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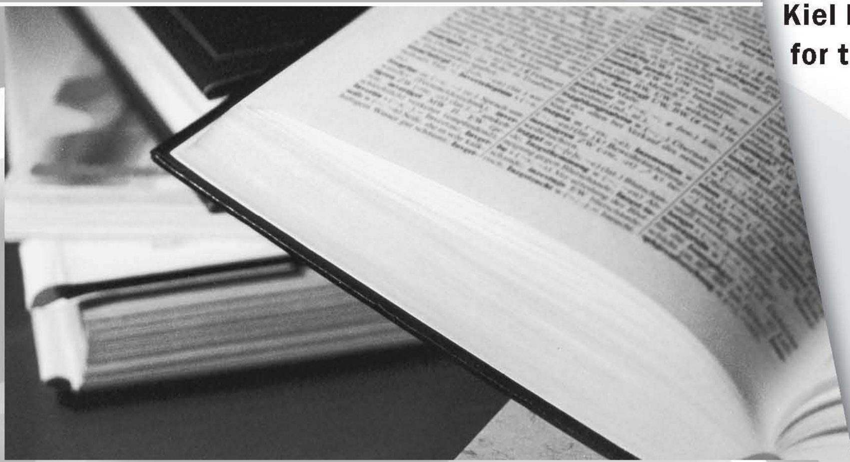

Layoff Taxes, Unemployment Insurance, and Business Cycle Fluctuations

by Steffen Ahrens, Nooshin Nejati, and Philipp L. Pfeiffer

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Keywords: search and matching, experience rating, unemployment insurance, Beveridge curve.

JEL classification: E24, J64, J65.

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Layoff Taxes, Unemployment Insurance, and Business Cycle Fluctuations*

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1 Motivation

This paper studies the role of labor market institutions in business cycle fluctuations. We incorporate a stylized US unemployment insurance system into a New Keynesian model with search and matching frictions. The unique feature of the US unemployment insurance system is the use of experience rating. According to the *Federal Unemployment Tax Act* from 1939, experience rating requires employers to pay contributions proportional to the expected fiscal cost of dismissed workers. We show that this empirically motivated form of layoff taxes has important implications for business cycles and labor market dynamics. As dismissal is not costless, layoff taxes create considerable employment adjustment costs along the destruction margin. Our approach helps reconcile the search and matching model with the empirical properties of its most salient variables. It helps explain the volatilities of key labor market variables and the negative correlation between vacancies and unemployment, i.e. the Beveridge curve.

Shimer (2005) and Costain and Reiter (2008) demonstrate that - despite the merits brought to the search and matching model - the model fails to account for the dynamic properties of two of its most important variables, i.e., vacancies and unemployment. Vacancies and unemployment are found to be much more volatile and much stronger negatively correlated in U.S. data compared to the predictions of the model. The former phenomenon is known as the unemployment volatility puzzle to the search and matching model, while the latter describes the Beveridge curve. Moreover, the model is unable to match the strong procyclicality of labor market tightness, which is defined as the number of open vacancies relative to the number of unemployed workers. Furthermore, Krause and Lubik (2007) show that the standard search and matching model in the context of a standard New Keynesian model fails to generate the negative correlation between the job creation rate and the job destruction rate.

The literature suggests several treats for these problems. Hall (2005) introduces wage norms to depress the volatility of wages and therewith increase the volatility of employment and vacancies. Krause and Lubik (2007) find that real wage rigidity somewhat helps reconcile the model with labor market data, in the sense that the model generates a weak Beveridge curve in response monetary policy and productivity shocks. The assumption of real wage rigidity, however, is at odds with empirical evidence (Babecký et al., 2010). Hagedorn and Manovskii (2008) choose a different route to circumvent these problems. They suggest a calibration exercise, which sets the bargaining power of workers close to zero. Under this condition, the volatility of real wages declines sufficiently so that the unemployment volatility puzzle resolves. Another potential solution can be found in the introduction of labor market institutions. Zanetti (2011a,b) shows that firing costs amplify the cyclical fluctuations of labor market tightness and generate a correlation between vacancies and unemployment slightly below zero, whereas the correlation between the job creation rate and the job destruction rate remains at odds with the data. Burda and Weder (2010) add a social insurance system and endogenous labor taxation to a real business cycle with labor market frictions. A funding constraint induces time-varying, countercyclical payroll taxes, which generate a Beveridge curve and increase the volatilities of labor market variables.

We offer a novel approach to bringing the search and matching model closer to the data. Our approach is related to the route taken by Zanetti (2011a,b). However, we differ from these studies in the specific way we model labor market institutions. We follow Cahuc and Malherbet (2004) and Albertini and Fairise (2013) and introduce a stylized version of US unemployment insurance system based on experience rating into our otherwise standard New Keynesian model with search and matching frictions. Experience rating requires employers to pay contributions to the unemployment insurance system proportional to the expected fiscal cost of dismissed workers. Therefore, the unemployment insurance system acts like a layoff tax, as, e.g., in Zanetti (2011a,b). In contrast to Zanetti (2011a,b), however, this layoff tax not only depends on the productivity of the dismissed worker, but also on the labor market conditions via its ramifications for the expected fiscal cost of dismissed workers. In times of economic prosperity unemployment spells are short and layoff taxes decline. Conversely, in times of economic slump, unemployment spells increase and expected layoff taxes rise. Thus, our model resembles the dynamic response of payroll taxes, as empirically documented by Burda and Weder (2010).

We find that incorporating the unemployment insurance system slightly increases the volatility of unemployment. Additionally, it generates a procyclical behavior of vacancies, which is consistent with empirical evidence. As a consequence a Beveridge curve is borne. At the same time, we offer simple but realistic microfoundations for real rigidities. We show that the unemployment insurance system significantly affect the transmission process of nominal shocks via the marginal costs channel. Moreover, the layoff taxes reduce the excess sensitivity of job destruction found in Krause and Lubik (2007) and strengthen the negative correlation of job creation and job destruction. In summary, the model matches well key labor market data while incorporating an important feature of US labor markets.

The remainder of the paper proceeds as follows. Section 2 develops and sets up our model, emphasizing the role of labor market institutions. In Section 3 we present the baseline calibration. Section 4 reports and discusses the findings. Section 5 rounds up the main argument and offers concluding remarks.

2 Model

In this Section, we present a New Keynesian business cycle model with search and matching frictions and unemployment insurance. The non-Walrasian labor market uses the specification of Mortensen and Pissarides (1994) and den Haan et al. (2000). The model is also closely related to Krause and Lubik (2007), however, we change the internal propagation mechanism of the frictional labor market by adding the US unemployment insurance system along the lines of Cahuc and Malherbet (2004) and Albertini and Fairise (2013). Unlike in Zanetti (2011a)[1] the unemployment insurance system is financed via layoff taxes and thus allows for an important connection between two important labor market institutions, unemployment insurance and layoff taxes.

The model economy consists of a representative household, a continuum of firms and a central bank. In addition, an unemployment insurance system is introduced. In the next subsections we offer a detailed description of the labor market and formalize the behavior of each agent in the economy.

[1] In Zanetti (2011a), unemployment benefits depend on the average steady state wage and are time-invariant. Layoff taxes, on the other hand, are productivity-dependent and exit the business cycle, i.e., they are lost.

2.1 The Large Family

The household sector consists of one infinitely-lived, large family. To keep the analysis simple, we follow Andolfatto (1996) and assume perfect risk sharing among family members. During each period $t = 0, 1, 2, ...$ the family members pool all their income from wages and unemployment benefits and redistribute equally. All members supply one unit of labor inelastically. The representative family maximizes its expected lifetime utility of the form

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma} - 1}{1 - \sigma} \right], \tag{1}$$

where β is the discount factor, σ is the degree of risk aversion and C_t denotes a composite consumption good, comprising different types of goods, subject to its intertemporal period budget constraint

$$C_t + \frac{B_t}{P_t} = \mathscr{W}_t + R_{t-1} \frac{B_{t-1}}{P_t} + (b_t + h^b) u_t + \Pi_t + T_t, \tag{2}$$

where B_t are bond holdings, which pay a gross interest rate R_t, P_t is the aggregate price index, and $\mathscr{W}_t$ is labor income. The variable b_t is the value of unemployment benefits and $h^b > 0$ is the value of home production by unemployed family members. Furthermore, Π_t are aggregate profits from firm ownership and T_t are real lump sum transfers from the government. The composite consumption good is given by the CES aggregate of differentiated products

$$C_t = \left(\int_0^1 C_{it}^{(\varepsilon-1)/\varepsilon} \, \mathrm{d}\, \varepsilon \right)^{\varepsilon/(\varepsilon-1)}, \tag{3}$$

where $\varepsilon > 1$ denotes the elasticity of substitution between the different varieties. Expenditure minimization with price P_{it} for each good $i \in [0, 1]$ yields the household's demand function for an individual good i given by

$$C_{it} = \left(\frac{P_{it}}{P_t} \right)^{-\varepsilon} C_t. \tag{4}$$

Finally, the household's intertemporal utility maximizing problem yields the standard Euler equation

$$C_t^{-\sigma} = \beta R_t E_t \left[\frac{P_t}{P_{t+1}} C_{t+1}^{-\sigma} \right]. \tag{5}$$

2.2 The Labor Market and the Firm Sector

Before turning to more specific features, we start the description of our model with a general discussion of the labor market. In the spirit of Mortensen and Pissarides (1994), our model is built on the idea that trade in the labor market is costly and time-consuming for both firms and workers. There is a fixed number of workers n_t. Due to the search and matching friction there is equilibrium unemployment in the model. Workers are either employed or unemployed and we normalize the labor force to one such that the number of unemployed workers satisfies $u_t = 1 - n_t$. Hiring does not take place instantaneously. Firms who want to recruit new workers have to post vacancies v_t. New jobs are formed through a matching process. The aggregate flow of matches m_t is given by the following Cobb-Douglas function

$$m_t = m u_t^{\mu} v_t^{1-\mu}, \tag{6}$$

where m describes the matching efficiency and $\mu \in]0,1[$ denotes the match elasticity. As the function exhibits constant returns to scale, we can define the fraction $\theta_t = \frac{v_t}{u_t}$ as the labor market tightness. Correspondingly, the probability of successfully filling a vacant job is $q(\theta_t) \equiv m(u_t, v_t)/v_t = m(u_t/v_t, 1)$ by homogeneity of degree one. Posting a vacancy creates an externality for all other firms, as the number of vacancies increases, *ceteris paribus*, the probability of filling an individual vacancy decreases. Therefore, this externality postulates a negative relationship between the vacancy filling probability and labor market tightness. Analogously, the individual worker's job finding rate is $m(u_t, v_t)/u_t = \theta_t q(\theta_t)$. Now unemployed workers create an externality on all other unemployed workers, as every new unemployed worker, *ceteris paribus*, decreases the probability of each individual unemployed worker to be matched to a vacancy. Therefore, this externality postulates a positive relationship between labor market tightness and the worker's job finding rate.

Workers are heterogeneous with respect to their labor productivity. Worker productivity comprises two components: aggregate productivity A_t, which is equal among all workers and idiosyncratic productivity a_{it}. In each period, before production takes place, a worker draws her idiosyncratic productivity from a time-invariant i.i.d. distribution with c.d.f $F(a)$ and with p.d.f. $f(a)$. A continuum of monopolistically competitive firms produce the differentiated consumption good. Total output of firm i depends on aggregate productivity A_t, labor input n_{it}, and the idiosyncratic productivity a_{it} of the individual jobs i:

$$y_{it} = A_t n_{it} \int_{\tilde{a}_{it}}^{\infty} a \frac{f(a)}{1 - F(\tilde{a}_{it})} \, \mathrm{d}a \equiv A_t n_{it} H(\tilde{a}_{it}), \tag{7}$$

where $H(\tilde{a}_{it})$, just as in Krause and Lubik (2007), is defined as the conditional expectation $\mathbb{E}[a | a \geq \tilde{a}_{it}]$. Put differently, $\tilde{a}_{it}$ endogenously determines a critical threshold below which a job is not profitable and separation takes place. This leads to an endogenous job destruction rate $\rho_{it}^n = F(\tilde{a}_{it})$. In addition, we assume that there is a fraction ρ^x of jobs (of all productivity levels) that are exogenously[2] destroyed. Total separations at firm i are determined by the flow into unemployment:

$$\rho_{it} = \rho^x + (1 - \rho^x)\rho_{it}^n. \tag{8}$$

The flow of workers in and out of unemployment jointly describe the evolution of employment at each firm i:

$$n_{it+1} = (1 - \rho_{it+1})(n_{it} + v_{it} q(\theta_t)). \tag{9}$$

Labor is the only input factor as we abstract from capital. The firm chooses an optimal vector of price, employment, the number of vacancies, and endogenous job destruction threshold. Each firm i maximizes profits given by

$$\Pi_{i0} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\lambda_t}{\lambda_0} \left\{ \frac{P_{it}}{P_t} y_{it} - \mathscr{W}_{it} - c v_{it} - \frac{\psi}{2} \left(\frac{P_{it}}{P_{it-1}} - \pi \right)^2 Y_t - \Phi(\tilde{a}_{it}) \right\}, \tag{10}$$

[2]Reasons for exogenous separation might include sickness, injury, death, relocation or liquidation of a job-position, or any other reason not connected to worker productivity. Further, we exclude quits, as quits lead to disqualification from benefits. We leave the analysis of quits in a framework like ours for future research. Note, however, that in the absence of exogenous separations, the results remain qualitatively unaltered. Also, the quantitative differences are negligibly small.

subject to the demand function (4), the production function (7) and the employment evolution equation (9). The variable λ_t denotes the Lagrangian multiplier with respect to the demand function. In the profit function, the first part represents the firm's revenue. The second term is the real wage bill. The third term are total vacancy costs, with c being the real cost of posting a single vacancy. The fourth part denotes the quadratic price adjustment costs, where ψ is the adjustment cost parameter and π is gross steady state inflation. The last term, $\Phi(\tilde{a}_{it})$, represents total layoff taxes of the firm. The precise expression for the layoff taxes is described in detail in section 2.4. However, we note that layoff taxes enter the firms intertemporal choice problem. The presence of employment adjustment costs reduces the firms incentive to layoff workers and potential layoff cost are taking into account when wages are not identical among workers but depend on the worker's idiosyncratic productivity level. The wage bill aggregates the individual wages $w_t(a)$ of the heterogeneous workers

$$\mathscr{W}_{it} = n_{it} \int_{\tilde{a}_{it}}^{\infty} w_t(a) \frac{f(a)}{1 - F(\tilde{a}_{it})} \, \mathrm{d}a. \tag{11}$$

Next, we impose symmetry across firms and rearrange the firms optimality conditions. Using the definitions $\beta_{t+1} \equiv \beta \frac{\lambda_{t+1}}{\lambda_t}$ for the stochastic discount factor and $\pi_t \equiv P_t/P_{t-1}$ for inflation yields:

$$n_t: \quad \zeta_t = \varphi_t A_t H(\tilde{a}_t) - \frac{\partial \mathscr{W}_t}{\partial n_t} + \mathbb{E}_t \beta_{t+1}(1 - \rho_{t+1})\zeta_{t+1} - \frac{\partial \Phi(\tilde{a}_t)}{\partial n_t}, \tag{12}$$

$$v_t: \quad \frac{c}{q(\theta_t)} = \mathbb{E}_t \beta_{t+1} \zeta_{t+1}(1 - \rho_{t+1}), \tag{13}$$

$$\tilde{a}_t: \quad \frac{\partial \rho(\tilde{a}_t)}{\partial \tilde{a}_t} \zeta_t (n_{t-1} + v_{t-1} q(\theta_{t-1})) = \varphi_t A_t n_t \frac{\partial H(\tilde{a}_t)}{\partial \tilde{a}_t} - \frac{\partial \mathscr{W}_t}{\partial \tilde{a}_t} - \frac{\partial \Phi(\tilde{a}_t)}{\partial \tilde{a}_t}, \tag{14}$$

$$P_t: \quad 1 - \psi(\pi_t - \pi)\pi_t + \mathbb{E}_t \beta_{t+1} \left[\psi(\pi_{t+1} - \pi)\pi_{t+1} \frac{Y_{t+1}}{Y_t} \right] = \varepsilon(1 - \varphi_t), \tag{15}$$

where φ_t and ζ_t are the Lagrangian multipliers associated with the production function and the employment evolution, respectively.

Job Creation Condition. Iterating (12) one period forward and inserting the expression for the shadow value of employment, ζ_{t+1}, into (13), gives the job creation condition. The job creation condition is such that the cost per vacancy equals the benefit of a new hire taking into account potential layoff taxes:

$$\frac{c}{q(\theta_t)} = \mathbb{E}_t \beta_{t+1}(1 - \rho_{t+1}) \left[\varphi_{t+1} A_{t+1} H(\tilde{a}_{t+1}) - \frac{\partial \mathscr{W}_{t+1}}{\partial n_{t+1}} + \frac{c}{q(\theta_{t+1})} - \Phi(\tilde{a}_t) \right]. \tag{16}$$

Job Destruction Condition. For optimality firms balance the lay-off cost with the value of the productivity gains. First substitute the shadow value of employment (12) into (14) and, to simplify the expression, make use of (13) gives

$$\begin{aligned} \frac{\partial \rho(\tilde{a}_t)}{\partial \tilde{a}_t}(n_{t-1} + v_{t-1} q(\theta_{t-1})) \left[\varphi_t A_t H(\tilde{a}_t) - \frac{\partial \mathscr{W}_t}{\partial n_t} + \frac{c}{q(\theta_t)} - \Phi(\tilde{a}_t) \right] = \\ \varphi_t A_t n_t \frac{\partial H(\tilde{a}_t)}{\partial \tilde{a}_t} - \frac{\partial \mathscr{W}_t}{\partial \tilde{a}_t} - \frac{\partial \Phi(\tilde{a}_t)}{\partial \tilde{a}_t}. \end{aligned} \tag{17}$$

Further, note that the employment dynamics follow

$$\frac{n_t}{(1-\rho_t)} = (n_{t-1} + v_{t-1}q(\theta_{t-1})). \tag{18}$$

From (17) and (18) and the explicit derivatives of $\Phi(\tilde{a}_t)$, yields, after some manipulations a critical threshold below which jobs are destroyed.

$$\frac{c}{q(\theta_t)} - \Phi(\tilde{a}_t) + \varphi_t A_t \tilde{a}_t - w_t(\tilde{a}_t) + \Omega_t^F = 0, \tag{19}$$

where $\Omega_t^F > 0$ specifies a share of saved unemployment benefits contributions.[3]

2.3 Wage Setting

So far, we have not specified how the wage is set when firms and workers meet on the labor market. Each firm i bargains with each worker individually. To identify the wage, we assume a standard Nash bargaining process where both parties divide the mutual economic surplus according to their constant relative bargaining power. Put differently, the wage is set to maximize the Nash product

$$w_t = \underset{w}{\operatorname{argmax}} \left(W_t(a_t) - U_t\right)^{\eta} \left(J_t(a_t) - V_t + \Phi(\tilde{a}_t)\right)^{1-\eta}, \tag{20}$$

where $0 < \eta < 1$ denotes the constant relative bargaining power parameter of the household and correspondingly $1-\eta$ is the bargaining power of the firm. The first term in (20) denotes the worker's surplus share and the latter term is the firm's surplus share. More specifically, W_t is the worker's asset value of being employed, while U_t is the asset value of being unemployed. J_t is the marginal asset value of a filled job for the firm and V_t is the firm's fall back option.[4] The bargaining solution is given by:

$$W_t(a_t) - U_t(a_t) = \frac{\eta}{\eta - 1}(J_t(a_t) + \Phi(\tilde{a}_t)). \tag{21}$$

Next, we derive the expressions for present-discounted asset values that characterize the problem of workers and firms. The job value of a hired worker consists of a match-specific wage and the continuation value of that job at date $t+1$.

$$W_t(a_t) = w_t(a_t) + \mathbb{E}_t\beta_{t+1}\left[(1-\rho_{t+1}(a_{t+1}))\int_{\tilde{a}_{t+1}}^{\infty} W_{t+1}(a)\frac{f(a)}{1-F(\tilde{a}_{t+1})}\,\mathrm{d}a + \rho_{t+1}(a_{t+1})U_{t+1}\right]. \tag{22}$$

Note that with probability $(1-\rho_{t+1})$ the job is continued, whereas with probability ρ_{t+1} the job is destroyed and the worker earns the value of being unemployed which is given by:

$$\begin{aligned} U_t = b_t + h^b + \mathbb{E}_t\beta_{t+1}\Big(&\theta_t q(\theta_t)(1-\rho_{t+1}(a_{t+1}))\int_{\tilde{a}_{t+1}}^{\infty} W_{t+1}(a)\frac{f(a)}{1-F(\tilde{a}_{t+1})}\,\mathrm{d}a \\ &+(1-\theta_t q(\theta_t))(1-\rho_{t+1}(a_{t+1}))U_{t+1}\Big). \end{aligned} \tag{23}$$

[3] $\Omega_t^F = [1+\beta(1-\theta_{t-1}q(\theta_{t-1}))]e\rho_R\frac{1}{n_t}\mathscr{W}_t^n$. The parameters e and ρ_R are introduced in section 2.4. Moreover, $\mathscr{W}_t^n = (1-\rho^x)n_t\int_0^{\tilde{a}_t} w_t(a)\frac{f(a_t)}{(1-F(\tilde{a}_t))})\,da$ represents the wage bill of all endogenously separated workers.

[4] A job without a worker has no value to the firm. This ensures that $V_t = 0\,\forall t$ in equilibrium.

An unemployed worker receives the value of unemployment insurance, b_t, the value of home production, h_b, the discounted continuation value of being unemployed, and, in case of a successful new match, the value of future employment. Correspondingly, the firm's asset value depends on the real revenue, the real wage and, if the job is not destroyed, the present-discounted net value at date $t+1$. Thus, the value of at job for a firm at date t in terms of period t units of consumption is

$$J_t(a_t) = \varphi_t A_t a_t - w(a_t) + \frac{c}{q(\theta_t)}. \tag{24}$$

Making use of the job creation condition (16), we can write (24) in terms of the Bellman equation

$$\begin{aligned} J_t(a_t) = \varphi_t A_t a_t - w(a_t) + \mathbb{E}_t \beta_{t+1} \Big[(1 - \rho_{t+1}(a_{t+1})) \int_{\tilde{a}_{t+1}}^{\infty} J_{t+1}(a) \frac{f(a)}{1 - F(\tilde{a}_{t+1})} \, \mathrm{d}a \\ -\rho_{t+1}(a_{t+1}) \Phi_{it+1}(a_{it+1}) \Big]. \end{aligned} \tag{25}$$

Inserting the value functions into (21), we can define the individual real wage as

$$w_t(a_t) = \eta \left[\varphi_t A_t a_t + c\theta_t + \Phi_{it}(a_{it}) - \rho_{t+1}(a_{t+1}) \Phi_{it+1}(a_{it+1}) \right] + (1 - \eta)(b_t + h_b). \tag{26}$$

Jobs are destroyed when $J_t(a_t) < -\Phi(a_t)$. Substituting the value functions in $J_t(a_t)$ and using the wage equation, we can define a critical threshold below which jobs are destroyed:

$$\begin{aligned} \tilde{a}_t = \frac{1}{(1 - \eta)\varphi_t A_t} \Big[(1 - \eta)(b_t + h_b) + \eta c \theta_t - \frac{c}{q(\theta_t)} - (1 - \eta) \Phi_{it}(a_{it}) \\ -\eta \rho_{t+1}(a_{t+1}) \Phi_{it+1}(a_{it+1}) \Big]. \end{aligned} \tag{27}$$

2.4 The Unemployment Insurance Financing

The experience rating system is a unique feature of US labor market institutions. It is based on the idea that employers contribute to the expected cost of unemployment benefits paid to their dismissed workers. Firms pay a layoff tax in case of separation to finance the unemployment benefits. Experience rating thus reduces incentives for firms to layoff workers. However, firms also take potential layoff costs into account when making their hiring decisions. We adopt a simplified representation of the US unemployment insurance system following Cahuc and Malherbet (2004) and Albertini and Fairise (2013). Consequently, the layoff tax per worker is proportional to the fiscal cost of an unemployed worker, Q_t,

$$\phi(\tilde{a}_t) = eQ_t \tag{28}$$

where $e > 0$ denotes the experience rating index. The fiscal cost of an additional unemployed worker can be defined recursively as

$$Q_t = b_t + \beta \mathbb{E}_t \left[\theta_t q_t \times 0 + (1 - \theta_t q_t(\theta)) Q_{t+1} \right]. \tag{29}$$

In case of dismissal, each unemployed worker receives benefits b_t, proportional to her idiosyncratic wage given by

$$b_t = \rho_R w_t(a_t), \tag{30}$$

where $\rho_R < 1$ is the average replacement, i.e., the share of wages that will be paid in case of dismissal. In this sense, layoff taxes, and thereby unemployment benefits, are idiosyncratic. Higher skills and higher education translate into higher layoff taxes if separation takes place. We assume that layoff taxes linearly depend on the worker's productivity, captured by the replacement rate parameter ρ_R.

Moreover, we assume that the unemployment fund's budget has to be balanced in each period and cannot be financed via debt or cross-subsidies. This imposes a constraint on the system as unemployment benefits must be financed entirely by layoff taxes. We assume that taxation takes place in the same period. This implies the intraperiod budget constraint

$$\Phi(\tilde{a}_t) = (1 - n_t)b_t, \tag{31}$$

where the right-hand side denotes the aggregate unemployment benefits defines as $(1-n_t)b_t = (1-\rho^x)\rho_R \mathscr{W}_t^n$. The variable $\mathscr{W}_t^n$ denote the average wage of endogenously separated workers.

2.5 Closing the Model

The aggregate quantities match in equilibrium. Thus, total household income equals total production output of the jobs:

$$Y_t = \mathscr{W}_t + \Pi_t = A_t n_t \int_{\tilde{a}_t}^{\infty} a \frac{f(a_t)}{1 - F(\tilde{a}_t)} \, \mathrm{d}a, \tag{32}$$

and goods markets clear so that $C_t = Y_t$. Finally, the central bank follows a standard Taylor (1993) rule and gradually adjusts the nominal interest rate to deviations from the steady state levels of output and inflation

$$\left(\frac{i_t}{\bar{i}}\right) = \left(\frac{\pi_t}{\bar{\pi}}\right)^{\phi_t} \left(\frac{Y_t}{\bar{Y}}\right)^{\phi_y} \exp(\varsigma_t). \tag{33}$$

The interest rate shock ς_t follows an AR(1) process

$$\exp(\varsigma_t) = \exp(\varsigma_{t-1})^{\rho_i} \exp(\epsilon_t^i), \tag{34}$$

where $0 < \rho_i < 1$ denotes the persistence parameter and $\epsilon_{i,t}$ is an exogenous white noise shock $\sim N(0, \sigma_i^2)$.

3 Calibration

We calibrate the model in accordance with standard values from the business cycle and the search and matching literature. A summary of the parameter values is presented in Table 1.

First, we describe the calibration of the preference and production parameters. The quarterly discount factor is set to $\beta = 0.99$, which implies an annual interest rate R of 4 percent. For the coefficient of relative risk aversion we choose $\sigma = 2$, which is a standard value in the business cycle literature (see, e.g., Krause and Lubik, 2007; Schmitt-Grohe and Uribe, 2007). The price elasticity of demand ε is set to 6, implying a steady state price markup of 20 percent. This value is in accordance with empirical evidence for US industries by Basu and Fernald (1997) and supported by Faia (2008, 2009) and Campolmi and Faia (2011). In line with macroeconomic estimates from Gali et al. (2001) and Sbordone (2002),

Table 1: Calibration

Parameter	Description	Value	Parameter	Description	Value
β	Discount factor	0.99	e	Experience rating index	0.65
σ	Relative risk aversion coefficient	2	$\bar{\rho}$	Steady state separations	0.1
ε	Elasticity of substitution	11	ρ^x	Exogenous steady state separations	0.068
ψ	Adjustment cost parameter	30	μ_{LN}	Mean of c.d.f of productivity	0
π	Steady state inflation	1	σ_{LN}	Variance of c.d.f of productivity	0.12
$\bar{q}$	Steady state job filling rate	0.7	ϕ_π	Taylor rule parameter on inflation	1.5
ζ	Search elasticity of matches	0.4	ϕ_y	Taylor rule parameter on output	0.5/4
η	Worker's bargaining power	0.5	ρ_i	AR(1) interest rate shock parameter	0.49
$\bar{u}$	Steady state unemployment rate	0.2	σ_i	Standard deviation of interest shock	0.0623
ρ_R	Replacement ratio	0.4			

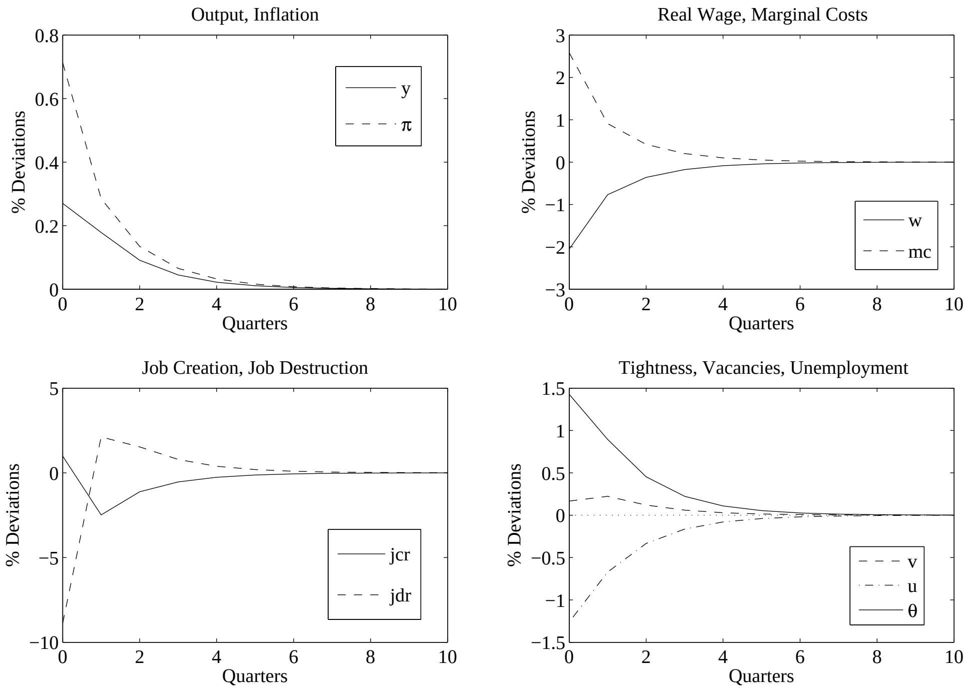
we set the price adjustment cost to $\psi = 30$. This value implies that prices remain fixed on average for approximately 3 quarters, which is also in line with microeconometric evidence by Klenow and Kryvtsov (2008) and Nakamura and Steinsson (2008). For simplicity, we assume that steady state inflation π is equal to unity.

On the labor market, we follow den Haan et al. (2000) and set the steady state matching rate to $q = 0.7$. For the match elasticity we follow empirical estimates of Blanchard and Diamond (1989, 1991) and choose $\mu = 0.4$. Due to the lack of empirical evidence, we follow the literature and assume that the surplus from Nash bargaining is split equally among firms and workers, implying $\eta = 0.5$ (e.g., Krause and Lubik, 2007; Trigari, 2009; Christoffel and Linzert, 2010). We choose a steady state unemployment rate equal to 0.2. This value may seem high at first glance, given unemployment rates observed in the data. However, this value is very close to the estimate of Trigari (2009), who finds $\bar{u} = 0.25$, and lies well within the range of unemployment rates in the search and matching literature.[5] Assuming such a high value is consonant with a broad definition of searching workers, which includes discouraged workers as well as workers which are only loosely attached to the labor force (Faia, 2009). Unemployed workers enjoy unemployment benefits equal to 40% of their wage, i.e., we choose a replacement ratio of $\rho_R = 0.4$. The experience rating index is calibrated to $e = 0.65$. Both figures are drawn from recent evidence of the United States Department of Labor. The former represents approximately the average of the replacement ratios from the year 2013 over all 52 federal states, while the latter represents the average over the experience ratings from 1988-2007 over all 52 federal states.

Following empirical evidence provided by Hall (1995) and Davis et al. (1996), the steady state separations rate is calibrated to $\rho = 0.1$. This value lies well within the interval of commonly applied values, which range from $\rho = 0.07$ (Merz, 1995) to $\rho = 0.15$ (Andolfatto, 1996). Further, den Haan et al. (2000) argue that exogenous separations are twice as likely as endogenous ones. Therefore, we set $\rho^x = 0.068$, which results in an endogenous separations rate of $\rho^n = (\rho - \rho^x)/(1 - \rho^x) = 0.034$. In the steady state the threshold for job destruction is computed by the inverse of the c.d.f. of the lognormal distribution, i.e., $\tilde{a} = F^{-1}(\rho)$. The worker's idiosyncratic productivity a_{it} is i.i.d. and lognormally distributed with a cumulative distribution function $F(\bullet)$ with a normalized mean $\mu_{LN} = 0$ and variance $\sigma_{LN} = 0.12$. Here, we follow Krause and Lubik (2007) and Cooley and Quadrini (1999) who find that job destruction is about seven times as volatile as employment. The choice for our parameter

[5] For instance, while den Haan et al. (2000) and Cole and Rogerson (1999) propose rather low steady state unemployment rates of $\bar{u} = 0.11$ and $\bar{u} = 0.12$, respectively, and Faia (2009) and Cooley and Quadrini (2004) suggest intermediate values around $\bar{u} = 0.4$, a (1996) applies a steady state unemployment rate as high as $\bar{u} = 0.58$.

Figure 1: Impulse responses to an interest rate shock: experience rating model



value lies well in the range of value used by den Haan et al. (2000) and Walsh (2005) ($\sigma_{LN} = 0.10$ and $\sigma_{LN} = 0.13$, respectively).

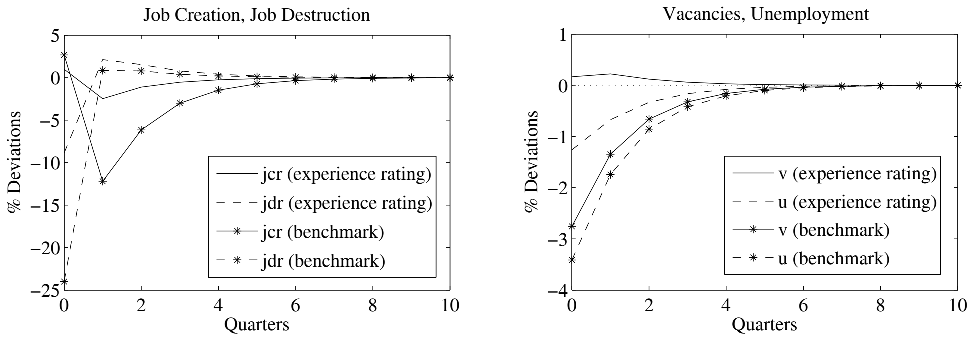
Finally, we calibrate the monetary authority. The parameters governing the Taylor rule are set to $\phi_\pi = 1.5$ and $\phi_y = 0.5/4$. These values are consistent with estimates of US monetary policy rules by Taylor (1999) and Clarida et al. (2000). For the characteristics of the monetary policy shock, we resort to Cooley and Quadrini (1999). Thus, the monetary policy shock follows an AR(1) process with persistence parameter $\rho_i = 0.49$ and standard deviation of the innovation $\sigma_i = 0.0623$.

4 Results

This section presents the main findings of our model. We solve the model using a first-order approximation around the non-stochastic steady state. First, we analyze the model's impulse responses to an unanticipated monetary policy shock. Then, we proceed to compare empirical our business cycle statistics with simulated data. We contrast our approach with a benchmark model as well as an alternative approach to modelling labor institutions. The benchmark model simply abstracts from the unemployment insurance system under experience rating. It is identical to the model by Krause and Lubik (2007) with the only difference that monetary policy is conducted via a Taylor rule instead of a money growth rule. Alternatively, we compare our results to an alternative benchmark, which stars a productivity-dependent firing tax of 54%[6]in the spirit of Zanetti (2011a). We find that experience rating significantly

[6]The value stems from Zanetti (2011b).

Figure 2: Impulse responses to an interest rate shock: model comparison



improves the model's ability to explain the dynamic effects of a monetary policy shock. At the same time, our model is able to replicate additional key labor market facts.

4.1 Impulse Response Analysis

Figure 1 shows the impulse responses of our model after a 1% expansionary monetary policy shock. On impact, output rises in line with inflation, followed by a drop in unemployment. This change is due to a significant drop in job destruction while job creation remains relatively less affected. With unemployment decreasing, the labor market tightens. A higher vacancy to unemployed ratio gives rise to lower expected spells of unemployment since it increases the job finding rate. As expected unemployment spells decline, the expected unemployment contributions per worker decrease. This loosens the pressure on real wages via the wage bargaining, since it lowers the threat point of the firm (Mortensen and Pissarides, 1999). By contrast, the decrease in unemployment leads to an upward pressure in real wages. As is apparent from Figure 1, the former effect dominates the latter, leading to an overall decrease of real wages, increasing the incentive for firms to post more vacancies. With vacancies increasing and unemployment decreasing, the model produces a strong procyclicality of labor market tightness as well as a Beveridge curve. As a consequence of the tight labor market conditions hiring costs increase, which amplifies the negative effect on real wages. Despite this reduction in real wages, marginal costs increase. This is due to the increase in hiring costs which outweighs the drop in real wages. As a result there is an increase in inflation via the Phillips curve.

We now highlight the role of the experience rating in the propagation of the shock. Experience rating influences the model through two distinct channels. First, the presence of experience rating interacts with the firms hiring and firing decision. In the presence of experience rating, hiring and firing become more costly. Since layoffs are costly, even relatively low productive workers (i.e., workers with a negative net present value for the firm) might remain profitable for the firm, as long as the negative net present value is smaller than the layoff costs in absolute value. As a consequence, the critical productivity threshold decreases and the amount of workers prone to job destruction declines. Due to the decline in the productivity threshold, less jobs are separated in the event of a shock. Consequently, experience rating dampens the reaction of job creation and job destruction relative to a model without experience rating. This can be seen in the left panel of Figure 2, which portrays the impulse

Table 2: Empirical and simulated business cycle properties in the U.S.

	US Economy	Benchmark	Alternative Benchmark	Experience Rating
Standard Deviations:				
Output	1.62	0.912	0.915	0.340
Inflation	1.11	0.208	0.243	2.303
Real Wage	0.69	0.651	0.580	6.565
Unemployment	6.90	4.340	4.337	4.350
Vacancies	8.27	3.383	2.548	0.915
Tightness	14.96	0.960	1.780	5.185
Job Creation	2.55	15.591	14.143	8.712
Job Destruction	3.73	26.357	26.104	27.318
Correlations:				
U,V	−0.95	0.999	0.999	−0.898
JCR,JDR	−0.36	−0.241	−0.291	−0.591
Autocorrelations:				
Output	0.87	0.568	0.568	0.604
Inflation	0.66	−0.124	−0.151	0.413

Notes: The statistics for the U.S. economy are calculated using quarterly HP-filtered data from 1964:1 to 2002:3 and are taken from Krause and Lubik (2007). The standard deviations of all variables are relative to the standard deviation of output. The benchmark model is based on the model of Krause and Lubik (2007) with a Taylor rule and abstracts completely from the experience rating unemployment insurance system. The alternative benchmark builds upon the model of Krause and Lubik (2007) with a Taylor rule and adds a productivity-dependent firing cost scheme as in Zanetti (2011).

response functions of the benchmark model in the absence of experience rating (marked with an asterisk) and the impulse response functions of the model in the presence of experience rating (unmarked). Both, a smaller increase in the job creation rate and a smaller decrease in the job destruction rate lead to a smaller decline in the unemployment rate (compared to the benchmark model), as can be seen in the right panel of Figure 2. This, *ceteris paribus*, leads to a smaller increase in real wages. The second channel arises via the expected layoff costs in the wage bargaining. As indicated above, layoff taxes lead to a reduction in real wage. This relative reduction in wages compared to the benchmark model boasts the firms incentive to create vacancies and therewith generates the Beveridge curve.

4.2 Business Cycle Dynamics

Table 2 summarizes business cycle statistics and confirms our results from the impulse response analysis above. The first column of Table 2 presents business cycle statistics based on U.S. data from 1964:1 to 2002:3 provided by Krause and Lubik (2007). The second, third, and fourth column of Table 2 presents the business cycle statistics implied by our benchmark model, the alternative benchmark model, and the model under experience rating, respectively. The business cycle statistics show how the introduction of experience rating can improve the model's ability to explain key labor market facts. Experience rating significantly improves the dynamic properties of the labor market, especially with respect to some of its most important variables, namely, vacancies and labor market tightness.

As is apparent from Table 2, in the benchmark model, the volatility of labor market tightness remains lower than in the U.S. data and it is only marginally procyclical, as vacancies and unemployment are both countercyclical, with the volatility of unemployment being slightly higher. This theoretical behavior of the benchmark economy is at odds with empirical evidence (see, e.g., Shimer, 2005). Therefore, the benchmark model is unable to explain the strong procyclicality of labor market tightness in the data and fails to generate the negative correlation between vacancies and unemployment, i.e. the Beveridge curve (Shimer, 2005; Krause and Lubik, 2007; Costain and Reiter, 2008). In the alternative benchmark, productivity-dependent firing costs increase the volatility of labor market tightness, but only marginally. Its volatility, however, remains lower than that of unemployment and a beveridge curve is still absent.[7] However, the volatility of labor market tightness increases significantly with the introduction of experience rating. Furthermore, labor market tightness is more volatile than unemployment in this case. This strong procyclicality of labor market tightness stems from the fact that, under experience, rating unemployment is countercyclical and vacancy posting is procyclical. The correlation between unemployment and vacancies is strongly negative (around -0.9) and its magnitude is consonant with U.S. data.

The correlation between job creation and job destruction increases when moving from the benchmark model via the alternative benchmark to the model with experience rating, albeit by a little too much. In the absence of labor market institutions, i.e. when layoffs are costless, firms adjust employment instantaneously and almost entirely along the separations margin, instead of waiting for new matches to arrive in the future. Therefore, job creation and job destruction are only marginally correlated in the model without experience rating. Productivity-dependent firing costs and experience rating, on the other hand, make layoffs costly, which depresses the separations margin relative to the creation margin. As is apparent from Table 2, this effect is stronger for experience rating than for productivity-dependent firing costs.

Despite the improved performance of the key labor market dynamics, our parsimonious model inherits some difficulties commonly found in dynamic general equilibrium models with search and matching frictions. It only marginally succeeds to generate an internal propagation mechanism for monetary policy shocks from the labor market to business cycle dynamics. The responses of output and inflation to monetary policy shocks still largely lack endogenously generated persistence. The entire persistence of inflation and almost all of the persistence of output are generated by the exogenous persistence of the monetary policy shock only. Nevertheless, in comparison to the standard search and matching model, experience rating gives rise to a much stronger propagation of the exogenous persistence of the monetary policy shock to inflation persistence.

4.3 Dynamics: Experience Rating System

One advantage of our approach is that it allows us to simulate the business cycle dynamics of the experience rating system. Individual layoff taxes are found to be countercyclical. In times of economic prosperity unemployment spells are short and layoff taxes decline. Conversely, in times of economic slump, unemployment spells increase and expected layoff taxes rise. This is line with empirical evidence provided by Burda and Weder (2010) for payroll taxes (which to a large part consist of contributions to the unemployment insurance system). Aggregate contributions, however, are found to be mildly procyclical. In booms aggregate contributions to the unemployment insurance system rise.

[7] It is worth noting that, given our calibration, for firing costs higher than 160% of productivity a Beveridge curve arises. Therefore, the alternative benchmark model in general is able to produce the Beveridge curve, but only for unreasonably high values of firing costs.

Figure 3: Impulse responses to an interest rate shock: Unemployment Insurance System

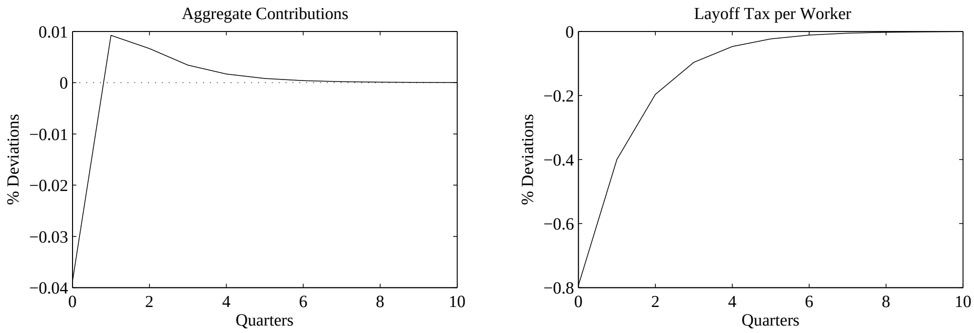
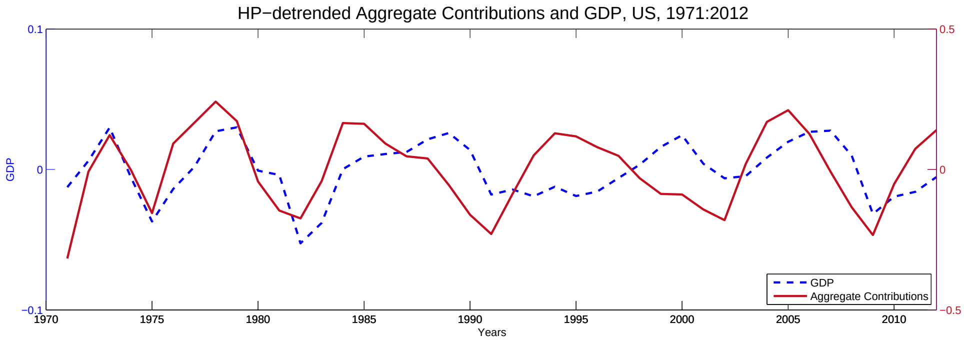


Figure 4: Cyclical Properties of Unemployment Insurance System



Note: HP-detrended yearly times series ($\lambda = 100$). Aggregate contributions and GDP exhibit a contemporaneous correlation coefficient of 0.4063. See Data Appendix for additional details.

This dynamic behavior is in line with US data: The panel in Figure 4 shows the cyclical (hp-filtered) components of the aggregate employer contributions to the unemployment insurance system and GDP after removing low-frequency components. Using annual data from 1970-2012, we find for the sample a positive contemporaneous correlation of aggregate contributions and GDP of 0.4063.

5 Conclusion

In this paper we use a New Keynesian business cycle model with search and matching frictions and incorporate a US style unemployment insurance system based on experience rating. The experience rating system requires firms to contribute to the payment of unemployment benefits via layoff taxes. Such an extended model helps reconcile the search and matching model with the empirical properties of its most important variables. More specifically, layoff taxes allow to generate the negative correlation between vacancies and unemployment, i.e., the Beveridge curve, without assuming real wage rigidities or implausible calibrations. The model can explain more cyclical volatility in its key variable labor market tightness and thus offers a complimentary solution to the Hall-Shimer puzzle.

Furthermore, the introduction of experience rating reduces the excess sensitivity of layoffs found in Krause and Lubik (2007) and strengthens the negative correlation of job creation and job destruction. The intuition is straightforward: As dismissal is not costless anymore, layoff taxes create countervailing employment adjustment costs along the destruction margin. At the same time, aggregate economic conditions enter via the experience rating system. Consequently, labor market regimes affect inflation dynamics and the transmission process of nominal shocks. Our results show that these stylized features of US labor markets can help realign the search and matching model with the data.

Finally, our model allows to analyze the dynamic properties of layoff taxes. Individual layoff taxes are found to be highly countercyclical, i.e. low in booms and high in recessions, which is in line with empirical evidence on payroll taxes provided by Burda and Weder (2010).

Data Appendix

Data Sources

GDP96: Billions of Chained 2009 Dollars, Annually, Seasonally Adjusted Annual Rate
Source: Federal Reserve Bank of St. Louis, FRED

CPIAUCSL: Consumer Price Index for All Urban Consumers, Annually,
Source: Federal Reserve Bank of St. Louis, FRED

CPIINDEX: CPIAUCSL(2009)=1

CONTRIBUTIONS COLLECTED: Annual Data
Source: Department of Labor, Employment and Training Administration,
`https://www.unemploymentinsurance.doleta.gov/unemploy/hb394/hndbkrpt.asp`

PAYEMS: All Employees, Total nonfarm, Annual Data,
Source: Federal Reserve Bank of St. Louis, FRED

Definition of Data Variables

GDP = GDP96
CPI = (CPIAUCSL/CPIINDEX)*100
REAL CONTRIBUTIONS = CONTRIBUTIONS COLLECTED/CPI
EMPLOYMENT = PAYEMS
LAYOFF TAX PER WORKER = log[REAL CONTRIBUTIONS (hp filtered)] - log[EMPLOYMENT (hp filtered)]

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