 5.3 Interpretation

Our model with variable labor taxation generates more realistic labor market behavior because it induces a relative rigidity of gross wages, i.e. employers' costs, and supports Hall's (2005) claim that sticky wages can help align search models and data.[24] Wages in our artificial economy accomplish this end even though they are endogenous. Although net wages and the return to work rise in upturns when labor markets are tightening, the negative effects on labor demand and vacancies are dampened by declining payroll taxation. Because gross wages react less strongly, higher employment does not translate as rapidly into higher costs for firms.

Consider a firm facing a higher realization of total factor productivity, $z_t$. Because posting of vacancies is a dynamic problem, present and future wage labor costs determine the optimal policy via (14). If labor costs faced by firms are expected to remain relatively flat over time, the expected surplus of

[23]The original model with a variable participation margin generates a similar pattern.

[24]As worker bargaining power approaches zero, the wage in (15) no longer responds to changes to productivity. Thus, variation of bargaining power can also account for cross-country variation of the Shimer statistic.

creating jobs will be higher, and firms post more vacancies, which raises their volatility as well. At the same time, countercyclical payroll taxes renders net after-tax wages much less procyclical. Hence, even with sticky gross wages, workers will expect greater benefits from search in booms (see Equation 10), but because vacancies respond so strongly, search is more effective and the optimal strategy involves less search in recessions, not more.

The dampened volatility of gross wages induced by payroll tax movements is essential for bringing our model correlations in line with the data. As Table 6 shows, the standard model without payroll taxes cannot generate countercyclical unemployment. Households respond to a positive productivity shock by moving out of leisure and into search activities, which raises the level of unemployment sharply. In our model, a flatter labor cost profile induces significantly higher vacancy creation than in the standard formulation, so while a positive technological shock makes search more attractive, searching workers are moved more rapidly out of leisure and into employment. At any stage of an expansion, fewer workers are unemployed, which is also consistent with empirical evidence that unemployment durations are strongly countercyclical. This is linked to the fact that vacancies become relatively more volatile than search (see Table 6) so under the payroll tax regime search unemployment will be countercyclical. The outcome is a negatively-sloped Beveridge curve.

While the variable and cyclical payroll tax regime and endogenous labor force participation cannot account for the Hall-Shimer puzzle individually, in tandem they can. This complementarity can be explained as follows. Suppose the model economy experiences a positive technology shock. In the standard model with two states, a declining path of future unemployment rates implies that for a given stock of vacancies, the probability of firms of finding a worker $q$ declines, reducing the effectiveness of vacancies and driving higher the cost of finding workers. In a three-state model, participation also responds and in fact it is procyclical, thus increasing the profitability of vacancies: even though job searchers spend only a short time in that state, their increased supply alleviates the matching congestion. More vacancies are thus created, which are filled by the new workers, creating more output, a larger wage bill and higher tax revenues, leading to lower future payroll taxes and labor costs, with commensurately greater vacancy posting.

# 6 Cross country evidence and secular trends

## 6.1 Cross-country implications: Dynamics

The mechanism described in this paper can help understand a wider range of countries' labor market dynamics besides those in Germany. In the following, we examine some of the implications of the model for patterns of payroll taxes and labor market dynamics across countries, while keeping in mind that we abstract from many alternative influences such as fiscal and monetary policy, the banking system, and nominal price and wage rigidities. We have summarized some of the regularities in quarterly data from five countries in the panels of Figure 6.[25]

The first implication is that countries in which the correlation between payroll taxation and the business cycle is the most negative should have the largest value of the Shimer statistic, $\sigma_\theta/\sigma_p$, of relative volatility of labor market tightness. Intuitively, the greater the countercyclical variation of the tax rate, the more damped are gross labor costs to firms and, as a result, the stronger the quantity response. Panel a) of Figure 6 provides evidence of this regularity for the period 1970-2008.

[25] Unfortunately, quarterly data availability and consistency for the longer period (1970-2008) limit the sample to five OECD countries.

A second implication is that long-run changes in the cyclical behavior of payroll taxes over time should be correlated with changes in the Shimer statistic. The second panel of Figure 6 shows this also to be the case for the five countries considered, with the most prominent changes originating in the United States (where the correlation between $\tau$ and GDP became markedly more negative over the sample) and in Sweden (where an earlier negative correlation turned positive). When payroll taxation becomes more countercyclical, on average labor market quantities become more volatile, supporting our theory's claim of a significant role of payroll taxation on the dynamics of labor markets. Finally, Figure 6c) shows a tight positive relationship between the volatility of labor market tightness and the level of payroll taxes, just as predicted by the theoretical model as illustrated by Figure 5.

**Figure 6 about here**

## 6.2 An alternative calibration: The United States

An important robustness check is to calibrate our model to other economies, and we chose the US economy as a salient counterexample to continental Europe for an alternative calibration. With $g_s = 0$, we set $\varepsilon$ to match $\tau = 0.12$ and target a steady state unemployment rate of five percent. Other parameters were not changed. The model economy's Beveridge correlation is $\rho(u, v) = -0.36$. Unemployment is countercyclical at $\rho(s, y) = -0.59$. Hence, the model and the payroll tax mechanism can help account for US labor facts. Moreover, $\sigma_\theta/\sigma_p$ is 8.22 – over one third of the US's observed value. While the model is not designed to explain all aspects of the US labor market, it nevertheless offers a partial solution to key puzzles discussed in the literature. While payroll taxes are less countercyclical in the US overall, this is not true of the second half of our sample, nor is it true of average marginal payroll tax rates constructed by Barro and Redlick (2011).[26] When looking across countries – say, when comparing Germany and the US –, the model preserves the relative sizes of $\sigma_\theta/\sigma_p$. However, absolute variances are more pronounced in the artificial economy than in the data. Other institutional differences not captured by our model appear to play an important role.

### 6.3 Accounting for secular trends

Our model not only matches key business cycle facts, but can also offer a plausible account of secular changes in payroll taxation, unemployment and employment over time. The increase of $\tau$ in Germany from an average of 0.28 in the period 1970-1990 to 0.37 in the late 1990s is generally attributed to a sharp rise in Eastern German unemployment, which triggered an extension of unemployment benefits to large groups of the employable population and an increase in active labor market policies funded by social contributions. While cyclical variation in $\tau$ is well-explained by cyclical variation in employment and unemployment, secular increases in $\tau$ can only result from expansions of the social welfare state – payroll-tax-financed public expenditures $g_s$, unemployment compensation $b$, or the generosity of social welfare $\varepsilon$. Indeed our own estimate of $g_s$ rose from 1990 from 5% of GDP to 6.5% in 2005 before falling back to 6% in 2012. During this same period $\tau$ rose from roughly 0.30 in 1990 to 0.35 in 2005, decreasing to 0.32 in 2012.

We investigated the power of our model to replicate these longer-run developments with a parametrization of the German economy similar to the

[26]Barro and Redlick (2011) construct annual series for average marginal federal, state and local income taxes as well as the federal payroll tax. While most tax series exhibted positive correlation with the business cycle, their payroll taxes series showed a correlation with HP-detrended GDP of -0.35 in the period 1980-2006 and -0.65 in the period 1990-2006.

baseline calibration. Details are provided in the Appendix. We set $g_s$ government purchases of output financed by payroll taxes, to 0.063, its average value in the period 1990-2012.[27] This calibration pins down total government purchases $g$ at $g/y = 0.19$, which is close to the value reported by the OECD (0.20). The government adjusts the payroll tax rate $\tau_t$ in each period to respect the budget constraint

$$g_s + bs_t + \varepsilon b(1 - s_t - h_t) = \tau_t w_t h_t.$$

As before, the calibration targets an unemployment rate of 7%; the shares of labor and vacancy costs in output, and unemployment to UI replacement ratio are identical to the benchmark calibration. As a result, the implied model parameters are slightly different for labor bargaining power ($\mu = 0.5255$). Varying each of $g_s$, $\varepsilon$ and $b$ individually, we calculate values necessary to match steady state values of $\tau$ to averages in the first and second halves of the sample ($\tau = 0.28$ and $\tau = 0.34$ respectively). The results as well as the implied steady state values of employment and unemployment are displayed in Table 10.[28]

Our model can track long-term shifts in mean values of unemployment, employment and other macroeconomic indicators observed in Germany since 1970. A 22% increase in government spending financed by the social security budget is sufficient to raise the steady state payroll tax rate from 30% to 34%. The unemployment rate rises from its baseline value of 7% to 8.4%, while the employment rate declines from 46.5% to 45.4%. The same hike in

[27]Source: Federal Statistical Office. According to the OECD, health costs in Germany were roughly 10% of GDP in the post 1990 period and roughly 8% in the 1970-1990 period. A large share of increases in German health costs can be associated with the reunification episode.

[28]While the new calibration alters the models steady state significantly, the model's dynamic properties remain robust: Beveridge curve $\rho(v, s) = -0.80$; labor market tightness and labor productivity: $\rho(\theta, p) = 0.44$, countercyclical unemployment: $\rho(s, y) = -0.84$; and the Shimer statistic: $\sigma(\theta)/\sigma(p) = 30.08$.

the steady-state payroll tax rate could be generated by an increase in the "misclassification rate" $\epsilon$ from 0.249 to 0.278, implying a rise in the unemployment rate to 8.6% and decline in the employment ratio to 45.1%. An increase of the unemployment benefit (measured in terms of output) of 3.1% would have the same fiscal impact, but raise the unemployment rate to 9.9%, depress the employment rate to 44.6%, and push the system to the limits of fiscal sustainability.

**Table 10:** Values of government spending $g_s$, welfare generosity $\epsilon$, and unemployment benefit $b$ necessary to track steady state $\tau$

| | Benchmark | Steady state values necessary for: | |
|---|---|---|---|
| | $\tau = 0.30$ | $\tau = 0.28$ | $\tau = 0.34$ |
| $g_s$ | 0.085 | 0.073 (-14.7%) | 0.104 (+22.2%) |
| implied $h$ : | 0.465 | 0.470 (+1.0%) | 0.454 (-3.4%) |
| $s$ : | 0.035 | 0.033 (-7.0%) | 0.043 (+22.3%) |
| $\ell$ : | 0.500 | 0.498 (-0.5%) | 0.503 (+0.6%) |
| | | | |
| $\epsilon$ | 0.249 | 0.230 (-7.8%) | 0.278 (+11.3%) |
| implied $h$ : | 0.465 | 0.471 (+1.3%) | 0.451 (-3.0%) |
| $s$ : | 0.035 | 0.033 (-6.3%) | 0.043 (+21.7%) |
| $\ell$ : | 0.500 | 0.496 (-0.8%) | 0.507 (+1.3%) |
| | | | |
| $b$ | 1.168 | 1.118 (-4.2%) | 1.203 (+3.1%) |
| implied $h$ : | 0.465 | 0.473 (+1.6%) | 0.448 (+3.7%) |
| $s$ : | 0.035 | 0.030 (-14.9%) | 0.050 (+41.4%) |
| $\ell$ : | 0.500 | 0.498 (-0.5%) | 0.503 (+0.5%) |

# 7 Conclusion

We have argued that payroll taxation can significantly affect business cycle dynamics. The average payroll tax burden, measured as a fraction of the wage bill, varies significantly in a countercyclical fashion in most Western

European economies as well as the United States for last two decades. Its behavior is consistent with Rogerson and Shimer's (2011) description of the labor wedge. Our analysis shows that the role of the social safety net – modeled as a generous system of unemployment insurance and subsidy of leisure – can create such cyclical movements of payroll taxation in an nonmonetary economy with labor market frictions. A balanced social insurance budget renders gross wages more rigid over the cycle and, as a result, strengthens the model's endogenous propagation mechanism. For conventional calibrations, the model generates a negatively-sloped Beveridge curve and matches the high volatility of vacancies and unemployment relative to labor productivity. Both endogenous labor force participation and countercyclical taxation are necessary for this result.

We are not claiming a general explanation of high volatility of labor market quantities in modern economies, but rather have found a new mechanism which can contribute towards understanding the labor market and its interaction with the business cycle. Countercyclical taxation of job matches can help resolve the Hall-Shimer puzzle and realign theory with many labor market regularities such as the Beveridge curve and countercyclical unemployment. Our results for a calibrated artificial economy imply that payroll taxes combined with a subsidy of leisure can significantly affect the qualitative properties of an important class of equilibrium business cycle models. Other tax and transfer mechanisms in which a balanced budget constraint is operative each period may work in a similar fashion. The novel aspects of our model allow it to mimic a particular aspect of many OECD labor markets, and for the US in the latter half of our sample. A payroll tax used aggressively to balance a large social insurance budget is a straightforward mechanism for generating key second moments in the data while incorporating an important feature of modern labor markets.

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# 8 Appendix: Wage equation

The surplus to the worker in terms of utility today can be written as

$$V_{h_t} - V_{s_t} = \frac{w_t(1-\tau_t) - b}{c_t} + \beta(1-\delta^h - f_t)E_t\left(V_{h_{t+1}} - V_{s_{t+1}}\right). \tag{18}$$

The first order condition from the Nash bargaining problem is

$$\frac{\mu\,(1-\tau_t)}{c_t\,(V_{h_t} - V_{s_t})} = \frac{(1-\mu)}{W_{h_t}}$$

or, using the fact that $W_{h_t}$, the firm's valuation of an additional worker is $(1-\alpha)\frac{y_t}{h_t} - w_t + (1-\delta^h)\frac{a}{q_t}$,

$$c_t\,(V_{h_t} - V_{s_t}) = \frac{\mu\,(1-\tau_t)}{1-\mu}\left[(1-\alpha)\frac{y_t}{h_t} - w_t + (1-\delta^h)\frac{a}{q_t}\right] \tag{A1}$$

Lead this expression by one period and premultiply by the pricing kernel $\rho_{t+1}$:

$$\rho_{t+1}c_{t+1}\left(V_{h_{t+1}} - V_{s_{t+1}}\right) = \frac{\mu\,(1-\tau_{t+1})}{1-\mu}\rho_{t+1}\left[(1-\alpha)\frac{y_{t+1}}{h_{t+1}} - w_{t+1} + (1-\delta^h)\frac{a}{q_{t+1}}\right].$$

Take expectation of both sides conditional on $t$, and the fact that $\rho_{t+1}c_{t+1} = \beta c_t$ to rewrite the last expression as

$$E_t\rho_{t+1}c_{t+1}\left(V_{h_{t+1}} - V_{s_{t+1}}\right) = \beta c_t E_t\left(V_{h_{t+1}} - V_{s_{t+1}}\right) = \frac{\mu E_t\,(1-\tau_{t+1})}{1-\mu}\frac{a}{q_t}$$

Premultiply both sides of the household surplus from employment by $c_t$, substitute the last expression and use $\rho_{t+1} = \beta c_t / c_{t+1}$ to obtain

$$c_t\,(V_{h_t} - V_{s_t}) = (1-\tau_t)w_t - b + (1-\delta^h - f_t)\frac{\mu E_t\,(1-\tau_{t+1})}{1-\mu}\frac{a}{q_t}c_t$$

Now insert this and (A1) into the Nash bargaining first-order condition:

$$\begin{aligned}
& \mu(1-\tau_t)\left[(1-\alpha)\frac{y_t}{h_t} - w_t + (1-\delta^h)\frac{a}{q_t}\right] \\
= \quad & (1-\mu)\left[(1-\tau_t)w_t - b + (1-\delta^h - f_t)\frac{\mu E_t\,(1-\tau_{t+1})}{1-\mu}\frac{a}{q_t}\right]
\end{aligned}$$

which can be solved to obtain

$$w_t = \frac{(1-\mu)\,b}{1-\tau_t} + \mu\,(1-\alpha)\,\frac{y_t}{h_t} + \mu(1-\delta^h)\frac{a}{q_t}\frac{E_t\,(\tau_{t+1}-\tau_t)}{1-\tau_t} + \mu\theta_t a\frac{E_t\,(1-\tau_{t+1})}{1-\tau_t}$$

or

$$w_t = \frac{(1-\mu)\,b}{1-\tau_t} + \mu\,(1-\alpha)\,\frac{y_t}{h_t} + \mu(1-\delta^h)\frac{a}{q_t} - \mu(1-\delta^n-f_t)\frac{a}{q_t}\frac{E_t\,(1-\tau_{t+1})}{1-\tau_t}.$$

# 9 Appendix: Alternative Calibration

| **Table A1:** Parameter values, alternative calibration $g_s > 0$ | |
|---|---|
| *Postulated/assumed:* | |
| Discount factor, $\beta$ | 0.99 |
| Steady state capital depreciation rate, $\delta^k$ | 0.025 |
| Job separation rate, $\delta^h$ | 0.06 |
| Frisch supply elasticity of nonleisure time, $-\chi^{-1}$ | 0.20 |
| Matching function elasticity, $\eta$ | 0.50 |
| AR coefficient of log TFP process $\rho$ | 0.95 |
| Vacancy cost share $av/y$ | 0.005 |
| | |
| *Calibrated/matched to data:* | |
| Labor share, $wh/y$ | 0.67 |
| Replacement rate, $b/w$ | 0.60 |
| Unemployment rate $s/(s+h)$ | 0.07 |
| Time working and searching, $h+s$ | 0.50 |
| Labor taxation rate $\tau$ | 0.30 |
| Consumption share $c/y$ | 0.58 |
| Government purchases paid by soc.sec. $g_s/y$ | 0.063 |
| | |
| *Calculated:* | |
| Elasticity of output wrt capital $\alpha$ | 0.3242 |
| Vacancy cost $a$ | 0.3036 |
| Social transfer (misclassification) rate $\epsilon$ | 0.2493 |
| Bargaining power of workers $\mu$ | 0.5698 |
| GDP share of government purchases $g/y$ | 0.1841 |

Figure 1: Payroll taxes as a fraction of total compensation, United States, 1970:1-2010:4

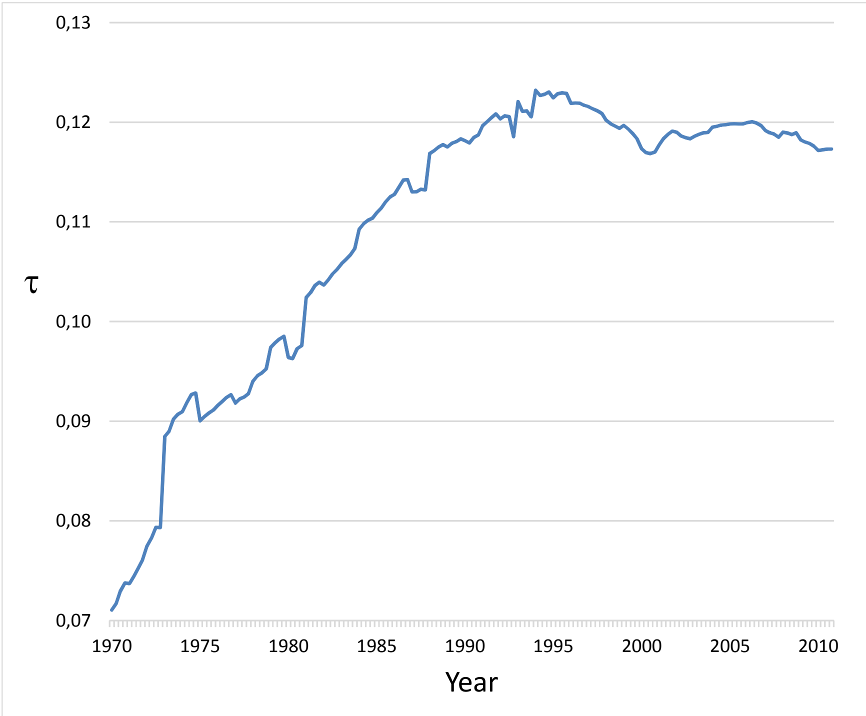

Figure 2: Payroll taxes as a fraction of total compensation, Germany 1970:1-2010:4

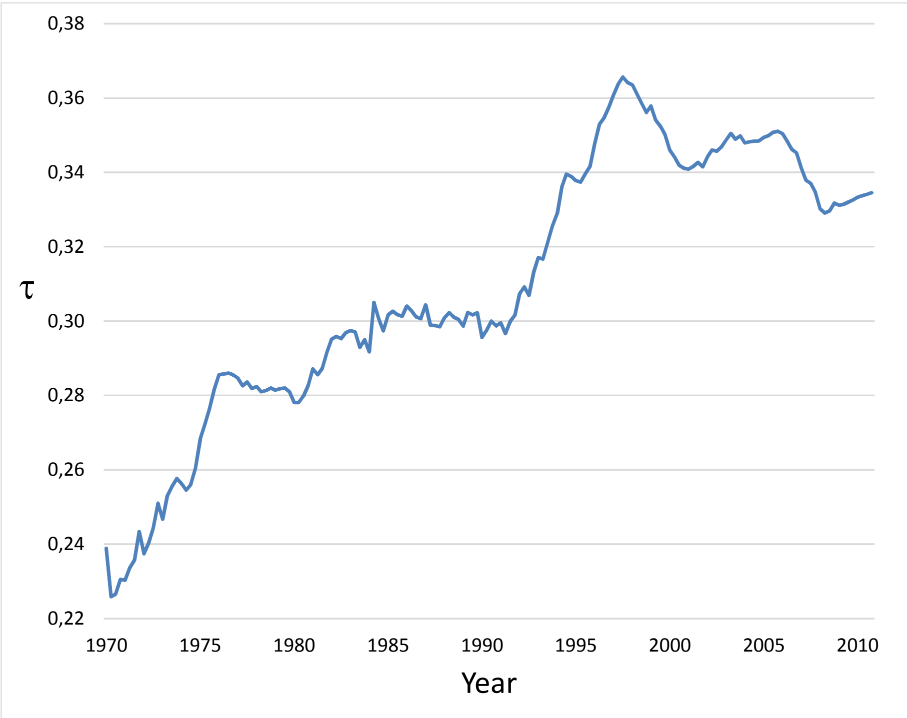

Figure 3: HP-detrended payroll taxes and GDP per capita, United States, 1970:1-2010:4

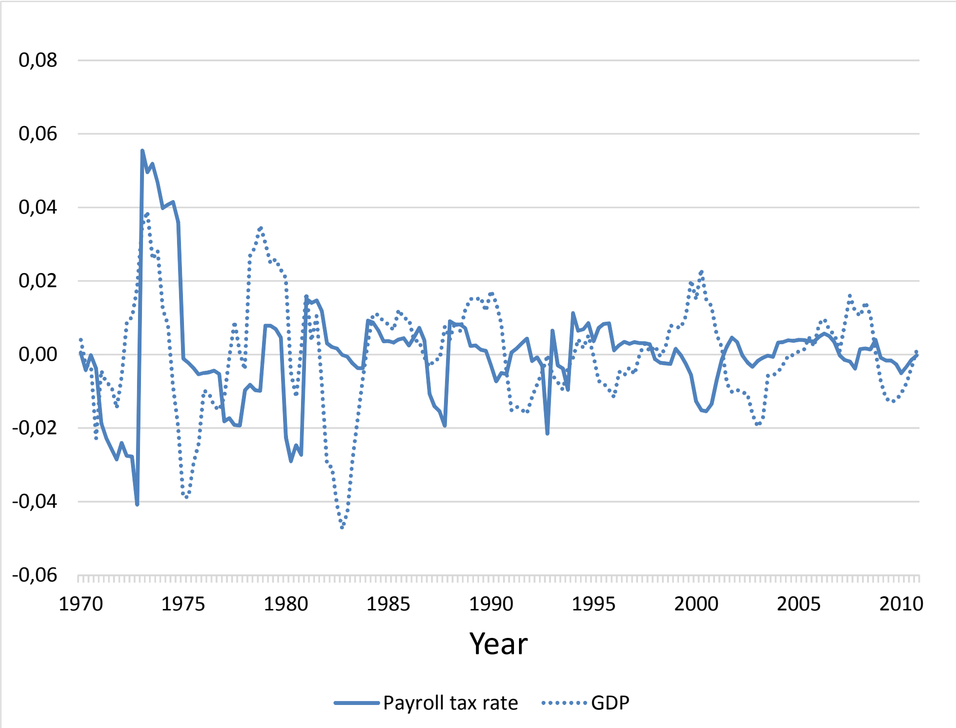

Figure 4: HP-detrended payroll taxes and GDP per capita, Germany 1970:1-2010:4

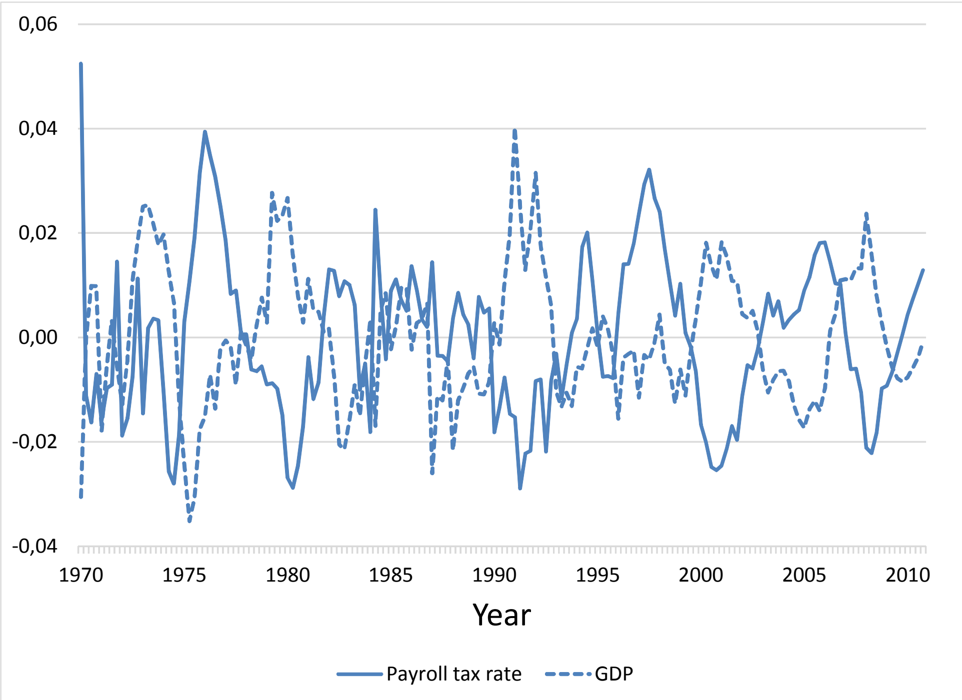

Figure 5: Steady state payroll taxation and the Shimer statistic in Merz's (1995) model

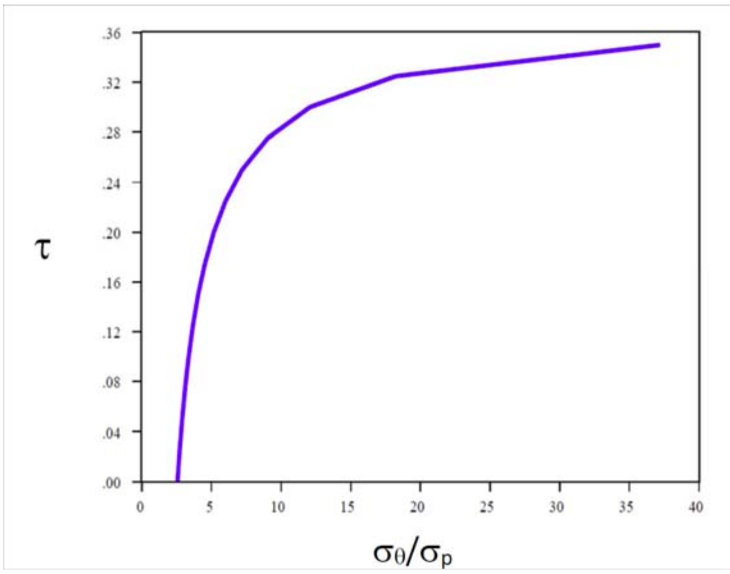

Figure 6: Payroll taxation, GDP and labor market tightness, five countries, 1970-2008