Payroll Taxes, Social Insurance and Business Cycles

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Mark Weder
University of Adelaide

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Overview

• Introduction
• The importance of payroll taxes
• A dynamic model with a social system fully-funded by payroll taxes, when there is “misclassification” of some workers as eligible for unemployment benefits
• Model derivation, calibration
• Results: Impulse responses, simulations
• Progress on the Hall-Shimer puzzle?
• Conclusion
Preview of Results

- Payroll tax rates exhibit countercyclical behavior in several but not all OECD economies.
- A self-financing social safety net (search contingent UI plus social welfare for non-search) introduces significant endogenous propagation and better matches the data in simulations.
- A new alternative explanation of the Hall-Shimer puzzle which complements and could possibly substitute for others.
Labor facts about payroll taxes

• Payroll taxes are significant (US≈12%, S and D≈32%, DK≈17%)
• In some OECD countries they are countercyclical
• Define the payroll tax rate $\tau$ as total payroll taxes paid divided by total labor compensation.
• Data: OECD Main Economic Indicators and Labor market, quarterly, 1971:1-2009:4
<table>
<thead>
<tr>
<th>Country</th>
<th>Ratio of payroll taxes to wage bill</th>
<th>Correlation of payroll tax with GDP*</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>0.097</td>
<td>0.120</td>
</tr>
<tr>
<td>Germany</td>
<td>0.278</td>
<td>0.337</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.291</td>
<td>0.293</td>
</tr>
<tr>
<td>UK</td>
<td>0.229</td>
<td>0.260</td>
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<tr>
<td>Sweden</td>
<td>0.246</td>
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<tr>
<td>France</td>
<td>0.366</td>
<td>0.410</td>
</tr>
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<td>Japan</td>
<td>0.167</td>
<td>0.240</td>
</tr>
<tr>
<td>Canada</td>
<td>0.055</td>
<td>0.091</td>
</tr>
<tr>
<td>Finland</td>
<td>0.143</td>
<td>0.166</td>
</tr>
</tbody>
</table>

Source: OECD, authors’ calculations based on quarterly seasonally unadjusted data.
*Real GDP and tax rates are HP-filtered with smoothing parameter \( \lambda = 1600 \).
Payroll taxation as a fraction of wage bill, Germany ($\tau$)

Source: OECD, authors' calculations
Cyclical behavior of $\tau$, Germany

Source: OECD, authors' calculations. Data are HP-detrended ($\lambda=1600$)
Cyclical behavior of τ, US

Source: OECD, authors' calculations. Data in right panel are HP-detrended (λ=1600)

<table>
<thead>
<tr>
<th>US (HP)</th>
<th>1970-08</th>
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<th>1990-08</th>
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<tbody>
<tr>
<td>ρ(τ, y)</td>
<td>0.18</td>
<td>−0.17</td>
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*Source: Shimer (2005). Statistics refer to HP-detrended data ($\lambda=100000$)*

**Puzzles**

**Hall-Shimer Puzzle**

**Beveridge curve**

**Persistence**
Why a model with labor market frictions?

- Gross worker flows are large and can easily exceed net flows by a factor of 20 or more.
- Average unemployment durations are significant (6-12 weeks) and long durations even more so.
- Vacancies ($v$), unemployment ($u$), and “tightness” of labor markets ($\theta=v/u$) are much more volatile than output or labor productivity.
- Yet there is a strong negative correlation between HP-detrended $v$ and $u$ (Beveridge curve).
Model: Search Labor Market

- Representative household of identical workers of mass 1.
- Workers can work $h_t$, search $s_t$, enjoy leisure $1 - h_t - s_t$
- No-job to-job transitions, matches break up at rate $\delta^h$
- Labor market, matching process joins mass of searching workers $s_t$ with stock of available vacancies $s_t$
  - Matching:
    \[ q_t = \frac{M(s_t, v_t)}{v_t} = M\left(\frac{s_t}{v_t}, 1\right) = \frac{M(1, \theta_t^{-1})}{\theta_t} = \frac{f_t}{\theta_t}. \]
  - Matching probabilities: $q(\theta_t)$ with $q'(\theta_t)<0$; $f(\theta_t)$ with $f''(\theta_t)>0$
  - Transition equation for employment:
    \[ h_{t+1} = v_t q_t + (1 - \delta^h) h_t = s_t f_t + (1 - \delta^h) h_t \]
Model: Social Insurance

• Fully funded social system
  – Unemployment benefits \( b \)
  – Social welfare payments \( \varepsilon \)
• Labor payroll taxation at \( \tau_t \) is set period-by-period so that the government budget constraint holds:

\[
bs_t + \varepsilon b(1 - s_t - h_t) = \tau_tw_th_t.
\]

• Interpretation: Searchers are paid \( b \), while those enjoying leisure are paid \( \varepsilon b \), so \( \varepsilon \) is misclassification rate or measure of generosity of overall welfare system.
Model: Households

- Households choose sequences of consumption \( \{c_t\} \), search time \( \{s_t\} \), capital utilization \( \{u_t\} \), capital depreciation \( \{\delta^k_t\} \), employment \( \{h_{t+1}\} \), and capital stock \( \{k_{t+1}\} \) to maximize

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

- subject to

\[
k_{t+1} + c_t = (1 - \tau_t) w_t h_t + (1 + u_t r_t - \delta^k_t) k_t + b s_t + \epsilon b (1 - s_t - h_t)
\]

\[
h_{t+1} = s_t f_t + (1 - \delta^h) h_t
\]

\[
\delta^k_t = \frac{1}{\theta} u^\theta_t
\]

- Taking \( k_0 \) and \( h_0 \), wages \( \{w_t\} \) capital rental rates \( \{r_t\} \) and job finding rates \( \{f_t\} \) as given.
Model: Households

• Recast the household’s recursive problem in Bellman equation form where $V(h, k)$ is the value function:

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

• subject to

$$k_{t+1} + c_t = (1 - \tau_t) w_t h_t + (1 + u_t r_t - \delta^k_t) k_t + b s_t + \epsilon b (1 - s_t - h_t)$$

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

$$\delta^k_t = \frac{1}{\Theta} u_t^\Theta$$

• given $k_0$ and $h_0$, wages $\{w_t\}$ capital rental rates $\{r_t\}$ and job finding rates $\{f_t\}$.

• Let $\lambda_t$ be the Lagrange multiplier at optimum.
Model: Firms

• Firms are owned by the household, and produce a single output with a constant returns technology:

\[ y_t = z_t \kappa_t^\alpha h_t^{1-\alpha} \]

where \( \kappa_t \equiv u_t k_t \) are capital services used in production, hired at rate \( r_t \).

• Technology \( z_t \) follows a trend-stationary autoregressive process in the natural logarithm (in particular, AR(1)).

• Firms post vacancies \( v_t \) today at cost \( a v_t \) to set employment tomorrow \( h_{t+1} \) via the employment transition equation, taking the vacancy matching rate \( q_t \) as given
Model: Firms

- Firms choose sequences of capital services \( \{ \kappa_t \} \), vacancies \( \{ v_t \} \), and employment \( \{ h_{t+1} \} \), to maximize expected discounted present value of periodic profits

\[
\Pi_t = z_t \kappa_t^\alpha h_t^{1-\alpha} - w_t h_t - \eta \kappa_t - au_t
\]

- Formally in each period the representative firm’s behavior is characterized by the following Bellman equation in \( W(h) \):

\[
W(h_t) = \max_{\{ \kappa_t, v_t, h_{t+1} \}} \Pi_t + E_t [\rho_{t+1} W(h_{t+1})]
\]

- using the stochastic marginal rate of substitution as discount factor

\[
\rho_{t+1} = \beta \lambda_{t+1} / \lambda_t
\]

- given \( h_t \), the sequence of job finding rates \( \{ f_t \} \) and subject to the employment transition equation for firm
Model: Wage Determination

• Define the wage $w_t$ as the gross payment by firms per worker for labor

• Period by period, the wage splits match surplus between employer and employee

• Assume Nash bargaining, with worker bargaining power given by $\mu \in [0,1]$. The wage solves

$$\max_{w_t} \left[ \frac{\partial V}{\partial h} \right]^\mu \left[ \frac{\partial W}{\partial h} \right]^{1-\mu}$$

where $V_h$ and $W_h$ are the partial derivatives of the value function with respect to employment. This incorporates the fact that the fallbacks $V_s(h) = W_v(h) = 0$. 
Equilibrium

- An equilibrium is defined as:
  - a set of sequences of wages \( \{w_t\} \), capital rental rates \( \{r_t\} \), labor market tightness \( \{\theta_t\} \) and job finding rates \( \{f_t\} \), such that consumption \( \{c_t\} \), search time \( \{s_t\} \), capital utilization rates \( \{u_t\} \), capital depreciation rates \( \{\delta_k\} \), employment \( \{h_{t+1}\} \), and capital stock \( \{k_{t+1}\} \) solve the household optimization problem and
  - the sequences of vacancies \( \{v_t\} \), employment \( \{h_{t+1}\} \) and capital services \( \{\kappa_t\} \) solve the firm’s optimization problem and
  - all resource constraints are respected
Equilibrium highlight

• **Wage equation** (gross of taxes, labor cost to firm):

\[ w_t = \frac{(1 - \mu)b}{1 - \tau_t} + \mu(1 - \alpha) \frac{y_t}{h_t} + \mu(1 - \delta^n) \frac{a}{q_t} - \mu(1 - \delta^n - f_t) \frac{a}{q_t} E_t \frac{(1 - \tau_t + 1)}{1 - \tau_t} \]

• As usual the wage is a weighted average of the income equivalent of leisure and labor productivity as well as the expected savings on vacancy costs.

• Now the equilibrium gross wage also depends positively on the payroll tax rate, and this depends on bargaining power.

• Taxes are endogenously determined by the state of the economy (the social system’s burden is countercyclical).  

• *Intertemporal path of taxes matters for the wage.*
Equilibrium highlight

• **Wage equation** (gross of taxes, labor cost to firm):

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

• **Intertemporal path of taxes matters for the (gross) wage.**

• **Example:**
  - \( z \uparrow \Rightarrow y, h, w \uparrow, s \downarrow \Rightarrow \tau \downarrow \) today, so \( w \) increase is *damped*
  - Next: holding *today’s* \( \tau \) *constant*, tomorrow’s \( \tau \) is changing. If \( \tau \) is rising, this will increase today’s wage, but if it continues to fall, this will further damp today’s wage.
  - Thus if effects on wage bill are persistent, the future tax rates will also be lower, putting further downward pressure on *today’s* wage. Result is *apparent* gross wage rigidity.
## Baseline Calibration (quarterly model)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
<th>Value</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>Elasticity of output with respect to labor</td>
<td>0.64</td>
<td>data; average labor share</td>
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<tr>
<td>$\beta$</td>
<td>Utility discount factor</td>
<td>0.99</td>
<td>literature</td>
</tr>
<tr>
<td>$\chi^{-1}$</td>
<td>Frisch inverse elasticity of nonleisure time</td>
<td>5.0</td>
<td>Literature</td>
</tr>
<tr>
<td>$\delta^h$</td>
<td>Dissolution rate of matches</td>
<td>0.078</td>
<td>data</td>
</tr>
<tr>
<td>$\delta^k$</td>
<td>Steady state depreciation rate of capital</td>
<td>0.025</td>
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<tr>
<td>$\mu$</td>
<td>Bargaining power of workers</td>
<td>0.4174</td>
<td>calibrated from steady state</td>
</tr>
<tr>
<td>$\psi$</td>
<td>Elasticity of matching (u)</td>
<td>0.5</td>
<td>literature</td>
</tr>
</tbody>
</table>
**Baseline Calibration (quarterly model)**

<table>
<thead>
<tr>
<th>Parameter</th>
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</tr>
</thead>
<tbody>
<tr>
<td>( \tau )</td>
<td>Steady state payroll tax rate</td>
<td>0.3</td>
<td>avg. value Germany 1970-2008</td>
</tr>
<tr>
<td>( \varepsilon )</td>
<td>social transfer or misclassification rate</td>
<td>0.395</td>
<td>calibrated</td>
</tr>
<tr>
<td>( \text{av/y} )</td>
<td>Vacancy cost as a fraction of GDP in steady state</td>
<td>0.01</td>
<td>calibrated</td>
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<tr>
<td>( \rho )</td>
<td>Serial correlation of productivity</td>
<td>0.95</td>
<td>literature</td>
</tr>
<tr>
<td>( b/w )</td>
<td>Replacement rate in steady state</td>
<td>0.60</td>
<td>data: Germany</td>
</tr>
<tr>
<td>( A )</td>
<td>Weight for utility deriving from nonleisure activities</td>
<td>0.0277</td>
<td>calibrated from steady state</td>
</tr>
</tbody>
</table>

Steady state unemployment rate: 7%
Impulse Responses: With social security

IRF(Y, A)

% deviation

Quarters

IRF(U, A)

% deviation

Quarters

IRF(T, A)

% deviation

Quarters

IRF(Share, A)

% deviation

Quarters
Impulse Responses: With social security

IRF(V,A)

IRF(H,A)

IRF(W,A)

IRF(V/U,A)
Impulse Responses: No social security

- IRF(Y, A)
- IRF(U, A)
- IRF(Share, A)
Impulse Responses: No social security

IRF(V,A)

IRF(H,A)

IRF(W,A)

IRF(V/U,A)
Simulation Results

- Model with payroll taxes $b=0.60$, $\varepsilon=0.395$, $\tau=0.30$
- Model without payroll taxes: $b/w=0.01$, $\varepsilon=0.01$, $\tau\approx0$

<table>
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<tr>
<th>Data</th>
<th>Model economies</th>
</tr>
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<tbody>
<tr>
<td>$v$</td>
<td>$1$</td>
</tr>
<tr>
<td>$u$</td>
<td>$-0.81$</td>
</tr>
<tr>
<td>$\theta$</td>
<td>$0.96$</td>
</tr>
<tr>
<td>$p$</td>
<td>$0.30$</td>
</tr>
<tr>
<td></td>
<td>$1$</td>
</tr>
<tr>
<td></td>
<td>$-0.24$</td>
</tr>
<tr>
<td></td>
<td>$0.29$</td>
</tr>
<tr>
<td></td>
<td>$1$</td>
</tr>
<tr>
<td></td>
<td>$1$</td>
</tr>
</tbody>
</table>

|      | 4. Model (no payroll tax) |
| $v$  | $1$ | $1$ |
| $u$  | $-0.02$ | $-0.02$ |
| $\theta$ | $0.99$ | $0.99$ |
| $p$  | $0.72$ | $0.72$ |
|      | $1$ | $1$ |
|      | $-0.14$ | $-0.73$ |
|      | $1$ | $0.78$ |
|      | $1$ | $1$ |
## Simulation Results

### The labor market

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<tr>
<td>$\sigma_{\nu}/\sigma_{y}$</td>
<td>13.24</td>
<td>1.57</td>
<td>11.69</td>
</tr>
<tr>
<td>$\sigma_{u}/\sigma_{y}$</td>
<td>11.41</td>
<td>1.24</td>
<td>8.34</td>
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<tr>
<td>$\rho(\nu, y)$</td>
<td>0.67</td>
<td>0.64</td>
<td>0.99</td>
</tr>
<tr>
<td>$\rho(u, y)$</td>
<td>-0.74</td>
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### Persistence of labor market

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**Correlation matrix**

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*Source: Shimer (2005). Statistics refer to HP-detrended data ($\lambda=100000$)*
The Hall-Shimer Puzzle

- In HP-filtered ($\lambda=10^5$) US quarterly data, the vacancy to unemployment ratio is about 20 times higher than in a model driven by productivity shocks with Nash-bargained wages.
- Volatility of both unemployment and vacancies as well as the Beveridge relationship are responsible.
- The Hall-Shimer fact also seems to hold in other OECD countries: Germany: $\frac{\sigma_v}{\sigma_p} \approx 35$.
- The standard model fails because Nash-bargained wages are “too flexible” and absorb too much of shocks which would otherwise lead to sharp fluctuations of $v$ and possibly of $u$. 
Some Proposed Solutions to the Hall-Shimer Puzzle

• Hall (2005), Shimer (2005): Rigid wages
• Pissarides (2007): Additional frictions, cyclical separations
• Fujita/Ramey (2006,2007): Not inactivity; vacancy creation costs
• Gertler/Trigari (2006): Multiperiod wage contracting
• Nagypal (2006), Krause/Lubik (2004): On-the-job search
• Hagedorn/Manovskii (2008): “Small surplus calibration” = high income equivalent of unemployment
## Simulation Results

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<td>20.45</td>
</tr>
<tr>
<td>$\rho(\theta, p)$</td>
<td>0.29</td>
<td>0.79</td>
<td>0.54</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$\tau$</th>
<th>GER</th>
<th>no payroll tax</th>
<th>payroll tax</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_\tau/\sigma_y$</td>
<td>1.57</td>
<td>na</td>
<td>1.34</td>
</tr>
<tr>
<td>$\rho(\tau, y)$</td>
<td>-0.55</td>
<td>na</td>
<td>-0.92</td>
</tr>
</tbody>
</table>
Conclusions

• Payroll taxes are countercyclical in many OECD countries.
• “Bismarckian” self-financing social welfare system and payroll taxation, combined with a pervasive social insurance system, can serve as a complement or even a substitute for existing explanations of Hall-Shimer puzzle.
• Adding a self-financing social system increases internal propagation, preserves the Beveridge curve and comes closer to the Hall-Shimer ratio – while the standard model without these features misses the mark.