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Effects of Labor Market Regulation on Employment and Working Hours in a Labor Search Model*

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Abstract

The past 30 years have witnessed lower employment rates and lower hours worked per worker, and thus lower hours worked per person, in Europe relative to the US. European countries have more regulated labor market then the US. This paper envisages the role the labor market regulation plays on the long-term difference in hours worked per person in Europe relative to the US. We study the issue in a neoclassical-growth and labor-search model. We find that our model has a unique steady state. Moreover, we analytically solve the effects of labor market regulation, represented by higher unemployment compensation and labor's bargaining shares, on the employment and hours worked per worker. Finally, using the US as a benchmark, we translate higher unemployment compensation and labor's bargaining shares in Europe into the data and quantify our model. We find that a more regulated labor market can lead to sizable differences in hours worked per person between Europe and the US, with the decomposition into employment and hours worked per worker being close to the data.

Keywords: search and matching, labor market regulation, employment and hours worked.

JEL classification: E24, J22.

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1 Introduction

This paper studies a neoclassical-growth and labor-search model in order to analyze the long-term effects of labor market regulation on differences in hours worked per person in Europe relative to the US with the decomposition into employment rates and hours worked per worker.

In the past 30 years, Europe had declining hours worked per worker relative to the US. There is a growing literature that seeks to understand the relative importance of the various factors as candidate explanations of lower working hours per worker in Europe relative to the US.[1] In particular, Alesina et al. (2005) found that European labor market regulation explained the bulk of the difference between the U.S. and Europe. Alesina et al. (2005) used a reduced-form model and estimated the effects. As a complement to Alesina et al. (2005), our paper uses a growth model to analyze and quantify the effects of labor market regulation on differences in hours worked per person between Europe and the US. In particular, we decompose differences in hours worked per person into employment and hours worked per worker. Alesina et al. (2005) and the above-mentioned papers differentiate per worker's hours worked from leisure without distinguishing employment from unemployment, but Europe had also declining employment rates relative to the US in the past 30 years.[2]

Our model follows from Fang and Rogerson (2009) by studying a model that not only differentiates working hours from leisure but also employment from unemployment. Fang and Rogerson (2009) embed a model of labor supply into a Pissaridis matching model. We extend the Fang and Rogerson (2009) model and include capital by embedding a neoclassical growth model into a Pissaridis matching model. As capital affects the marginal product of employment and working hours in the future, employment, hours worked per worker and hours worked per person in a steady state are thus affected.

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[1] Prescott (2004), Ohanian *et al.* (2008), Jacobs (2009) and Rogerson and Wallenius (2009) argued that the differences in taxes explain much variation in hours of work. Other kinds of explanation include entry cost (Fonseca *et al.*, 2001), preferences (Blanchard, 2004), changes in technology and government (Rogerson, 2006), working-time regulation and employment protection (Causa, 2008), home production (Ngai and Pisssarides, 2008; Olovsson, 2009) and different attitudes toward leisure and leisure externalities (Azariadis *et al.*, 2010).

[2] There is literature that inquires about the reasons for the rise of unemployment in Europe. Ljungqvist and Sargent (1998) highlighted the role of skill accumulation on the job and skill loses during unemployment, whereas Ljungqvist and Sargent (2007) stressed heterogeneous skills and adverse congestion externalities due to search and match. Mortensen and Pissarides (1999)emphasized skill-biased shocks, Blanchard and Wolfers (2000) underscored interactions between price and technology shocks and an adverse labor market, and Blanchard and Giavazzi (2003) pointed out interaction between monopolistic product market and labor union. Moreover, Ljungqvist and Sargent (2008) drew attention to higher dismissal costs and more generous unemployment compensation in Europe.

Specifically, as is standard, we assume a large household. The representative household has a utility non-separable in consumption and leisure with a constant *elasticity of substitution* (henceforth ES) between consumption and leisure. A large firm rents capital from the household and hires labor to produce output. Moreover, the firm creates multiple vacancies. Job creation and labor search are costly and vacancies and job seekers are brought together by a matching technology exhibiting constant returns. A passive government pays unemployment compensation by lump-sum taxes so as to balance its budget. The wage is determined by the bargaining game. The marginal cost and the marginal benefit of vacancies determines the employment. Finally, the equalization of the marginal rate of substitution between leisure and consumption to the wage rate determines hours worked per worker.

We show that there exists a unique steady state in our model (proposition 1). Moreover, we study the comparative-static effects of a more regulated labor market on employment and hours worked per worker in the long run (proposition 2). A more regulated labor market is represented by higher unemployment compensation rate and higher labor bargaining shares. We find that under a sufficiently small ES between consumption and leisure and thus a large income effect, higher unemployment compensation rate and higher labor bargaining shares both unambiguously increase the wage rate and leisure hours. As a result, the employment rate and hours worked per worker are lower in a steady state and thus hours worked per person decrease when the labor market is more regulated. In particular, higher unemployment compensation rate and higher labor bargaining shares affect hours worked per worker mainly through households' tradeoff between consumption and leisure and thus the hour supply, but they influence employment mainly via firms' vacancy creation and thus the employment demand.

Finally, we quantify the effects of a more regulated labor market to shed light on differences in employment and hours worked per worker between Europe and the US. European countries offer higher unemployment compensation than the US (Nickell, 1998; OECD, 1999; Alesina *et al.*, 2005).[3] Moreover, Europe has a stronger labor union than the US (Blanchard, 2004; Alesina *et al.* 2005; Ljungqvist and Sargent, 2008).[4] Using the US as a benchmark, a more regulated labor market

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[3] According to the OECD (1999, Tables 2.2, 2.9 and 3.8), as a percentage of gross earnings, the payment rate was 60% in Belgium and Germany and 75% in France but was 50% in the US. The duration of unemployment benefits had no limits in Belgium and was 60 months in France and 12 months in Germany, but only 6 months in the US. Similar durations of unemployment benefits were reported by Nickell (1998, Table 1). Alesina *et al.* (2005, Tables 3 and 4) also documented that other than more holidays and vocation weeks, Europe had more days of absences than the US based on sickness, maternity and other non-holiday reasons.

[4] According to Calmfors *et al.* (2001, Figure 2.1), union density rates between Europe and the US have been

in the EU is translated partly into unemployment compensation and partly into labor's bargaining shares both larger than the benchmark value. We find that a more regulated labor market can explain sizable differences in hours worked per person between the EU and the US with the decomposition into employment and hours worked per worker being close to the European average. Thus, a more regulated labor market is one of the reasons why Europe has smaller hours worked per person.

The remainder of this paper is as follow. In the next section, we document some data concerning differences in hours worked between Europe and the US. In Section 3, we set up a search-theoretical cum neoclassical growth model. In Section 4, we characterize the steady state equilibrium and carry out comparative-static exercises of a more regulated labor market. Section 5 calibrates the model and quantifies the effects of a more regulated labor market on hours worked per worker, employment and hours worked per person. Finally, we offer some concluding remarks in Section 6. Mathematical appendix is delegated in Section 7.

2 Some Data

Before proceeding to the model, we briefly summarize some of the evidence concerning differences in hours worked per person in Europe relative to the US and the decomposition of these differences into employment and hours worked per worker. Data on total numbers of hours worked and total numbers of the employed are taken from OECD (2010a), whereas data on total numbers of the population aged 15-64 are taken from OECD (2010b).[5] Table 1 presents the data for eleven European countries (EU-11), along with Belgium, France, German, with the US data normalized at 100.

[Insert Table 1 here]

According to Table 1, in the early 1970s, Germany had hours worked per person 30% higher

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widening since 1978 with the density rate being around 15% in the US and 35% in Europe in the 1990s. Nickell (1998, Table 1) documented that in 1989-1994, the labor market in Europe was much more rigid than the US, with the index of the employment protection being 1 in the US and 17 in Belgium, 14 in France and 15 in Germany. Alesina *et al.* (2005) also recorded that the percentage covered by a collective bargaining agreement was 18% in the US, but the percentage in the EU was higher with Belgium, France and Germany being more than or equal to 90%.

[5] To compare the statistics, we employ the same method as those used in Prescott (2004) and Rogerson (2006). Specifically, we divide total hours worked by the number of the employed and by the number of the population aged 15-64, respectively, to obtain hours worked per worker and hours worked per person. The employment rate is the number of the employed divided by the number of the population aged 15-64. We use the population of a country as a weight of the country in calculating the data for the EU-11. All US values are normalized to 100 in 1970-73 and 2000-03.

than that in the US and France had 9% higher than that in the US. Although Belgium had lower hours worked per person than the US, the eleven European countries (EU-11) on average had 9% higher than the US. In the early 2000s, Belgium, France and Germany all had hours worked per person 30% lower than the US and the EU-11 had hours worked per person 19% lower than the US. These numbers indicate large declines of hours worked per person in European countries relative to the US from the early 1970s to the early 2000s. While Germany drops by 55%, France by 35% and Belgium by 20%, the EU on average drops by 28%.

A part of the drop in hours worked per person comes from the drop in employment and a part from the drop in hours worked per worker. First, for employment, Germany, France and the EU-11 had higher employment rates than the US, while Belgium had a slightly smaller employment rate than the US in the early 1970s. In the early 2000s, they all had lower employment rates than the US. From the early 1970s to the early 2000s, the employment rate drops by 12% in Belgium, 14% in France, 18% in Germany and 13% in the EU.

Next, for hours worked per employed worker, in the early 1970s, Germany, France and the EU-11 had higher hours worked per worker than the US, while Belgium had about the same hours worked per worker as the US. In the early 2000s, they all had lower hours worked per worker. From the early 1970s to the early 2000s, hours worked per worker drop by 11% in Belgium, 22% in France, 37% in Germany and 16% in the EU.

To summarize the data, from the early 1970s to the early 2000s, European countries had declining hours worked per person relative to the US. A part of the declines came from declining employment rates and a part came from declining hours worked per employed worker. The EU-11 on average declined 28.23% hours worked per person relative to the US, with the composition of the decline being about 40% from lower employment rates and 60% from lower hours worked per employed worker.

3 The Model

Time is discrete. The economy is populated with a continuum of identical infinitely-lived large households, a continuum of identical infinitely-lived large firms, and a passive fiscal authority. We adopt the assumption of the large household setup to assure full insurance in order to ease unnecessary complexity involved in tracking the distribution of the employed and the unemployed. This setup eliminates the possibility of an endogenous distribution of physical capital as a result of idiosyncratic searches and matching risks in the frictional labor market. The large household comprises a continuum of members (of measure one), who are either (i) employed, by engaging in work or leisure, or (ii) unemployed, by engaging in a job search only. See Figure 1. While the employed obtain the wage when working, the unemployed acquire unemployment compensation. We assume that households own both capital and labor.

[Insert Figure 1 here]

The goods market is Walrasian and the capital market is perfect, while the labor market exhibits search and entry frictions. The cost of household's (endogenously determined) job search and thus labor market participation is a foregone earning cost. A firm can create and maintain (multiple) vacancies by paying a vacancy creation and maintenance cost in the form of material inputs. Unfilled vacancies and active job seekers are met bilaterally through a Diamond (1982) type matching technology, with each vacancy being filled by exactly one job seeker. In our model, the matching flow rates (job finding and employee recruitment rates) are both endogenous, depending on the masses of both matching parties. In every period, filled vacancies and employed workers are separated at an exogenous rate. Finally, the fiscal authority's behavior is simple: it levies lump-sum taxes in order to finance unemployment compensation.

3.1 Households

The representative large household has a unified preference and pools all resources and enjoyment for its members. In period t, a fraction e_t of the members is employed and the remaining fraction $1-e_t$ is unemployed. Given a fixed time endowment normalized at unity, each employed member allocates a fraction l_t of the total time to work and the remaining fraction $1-l_t$ to leisure. Unemployed members devote their entire time to job search.

From the household's perspective, the employment changes according to the following birth-death process

$$e_{t+1} - e_t = \mu_t \left(1 - e_t\right) - \psi e_t, \tag{1}$$

where μ_t denotes the (endogenous) job finding rate and ψ is the (exogenous) job separation rate. Thus, the change in employment ($e_{t+1}-e_t$) is equal to the inflow of workers into the employment pool ($\mu_t(1-e_t)$) net of the outflow as a result of separation (ψe_t).

The representative household obtains utility from consumption and leisure. The household's lifetime preference is given by[6]

$$\max_{c_t, l_t} \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho}\right)^t u\left(c_t, x_t\right),$$

[6] Since we are interested in hours worked in employment, we assume that only the employed members e choose leisure while the non-employed 1-e all search for jobs and do not choose leisure.

where c_t is consumption, $x_t \equiv e_t(1\text{-}l_t)$ is leisure, and $\rho>0$ is the time preference rate.

Denote k_t as the capital stock with δ the depreciation rate. Further, denote w_t and r_t as the wage rate and the interest rate, respectively. Let the unemployment compensation be b and the lump-sum tax per household be T_t. The representative household's budget constraint is

$$c_t + \left[k_{t+1} - \left(1-\delta\right)k_t\right] + T_t = r_t k_t + w_t e_t l_t + b\left(1-e_t\right). \tag{2}$$

The household receives three types of income: the capital interest, the wage earned by employed members, and the compensation received by unemployed members. It allocates income to consumption, investment and lump-sum taxes.

The household's optimal control problem is written as the following Bellman equation,

$$U\left(k_t, e_t\right) = \max_{c_t, l_t}\left[u\left(c_t, x_t\right) + \frac{1}{1+\rho}U\left(k_{t+1}, e_{t+1}\right)\right], \tag{3}$$

subject to the constraints (1) and (2).

The first-order conditions with respect to c_t and l_t are

$$u_c(c_t, x_t) = \frac{1}{1+\rho}U_k\left(k_{t+1}, e_{t+1}\right), \tag{4a}$$

$$u_x(c_t, x_t) = u_c(c_t, x_t)w_t. \tag{4b}$$

Notice that the optimal tradeoff in (4b) equates the marginal rate of substitution between leisure and consumption to the wage rate.

The Benveniste-Scheinkman conditions for k_t and e_t are

$$U_k\left(k_t, e_t\right) = u_c(c_t, x_t)\left(1-\delta+r_t\right), \tag{4c}$$

$$U_e\left(k_t, e_t\right) = u_c(c_t, x_t)\left(w_t l_t - b\right) + u_x(c_t, x_t)\left(1-l_t\right) + \frac{1}{1+\rho}U_e\left(k_{t+1}, e_{t+1}\right)\left(1-\psi-\mu_t\right). \tag{4d}$$

These two conditions correspond to the marginal gains, in terms of lifetime utility, of the representative household from adding an extra unit of capital and employment, respectively.

Forwarding (4c) by one period and substituting it into (4a) gives the following Euler equation

$$u_c(c_t, x_t) = \frac{1}{1+\rho}u_c(c_{t+1}, x_{t+1})\left(1-\delta+r_{t+1}\right). \tag{5}$$

3.2 Firms

The representative firm rents capital and hires labor from households to produce a single final good y_t. The production technology is neoclassical and we use the Cobb-Douglas function.

$$y_t = Ak_t^{\alpha}(e_t l_t)^{1-\alpha}, \tag{6}$$

where A>0 is a productivity parameter and $\alpha \in (0, 1)$ is capital's income share. The technology exhibits a diminishing marginal productivity for each factor input.

Denote η_t as the (endogenous) recruitment rate and v_t as (endogenously) created vacancies. From the firm's perspective, the employment is increased by the inflow of employees ($\eta_t v_t$) and is decreased by the outflow (ψe_t).

$$e_{t+1} - e_t = \eta_t v_t - \psi e_t . \tag{7}$$

We assume a convex cost function of creating and maintaining vacancies: $\Lambda(v_t) = \lambda_0 v_t + \lambda_1 (v_t^2 / 2)$, where λ_0>0, λ_1>0. Hence, the firm's flow profits in t equal the output net of the costs of labor, capital, and vacancies; i.e.,

$$\pi_t = A k_t^{\alpha} (e_t l_t)^{1-\alpha} - w_t e_t l_t - r_t k_t - \Lambda(v_t). \tag{8a}$$

The representative firm chooses capital and vacancies in order to maximize the discounted sum of flow profits. The Bellman equation associated with the firm is

$$\Pi(e_t) = \max_{k_t, v_t} \left[\left(A k_t^{\alpha} (e_t l_t)^{1-\alpha} - w_t e_t l_t - r_t k_t - \lambda_0 v_t - \lambda_1 \frac{v_t^2}{2} \right) + \frac{1}{1+r_t} \Pi(e_{t+1}) \right], \tag{8b}$$

subject to constraint (7).

The first-order conditions with respect to k_t and v_t and the Benveniste-Scheinkman condition for e_t are as follows.

$$\alpha A (\frac{k_t}{e_t l_t})^{\alpha-1} = r_t , \tag{9a}$$

$$\left(\lambda_0 + \lambda_1 v_t\right) = \frac{\eta_t}{1+r_t} \Pi_e(e_{t+1}), \tag{9b}$$

$$\Pi_e(e_t) = [\left(1-\alpha\right) A (\frac{k_t}{e_t l_t})^{\alpha} - w_t] l_t + \frac{1-\psi}{\eta_t} \left(\lambda_0 + \lambda_1 v_t\right). \tag{9c}$$

While capital is determined by the marginal product of capital and the rental rate in (9a), the vacancy creation is determined by a new vacancy's marginal cost today and marginal benefit in the next period in (9b). Together (9b) and (9c), the marginal benefit of a new vacancy in the next period is $\Pi_e(e_{t+1}) = [MPL_{t+1} - w_{t+1}] l_{t+1} + \frac{1-\psi}{1+r_{t+1}} \Pi_e(e_{t+2})$, the sum of the marginal product of employment (MPL) net of the wage rate multiplied by the number of hours worked and the future benefit of the new vacancy. As we will see later, the employment is determined mainly by the vacancy creation condition. When capital is changed, the marginal benefit of vacancy creation is affected and as a result, the employment is altered.

As the capital market is perfect, (9a) equates the marginal product of capital to the interest rate, which can be rewritten as

$$\frac{k_t}{e_t l_t} = \left(\frac{\alpha A}{r_t}\right)^{\frac{1}{1-\alpha}}. \tag{9d}$$

Thus, the market effective capital-labor ratio is decreasing in the interest rate**.**

3.3 Labor Matching and Bargaining

The labor market exhibits search frictions. Following Diamond (1982), we assume pair-wise random matching. The matching technology takes the following constant-returns form.[7]

$$M_t = m(1-e_t)^{\gamma}(v_t)^{1-\gamma},$$

where $m>0$ measures the degree of matching efficacy and $\gamma \in (0, 1)$ the contribution of job seekers in matching.

The household's surplus acquired from a successful match is evaluated by its augmenting value of supplying an additional worker (U_e) whereas the firm's surplus from a successful match is gauged by its incremental value of recruiting an additional employee (Π_e). The representative household and the representative firm determine the effective wage rate by a cooperative bargaining game that maximizes the following joint surplus.

$$\max_{w_t} \; [U_e(k_t, e_t)]^{\beta}[\Pi_e(e_t)]^{1-\beta},$$

where $\beta \in (0, 1)$ measures labor's bargaining power.

In solving the bargaining problem, the household-firm pair treats matching rates (μ_t and η_t), the beginning-of-period level of employment (e_t), and the market interest rate (r_t) as given. When the bargaining is efficient, the Hosios (1990) rule stipulates that $\beta=\gamma$ and thus, the bargaining share is pinned down by the matching elasticity. The first-order condition of the bargaining problem is

$$\frac{\beta}{U_e(k_t, e_t)} \frac{dU_e(k_t, e_t)}{dw_t} = -\frac{1-\beta}{\Pi_e(e_t)} \frac{d\Pi_e(e_t)}{dw_t}. \tag{10}$$

3.4 The Government

[7] In a survey of micro foundations underlying the matching function and its empirical success, Petrongolo and Pissarides (2001) referred to the matching function as a useful modeling device for building labor market frictions into equilibrium macroeconomic models of wages, employment, and unemployment that occupies the same place in the macroeconomist's tool kit as other aggregate functions such as the production function.

The government's behavior is exogenous: it levies per household lump-sum taxes in order to pay unemployment compensation so as to meet following constraint

$$T_t = b\left(1 - e_t\right). \tag{11}$$

4 Equilibrium

A dynamic search equilibrium is a tuple of individual quantity variables, $\{e_t, l_t, v_t, c_t, k_t, y_t\}$, a pair of aggregate quantities, $\{M_t, T_t\}$, a pair of matching rates, $\{\mu_t, \eta_t\}$, and a pair of prices, $\{w_t, r_t\}$, such that: (i) all households and firms optimize; (ii) all employment evolutions hold, (iii) labor-market matching and wage bargaining conditions are met; (iv) the government budget is balanced; and (v) the goods market clears.

4.1 Steady State

A steady state is a dynamic search equilibrium when all variables do not change over time. First, in a steady state the Euler equation in (5) gives the following standard result

$$r = \rho + \delta, \tag{12a}$$

which equates the equilibrium interest rate to the time preference rate and the capital depreciation rate. Substituting (12a) into (9d) yields the market effective capital-labor ratio in a steady state

$$\frac{k}{el} = \left(\frac{\alpha A}{\rho + \delta}\right)^{\frac{1}{1-\alpha}} \equiv q. \tag{12b}$$

Next, if we use the household's budget constraint (2) and the firm's flow profits, together with the government's budget constraint (11), we derive the goods market clearing condition

$$y = c + \delta k + \pi + \Lambda(v). \tag{12c}$$

Moreover, in a steady state the labor market must satisfy the following steady-state matching (Beveridge curve) relationships given by

$$\mu(1-e) = \eta v = m(1-e)^{\gamma}(v)^{1-\gamma} = \psi e. \tag{13}$$

Thus, in a steady state, the employment inflow from the household side, $\mu(1-e)$, is equal to the employment inflow from the firm side, ηv, which is equal to the number of successful job matches and is also equal to the employment outflow because of job separating. The above relationships enable us to solve two matching rates and equilibrium vacancies as functions of e.

$$\mu(e) = \frac{\psi e}{1-e}, \quad \text{where} \quad \mu = \mu(\underset{+}{e};\underset{+}{\psi}), \tag{14a}$$

$$\eta(e) = m^{\frac{1}{1-\gamma}} (\frac{\psi e}{1-e})^{\frac{-\gamma}{1-\gamma}} = m^{\frac{1}{1-\gamma}} [\mu(e)]^{\frac{-\gamma}{1-\gamma}}, \quad \text{where} \quad \eta = \eta(\underset{-}{e}; \underset{+}{m}, \underset{-}{\psi}), \tag{14b}$$

$$v(e) = \left[\frac{\psi e}{m(1-e)^{\gamma}} \right]^{\frac{1}{1-\gamma}} = m^{\frac{-1}{1-\gamma}} [\mu(e)]^{\frac{\gamma}{1-\gamma}} \psi e, \quad \text{where} \quad v = v(\underset{+}{e}; \underset{-}{m}, \underset{+}{\psi}). \tag{14c}$$

In these above relationships, the job finding rate and the equilibrium vacancy are positively related to employment and the employee recruitment rate is negatively related to employment.

Furthermore, using (12a), household's budget constraint in (2) gives

$$c = (w + \rho q) el + b(1-e) - T. \tag{15}$$

Then, from (4b) and (4d), the household's surplus accrued from a successful matching is

$$U_e = \frac{1+\rho}{\rho + \psi + \mu} (w - b) u_c. \tag{16a}$$

To simplify the analysis, we use the following utility function with a general constant elasticity of substitution.

$$u(c_t, x_t) = \left[\varepsilon c_t^{1-\sigma} + (1-\varepsilon) x_t^{1-\sigma} \right]^{\frac{1}{1-\sigma}},$$

where $0<\varepsilon<1$ is the share of consumption and $\sigma>0$ is the reciprocal of the ES between consumption and leisure. A utility with a general constant ES between consumption and leisure is helpful in the analysis of the effects on working hours as the income effect relative to the substitution effect plays important roles. Straightforward differentiation leads to

$$\frac{1}{U_e} \frac{dU_e}{dw} = \frac{1}{w-b} - \sigma(1-\varepsilon) \left[\varepsilon (\frac{c}{x})^{1-\sigma} + 1 - \varepsilon \right]^{-1} \frac{el}{c}. \tag{16b}$$

Denote the marginal product of labor as $MPL \equiv (1-\alpha) A q^{\alpha}$. Using (12a), (9b) and (9c) give firm's surplus accrued from a successful match

$$\Pi_e = \frac{1+\rho+\delta}{\rho+\delta+\psi} (MPL - w) l, \tag{16c}$$

and then we obtain

$$\frac{1}{\Pi_e} \frac{d\Pi_e}{dw} = \frac{-1}{MPL - w}. \tag{16d}$$

Thus, by using (16b)-(16d), we can rewrite (10) as

$$MB_w(\underset{(-)}{w}, l; \underset{(+)}{\beta}, \underset{(+)}{b}) \equiv \frac{\beta}{w}\left\{\frac{w}{w-b} - \sigma(1-\varepsilon)\left[\varepsilon(\frac{c}{x})^{1-\sigma} + 1 - \varepsilon\right]^{-1}\frac{wel}{c}\right\} = \frac{1-\beta}{MPL-w} \equiv MC_w(\underset{(+)}{w}; \underset{(-)}{\beta}), \quad (17a)$$

where the left-hand of (17a) is the marginal benefit of the household from asking higher wages, referred to as MB_w, while the right-hand side of (17a) is the marginal cost of the firm from accepting higher wages, referred to as MC_w.[8]

By using c in (15) and the condition in (11), it is easy to show that the marginal benefit of the household from asking higher wages is decreasing in the wage rate and he marginal cost of the firm from accepting higher wages is increasing in the wage rate. Moreover, it is clear to see that the value of MB_w approaches to the infinity when w approaches to 0 and the value of MC_w is finite when w is 0 and approaches to the infinite when w approaches to MPL. Thus, there is a unique bargained wage in equilibrium. See E_0 in Figure 2.

[Insert Figure 2 about here]

Characterizing the bargained wage, we obtain the following results (see Appendix). First, with other things being equal, a larger working hour has an ambiguous effect on the bargained wage. To see this, a larger working hour shifts the MB_w locus upwards if $\sigma<1$ but downwards if $\sigma>1$. As hours worked do not affect the MC_w locus, the relationship between w and l is positive (*resp.* negative) if $\sigma<$ (*resp.* $>$) 1 and thus $\Phi >$ (*resp.* $<$)0. See E_1 (*resp.* E_2) in Figure 2. Intuitively, under $\sigma<1$, the ES between consumption and leisure is larger than 1 and the substitution effect is larger than the income effect. Thus, the relationship between the wage rate and working hours is positive. Alternatively, under $\sigma>1$, the substitution effect is smaller than the income effect and thus the relationship between the wage rate and working hours is negative.

Second, given hours worked, a higher labor's bargaining power shifts the MB_w locus upwards and the MC_w locus downwards and thus w is increasing in β. See E_3 in Figure 2. Finally, given hours worked, a higher unemployment compensation only shifts the MB_w locus upwards and thus w is increasing in b. See E_1 in Figure 2. Thus, (17a) yields the following relationship for the wage.

$$w = w(\underset{\substack{+ if\, \sigma<1 \\ - if\, \sigma>1}}{l}; \underset{+}{\beta}, \underset{+}{b}) \quad (17b)$$

Then, (15) can be rewritten as

$$c = (w + \rho q)el. \quad (18)$$

Finally, using (17b) and (18), the consumption-leisure tradeoff condition in (4b) is written as

[8] (17) can be written as $[\beta(MPL-b)-(w-b)][\varepsilon(\frac{(w+\rho q)l}{1-l})^{1-\sigma} + 1 - \varepsilon](w+\rho q) = \sigma(1-\varepsilon)(w-b)\beta(MPL-w)$.

$$MU_l(\underset{(+)}{l}) \equiv \frac{(1-\varepsilon)}{(1-l)^{\sigma}} = \varepsilon \frac{w(l)}{(c/e)^{\sigma}} = \varepsilon \frac{w(l)}{[(w(l)+\rho q)l]^{\sigma}} \equiv MU_c(\underset{(-)}{l}). \tag{19}$$

The above relationship equates the marginal utility of leisure, $MU_l(l)$, to the marginal utility of consumption, evaluated by the wage rate, $MU_c(l)$. Using (17d), this relationship determines working hours in a steady state. We can show the following result.

Proposition 1. *There exists a unique steady state.*

The proposition is easily proved as follows. It is easy to show that $MU_l(l)$ is increasing in l and $MU_c(l)$ is decreasing in l. Moreover, the value of $MU_l(l)$ is (1-ε) at l=0 and approaches to the infinity at l=1, while the value of $MU_c(l)$ approaches to the infinite at l=0 and is a finite constant at l=1. Thus, there exists a unique equilibrium working hour, l^*. See E_0 in Figure 3.

[Insert Figure 3 about here]

By combining (12a), (14b), (14c), (16c) and (17d), and substituting in l^* that is obtained from (19), the firm's employment optimization condition in (9b) is written as

$$MB_v(\underset{(-)}{e}) \equiv \frac{\eta(e)}{\rho+\delta+\psi}\left[MPL - w(l^*)\right]l^* = \lambda_0 + \lambda_1 v(e) \equiv MC_v(\underset{(+)}{e}), \tag{20}$$

which equates firm's marginal benefit of vacancies in the left-hand side, $MB_v(e)$, to firm's marginal cost of vacancies in the right-hand side, $MC_v(e)$. It is straightforward to show that the $MB_v(e)$ locus is decreasing in e from the infinite when e=0 to zero when e=1 and the $MC_v(e)$ locus is increasing in e and is from zero at e=0 and to the infinite at e=1. Thus, there exists a unique equilibrium level, e^*. See E_0 in Figure 4.

[Insert Figure 4 about here]

Once we determine the unique pair of hours worked per worker (l^*) and employment (e^*) in a steady state, we can use other conditions to solve for other variables in a steady state. In particular, hours worked per person (e^*l^*) is the product of employment (e^*) and hours worked per worker (l^*).

4.2 Effect of the Labor Market Regulation

A labor market is more regulated if unemployment compensation and the labor's bargaining share are higher. This sub-section studies the effects of a more regulated labor market of this kind on hours worked per worker, employment and hours worked per person.

First, the effect on hours worked per worker can be analyzed using Figure 3. With other things being equal, higher unemployment compensation and higher labor's bargaining power both increase the wage (cf. 17b) which affect the marginal utility of consumption evaluated by the wage rate, $MU_c(l)$ in Figure 3. The wage increase has two offsetting effects on $MU_c(l)$: (i) it directly increases $MU_c(l)$; (ii) it indirectly decrease $MU_c(l)$ via an increase in consumption. In the case if σ is small (thus the ES is large), the effect via (i) dominates and thus the net effect is to increase $MU_c(l)$. Then, the $MU_c(l)$ locus shifts upward which increases hours worked per worker (see E_1 in Figure 3). Alternatively, in the case if σ is large (thus the ES is small) which is the focus of our paper, the effect via (ii) dominates and thus the net effect is to decrease $MU_c(l)$. Then, the $MU_c(l)$ locus shifts downward which decreases hours worked per worker (see E_2 in Figure 3). Thus, only if the ES is small so the income effect is sufficiently strong, then higher unemployment compensation and higher labor's bargaining power can result in smaller hours worked per worker.

To specifically derive the results, denote

$$\tilde{\sigma} \equiv 1 + \rho(\tfrac{\alpha A}{\rho+\delta})^{\frac{1}{1-\alpha}} \tfrac{1}{w^*(A,\alpha,\varepsilon)} > 1,$$

$$\Phi \equiv \beta(1-\sigma)\sigma\varepsilon(1-\varepsilon)\tfrac{l^*}{1-l^*}\chi^{-2}\left(\tfrac{(w^*(A,\alpha,\varepsilon)+\rho q)}{1-l^*}\right)^{-\sigma} \gtrless 0 \ \ if\ \sigma \lessgtr 1;$$

$$\Omega \equiv \beta\{(1-\sigma)[\tfrac{1}{(w^*-b)^2} - (\tfrac{\sigma(1-\varepsilon)}{(w^*+\rho q)}\chi^{-1})^2 \tfrac{\varepsilon}{\sigma(1-\varepsilon)}(\tfrac{(w^*+\rho q)l^*}{1-l^*})^{1-\sigma}] + \sigma[\tfrac{1}{(w^*-b)^2} - \tfrac{(1-\varepsilon)}{(w^*+\rho q)^2}\chi^{-1}]\} > 0;$$

$$\Delta \equiv [\tfrac{-(\sigma-1)w^*+\rho q}{w^*(w^*+\rho q)}][\Omega + \tfrac{1-\beta}{(MPL-w^*)^2}]^{-1}.$$

We consider $\sigma > \max\{\tilde{\sigma},\ \Delta\Phi\}$. Thus, we focus on the case when the ES is sufficiently smaller than unity ($1/\sigma<1$) such that $\sigma > \tilde{\sigma} > 1$, so the income effect is sufficiently strong. Under $\sigma > \tilde{\sigma} > 1$, then $\Delta<0$ and $\Phi<0$ and $\sigma>\Delta\Phi>0$, and thus $\Delta(\sigma-\Delta\Phi)<0$.

We have shown in the Appendix that under $\Delta(\sigma-\Delta\Phi)<0$, higher unemployment compensation and higher labor's bargaining power both decrease hours worked per worker.

$$\frac{dl}{db} = \frac{l^*(1-l^*)\Delta}{\sigma-\Delta\Phi}[\frac{\beta}{(w^*-b)^2}] < 0, \tag{21a}$$

$$\frac{dl}{d\beta} = \frac{l^*(1-l^*)\Delta}{\sigma-\Delta\Phi}[\frac{1}{\beta}\frac{1}{MPL-w^*}] < 0. \tag{21b}$$

Next, the effect on employment can be envisaged using Figure 4. With other things being equal, higher unemployment compensation and higher labor's bargaining power each exerts two effects on firm's marginal benefit of vacancies without affecting the marginal cost of vacancies (cf. (20)). When the ES is small and thus σ is large, they reduce a recruited worker's working hours which reduces firm's marginal benefit of vacancies. Moreover, they increase the wage rate which also reduces firm's marginal benefit of vacancies. In both effects, the $MB_v(e)$ locus is shifted downward. Thus, higher unemployment compensation and higher labor's bargaining power both reduce vacancy creation and thus lower the employment demand and thus the level of employment.

In the Appendix we have also shown that under $\Delta(\sigma\text{-}\Delta\Phi)<0$, higher unemployment compensation and higher labor's bargaining power both decrease employment.

$$\frac{de}{db}=[\frac{\lambda_1 v'(e^*)}{\lambda_0+\lambda_1 v(e^*)}-\frac{\eta'(e^*)}{\eta(e^*)}]^{-1}[\frac{-1}{MPL-w^*}\frac{dw}{db}+\frac{1}{l^*}\frac{dl}{db}]<0, \tag{22a}$$

$$\frac{de}{d\beta}=[\frac{\lambda_1 v'(e^*)}{\lambda_0+\lambda_1 v(e^*)}-\frac{\eta'(e^*)}{\eta(e^*)}]^{-1}[\frac{-1}{MPL-w^*}\frac{dw}{d\beta}+\frac{1}{l^*}\frac{dl}{d\beta}]<0, \tag{22b}$$

where $[\frac{\lambda_1 v'(e^*)}{\lambda_0+\lambda_1 v(e^*)}-\frac{\eta'(e^*)}{\eta(e^*)}]>0$ according to (14b) and (14c) and $\frac{dw}{db}>0$ and $\frac{dw}{d\beta}>0$ under $\Delta(\sigma\text{-}\Delta\Phi)<0$.

Finally, changes in the hours worked per person are the results of changes in the hours worked per employed worker and changes in employment: $d(el)=e(dl)+l(de)$. In the Appendix, we have shown that under Condition ES, higher unemployment compensation and higher labor's bargaining power both decrease hours worked per person.

$$\frac{d(el)}{db}=e^*\frac{dl}{db}+l^*\frac{de}{db}<0, \tag{23a}$$

$$\frac{d(el)}{d\beta}=e^*\frac{dl}{d\beta}+l^*\frac{de}{d\beta}<0. \tag{23b}$$

Thus, under $\Delta(\sigma\text{-}\Delta\Phi)<0$ when the ES is sufficiently small, a more regulated labor market represented by higher unemployment compensation and higher labor's bargaining power decrease both hours worked per worker and the employment rate. As a result, the hours worked per person decrease. To summarize the results,

Proposition 2. *If the elasticity of substitution between consumption and leisure is sufficiently small, a more regulated labor market decreases hours worked per worker, decreases the employment rate and decreases hours worked per person.*

5 Quantitative Analysis

It is worth investigating whether a more regulated labor market, represented by higher unemployment compensation and higher labor's bargaining power, can quantitatively account for differences in employment, hours worked per worker, and hours worked per person between Europe and the US. This section uses quarterly US data to calibrate our model in a steady state and then quantifies the effects.

5.1 Calibration

With the annual depreciation rate of capital in the range of 3% -8% and the annual time preference rate of 6%, we set the quarterly capital depreciation rate to δ=0.01 and the quarterly time preference rate to ρ=0.015. Then we use (12a) to calibrate the interest rate at r=0.025.

The coefficient of technology is normalized to A=1. The capital share is about one-third and we use the value α=0.33. With the values of A and α, we use (12b) to compute the effective capital-labor ratio q=47.0434, which in turn gives MPL=2.3878 and, via (6), the capital-output ratio k/y=13.20.

According to Shimer (2005), the monthly job finding rate is 0.45. We go along with this and translate it into the quarterly value of $\mu=1-(1-0.45)^3=0.8336$. The fraction of employment in the working-age population is about 72% percent (cf. Alesina *et al.* 2005, Table 1) and thus we set e=0.72. Then, we employ (13) to compute the quarterly separation rate as the fraction of employment at $\psi=(\mu/e)-\mu=0.3242$. Moreover, we follow Shimer (2005) by normalizing the steady-state ratio of vacancies to searching workers to one ($v/(1-e)=1$) which implies the vacancy creation in a steady state at v=0.28. The, we utilize (13) to calibrate $\eta=m=0.8336$.

By setting the consumption-output ratio at c/y=0.6, we calibrate the wage rate at w=1.4327 from (18). In accordance with Shimer (2005), the ratio of the unemployment compensation to the wage rate is set to 0.4, and hence we calibrate $b=0.4\times w=0.5731$. The fraction of productive time allocated to the market (el) is chosen at 25% as pointed out by Prescott (2006). This implies l=0.3472. For the parameters in the cost function of the job creation and maintenance, we set $\lambda_1=1$ and then use (20) to calibrate $\lambda_0=0.5117$.

Finally, we choose the value of the ES between consumption and leisure at $1/\sigma=0.4$ (i.e., $\sigma=2.5$). We choose the value for two reasons. First, the value assures that the ES between consumption and leisure is sufficiently small so the income effect is large.[9] Next and more important, the value is within the estimated value of the ES in Europe.[10] Under $e^*=0.72$, $l^*=0.3472$ and $1/\sigma=0.4$, the implied value of the ES between consumption and the labor supply is thus 0.7521. With $\sigma=2.5$, we obtain the share of consumption $\varepsilon=0.4906$ from (19) and the labor share in the

[9] A large income effect is consistent with the argument made by Blanchard (2004, p.4) and others that Europe has used some of the increase in productivity to increase leisure hours.

[10] Using data in the UK, Zabalza *et al.* (1980) found that the ES between income and leisure is 0.25 for men and 1.30 for women. Our value is within the values for men and women estimated by these authors.

wage bargain β=0.6718 from (17a), which is a little bit smaller than those used by Shimer (2005) and Hall (2005).[11] Under the Hosios' rule and thus efficient Nash bargaining, the share of a search worker's contribution in matching is equal to the labor's share in the wage bargaining, $\gamma=\beta$=0.6718. The parameter values, observables and calibrated values are listed in Table 2. Under the benchmark parameter values, we obtain a unique steady state.

[Insert Table 2 here]

5.2 Quantitative Results

We now quantify the effects of a more regulated labor market represented by higher unemployment compensation (higher b) and higher labor's bargaining power (higher β). We study the effects of increases in each of these two parameter values from the baseline on hours worked per worker (l), employment (e) and hours worked per person (el).

Data indicate that European countries have higher unemployment payment rates, longer duration rates and more days of non-holiday absences than the US. Statistics also suggest that the union density rates in European countries are more than twice that in the US. To translate the data into differences in the values of b and β, we increase the values of b and β by 25% from the baseline parameterization.[12] A 25% difference may be conservative and cannot capture the difference in the labor market regulation between the EU and the US. A larger value of b and β from the baseline can explain more of differences in hours worked per person. Nevertheless, the composition into differences in hours worked per worker and is less sensitive to changes in the values of b and β.

The quantitative results are in Table 3. First, with other things being equal, when the unemployment compensation is increased by 25%, the equilibrium wage rate is increased by 7.68%. As a result of a large income effect, hours worked per worker are decreased by 1.34% and the employment rate is decreased by 1.35%. Thus, higher unemployment compensation has a larger detrimental effect on the employment rate. With these two effects together, a 25% higher unemployment compensation reduces hours worked per person by 2.67%.

[Insert table 3 here]

Next, with other things being equal, when the labor's bargaining share is increased by 25%, the equilibrium wage rate is increased dramatically by 18.95%. As a result, hours worked per worker are decreased sizably by 3.25% and the employment rate is decreased by 1.48%. Apparently, a higher

[11] While Shimer (2005) used β = 0.72, Hall (2005) used β = 0.74.

[12] It is worth noting that a one-quarter increase is similar to a 12.5% deviation from the benchmark value.

labor's bargaining share has a much larger harmful effect on hours worked per employed worker. With these two effects together, a 25% higher labor's bargaining share reduces hours worked per person by 4.68%.

Finally, when we sum up the effects of a 25% more regulated labor market, hours worked per worker are reduced by 4.42% from the benchmark level which is 26.91% differences in hours worked per worker between the EU and the US from the early 1970s to the early 2000s in Table 1. Moreover, the employment rate is decreased by 2.23% from the benchmark level which is 17.68% differences in the employment between the EU and the US in the past 30 years. Together, a 25% more regulated labor market reduces hours worked per person by 6.55% which explains about one-quarter differences (23%) in the hours worked per person between the EU and the US in the past three decades. For the explained one-quarter differences in the hours worked per person, we find that 34% is caused by differences in employment and 66% is based on differences in hours worked per worker. These figures are close to those in Table 1 wherein about 40% is from differences in employment and about 60% is from differences in hours worked per worker.

5.3 Quantitative Results: Profit Are Redistributed to Households

In our model, there are profits since the bargained wage is below the wage in a competitive labor market and is thus smaller than the marginal product of labor. In this subsection, we redistribute profits to households and investigate how much a slightly more regulated labor market explains differences in the labor market between the EU and the US. It is worth noting that redistributed profits increase effective consumption and reduces the income effect which increases labor's responses to higher unemployment compensation and labor bargaining shares. Thus, it is expected that a more regulated labor market will explain a smaller fraction of differences in hours worked per person between the EU and the US. Nevertheless, the composition into hours worked per person and employment would be less affected.

Adding profits to the household's budget constraint (2) would not change the household's optimal decisions but this modifies the steady-state goods market clearance condition in (12) to $y=c+\delta k+A(v)$. Using (8a) and (14c), the profits are

$$\pi = \left(Aq^{\alpha} - w - rq \right) el - \lambda_0 v(e) - \lambda_1 \frac{v(e)^2}{2}. \tag{26a}$$

Then, the effective consumption in (15) becomes

$$\overline{c} = c + \pi = \left(Aq^{\alpha} - \delta \right) el - \lambda_0 v(e) - \lambda_1 \frac{v(e)^2}{2} \equiv c(e,l). \tag{26b}$$

Then, while (20) is unchanged, (17a) and (19) become, respectively,

$$\frac{\beta}{w}\left\{\frac{w}{w-b}-\sigma\left(1-\varepsilon\right)\left[\varepsilon\left(\frac{c(e,l)}{x}\right)^{1-\sigma}+1-\varepsilon\right]^{-1}\frac{wel}{c(e,l)}\right\}=\frac{1-\beta}{MPL-w}, \tag{27a}$$

$$\frac{(1-\varepsilon)}{\left[\left(1-l\right)\right]^{\sigma}}=\varepsilon\frac{w(l)}{[c(e,l)/e]^{\sigma}}. \tag{27b}$$

The steady-state system includes (20), (27a) and (27b) that simultaneously solves for w, e and l. We can then differentiate (20), (27a) and (27b), together with (26b), to obtain the effects of higher b and higher β on w, l and e, and thus, el. The results are qualitatively similar to those in Section 3.2. To save space, we will not repeat the exercises here.

To quantify the effects of a slightly more regulated labor market, we continue to use all the values of benchmark parameters and observables in Table 2 except for the values of δ and ρ. In order to calibrate a value of β so as to be not far from that in Shimer (2005) and Hall (2005) and to maintain the same steady-state value of e^{*}=0.72 and l^{*}=0.3472, we use δ=0.025 and ρ=0.01. Our calibration gives r=0.0350, q=28.4706, ψ=0.3242, v=0.28, η=m=0.8336, k/y=9.4286, w=1.2998, b=0.5199, λ_0=0.3029, ε=0.4123 and β=γ=0.7383. Under these parameter values, we obtain a unique steady state.

We then quantify the effects of slightly increasing the unemployment compensation and the labor's bargaining share from their benchmark values both by one quarter. The results are in Table 4. With other things being equal, we find that hours worked per worker are decreased by 1.36% and the employment rate is decreased by 1.20% which is 8.29% and 9.54%, respectively, of differences between the EU and the US. As a result, hours worked per person are decreased by 2.55% which is 9.02% of differences in hours worked per person between the EU and the US.

[Insert Table 4 here]

The above results indicate that when profits are redistributed to households, the income effect is weaker. Thus, the same slightly more regulated labor market can explain one-tenth differences in hours worked per person that is a little bit more than one third of that in Table 3 when profits are not redistributed. Nevertheless, the explained difference in hours worked per person suggests that 46.87% is due to differences in employment and 53.13 % is attributable to differences in hours worked per worker. These numbers are close to those in Table 1 wherein about 40% is thanks to differences in employment and about 60% is owing to differences in hours worked per worker.

6 Concluding Remarks

This paper studies a neoclassical-growth and labor-search model. Our model includes the differentiation between employment and unemployment and between working and leisure. One model adds values by analytically determining employment and working hours when there is capital accumulation which affects the marginal product of employment and working hours. We find that there exists a unique steady state. Moreover, we analytically solve the effects of a more regulated labor market on employment and hours worked per worker. We find that if the elasticity of substitution between consumption and leisure is sufficiently small so the income effect is sufficiently large, a more regulated labor market decreases hours worked per worker and the employment rate in a steady state. As a result, hours worked per person decrease when the labor market is more regulated. The effects on hours worked per worker are mainly via households' consumption-leisure tradeoff and thus the hour supply, while the effects on employment are primarily through firms' vacancy creation and thus the employment demand.

Europe has a more regulated labor market with higher unemployment payment rates and larger union density rates than the US. Using the US as a benchmark, we increase unemployment compensation and bargaining shares from the benchmark level and quantify the effects on hours worked per person and the composition into employment and hours worked per worker. We find that a more regulated labor market can explain more differences in hours worked per person between the EU and the US when profits are not redistributed to households than when profits are redistributed to households. Nevertheless, no matter if profits are redistributed to households or not, the decomposition of differences in hours worked per person into differences in employment and hours worked per worker is close to the data. Thus, in the case of a more regulated labor market, our model can properly differentiate and successfully quantify the composition between employment and working hours.

7 Mathematical Appendix

7.1. The wage equation.

With other things being equal, if we differentiate MC_w in (17a), we obtain

$$dMC_w = \frac{1-\beta}{(MPL-w)^2}dw - \frac{1}{MPL-w}d\beta, \tag{A1a}$$

and thus the marginal cost of the firm from accepting higher wages is increasing in the wage rate, $\frac{1-\beta}{(MPL-w)^2} > 0$. Moreover, by using c in (15) and the condition in (11), if we differentiate MB_w in (17a), we obtain

$$dMB_w = -\Omega dw + \tfrac{\Phi}{l(1-l)} dl + \frac{1}{\beta}\frac{1-\beta}{MPL-w} d\beta + \frac{\beta}{(w-b)^2} db, \tag{A1b}$$

where $\Omega \equiv \beta\{(1-\sigma)[\tfrac{1}{(w-b)^2} - (\tfrac{\sigma(1-\varepsilon)}{(w+\rho q)}\chi^{-1})^2 \tfrac{\varepsilon}{\sigma(1-\varepsilon)}(\tfrac{(w+\rho q)l}{1-l})^{1-\sigma}] + \sigma[\tfrac{1}{(w-b)^2} - \tfrac{(1-\varepsilon)}{(w+\rho q)^2}\chi^{-1}]\} > 0;$

$$\Phi \equiv \beta(1-\sigma)\varepsilon\sigma(1-\varepsilon)\tfrac{l}{1-l}\chi^{-2}\left(\tfrac{(w+\rho q)}{1-l}\right)^{-\sigma} \gtrless 0 \ \ if\ \sigma \lessgtr 1;$$

$$\chi \equiv \varepsilon(\tfrac{(w+\rho q)l}{1-l})^{1-\sigma} + 1 - \varepsilon > 0.$$

The diminishing marginal benefit of the household from asking higher wages requires $-\Omega<0$ and thus, $\Omega>0$.

Equating (A1a) to (A1b) gives

$$-\Omega dw + \tfrac{\Phi}{l(1-l)} dl + \frac{1}{\beta}\frac{1-\beta}{MPL-w} d\beta + \frac{\beta}{(w-b)^2} db = \frac{1-\beta}{(MPL-w)^2} dw - \frac{1}{MPL-w} d\beta. \tag{A1c}$$

which gives the wage equation in (17b).

7.2. Comparative-Static Effects in Steady State

First, differentiating (19) gives

$$[\frac{\sigma}{l^*\left(1-l^*\right)}]dl = [\frac{-(\sigma-1)w^* + \rho q}{w^*\left(w^* + \rho q\right)}]dw. \tag{A2a}$$

Substituting (17b) into (A2a) yields

$$\frac{\sigma}{l^*(1-l^*)} dl = \Delta[\tfrac{\Phi}{l(1-l)} dl + \frac{1}{\beta(MPL-w^*)} d\beta + \frac{\beta}{(w^*-b)^2} db]. \tag{A2b}$$

Using (A2b), we obtain

$$\frac{dl}{db} = \frac{l^*(1-l^*)\Delta}{\sigma-\Delta\Phi}[\frac{\beta}{(w^*-b)^2}] < 0, \quad \text{if} \quad \Delta(\sigma-\Delta\Phi) < 0; \tag{A3a}$$

$$\frac{dl}{d\beta} = \frac{l^*(1-l^*)\Delta}{\sigma-\Delta\Phi}[\frac{1}{\beta}\frac{1}{MPL-w^*}] < 0, \quad \text{if} \quad \Delta(\sigma-\Delta\Phi) < 0. \tag{A3b}$$

Note that Condition ES implies $\Delta(\sigma-\Delta\Phi) < 0$.

Next, if we substitute (A2b) into (A1c), we obtain

$$\frac{dw}{db} = [1+\frac{l^*(1-l^*)\Delta\Phi}{\sigma-\Delta\Phi}][\Omega+\frac{1-\beta}{(MPL-w^*)^2}]^{-1}[\frac{\beta}{(w^*-b)^2}] > 0, \ \text{if} \ \ \sigma > \Delta\Phi; \tag{A4a}$$

$$\frac{dw}{d\beta} = [1+\frac{l^*(1-l^*)\Delta\Phi}{\sigma-\Delta\Phi}][\Omega+\frac{1-\beta}{(MPL-w^*)^2}]^{-1}[\frac{1}{\beta}\frac{1}{MPL-w^*}] > 0, \ \text{if} \ \ \sigma > \Delta\Phi. \tag{A4b}$$

Moreover, differentiating (20) gives

$$[\frac{\lambda_1 v'(e^*)}{\lambda_0+\lambda_1 v(e^*)}-\frac{\eta'(e^*)}{\eta(e^*)}]de=\frac{-1}{MPL-w^*}dw+\frac{1}{l^*}dl, \qquad \text{(A5)}$$

where $[\frac{\lambda_1 v'(e^*)}{\lambda_0+\lambda_1 v(e^*)}-\frac{\eta'(e^*)}{\eta(e^*)}]>0$ according to (14b) and (14c). Then, using (A3a), (A3b), (A4a) and (A4b), we obtain

$$\frac{de}{db}=[\frac{\lambda_1 v'(e^*)}{\lambda_0+\lambda_1 v(e^*)}-\frac{\eta'(e^*)}{\eta(e^*)}]^{-1}[\frac{-1}{MPL-w^*}\frac{dw}{db}+\frac{1}{l^*}\frac{dl}{db}]<0, \text{ if } \Delta(\sigma-\Delta\Phi)<0; \qquad \text{(A6a)}$$

$$\frac{de}{d\beta}=[\frac{\lambda_1 v'(e^*)}{\lambda_0+\lambda_1 v(e^*)}-\frac{\eta'(e^*)}{\eta(e^*)}]^{-1}[\frac{-1}{MPL-w^*}\frac{dw}{d\beta}+\frac{1}{l^*}\frac{dl}{d\beta}]<0, \text{ if } \Delta(\sigma-\Delta\Phi)<0. \qquad \text{(A6b)}$$

Finally, $d(el)=e(dl)+l(de)$ and thus we obtain

$$\frac{d(el)}{db}=e^*\frac{dl}{db}+l^*\frac{de}{db}<0, \text{ if } \Delta(\sigma-\Delta\Phi)<0; \qquad \text{(A7a)}$$

$$\frac{d(el)}{d\beta}=e^*\frac{dl}{d\beta}+l^*\frac{de}{d\beta}<0, \text{ if } \Delta(\sigma-\Delta\Phi)<0. \qquad \text{(A7b)}$$

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Table 1: Hours and Employment in the EU Relative to the US, 1970-73 and 2000-2003.

	Hours worked per person			Employment rate			Hours worked per worker		
	70-73	00-03	diff.	70-73	00-03	diff.	70-73	00-03	diff.
Belgium	92.86	72.5	-20.36	95.44	83.65	-11.79	97.29	86.7	-10.59
France	109.63	74.87	-34.76	103.36	89.52	-13.84	106.07	83.65	-22.42
Germany	132.79	77.42	-55.37	107.91	90.34	-17.57	123.04	85.7	-37.34
EU-11	109.63	81.4	-28.23	101.51	88.91	-12.60 (43.42%)	107.99	91.57	-16.42 (56.58%)
United States	100	100	0	100	100	0	100	100	0

Note: 1. All US values normalized to 100 in 1970-73 and 2000-03. All EU data in 1970-73 and 2000-03 normalized to the U.S. values in the respective period. EU-11 includes Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Spain, Sweden and the UK.

2. Numbers in parenthesis are the composition of differences in hours worked per person in EU-11 into employment and hours worked per worker.

Sources: OECD (2010a, 2010b).

Table 2 Benchmark parameter values and calibration

Benchmark Parameters and Observables		quarterly
physical capital's depreciation rate	δ	0.0100
time preference rate	ρ	0.0150
aggregate consumption-aggregate output ratio	c/y	0.6000
capital's share	α	0.3300
job finding rate	μ	0.8336
fraction of employment	e	0.7200
vacancy-searching worker ratio	$v/(1-e)$	1.0000
coefficient of goods technology	A	1.0000
coefficient of the cost of vacancy creation and management	λ_1	1.0000
fraction of time devote to work	el	0.2500
inverse of elasticity of substitution between c and x	σ	2.5000
Calibration		
rate of return of capital	r	0.0250
effective capital-labor ratio	q	47.0434
job separation rate	ψ	0.3242
vacancy creation	v	0.2800
hours worked per worker	l	0.3472
employee recruitment rate	η	0.8336
matching efficacy	m	0.8336
capital-output ratio	k/y	13.2000
equilibrium wage	w	1.4327
unemployment compensation	b	0.5731
coefficient of the cost of vacancy creation and management	λ_0	0.5117
utility weight of consumption	ε	0.4906
labor searcher's bargaining power	β	0.6718
labor searcher's share in matching production	γ	0. 6718

Table 3: Quantitative Results

	el		*e*		*l*		*w*	
Benchmark	**0.250000**	**100.00%**	**0.720000**	**100.00%**	**0.347222**	**100.00%**	**1.432684**	**100.00%**
$b \uparrow$ 25%	0.243318	-2.67%	0.710263	-1.35%	0.342574	-1.34%	1.542680	7.68%
$\beta \uparrow$ 25%	0.238294	-4.68%	0.709316	-1.48%	0.335949	-3.25%	1.704247	18.95%
b and $\beta \uparrow$ 25%	0.233632	**-6.55%**	0.703965	**-2.23%**	0.331881	**-4.42%**	1.806753	26.11%
Percentages of those in Table 1		**23.19%**		**17.68%**		**26.91%**		
Percentages of changes in *el*		**100%**		**33.51%**		**66.49%**		

Note: 1. Parameter values are in Table 2.

Table 4: Quantitative Results with profits redistribution

	el		*e*		*l*		*w*	
Benchmark	**0.250000**	**100.00%**	**0.720000**	**100.00%**	**0.347222**	**100.00%**	**1.432684**	**100.00%**
$b \uparrow$ 25%	0.247166	-1.13%	0.713305	-0.93%	0.346509	-0.21%	1.393556	7.22%
$\beta \uparrow$ 25%	0.245765	-1.69%	0.714237	-0.80%	0.344094	-0.90%	1.577088	21.34%
b and $\beta \uparrow$ 25%	0.243632	**-2.55**%	0.711348	**-1.20**%	0.342493	**-1.36**%	1.668403	28.36%
Percentages of those in Table 1		**9.02%**		**9.54%**		**8.29%**		
Percentages of changes in *el*		**100%**		**46.87%**		**53.13%**		

Note: 1. Observable parameter values are in Table 2 except for δ=0.025 and ρ=0.01.

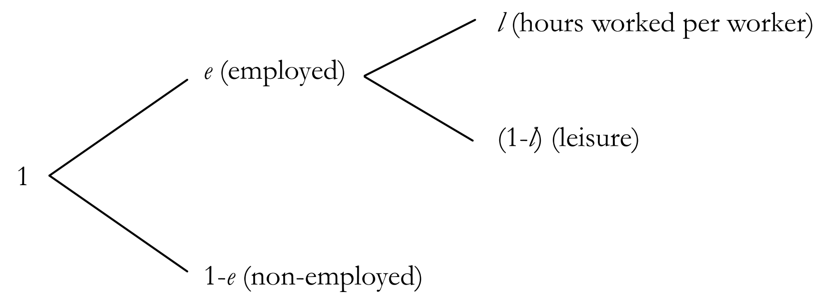

Figure 1: Labor Allocation for Households

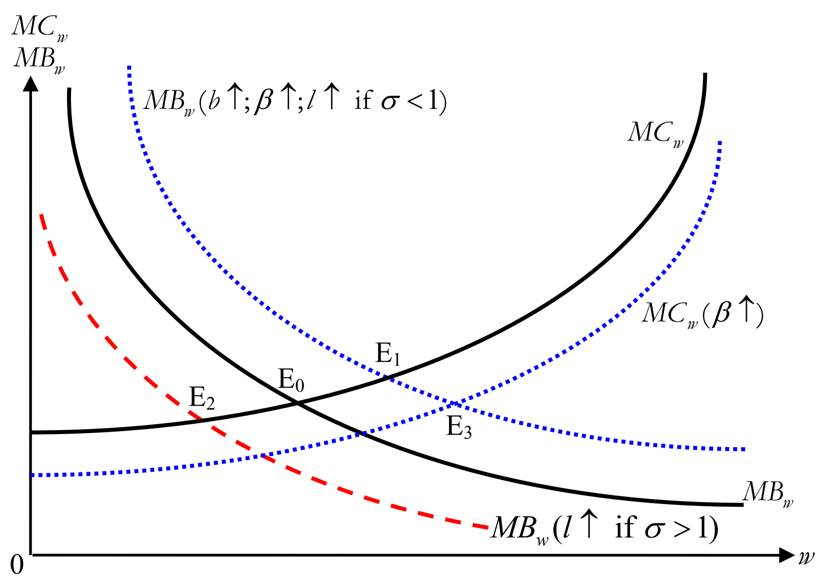

Figure 2: Equilibrium Wage

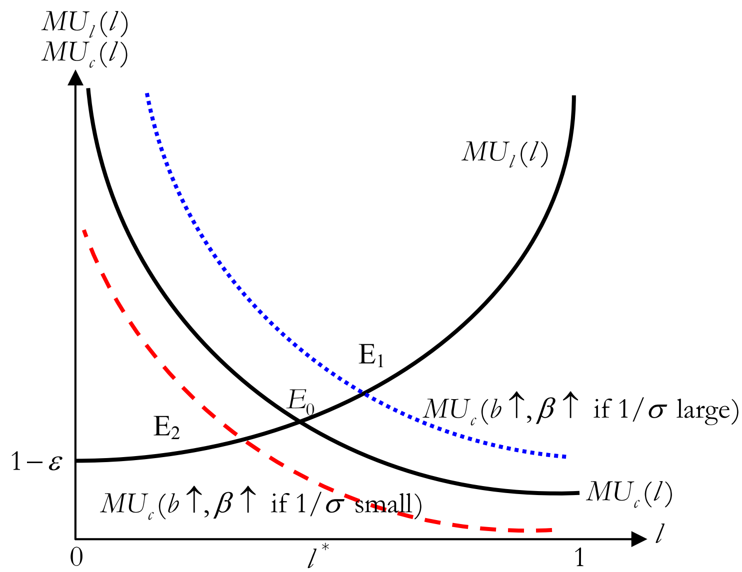

Figure 3: Equilibrium Hours Worked Per Worker

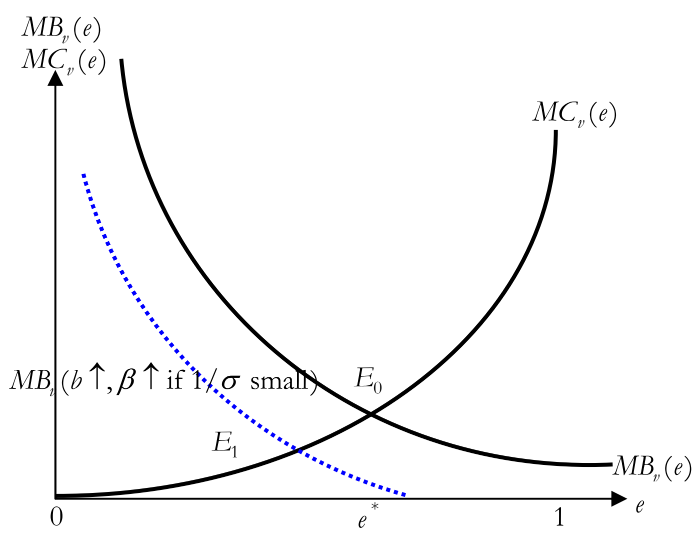

Figure 4: Equilibrium Employment

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