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Labor-Market Policies in an Equilibrium Search Model

1. *Introduction*

Labor markets perform quite differently across countries. An often cited example is the sharp contrast in unemployment rates between Europe and the United States. There are large and persistent differences in labor-market policies as well.[1] The goal of this paper is to explore to what extent differences in labor market policies can generate differences in labor-market performance. In particular, the paper builds a general equilibrium model to evaluate the aggregate effects and welfare consequences of a variety of labor-market policies and institutions, mainly minimum wages, firing restrictions, unemployment insurance, and unions. The model embodies a McCall search model in a general-equilibrium production economy by modifying Lucas and Prescott's (1974) island model to incorporate undirected search and out-of-the-labor-force participation.

Production takes place in a large number of separate locations called islands, which use labor as an input of production in a decreasing-returns-to-scale technology. In each island there are a fixed number of firms which share a common productivity shock. Productivity shocks follow a Markov process, and are identically and independently distrib-

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1. This has been documented in a number of OECD Jobs Studies and surveyed and analyzed by Nickell (1997), among others.

uted across islands. At the beginning of a period, there is a given distribution of agents across islands. After shocks are realized, agents decide whether to leave their islands and become nonemployed, or stay and work. Nonemployed agents must decide whether to search or engage in home production. If an agent searches, he is randomly assigned to an island the following period. In this sense search is undirected.

Labor markets are competitive within each island: firms and workers take the process for spot wages as given. We also assume that firms and workers have access to a complete set of state-contingent securities indexed by the shocks to each island. Given this market structure, workers and firms maximize the expected discounted value of their earnings. The model abstracts from any insurance role of labor-market policies. In Alvarez and Veracierto (1998) we analyzed unemployment insurance and severance payments in a model with incomplete markets and found that the insurance role of these policies was quantitatively very small.[2] Their welfare implications were dominated by their effects on productivity, search decisions, and firm dynamics. Those findings motivate our current assumption of complete markets; it considerably simplifies the analysis, allowing us to analyze a richer set of policies while still capturing most of the effects of these policies.

The model is general equilibrium in the sense that: (1) wages are consistent with market clearing in each island, (2) the cross-sectional distribution of employment and wages is endogenous, (3) the endogenous distribution of wages across islands is consistent with the incentives to search, and (4) aggregate employment is consistent with the number of workers that search and the aggregate labor supply.

The model is closely related to two strands in the literature. First, it incorporates important elements of industry equilibrium models where the job creation and destruction process is determined by changes in the labor demand of firms. Examples of these models include Bertola and Caballero (1994), Bentolila and Bertola (1990), Hopenhayn and Rogerson (1993), Campbell and Fisher (1996), and Veracierto (1995). Second, it incorporates features of standard search models where the job creation and destruction process is determined by the accept–reject decisions of workers. Examples of these models include McCall (1970), Mortensen (1986), Wolpin (1987), and Lundqvist and Sargent (1998).

Industry equilibrium models (e.g., Hopenhayn and Rogerson (1993)) have typically abstracted from unemployment decisions, focusing on the employment–nonemployment decision. Most equilibrium models of unemployment that have been used for policy analysis (e.g.,

2. Also see Costain (1997), Hansen and Imrohoroglu (1992), and Valdivia (1996).

Millard and Mortensen (1997)) have abstracted from the employment–nonemployment decision and studied production units that consist of single workers. The model in this paper incorporates all three margins: (1) the employment decision of firms, which allows to study firms dynamics; (2) home vs. market production decisions, which allows us to analyze labor-force participation; and (3) the search decisions of workers, which allows us to study unemployment.[3] In fact, the labor-market policies that we analyze will have important consequences for all of these margins.

We start by considering a laissez-faire regime. Since this is an economy where the laissez-faire equilibrium is efficient (despite the search frictions), we use it as a benchmark when comparing the effects of different policies. We show how to modify the basic environment to introduce minimum wages, unions, firing taxes, and unemployment benefits. In all cases, we consider stationary equilibria only. We select parameter values by matching model moments with selected U.S. statistics under a stylized version of U.S. policies.

Minimum wages are introduced as in textbook analyses: if equilibrium wages in a given island are lower than the minimum wage, jobs must be rationed in some way until wages equal the minimum wage. We experiment with different ways of rationing the supply of workers. For instance, we allow for a distinction between "insiders" and "outsiders." We find that the aggregate effects of minimum wages are extremely small in all the cases.

We introduce unions, by assuming that the workers in a certain fraction of the islands sector are unionized. As in textbook analyses, unions restrict employment in order to increase total wage earnings. As a consequence, unionized islands generate higher unemployment rates than competitive islands. We consider two models of unions, with quite different implications. In one version, a union is consistituted by the coalition of all workers present in the island at a given period of time. The workers collude to extract rents from the fixed factor, sharing the benefits equally among themselves. In the other version, the union is dominated by a "union boss" who appropriates all the rents from the fixed factor, and pays workers their opportunity cost. We find that in the coalition model of unions, higher degrees of unionization increase the unemployment rate and decrease welfare levels substantially. This is due to the incentives to search for a unionized island in order to appropriate rents.

3. On the other hand, our model abstracts from entry and exit and from any search done by firms, two margins that have been analyzed in previous studies.

The rationing of employment in unionized islands contributes to larger flows into unemployment as well.

Following Bentolila and Bertola (1990) and Hopenhayn and Rogerson (1993), we introduce firing restrictions as a tax on employment reductions. This tax makes the firms' employment decisions dynamic, since increasing current employment exposes firms to future firing costs. Firms react to the firing taxes by firing and hiring workers less often, leading to higher unemployment duration and lower unemployment incidence. Under our parametrization, the decrease in unemployment incidence dominates the increase in unemployment duration. As a consequence, firing taxes reduce the unemployment rate in the economy. Similarly to previous studies, we find that firing taxes equivalent to one year of wages have large negative welfare effects. However, firing taxes of similar magnitudes to the severance payments observed in OECD countries produce relatively small negative effects.

Finally, we model unemployment insurance (UI) benefits as payments that accrue to workers after a job separation. In our model, unemployment benefits have similar effects to firing subsidies.[4] In particular, agents choose to stay out of the labor force and not search as long as they are eligible for UI benefits. We find that UI benefits have large effects on unemployment rates, since they increase both the duration and the incidence of unemployment. For instance, doubling the present value of UI benefits (from U.S. values) increases unemployment rates by about 1%.

Our quantitative analysis indicates that the responses of the unemployment rate and employment to changes in UI benefits, degree of unionization, minimum wages, and firing taxes are broadly consistent with estimates in the empirical literature (Nickell, 1977, for example). This provides some confidence about the structure of our model economy and the welfare results obtained.

The paper is organized as follows. Section 2 describes the economy. Section 3 describes the laissez-faire equilibrium. Section 4 introduces different policies/institutions into the basic model. Section 5 explains our choice of parameter values. Section 6 describes the effects of the different policies in the calibrated economy. Finally, Section 7 compares these effects with estimates provided by the empirical literature.

2. *The Economy*

The economy is populated by a measure one of ex ante identical agents with preferences given by

4. In fact, they are completely equivalent when the UI benefits are small.

$$E \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{1-\gamma} - 1}{1 - \gamma} + h_t \right),$$

where c_t is consumption of market goods, h_t is consumption of home goods, $\gamma \geq 0$, and $0 < \beta < 1$.

The market good is produced in a continuum of islands. Each island has a production technology given by

$$y_t = F(g_t, z_t) \equiv z_t g_t^{\alpha},$$

where y_t is output, g_t is the labor input, z_t is an idiosyncratic productivity shock, and $0 < \alpha < 1$. The productivity shock z_t evolves according to the following AR(1) process:

$$\ln z_{t+1} = a + \rho \ln z_t + \epsilon_{t+1},$$

where $\epsilon_{t+1} \sim N(0,\sigma^2)$ and $0 < \rho < 1$. Realization of z_t are assumed to be independent across islands. Throughout the paper we will refer to Q as the corresponding transaction function for z_t, and to $f(g_t,z_t) = \partial F(g_t,z_t)/\partial g_t$ as the marginal productivity of labor.

Home goods are produced in a nonmarket activity which requires labor as an input of production. If an agent spends a period of time at home, he obtains w^h units of the home good. Home and market activities are mutually exclusive: agents cannot engage in both at the same time.

At the beginning of every period there is a given distribution of agents across islands. An island cannot employ more than the total number of agents x_t present in the island at the beginning of the period. If an agent stays in the island in which he is currently located, he produces market goods and starts the following period in that same location. Otherwise, the agent leaves the island and becomes nonemployed.

A nonemployed agent has two alternatives. First, he can leave the labor force and engage in home production during the current period. In this case, the following period the agent will remain nonemployed. The second alternative is to search. If the agent searches, he obtains zero home production during the current period, but becomes randomly assigned to an island at the beginning of the following period. A key feature of the search technology is that agents have no control over which island they will be assigned to, i.e., search is undirected. In particular, we assume that searchers arrive uniformly across all islands in the economy.

Hereafter, we refer to agents doing home production as being *out of the* *labor force,* agents working in the islands sector as *employed,* and agents searching as *unemployed.*

We now describe feasibility for stationary allocations.[5] An island is indexed by its current productivity shock z and the total number of x agents available at the beginning of the period. Feasibility requires that the island's employment level, denoted by $g(x,z)$, cannot exceed the number of agents initially available:

$$g(x,z) \leq x.$$

The number of agents in the island at the beginning of the following period, denoted by x', is given by

$$x' = U + g(x,z),$$

where U is total unemployment in the economy. Note that this equation uses the fact that unemployed agents become uniformly distributed across all islands in the economy.

The law of motion for x and the Markov process for z generate an invariant distribution μ which satisfies

$$\mu(X',Z') = \int_{\{(x,z)\,:\,g(x,z)\,+\,U\,\in\,X'\}} Q(z,Z')\mu(dx \times dz)$$

for all X' and Z'. This equation states that the total number of islands with a number of agents in the set X' and a productivity shock in the set Z' is given by the sum of all islands that transit from their current shocks to a shock in Z' and chose an employment level such that x' is in X'.

Aggregate employment N is then given by

$$N = \int g(x,z)\mu(dx \times dz),$$

and aggregate consumption by

$$c = \int F(g(x,z),z)\mu(dx \times dz).$$

Both expressions are obtained by adding the corresponding magnitudes across all islands in the economy.

5. Since our analysis will focus on steady-state equilibria, we restrict our discussion of feasibility to stationary allocations.

Finally, the number of agents that stay out of the labor force cannot be negative:

$$1 - U - N \geq 0.$$

3. *Laissez-Faire Competitive Equilibrium*

In this section we describe a competitive equilibrium with complete markets. For expository purposes, we first discuss the case where the market good and the home good are perfect substitutes, i.e., where $\gamma = 0$. The case $\gamma > 0$ will be discussed at the end of the section. When both goods are perfect substitutes, agents seek to maximize the expected discounted value of their wage earnings and home production. We assume competitive spot labor markets in every island. As a consequence wages are given by the marginal productivity of labor, f.

Let consider the decision problem of an agent who begins a period in an island of type (x,z) and must decide whether to stay or leave, taking the employment level of the island $g(x,z)$ and the aggregate unemployment level as given. If the agent decides to stay, he earns the competitive wage rate $f(g(x,z),z)$ and begins the following period in the same island. If the agent decides to leave, he becomes nonemployed and obtains a value of θ (to be determined below). His problem is then described by the following Bellman equation:

$$v(x,z) = \max\left\{ \theta, f(g(x,z),z) + \beta \int v(g(x,z) + U,z')Q(z,dz') \right\}, \tag{1}$$

where $v(x,z)$ is the expected value of beginning a period in an island of type (x,z).

At equilibrium, the employment rule $g(x,z)$ must be consistent with individual decisions. In particular,

1. if $v(x,z) > \theta$ (agents are strictly better off staying than leaving), then

$$g(x,z) = x; \tag{2}$$

2. if $v(x,z) = \theta$ (agents are indifferent between staying or leaving), then

$$g(x,z) = \bar{g}(z), \tag{3}$$

where $\bar{g}(z)$ satisfies

$$\theta = f(\bar{g}(z),z) + \beta \int v(\bar{g}(z) + U,z')Q(z,dz'). \tag{4}$$

Figure 1 EMPLOYMENT DETERMINATION, LAISSEZ-FAIRE

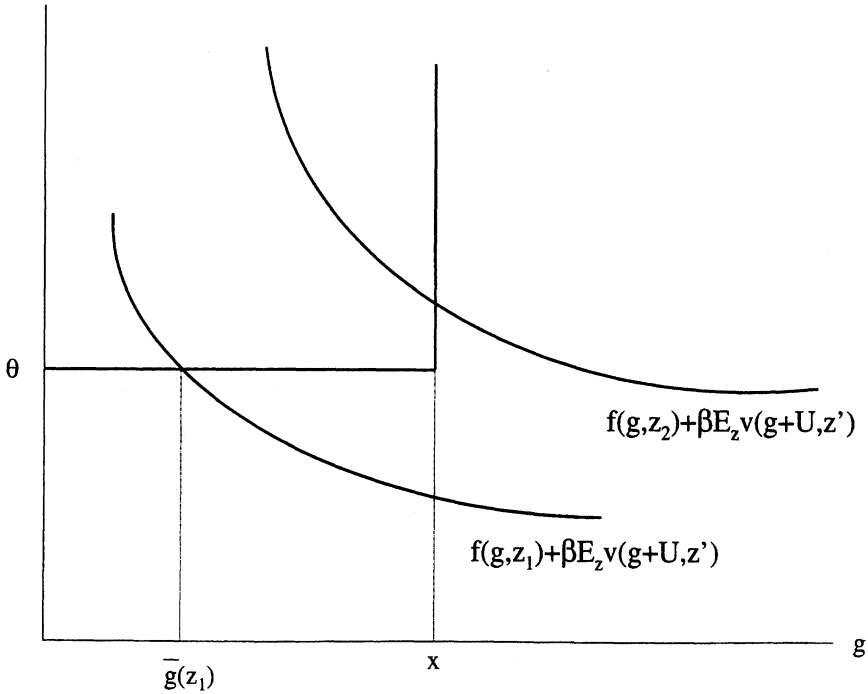


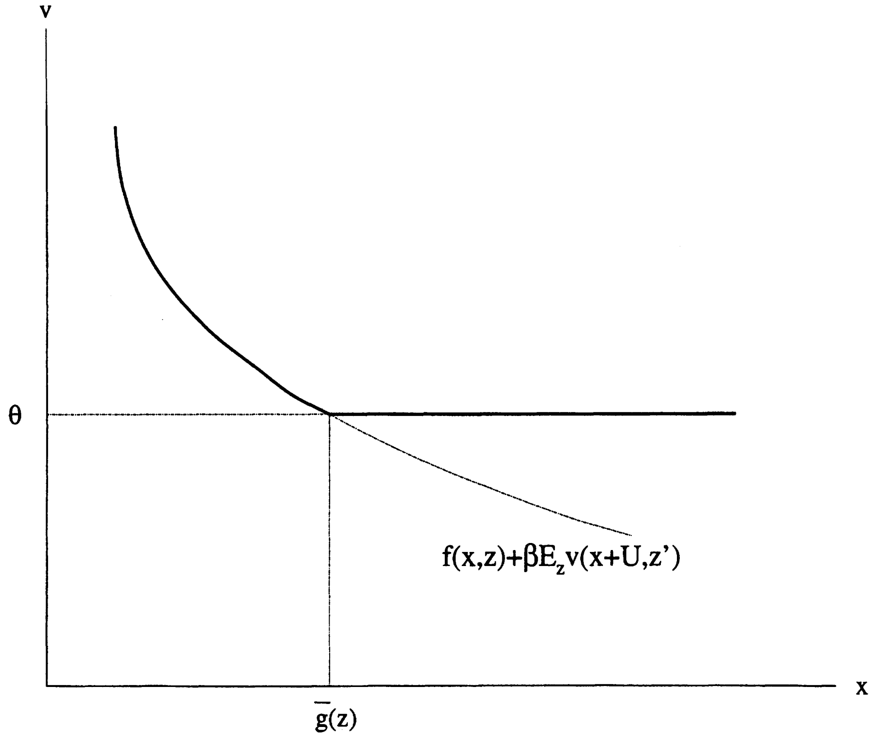
Figure 1 illustrates the labor market within an island. Between 0 and x, the labor supply is infinitely elastic at θ, since at that value agents are indifferent between staying and leaving. For values larger than θ all agents prefer to stay, so the labor supply becomes inelastic at x. For values lower than θ all agents prefer to leave, so the labor supply becomes inelastic at zero.

The downward-sloping curve is the marginal value of a worker at the island, which can be interpreted as a demand function for labor. If the intersection of both curves occurs at the left of x, the equilibrium employment level is $\bar{g}(z)$. Otherwise, the equilibrium employment level is x.

Figures 2 and 3 depict the equilibrium values $v(x,z)$ and equilibrium employment $g(x,z)$ that correspond to Figure 1. If x is larger than $\bar{g}(z)$, the equilibrium employment is $\bar{g}(z)$ and the equilibrium value is θ. If x is smaller than $\bar{g}(z)$, the equilibrium employment is x and the equilibrium value is the marginal value of labor evaluated at x.

Let us now consider the problem of a nonemployed agent who must decide whether to go home and obtain home production or search for a

Figure 2 VALUE FUNCTION, LAISSEZ-FAIRE



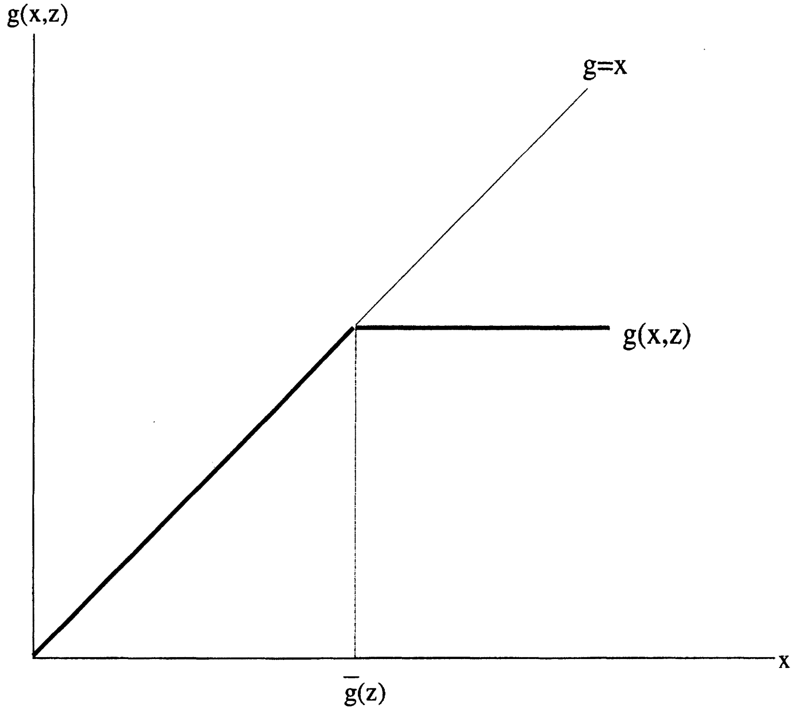
job. If the agent chooses to stay out of the labor force, he obtains w^h of home goods during the current period but remains nonemployed the following period. If the agent decides to search, he obtains no home production during the current period but gets a new draw at the beginning of the following period from the invariant distribution μ of islands. Thus the problem of a nonemployed agent is described by the following equation:

$$\theta = \max\left\{ w^h + \beta\theta,\ \beta \int v(x,z)\mu(dx \times dz) \right\}. \tag{5}$$

If $w^h + \beta\theta < \beta\int v(x,z)\mu(dx \times dz)$ (nonemployed agents strictly prefer searching to staying at home) no one stays at home and the employment feasibility becomes

$$U + \int g(x,z)\mu(dx \times dz) = 1. \tag{6}$$

Figure 3 EMPLOYMENT POLICY, LAISSEZ-FAIRE



If $w^h + \beta\theta = \beta\int v(x,z)\mu(dx \times dz)$ (nonemployed agents are indifferent between searching and staying at home) some agents may stay out of the labor force and employment feasibility becomes

$$U + \int g(x,z)\mu(dx \times dz) \leq 1. \tag{7}$$

The inequality $w^h + \beta\theta > \beta\int v(x,z)\mu(dx \times dz)$ implies that $U = 0$, which is inconsistent with an equilibrium (see Alvarez and Veracierto, 1999). It follows that

$$\theta = \beta \int v(x,z)\mu(dx \times dz). \tag{8}$$

In Alvarez and Veracierto (1999) we show that despite the search frictions, this is an economy where the welfare theorems hold: laissez-faire competitive allocations coincide with the stationary solutions to a Pareto problem. We also establish the existence and uniqueness of stationary competitive equilibria. Moreover, our proof provides an efficient algorithm to compute the unique steady-state equilibrium.

When $\gamma > 0$ market goods and home goods are imperfect substitutes, which is the preference specification used by Hopenhayn and Rogerson (1993) to analyze the employment and welfare effects of firing taxes. Following them, we assume that agents have access to employment lotteries and financial markets where they can diversify the income risk associated with search and employment histories.[6] The employment lotteries are not realistic. Nevertheless, we think that the tractability that they bring to the problem more than compensates for their lack of realism.

The case of $\gamma > 0$ requires only minor modifications to the equilibrium conditions presented above. If θ is interpreted as the present value of search in terms of market goods, equation (8) is satisfied by definition and the functional equation (1) still describes optimal behavior by agents and firms within the islands sector. The only equilibrium condition that must by modified is the one that determines the optimal mix of agents between market and home activities. The new relevant condition is

$$\frac{w^h}{1-\beta} \leq c^{-\gamma}\theta.$$

The left-hand side of this equation gives the present-value gain of increasing by one unit the number of agents in the home sector. The right-hand side represents the present-value loss of decreasing by one unit the number of agents that search: it is the present value of forgone wages in terms of consumption goods, θ, times the marginal utility of consuption, $c^{-\gamma}$. At equilibrium, both sides must be equal if there is a positive number of agents at home. If the right-hand side is larger than the left-hand side, no one must be at home in equilibrium.

In Alvarez and Veracierto (1999) we show that the equilibrium unemployment rate is independent of the value of γ. Instead γ determines the elasticity of the labor supply, with $\gamma = 0$ corresponding to an infinitely elastic labor supply and a large γ corresponding to a low elasticity.

In the description that follows of the equilibrium conditions for the different policies we focus on the case where $\gamma = 0$ to simplify the exposition. The case where $\gamma > 0$ would require modifications to the optimal nonemployment decisions analogous to the ones just described.

6. Prescott and Rios-Rull (1992) show how to use classical competitive equilibrium analysis to study a similar economy by using lotteries.

4. Labor-Market Policies

In this section we introduce a variety of labor-market policies and institutions into our model economy. In particular, we consider minimum wages, unions, firing taxes, and unemployment insurance.

4.1 MINIMUM WAGES

The first labor-market policy we consider is minimum-wage legislation. If equilibrium wages in an island are lower than the mandated minimum wage $\underline{\omega}$, employment must be rationed. In this case, a lottery determines who becomes employed. The losers of the lottery are forced to leave the island and become nonemployed.[7] Throughout the section we denote by $\tilde{x}(z)$ the maximum employment level consistent with $\underline{\omega}$ and z, i.e.,

$$\underline{\omega} = f(\tilde{x}(z),z).$$

Let's consider the problem of an agent that begins a period in an island of type (x,z). If $g(x,z) < \tilde{x}(z)$, the minimum wage does not bind in the island and the problem of the agent is similar to laissez-faire:

$$v(x,z) = \max\left\{ \theta, f(g(x,z),z) + \beta \int v(g(x,z) + U,z')Q(z,dz') \right\}.$$

But if $g(x,z) = \tilde{x}(z)$, the minimum wage binds and an employment lottery takes place. Since the lottery treats all agents the same way, the probability that the agent wins is given by $\tilde{x}(z)/x$. In that case he receives the minimum wage $\underline{\omega}$ during the current period and begins the following period in the same island. His expected value is then given by[8]

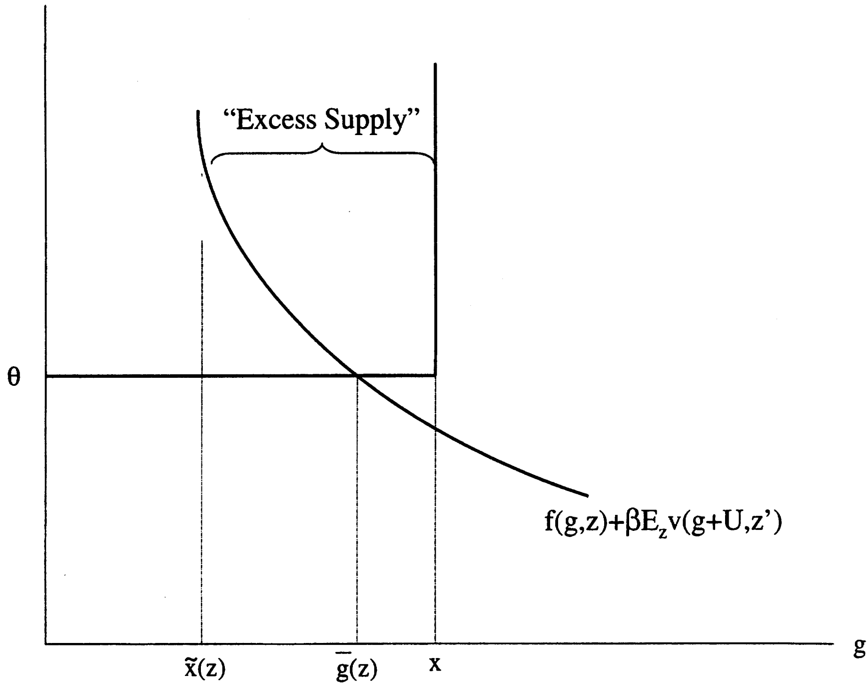
$$v(x,z) = \frac{\tilde{x}(z)}{x}\left(f(\tilde{x}(z),z) + \beta \int v(\tilde{x}(z) + U,z')Q(z,dz') \right) + \frac{x - \tilde{x}(z)}{x}\,\theta.$$

Figure 4 illustrates the labor market when the minimum wage binds. At the equilibrium employment level, wages are lower than the minimum wage. Hence, the labor supply must be rationed down to $\tilde{x}(z)$ workers.

The decision problem of nonemployed agents as well as the rest of the equilibrium conditions are the same as under laissez-faire.

7. In actual computations we allow the losers of the lotteries to stay in the islands if they so desire. But (except for extreme cases) we found that they always preferred to leave rather than to stay without working. As a consequence, here we describe the more restrictive but simpler case where agents are forced to leave. In Alvarez and Veracierto (1999) we discuss the more general case.
8. In Alvarez and Veracierto (1999) we show that $f(\tilde{x}(z),z) + \beta \int v(\tilde{x}(z) + U,z')Q(z,dz') > \theta$: agents always prefer going through the employment lottery to leaving directly.

Figure 4 EMPLOYMENT DETERMINATION, MINIMUM WAGES



4.1.1. Insider–Outsider Model of Minimum Wages We explore a variation on the previous case in order to capture the distinction between insiders and outsiders. In this case we assume that when the minimum wage is binding, the rationing scheme gives priority to the previously employed agents. More specifically, the agents that worked in the island last period (the *insiders,* of whom there are $x - U$) are given priority over the ones that searched last period and just arrived (the *outsiders,* of whom there are U). We assume that if rationing must take place, one of the following two cases applies: either (1) all insiders stay employed and the remaining $\tilde{x}(z) - x - U$ positions are rationed among the U outsiders, or (2) the available $\tilde{x}(z)$ positions are rationed among the $x - U$ insiders, and none of the U outsiders are employed.

The analysis of minimum wages for this case is similar to the previous one, but it requires some additional notation to consider the different problems of outsiders and insiders. The details of the analysis can be found in Alvarez and Veracierto (1999).

4.2 UNIONS

We assume that a fraction λ of the islands are unionized. In these islands a union determines the total labor supply, taking the wages of the rest of the economy as given. Once the union decides how many agents are permitted to work in the island, there is a competitive market in which workers are paid their marginal productivity. Agents that are restricted from entering this competitive labor market leave the island and become nonemployed. We explore two extreme assumptions on the distribution of the rents generated by the union. In the first case, which we label the *coalition model,* we assume that rents are shared equally among all current union members. In the second case, which we label the *union-boss model,* we assume that they are entirely captured by one individual.

We use a simple story to illustrate the two models. Consider an economy made out a large number of piers, where cargo must be unloaded from ships, and where the number of ships arriving at each pier is random. Workers are distributed across piers and take one period to move between them. There is a gate in each pier, on the other side of which ship managers hire workers in a competitive spot market. The two model of unions differ on the assumption about the control over the gate. In the coalition model the gate is controlled by all the workers present in the pier at the beginning of the period. In the union-boss model the gate is controlled by a union boss.

4.2.1 The Coalition Model We denote the total expected discounted earnings of the coalition in an island of type (x,z) by $u(x,z)$. Since we assume that the monopoly rents of the coalition are shared equally among all workers in the island, each agent receives a value $u(x,z)/x$. The union maximizes the expected discounted value of earnings of its current members. Hence, u satisfies

$$u(x,z) = \max_{0 \leq g \leq x} \left\{ f(g,z)g + \theta[x - g] + \beta \int \frac{g}{g + U} u(g + U,z')Q(z,dz') \right\}, \quad (9)$$

where g is the number of agents that the union allows to work—i.e. those allowed to cross the gate. The present discounted value of total earnings of the agents that leave the island equals $\theta[x - g]$. On the other hand, the total current wage earnings of the agents that become employed equal $f(g,z)g$. Each of these agents receive a value $u(g + U,z')/(g + U)$ starting the following period, since they will form a coalition with the U new agents that will arrive to the island. The total expected discounted value of the g members that are allowed to stay is given by last term in equation (9).

The Bellman equation in (9) has a nonstandard structure due to the endogenous discount factor $\beta g/(g + U)$. However, in Alvarez and Veracierto (1999) we show that a unique value function u satisfies this Bellman equation, that it is concave and differentiable, and that its optimal employment policy is described by a threshold rule of the same form as in the competitive islands.

Competitive islands behave exactly the same as under laissez-faire. The employment decision rule of unionized islands generates an invariant distribution μ^u, while the employment decision rule of competitive islands generates an invariant distribution μ. The decision problem of nonemployed agents is then given by

$$\theta = \max\left\{ w^h + \beta\theta, \right.$$
$$\left. \beta\lambda \int \frac{u(x,z)}{x} \mu^u(dx \times dz) + \beta(1 - \lambda) \int v(x,z)\mu(dx \times dz)\right\}.$$

Note that agents that search have no control over whether they will arrive at a unionized island or not. As in the previous cases, if the right-hand side of this expression is larger than the left-hand side, no one stays out of the labor force.

4.2.2 The Union-Boss Model In a unionized island a union boss acts as a monopolist with respect to the competitive firms and as a monopsonist with respect to the workers. The union boss maximizes his own expected discounted revenue net of payments to workers, so he solves

$$V(x,z) = \max_{0 \leq g \leq x} \left\{ f(g,z)g - g\theta(1 - \beta) + \beta \int V(g + U,z')Q(z,dz') \right\}, \quad (10)$$

where g is the number of workers that he allows to work. Letting θ denote the equilibrium nonemployment value for a worker, note that a worker is indifferent between working at the wage $\theta(1 - \beta)$ and leaving the island. The union boss can then charge an access fee to workers, so that after paying this fee they receive only $\theta(1 - \beta)$. In Alvarez and Veracierto (1999) we show that the optimal employment policy is described by a threshold rule similar to that which characterizes employment in competitive islands.

Letting μ^u and μ be the invariant distribution corresponding to unionized and competitive islands, optimality of search decisions requires that

$$\theta = \max \{w^h + \beta\theta, (1 - \lambda)\beta \int v(x,z)\mu(dx \times dz) + \lambda\beta\theta\},$$

where we use the fact that the value for a worker of arriving at an unionized island is θ.

4.3 FIRING TAXES

In this subsection we consider a competitive equilibrium with firing taxes: whenever a firm reduces employment below its previous-period level, the firm must pay a tax τ per unit reduction in employment. The proceeds are rebated as lump-sum transfers.

Because of the firing cost τ, the firms' maximization problem now becomes dynamic. The individual state of a firm is given by (x,n,z), where n is its previous-period employment level. The firms's problem is described by the following Bellman equation:

$$R(x,n,z) = \max_{0 \leq g \leq x} \left\{ F(g,z) - w(x,z)g - \tau \max\{n - g,0\} + \beta \int R(G(x,z) + U,g,z')Q(z,dz') \right\}, \tag{11}$$

where g is current employment, $F(g,z)$ is output, and $\tau \max\{n - g,0\}$ are the firing taxes. The firm behaves competitively, taking the equilibrium employment level $G(x,z)$ of the island, the equilibrium wage rate $w(x,z)$, and the number U of agents that search as given. We denote the optimal employment decision rule for this problem by $g(x,n,z)$.

Note that at equilibrium, the islands' employment rule must be generated by the individual decisions of firms. In particular,

$$g(x,x - U,z) = G(x,z) \qquad \text{for all } x,z,$$

where $x - U$ is the previous-period employment level of the island.

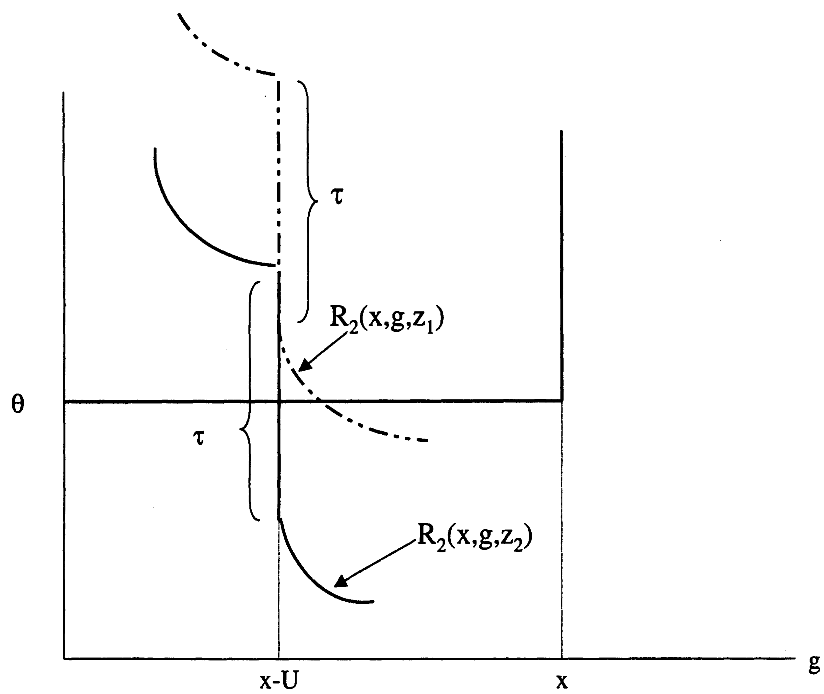
The problem of a worker in an island of type (x,z) is given by the following Bellman equation:

$$H(x,z) = \max \left\{ w(x,z) + \beta \int H(G(x,z) + U,z')Q(z,dz'),\ \theta \right\}, \tag{12}$$

where θ is the value of nonemployment. The worker chooses to leave the island whenever the expected discounted value of wages in the island is less than the value of nonemployment. Similarly to firms, workers behave competitively, taking the island's employment level $G(x,z)$, the equilibrium wage rate $w(x,z)$, and the number U of agents that search as given.

Figure 5 illustrates the behavior of an island's labor market under firing taxes. The supply curve is similar to that under laissez-faire: it is infinitely elastic at θ, and becomes inelastic at x for values larger than θ. On the contrary, the demand for labor is substantially different. In par-

Figure 5 EMPLOYMENT DETERMINATION, FIRING TAXES (FIRMS PAY TAX)



ticular, the firing tax introduces a wedge between the marginal value of hiring and the marginal value of firing a worker. This translates into a jump of size τ at the previous-period employment level n, which in equilibrium equals $x - U$. Note that only large enough shocks induce firms to hire or fire workers. For intermediate shocks, firms will leave their labor force unchanged.

The decision problem of nonemployed agents and the rest of the equilibrium conditions are the same as under laissez-faire, so we omit them. Note that equilibrium wages $w(x,z)$ are not equal to marginal productivities $f(g(x,z),z)$. Instead, wages have to be lower than marginal productivities, effectively making workers prepay the firing taxes.

In Alvarez and Veracierto (1999) we show that a competitive equilibrium with firing taxes coincides with the stationary solution to a constrained Pareto problem, where the planner treats the employment separation costs as technological. This is an important result. It establishes that the spot labor contracts considered above are sufficient to exploit all mutually beneficial trades, even in the presence of search frictions and firing taxes. We also show that the equilibrium described above coincides (except for equilibrium wages) with a competitive equilibrium where the firing taxes are paid directly by the workers. The advantage of this alternative decentralization is that it is much simpler to analyze, since it requires only a small variation on the arguments used in the laissez-faire case.

4.4 UNEMPLOYMENT INSURANCE

In this subsection we introduce an unemployment insurance system in which the government plays unemployment benefits b to eligible agents, financing the system with lump-sum taxes. Nonemployed agents may or may not be eligible for benefits. Whenever an agent leaves an island where he was employed during the previous period, he becomes eligible for benefits with probability κ. Eligible agents lose their eligibility for the following period with probability ψ. Agents that lose their benefits cannot regain eligibility within the same spell of unemployment.[9]

Given the nature of the unemployment insurance system, we must keep track not only of whether nonemployed agents are out of the labor force or unemployed, but of whether they are eligible for benefits or not.

Let θ_0 be the expected value of being nonemployed without benefits, θ_1 the value of being nonemployed with benefits, U_0 the number of new arrivals (i.e., agents that searched during the previous period) who are not eligible for benefits during the current period, and U_1 the number of new arrivals who are eligible for benefits during the current period. Note that $U = U_0 + U_1$. Agents learn whether they are eligible for benefits or not at the beginning of the period.

The problem of an agent who was employed during the previous period in an island with current state (x,z) is described by the following Bellman equation:

$$v(x,z) = \max \left\{ \kappa\theta_1 + (1 - \kappa)\theta_0, f(g(x,z),z) + \beta \int v(g(x,z) + U,z')Q(z,dz') \right\},$$

where $g(x,z)$ and U are taken as given by the agent.

The problem of an agent who searched the previous period, has UI eligiblity i, and arrives at an island with current state (x,z) is given by

$$u_i(x,z) = \max \left\{ \theta_i, f(g(x,z),z) + \beta \int v(g(x,z) + U,z')Q(z,dz') \right\},$$

where $i = 1$ if the agent is eligible for benefits, and $i = 0$ otherwise.

9. We model the eligibility and duration of the benefits as stochastic to reduce the dimension of the state in the agent's problem.

We now consider the nonemployment decisions of eligible and ineligible agents. If an agent not eligible for UI benefits decides to stay at home, he obtains home production w^h during the current period. The following period he will be nonemployed and ineligible for benefits, obtaining a value θ_0. If he decides to search, he will draw an island of type (x,z) under the invariant distribution, obtaining a value $u_0(x,z)$. His problem is then described by

$$\theta_0 = \max\left\{ w^h + \beta\theta_0,\ \beta \int u_0(x \times z)\mu(dx \times dz) \right\}.$$

If an agent eligible for UI benefits decides to go home, he obtains home production w^h during the current period. The following period he will become ineligible for benefits with probability $1 - \psi$ and will still be eligible for benefits with probability ψ, obtianing values θ_1 and θ_0 respectively. If the agent decides to search, he will draw an island type (x,z) under the invariant distribution, obtaining a value $u_0(x,z)$ with probability $1 - \psi$ and a value $u_1(x,z)$ with probability ψ, depending whether the agent loses his eligibility for UI benefits or not. His decision problem is then described by the following equation:

$$\theta_1 = b + \max\left\{ \begin{array}{l} w^h + \beta[\psi\theta_1 + (1 - \psi)\theta_0], \\ \beta \int [\psi u_1(x,z) + (1 - \psi)u_0(x,z)]\mu(dx \times dz) \end{array} \right\}.$$

Note that the agent receives UI benefits independently of whether he stays out of the labor force or searches.

We denote by $\phi_i \in [0,1]$ the fraction of nonemployed agents with eligiblity $i = 0, 1$ that decide to search. The equilibrium values of ϕ_i must be consistent with the optimal nonemployment decision described above. In particular,

$$\begin{array}{lll} w^h + \beta\theta_0 > \beta \int u_0(x,z)\mu(dx \times dz) & \Rightarrow & \phi_0 = 0, \\ w^h + \beta\theta_0 < \beta \int u_0(x,z)\mu(dx \times dz) & \Rightarrow & \phi_0 = 1, \end{array}$$

and correspondingly for ϕ_1.

To describe aggregate consistency, it is useful to introduce the following notation. Let H_i be the number of nonemployed agents that stayed home during the previous period and have eligibility i during the current period, and let D_i be the total number of agents with eligibility i that leave the islands during the current period. Note that D_1 includes two types of agents: (1) agents who searched during the previous period, whose benefits have not expired during the current period, and who reject employment, and (2) all previously employed agents who decide to leave their islands and gain eligibility. In particular,[10]

$$D_1 = \int \min\{U_1, x - g(x,z)\}\ \mu(dx \times dz)$$
$$+ \kappa \int \max\{\min\{x - U_1 - U_0, x - U_1 - g(x,z)\}, 0\}.$$

On the other hand, D_0 consists of (1) all new arrivals without benefits who decide not to accept employment, and (2) all previously employed agents who leave and do not gain eligibility:

$$D_0 = \int \max\{U_0 - g(x,z), 0\}\ \mu(dx \times dz)$$
$$+ (1 - \kappa) \int \max\{\min\{x - U_1 - U_0, x - U_1 - g(x,z)\}, 0\}.$$

In steady state, U_0, U_1, H_0, and H_1 satisfy their laws of motion:

$$U_0 = \phi_0(D_0 + H_0) + (1 - \psi)\phi_1(D_1 + H_1),$$
$$U_1 = \psi\phi_1(D_1 + H_1),$$
$$H_0 = (1 - \phi_0)(D_0 + H_0) + (1 - \psi)(1 - \phi_1)(D_1 + H_1),$$
$$H_1 = \psi(1 - \phi_1)(D_1 + H_1).$$

The market-clearing condition is given by

$$U_0 + H_0 + U_1 + H_1 + \int g(x,z)\mu(dx \times dz) = 1.$$

4.4.1 UI Benefits, Firing Subsidies, Firing Taxes, and Severance Payments We conclude this section with a brief analysis of the relationship between UI benefits, firing taxes, firing subsidies, and severance payments. Define p as the expected discounted payments that an agent is entitled to after a job separation, contingent on not becoming employed until the expiration of benefits, so that

$$p = \kappa \frac{b}{1 - \psi\beta}. \tag{13}$$

In Alvarez and Veracierto (1999) we show that nonemployed agents with benefits search ($\phi_1 > 0$) only if all nonemployed agents without benefits search ($\phi_0 = 1$). Moreover, we establish that for small values of p, equilib-

10. Since $\theta_1 > \theta_0$, the first agents to leave an island are those who have just arrived and are eligible for benefits, the second group to leave are those who were employed the previous period, and the last agents to leave are those who have just arrived and are not eligible for benefits.

ria with UI benefits have $\phi_1 = 0$ and $0 < \phi_0 < 1$. In words, agents that receive UI benefits do not seach, and agents that have no UI benefits are indifferent between searching and staying out of the labor force. It follows that the only feature that is important in the UI benefits system is the expected discounted value of payments (p), regardless of the particular combination of duration (ψ), benefits per period (b), and eligiblity (κ). Since agents eligible for benefits do not search, this results shows that in our model UI benefits are equivalent to a firing subsidy in the amount p.

The previous result has the following two important corrolaries about the combined effects of firing taxes and UI benefits, whose proofs can be found in Alvarez and Veracierto (1999). First, these policies can be summarized by a single number: the expected discounted value of UI benefits minus of the value of firing taxes. In particular, if $p' \equiv p - \tau > 0$, then the equilibrium is the same as with a firing subsidy of p'. Alternatively, if $p' < 0$ the equilibrium is the same as with a firing tax of size p'. Second, if we interpret severance payments as a tax on the firms proportional to the employment reductions and a simultaneous subsidy to each worker that leaves the firm, then one obtains that severance payments have no effect. This is a known result for competitive markets; see for example Lazear (1990). What is interesting is that it holds even in the presence of the search frictions.

5. *Calibration*

To explore the effects of the labor-market policies described above, we parametrize the economy in the following way. There are six structural parameters to determine: (1) the Cobb–Douglas parameter α, (2) the time discount factor β, (3) the home productivity w^h, (4) the curvature parameter in the utility function, γ, (4) the persistence of productivity shocks, ρ, and (5) the variance of the innovations, σ^2. Additionally we have to choose the model period. Parameter values are chosen to reproduce selected U.S. observations under a policy regime that resembles the U.S. unemployment insurance system. We select a model period of one and a half months as a compromise between computational costs and our interest in matching the short average duration of unemployment in the United States.

A characteristic of the U.S. system is that it is financed by experience-rated taxes. Experience-rated taxes work as firing taxes: they increase the tax liabilities of employers when workers are fired. Anderson and Meyer (1993) report that they are quite substantial in magnitude: for each dollar that the government pays as unemployment insurance, about 60 cents are paid by employers as experience-rated taxes. For this reason we want to consider a policy regime with both unemployment insurance and experience-rated taxes. We use the property of the model described in Section 4.4.1 to introduce both policies in a parsimonious way. We interpret the experience-rated UI tax as a firing tax and set the UI benefits in the model equal to the present value of the UI benefits net of this firing tax. In particular, we consider the "net" UI benefits to be 40% of the U.S. unemployment insurance benefits.

In a sample of agents that collected insurance benefits between 1978 and 1983, Meyer (1990) found an average replacement ratio of about 66%. Given Anderson and Meyer's estimate of experience-rated taxes and our previous discussion, we select a replacement ratio which is 60% of Meyer's, or 26%. Meyer (1990) also reported that the average duration of agents in his sample is 13 weeks. Since we are proceeding under the assumption that agents that collect benefits do not search, we identify the 13 weeks with the average duration of UI benefits. Given a model period of 6 weeks, this translates to a persistence of UI benefits, ψ, of about 0.50.

The probability κ that an agent becomes eligible for UI benefits at the start of an unemployment spell is chosen as follows. Let h be the escape rate from unemployment, and I the flow out of employment. Then in steady state

$$hU = I. \tag{14}$$

Let H_1 be the number of agents that stay out of the labor force collecting UI benefits. Note that

$$(1 - \psi)H_1 = \kappa I, \tag{15}$$

since the flow out of H_1 is given by the number of agents that lose their benefits, and the flow into H_1 is equal to a fraction κ of the flow out of employment. At steady state the two flows must be equal. Substituting (14) in (15), we obtain

$$\kappa = \frac{1 - \psi}{h} \frac{H_1}{U}.$$

Note that H_1/U is the ratio of the number of agents that receive UI benefits to the total number of agents that are unemployed. In OECD (1994, Table 8.4), we find that this ratio is about 0.35 for the U.S. economy. On the other hand, a 4-month average duration of unemployment in the U.S. suggests a value of $1/h$ equal to 2.66 model periods. The value of κ consistent with these magnitudes is 0.50.

The Cobb–Douglas parameter α was set to match a labor share of 0.64, which is the value implicit in the NIPA accounts. The discount factor β was selected so that its reciprocal reproduces an annual interest rate of 4%, a compromise between the return on equity and the return on bonds.

Given all the previous choices, the persistence of the productivity shocks (ρ) and the variance of its innovations (σ^2) were selected to generate an average duration of unemployment equal to 4 months and an unemployment rate of 6.2%. Note that there is no analytical relation between these parameters and the corresponding observations; we experimented until a good fit was obtained.

In Alvarez and Veracierto (1999) we show that the productivity of home production, w^h, affects only the labor-force participation ratio, leaving all other ratios unchanged. The productivity w^h was then selected to reproduce a labor force participation of 0.79, which is the ratio of labor force to working-age population in the United States (OECD, 1994, Table 8.4).

The curvature parameter γ in the utility function determines the degree of substitutability between home goods and market goods, but has no effect on steady-state observations (it only affects the value of w^h that is needed to reproduce a given labor-force participation). However, γ is an important determinant of the elasticity of labor supply. In particular, it can be shown that the elasticity of labor-force participation with respect to labor taxes is equal to

$$\epsilon = -\frac{1}{1 - \alpha - \alpha\gamma}\,\frac{\tau}{1 - \tau}, \tag{16}$$

where τ is the labor tax.

One way of selecting γ is then to use equation (16) to calibrate to some empirical estimate of the elasticity ϵ. The regression coefficients in Nickell (1997, Table 7) indicate that a cross-country elasticity ϵ equal to 0.18 is not unreasonable. Since the average labor tax in Nickell's sample is about 50%, our choice of α requires a value of γ equal to 8 to reproduce such an elasticity.

Another way of selecting γ is to use macro observations. One stylized fact that has been emphasized in the macroeconomic literature is that wages have increased substantially over long period of times, while total hour worked have displayed no trend. To reconcile this observation with the theory, preferences where income and substitution effects cancel

Table 1

Parameters		
α	Cobb–Douglas parameter	0.64
β	Time preference	0.9951
γ	Substitution between market and home goods	1
ρ	Persistence of z	0.98724
σ^2	Innovation variance of z	0.00838
w^h	Productivity at home	0.817
U.S. Observations		
	Labor share	0.64
	Interest rate	4% (annual)
	Employment/population	0.79
	Average duration of unemployment	4 months
	Unemployment rate	6.2%
U.S. Policies		
	Average duration of UI benefits collected	3 months
	UI recipients/unemployed	35%
	Replacement ratio	66%
	Experience rating	60%

each other are needed. This requires a choice of $\gamma = 1$ under our preference specification. This parameter value is not only consistent with macro secular observations (and consequently common in the macroeconomic literature), but is what Hopenhayn and Rogerson (1993) have used to estimate the welfare costs of firing taxes. As a consequence we will treat it as our benchmark, but we will also report results under $\gamma = 0$ and $\gamma = 8$.

Table 1 reports selected parameter values under the benchmark case.[11]

6. *Experiments*

This section analyzes the effects of the labor-market policies and institutions introduced above for the parameters selected in the previous section. In each subsection we report how the corresponding policy affects laissez-faire, which serves as our benchmark case.

Tables 2 through 5 show the results. To illustrate the role of the elasticity of labor supply, the tables report results for different values of γ. The efects on the unemployment rate, the average duration of unemployment, and the rate of of incidence into unemployment are presented at the top of each table since they are independent of γ. The rest of each table shows results under $\gamma = 0$ (the case where home and

11. Parameter values under $\gamma = 0$ and $\gamma = 8$ are available upon request.

market goods are perfect substitutes), $\gamma = 1$ (our benchmark log utility case), $\gamma = 8$ (the case of low elasticity of labor supply). For each of these we report the following: (1) total unemployment (i.e. the total number U of agents that search in the model economy), (2) total employment, (3) total market output, and (4) total home output. Each of these numbers is normalized by its corresponding laissez-faire value. Additionally a welfare measure is provided. It is defined as the permanent increase in consumption that must be given to agents in the laissez-faire economy to attain the same utility level as under the policy considered.

6.1 MINIMUM WAGES

Table 2a describe the effects of minimum wages. The third column corresponds to laissez-faire, while the fourth and fifth columns correspond to minimum wages equivalent to 85% and 90% of average wages, respectively. In the first case only 5% of employed agents receive the minimum wage; in the second case the fraction is 27%.

We see in Table 2a that introducing a minimum wage into an otherwise laissez-faire economy increases the incidence of agents into unemployment. The reason is that employment must now be rationed in islands where the minimum wage becomes binding. For the same reason it becomes more difficult for unemployed agents to find employment. As a consequence the average duration of unemployment increases. Both effects tend to increase the unemployment rate relative to laissez-faire. However, we find that the effects are small: a minimum wage equal to 85% of average wages increases the unemployment rate only from 5.3% to 5.4%. Higher minimum wages can increase the unemployment rate further. But even a minimum wage which is large enough so that 27% of employed agents receive it increases the unemployment rate from 5.3% to only 6.6%, a small effect compared to other policies.

The minimum-wage regulation has the effect of increasing average wages. As a result, the number of agents that search for a job (U) increases until indifference between working at home and at the market is restored [i.e. until equality in equation (8) is obtained]. Table 2a shows that when home and market goods are perfect substitutes ($\gamma = 0$), a minimum wage equal to 90% of average wages increases the number of agents unemployed (U) by 24.7%. However, employment falls by 1.9% because the increase in the unemployment rate is large relative to the increase in the number of agents unemployed. The fall in employment dominates the increase in unemployment, and labor-force participation decreases. This leads to an increase in home output of 1.8% and a decrease in market output of 0.5%.

At the other extreme, when $\gamma = 8$, the effects are quite different. The

Table 2 MINIMUM WAGES AS PERCENTAGE OF AVERAGE WAGES

		Value		
			Minimum Wage	
γ	*Quantity*	*Laissez-Faire*	*85%*	*90%*
(a) No Priority				
	Unemployment rate	5.3	5.4	6.6
	Avg. duration of unemployment	2.4	2.4	2.8
	Incidence of unemployment	2.3	2.3	2.6
0.0	Employment	100.0	99.9	98.1
	Unemployment	100.0	102.1	124.7
	Market output	100.0	100.0	99.5
	Home output	100.0	100.1	101.8
	Change in welfare[a]	0.0	0.0	−0.2
1.0	Employment	100.0	99.9	98.6
	Unemployment	100.0	102.1	125.4
	Market output	100.0	100.0	99.8
	Home output	100.0	100.0	100.0
	Change in welfare[a]	0.0	0.0	−0.2
8.0	Employment	100.0	99.9	98.9
	Unemployment	100.0	102.3	126.0
	Market output	100.0	100.0	100.0
	Home output	100.0	100.0	99.0
	Change in welfare[a]	0.0	0.0	−0.1
(b) Priority				
	Unemployment rate	5.3	5.4	6.6
	Avg. duration of unemp.	2.4	2.4	2.8
	Incidence of unemp.	2.3	2.3	2.5
0.0	Employment	100.0	100.0	97.8
	Unemployment	100.0	102.3	124.8
	Market output	100.0	100.1	99.3
	Home output	100.0	99.8	102.5
	Change in welfare[a]	0.0	0.0	−0.2
1.0	Employment	100.0	99.9	98.5
	Unemployment	100.0	102.2	125.7
	Market output	100.0	100.0	99.7
	Home output	100.0	99.9	100.1
	Change in welfare[a]	0.0	0.0	−0.2
8.0	Employment	100.0	100.0	98.9
	Unemployment	100.0	101.4	125.6
	Market output	100.0	100.1	100.0
	Home output	100.0	99.7	98.9
	Change in welfare[a]	0.0	0.0	−0.2

[a]Percentage of consumption, with respect to laissez-faire.

fall in market output increases the marginal utility of market goods so much that agents respond by substituting away from home activities towards market activities. As a consequence, the labor-force participation increases and home production decreases. Employment still decreases, because the increase in labor-force participation is small compared to the increase in the unemployment rate. However, the fall in market output now becomes negligible.

The welfare effects of minimum wages are extremely small. Even for a minimum wage equal to 90% of average wages, the welfare cost is only about 0.2% in terms of consumption.

In Table 2b we compute the effects of minimum wages when the employment rationing scheme gives priority to insiders over outsiders. This feature could potentially increase the duration of unemployment, since outsiders—agents that search—are rationed more often. However, the results are virtually the same: we still find small effects of minimum wages.

6.2 UNIONS

Table 3a reports the effects of the coalition model of unions. Table 3b reports the effects of the union-boss model. In both cases we compare laissez faire with economies that have 20%, 40%, 60%, and 80% of their islands unionized.

We describe the coalition model of unions first. Recall that a union obtains monopolistic rents from the fixed factor by restricting the labor supply of its members. As a consequence, unionized islands have higher unemployment rates than competitive islands (for instance, with 20% of the labor force unionized, the unemployment rate is 4 percentage points smaller in the competitive sector than in the unionized sector). As the number of unionized islands increases, the aggregate unemployment rate of the economy increases due to a composition effect. Moreover, as the size of the unionized sector becomes larger, the average duration of unemployment and the incidence into unemployment in both sectors tend to increase. The reason is that agents demand better conditions to become and remain employed, since it is easier for them to find monopolistic rents somewhere else. As a consequence, a larger unionized sector unambiguously increases the aggregate unemployment rate in the economy. In fact Table 3a shows that the effects of unions are surprisingly large. When 60% of the islands become unionized, the unemployment rate increases from 5.3% to 12.5%.

Since unions extract rents from the fixed factor, average wages increase with the size of the union sector (since the opportunity cost of becoming employed in the competitive sector increases, wages increase in the competitive sector as well). When home and market goods are

Table 3

(a) Unions as Coalitions

γ	Quantity	Value				
			Islands Unionized			
γ	*Quantity*	*Laissez-Faire*	*20%*	*40%*	*60%*	*80%*
	Unemployment rate	5.3	7.1	9.5	12.5	16.3
	Avg. duration of unemp.	2.4	3.0	3.6	4.5	5.5
	Incidence of unemp.	2.3	2.7	3.0	3.4	3.7
	Wage Premium[a] (%)		12.5	10.9	8.9	6.6
0.0	Employment	100.0	96.5	91.0	83.9	75.6
	Unemployment	100.0	132.8	171.7	215.9	264.5
	Market output	100.0	98.3	95.1	90.7	85.5
	Home output	100.0	105.2	114.9	128.4	144.7
	Change in welfare[b]	0.0	−0.7	−1.9	−3.4	−5.3
1.0	Employment	100.0	98.2	95.7	92.5	88.5
	Unemployment	100.0	135.2	180.6	238.0	309.3
	Market output	100.0	99.4	98.2	96.6	94.5
	Home output	100.0	99.6	99.4	99.5	99.6
	Change in welfare[b]	0.0	−0.7	−1.9	−3.5	−5.6
8.0	Employment	100.0	99.0	97.9	96.7	95.0
	Unemployment	100.0	136.4	184.8	248.8	332.2
	Market output	100.0	99.9	99.7	99.3	98.9
	Home output	100.0	96.5	90.9	82.9	72.5
	Change in welfare[b]	0.0	−0.7	−1.8	−3.2	−4.8
	Competitive islands:					
	Unemployment rate		6.6	8.0	9.6	11.3
	Avg. duration of unemp.		2.7	3.1	3.6	4.0
	Incidence of unemp.		2.6	2.8	3.0	3.2
	Unionized islands:					
	Unemployment rate		10.6	13.0	15.6	18.3
	Avg. duration of unemp.		3.8	4.4	5.1	5.8
	Incidence of unemp.		3.1	3.4	3.6	3.8

(b) Union-Boss Model

γ	*Quantity*	*Value*				
			Islands Unionized			
		Laissez-Faire	*20%*	*40%*	*60%*	*80%*
	Unemployment rate	5.3	4.8	4.2	3.5	2.4
	Avg. duration of unemployment	2.4	2.3	2.2	2.0	1.7
	Incidence of unemployment	2.3	2.2	2.1	1.9	1.5
0.0	Employment	100.0	92.2	82.9	71.0	53.3
	Unemployment	100.0	83.5	65.8	46.1	23.5
	Market output	100.0	94.4	87.6	78.6	64.1
	Home output	100.0	125.8	155.9	193.7	249.3
	Change in welfare[b]	0.0	−0.3	−1.0	−2.2	−5.2
1.0	Employment	100.0	97.6	94.6	90.4	83.1
	Unemployment	100.0	88.5	75.1	58.6	36.7
	Market output	100.0	97.9	95.3	91.7	85.2
	Home output	100.0	109.9	122.3	139.1	167.1
	Change in welfare[b]	0.0	−0.3	−0.7	−1.5	−3.7
8.0	Employment	100.0	100.2	100.5	101.0	101.9
	Unemployment	100.0	90.8	79.8	65.5	44.9
	Market output	100.0	99.6	99.1	98.4	97.1
	Home output	100.0	101.2	102.2	103.6	104.2
	Change in welfare[b]	0.0	−0.2	−0.5	−1.1	−2.4
	Competitive islands					
	Unemployment rate		4.6	4.8	2.9	1.7
	Avg. duration of unemployment		2.2	2.0	1.8	1.5
	Incidence of unemployment		2.2	2.0	1.7	1.2
	Unionized islands					
	Unemployment rate		6.0	5.1	4.0	2.6
	Avg. duration of unemployment		2.6	2.4	2.1	1.7
	Incidence of unemployment		2.4	2.2	2.0	1.6

[a](Average earnings per union member)/(average competitive wages).

perfect substitutes and 60% of the islands become unionized, the number of agents unemployed (U) must increase by 115.9% before agents again become indifferent between participating in market activities and working at home [i.e. before equality in equation (8) is restored]. However, the unemployment rate increases so much that employment falls by 16.1%. The fall in employment dominates the increase in the number of agents unemployed, leading to a decrease in labor-force participation and a consequent increase in home production of 28.4%. Market output falls by 9.3% because of the large fall in employment. Note that the effects of unions are qualitatively similar to those of minimum wages, since both regimes transfer rents from firms towards workers. However, the effects of unions are much larger, since minimum-wage legislation extracts rents only when the minimum wage becomes binding (i.e., only wages in the lower tail of the distribution are affected), while unions extract rents at all levels.

When $\gamma = 8$, the marginal utility of home goods increases so much when market output falls that agents substitute away from home activities to sustain the level of market output. In this case, the labor-force participation increases, and home output consequently falls by 17.1%. The increase in the labor force is not enough to outweigh the higher unemployment rate, and employment still falls by 3.3%. However, market output now decreases only by 0.7%.

We find that the welfare cost of unions is extremely large: when $\gamma = 1$ and 60% of the islands become unionized, the welfare loss is 3.5% in terms of consumption.

We now turn to the results under the union-boss model, as described in Table 3b. We see that the effects are very different from the coalition model: larger unionized sectors lead to lower unemployment rates. To understand this difference, notice that in this case it is the union boss who retains all monopolistic rents; workers in the union sector are paid only their opportunity cost. As a consequence, average wages fall as the size of the unionized sector increases. With lower average wages, both union bosses and competitive firms hire more workers, and unemployment rates decrease in each sector. Observe that the unemployment rate is always higher in the unionized sector than in the competitive sector, since union bosses restrict the labor supply. However, the composition effect doesn't dominate: unemployment rates fall so rapidly in each sector as the degree of unionization increases that the economy-wide unemployment rate decreases. In fact, as the fraction of islands unionized increases to 60%, the unemployment rate decreases from 5.3% to 3.5%.

When home goods and market goods are perfect substitutes ($\gamma = 0$), the fall in average wages is so large when 60% of the islands become unionized that the number of agents that search (U) must fall by 53.9% before agents again become indifferent between working at home and working in the market [i.e., before equality in equation (8) is restored]. The fall in unemployment is so large that employment decreases by 29%, despite the fall in the unemployment rate. The consequent reduction in labor-force participation leads to an increase of 93.7% in home output. In contrast, market output decreases by 21.4%.

When $\gamma = 8$, the fall in market output increases the marginal utility of market goods so much that agents substitute away from home activities to sustain the level of market output. Even though this effect is large enough to increase employment by 1%, it is not enough to increase labor-force participation: home output still increases, but only by 3.6%. As a counterpart, market output decreases by merely 1.6%.

Notice that even though unemployment rates are lower, the negative welfare effects of unions are quite large. For instance, with 60% of the labor force unionized the welfare cost of unions is equivalent to a 1.5% permanent reduction in consumption under $\gamma = 1$.

Since the two models of unions predict such different effects on unemployment rates, it is important to discuss what evidence favors one type of model over the other. Note that in the coalition model of unions, union members receive higher wages than workers in the competitive sector. The opposite is true in the union-boss model. Thus, an indirect test of the relative relevance of the two models would be provided by the sign of the union wage premium in the data. Card (1996) provides such evidence. Using panel data from the 1987 and 1988 Current Population Surveys, he reported that the union wage premium is about 15% in the U.S. economy. The sign of this premium favors the coalition model of unions over the union-boss model. However, the evidence in favor is stronger than this. In order to obtain a wage premium of the magnitude reported by Card, about 20% of the islands must be unionized (the generated wage premium is 12.5%). Under this degree of unionization we verify that 13% of the work force is employed in the unionized sector. This is surprisingly close to the empirical counterpart of 15.6% reported by Nickell (1997), providing additional confidence about the quantitative relevance of the coalition model of unions.

6.3 FIRING TAXES

Table 4 shows the effects of firing taxes that range between 3 months and 12 months of average wages. To understand these results, note that in the presence of firing taxes firms change their behavior in two important ways: (1) they become less willing to fire workers (as they try to avoid current taxes), and (2) they become less willing to hire workers (as they

Table 4 EFFECTS OF FIRING TAXES

		Value			
			Firing Tax[a]		
γ	*Quantity*	*Laissez-Faire*	*3.0*	*6.0*	*12.0*
	Unemployment rate	5.3	4.6	4.2	3.7
	Avg. duration of unemp.	2.4	3.7	4.2	5.1
	Incidence of unemp.	2.3	1.3	1.1	0.1
0.0	Employment	100.0	93.7	90.1	86.1
	Unemployment	100.0	81.0	71.5	60.0
	Market output	100.0	94.9	91.9	88.0
	Home output	100.0	121.6	133.7	147.3
	Change in welfare[b]	0.0	−0.6	−1.2	−2.3
1.0	Employment	100.0	98.7	98.1	97.9
	Unemployment	100.0	85.3	77.8	68.2
	Market output	100.0	98.1	97.0	95.5
	Home output	100.0	106.8	110.3	112.7
	Change in welfare[b]	0.0	−0.6	−1.2	−2.3
8.0	Employment	100.0	101.2	102.1	103.9
	Unemployment	100.0	87.4	80.9	72.3
	Market output	100.0	99.7	99.5	99.2
	Home output	100.0	98.5	96.6	91.8
	Change in welfare[b]	0.0	−0.6	−1.1	−2.1

[a]In months of average wages.
[b]Percentage of consumption, with respect to laissez-faire.

try to avoid future taxes). These effects tend to reduce the incidence of unemployment and increases the average duration of unemployment, respectively. Depending on which effect is larger, the unemployment rate can decrease or increase. Under our choice of parameter values we find that the effect on the firing rate dominates: the unemployment rate decreases from 5.3% to 3.7% with firing taxes equal to 12 months of wages.

The distortions in the firing and hiring process introduced by the firing taxes reduce the productivity in the islands sector quite substantially. As a consequence wages fall considerably. When home and market goods are perfect substitutes ($\gamma = 0$), this induces the number of agents that search for employment to decrease by 40% before agents become indifferent between searching and staying at home. The fall in the total number of agents unemployed is so dramatic that it drags employment down with it, despite the decrease in the unemployment rate. In particular, employment decreases by 13.9%. The consequent fall in labor-force participation increases home output by 47.3%. On the other hand, market output decreases by 12%, both because of the decrease in employment and because of the distortions introduced in the job reallocation process.

When $\gamma = 8$, the decrease in market output is so large that the marginal utility of market goods increases quite dramatically. This induces agents to substitute away from home activities towards market activities. As a consequence the total number of agents unemployed falls by only 16.7%. This is a small decrease compared to that in the unemployment rate, leading to an increase in employment of 3.9%. Labor-force participation increases so much that home output falls by 7.2%. In contrast, market output falls only by 0.8%.

It is interesting to compare our results with those obtained by Hopenhayn and Rogerson (1993), who calculated the costs of firing taxes in a frictionless economy without unemployment, where labor could freely reallocate across production units. Since they considered log preferences, we restrict our discussion to the case $\gamma = 1$.

Table 3 in Hopenhayn and Rogerson (1993) reports that a firing tax equivalent to one year of wages lowers output by 4.6%, decreases employment by 2.5%, and lowers welfare by 2.8% in terms of consumption in their model economy. Table 4 in this paper shows that the same policy produces a fall of 4.5% in output, a decrease in employment of 2.1%, and a welfare cost of 2.3% in our model economy. These results are surprisingly similar, and consequently they are robust to the search frictions introduced. However they are not robust to the preference parameter γ. As in Hopenhayn and Rogerson (1993), the effects of firing taxes on employment and output depend on the income and substitution effects on the labor supply. If the substitution effect dominates (as in the case $\gamma = 0$), employment decreases; if the income effect dominates (as in the case $\gamma = 8$), employment increases.

6.4 UNEMPLOYMENT INSURANCE

In Table 5 we analyze the effect of introducing unemployment compensations with different expected discounted value of benefits into the laissez-faire economy. We measure the generosity of the UI system by the present value of UI benefits p, given by $\kappa\, b/(1 - \beta\psi)$, where κ is the fraction of separations that qualified for UI benefits, b is the number of the benefits per period, ψ is the per-period probability of maintaining UI benefits, and β is the reciprocal of the gross interest rate. In Table 5 we

Table 5 EFFECTS OF UNEMPLOYMENT BENEFITS

		Value					
			Present Value of Unemployment Benefits[a]				
γ	*Quantity*	*Laissez-Faire*	*0.28*	*0.50*	*0.75*	*1.00*	*1.25*
	Unemployment rate	5.3	6.2	7.3	9.1	11.9	15.0
	Avg. duration of unemployment	2.4	2.7	2.9	3.4	4.1	5.0
	Incidence of unemployment	2.3	2.5	2.7	2.9	3.3	3.6
0.0	Employment	100.0	105.0	108.0	111.6	115.2	118.5
	Unemployment	100.0	125.5	153.3	201.9	279.4	377.8
	Market output	100.0	103.8	106.2	109.2	112.1	114.7
	Home output	100.0	81.2	68.0	49.5	26.5	0.7
	Change in welfare[b]	0.0	0.0	−0.3	−1.2	−3.0	−5.6
1.0	Employment	100.0	101.2	101.7	102.2	102.7	103.3
	Unemployment	100.0	120.9	144.3	184.9	249.2	329.2
	Market output	100.0	101.4	102.2	103.2	104.2	105.1
	Home output	100.0	92.4	86.5	77.2	63.7	47.2
	Change in welfare[b]	0.0	0.0	−0.3	−1.0	−2.5	−4.6
8.0	Employment	100.0	99.4	98.9	98.2	97.5	97.0
	Unemployment	100.0	118.8	140.3	177.6	236.4	309.0
	Market output	100.0	100.2	100.4	100.6	100.8	100.9
	Home output	100.0	98.7	96.4	91.6	82.5	70.2
	Change in welfare[b]	0.0	0.0	−0.2	−0.8	−2.1	−3.6

[a]In model periods of average wages.
[b]Percentage of consumption, with respect to laissez-faire.

calculate the equilibrium for different values of p, starting with the one that corresponds to our depiction of U.S. policies (see Section 5 above for the details). Recall that for the U.S. we select p to be 0.28 average model period of wages, where the model period equals one and a half months. The other values of p considered are 0.5, 0.75, 1.0, and 1.25 model periods of wages.

As the size of the UI benefits increases, workers are more willing to leave an island after a bad shock. This increases the rate of incidence into unemployment. On the other hand, there are two effects on the average duration of unemployment. First, agents tend to accept employment more easily, since they obtain eligiblity for UI benefits. This leads to a decrease in average duration. Second, since searching for a job becomes more attractive than staying at home without UI benefits, the number of agents that search (U) must increase until agents are once again indifferent between the two activities [i.e., equality in equation (8) is restored]. This leads to an increase in the average duration of unemployment. In Table 5 we observe that this general equilibrium effect dominates: larger UI benefits increase the average duration of unemployment. Since both the rate of incidence and the average duration of unemployment increase, the unemployment rate increases quite substantially. We see that a present value of UI benefits equivalent to one model period of wages increases the unemployment rate from 5.3% to 11.9%.

When market goods and home goods are perfect substitutes ($\gamma = 0$), the general-equilibrium effect described above is large: the total number of unemployed (U) increases by 179.4% on moving from laissez-faire to a present value of UI benefits equivalent to 1 model period of wages. This increase in the total number of unemployed is so important that employment increases by 15.2% despite the increase in the unemployment rate. This leads to such an increase in labor-force participation that home output falls by 73.5%. Market output increases by 12.1%.

Under $\gamma = 8$, the higher market output decreases the marginal utility of market goods, inducing agents to substitute away from market activities. As a consequence, the total number of unemployed (U) increases by a more moderate 136.4%, and employment falls by 2.5%. The lower labor-force participation dampens the fall in home output to only 17.5%. On the other hand, market output increases by merely 0.8%.

The welfare costs of introducing UI benefits are quite large: a present value of UI benefits equivalent to 1 model period of wages reduces welfare by 2.5% in terms of consumption under $\gamma = 1$.

7. *A Comparison with the Empirical Evidence*

We end the paper by contrasting our results with some of the empirical evidence available on the effect of different policies/regimes.

7.1 MINIMUM WAGES

While empirical studies for the U.S. economy have traditionally found that minimum wages affect teenage employment with an elasticity of about −0.1, the evidence has become more tenuous over time (see Card and Krueger, 1995). The evidence that minimum wages affect adult employment is even weaker, suggesting that minimum wages have little effect on the aggregate unemployment rate and employment level.

Card and Krueger (1995) observe that in the U.S. economy only 5% of workers are paid the minimum wage. Since in Table 2a the economy with a minimum wage equal to 80% of average wages generates a similar proportion of recipients, we identify it with the U.S.[12] Given the small differences between that economy and laissez-faire, we find our results to be broadly consistent with the empirical evidence.

While a large empirical literature has investigated the effects of minimum wages on income inequality, our model is not well suited to address those issues. The only heterogeneity that our model generates is due to time variation in wages: all agents face the same stochastic process for wages. As a consequence, the wage distribution that the model produces is more concentrated than the data (the standard deviation of wages in the benchmark U.S. case is only 13%). To analyze distributional issues we would have to incorporate different income groups, but that would complicate the model considerably and is outside the scope of this paper.

7.2. UNIONS

In Section 6.2 we argued in favor of the coalition model of unions over the union-boss model, due to its ability to generate jointly an empirically relevant union wage premium and degree of unionization. We now compare its predictions with some of the estimates found in the empirical literature.

Nickell (1997) reports that union densities vary widely across countries: from 9.8% in France and 11% in Spain, up to 72% in Finland and 82.5% in Sweden. Table 3a considered degrees of unionization on this range and found that the effect is to increase unemployment rates from 7.1% to 16.3%. We consider the magnitude of these effects to be consistent with empirical findings. In particular, the coefficients in Nickell's regressions indicate that the elasticity of the unemployment rate with respect to union density is about 0.48. The corresponding elasticity underlying Table 3a is 0.38, which is very close to Nickell's estimate.[13]

Nickell's regression coefficients also indicate an elasticity of employment relative to union density of about −0.05. Di Tella and MacCulloch

12. In order for 5% of workers to be subject to the minimum wage, the minimum wage has to be 80% of average wages in the model economy. In the U.S. the minimum wage is only 26% of average wages (see Card and Krueger, 1995). The reason for the difference is that the wage distribution is more concentrated in the model than in the data. See the comments in the next paragraph.

13. We calculated each of the elasticities of change relative to the economy with 20% of unionization, and then we averaged them.

(1999) provide a similar estimate. As has been previously discussed, the corresponding elasticity in the model economy depends on the substitutability between home and market goods given by the parameter γ. For $\gamma = 1$ the model elasticity is -0.03, which is also close to Nickell's estimate.

7.3 FIRING TAXES

Table 4 reported the effects of firing taxes between three months and one year of wages. We saw that firing taxes equal to one year of wages decreased the unemployment rate from 5.3% to 3.7% and decreased employment by 2.1% in the benchmark case ($\gamma = 1$). These are large effects. However, firing taxes equal to one year of wages are large compared to observed policies in OECD countries. Table 6 reports the sum of advance-notice and severance payments (adjusted for tenure) as multiples of average model-period wages. According to this measure, one year of firing taxes (equal to 8 model periods) is at the upper end of what is observed.[14]

Ths sign of the relation between unemployment rate and firing taxes in the model economy is consistent with Nickell's results: in his regression of unemployment rate he finds a negative coefficient on a measure of employment protection. On the other hand, Lazear (1990) reports a positive coefficient for severance payments. Neither of the two coefficients is statistically significantly different from zero. Di Tella and MacCulloch (1999) find a negative effect of labor-market flexibility on unemployment rate, controlling for random effects, but the result is not significant when they control for both country and year fixed effects.

Nickell (1997), Lazear (1990), and Di Tella and MacCulloch (1999) find that larger employment protection reduces aggregate employment. In our model economy, the sign of that relation depends on the degree of substitution between home and market goods. However, for the benchmark economy ($\gamma = 1$) we find a negative relation. Lazear (1990) reports that moving from laissez-faire to three months of severance payments reduces the employment–population ratio by about 1%. In our benchmark case of $\gamma = 1$ we find that three months of severance payments reduce the employment–population ratio from 73.6% to 72.7%, which is consistent with Lazear's estimate.

14. Moreover, as explained at the end of the next subsection, in the model economy severance payments can be undone perfectly. To the extent that in actual economies severance payments can be partially undone, the relevant measure of firing taxes will be lower than shown in Table 6. For instance, if severance payments could be undone perfectly, firing taxes would only include expected legal costs of litigation. For Germany, Italy, France, and the United Kingdom, Bentolila and Bertola (1990) report that these costs are well below one month of wages.

Table 6 GENEROSITY OF UI BENEFITS AND FIRING TAXES

Country	*Maximum Duration of Benefits*[a]	*Benefit Recipients per Unemployed*	*Monthly Hazard out of Unemployment*[b]	*Replacement Ratio*[c]	*Present Value of Unemployment Benefits*[d,e]	*Estimated Severance Payments*[d,f]	*Present Value of "Net" UI Benefits*[d]
Belgium	32.00	1.48	0.08	0.66	7.88	1.52	6.36
Canada	7.69	1.29	0.26	0.67	2.23	NA	NA
Denmark	19.85	1.13	0.19	0.73	2.73	0.46	2.27
Finland	16.00	1.12	0.13	0.75	4.23	NA	NA
France	19.85	0.98	0.03	0.71	6.75	6.31	0.44
Germany	7.94	0.89	0.09	0.71	2.78	1.38	1.40
Ireland	9.92	1.07	0.03	0.64	3.11	0.00	3.11
Italy	3.97	NA	0.09	0.47	NA	9.41	NA
Japan	4.62	0.36	0.13	0.42	0.78	0.00	0.78
Netherlands	23.82	1.05	0.05	0.77	8.70	1.33	7.37
Portugal	8.60	0.41	0.14	NA	NA	3.45	NA
Spain	15.88	0.59	0.02	0.75	5.76	4.16	1.60
Sweden	9.23	0.93	0.17	0.84	3.10	0.51	2.59
Switzerland	7.69	0.53	NA	0.89	NA	0.67	NA
U.K.	8.00	0.71	0.09	0.51	2.01	0.60	1.41
U.S.	4.00	0.34	0.34	0.68	0.45	0.00	0.45

[a]In model periods; from Table 7.2 in OECD Jobs Study (1994).
[b]Monthly flow rate out of unemployment for ages 25–54 from Table 1.9 in OECD, *Employment Outlook*, 1995 (most recent year).
[c]From Table 2.1 in OECD, *Employment Outlook*, 1996 (net replacement rates at APW level of earnings for couple with two children).
[d]In model periods of average wages.
[e]Computed as $p = b\kappa(1 - \beta\psi)$.
[f]Sum of severance and advance-notice payments (Lazear, 1990), in month's wages. The severance payments, given by Lazear at 10 years' tenure, are adjusted to median tenure as given in Table 5.5 of OECD, *Employment Outlook*, 1995.

7.4 UNEMPLOYMENT INSURANCE

Table 5 reported how changes in the present value of UI benefits affect unemployment rates and employment levels. We found large effects. But the present values considered ranged up to 5 times the benchmark value for the U.S. economy. While we evaluated relatively large present values of UI benefits, we consider that the responsiveness of the model to UI benefits is within what the empirical evidence suggests.

Nickell (1997) reports regression coefficients that imply an elasticity of the unemployment rate, with respect to the UI-benefit replacement ratio, of about 0.62. The average elasticity in Table 5 is 0.34, which is smaller than Nickell's estimate, but is of the right order of magnitude. Observe that our theory predicts that the elasticity of the unemployment rate with respect to the replacement ratio is the same as with respect to benefit duration [see equation (13)]. The elasticity that Nickell reports with respect to benefit duration is about 0.20, which is lower than his estimated elasticity with respect to the replacement ratio. However, his coefficient on benefit duration is estimated with a larger standard deviation.

The elasticity of employment with respect to UI benefits in Nickell's calculations is −0.02.[15] While the results in the model economy depend on the substitutability between market and home goods, for the benchmark economy ($\gamma = 1$) the average elasticity in Table 5 is −0.01. This elasticity is lower than Nickell's estimate but again is of the correct order of magnitude.

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Comment

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1. Introduction

Equilibrium search models have been quite useful and successful in the investigation of labor-market dynamics. We are now at an early stage of their practical application to policy analysis. Alvarez and Veracierto (AV) provide one of the first quantitative and comprehensive evaluations of labor-market policies in a general-equilibrium search environment. Their model combines ideas from two parallel traditions, the Lucas–Prescott (1974) island model and the *matching* or *flow approach* to labor markets (e.g., Blanchard and Diamond, 1990, or Mortensen and Pissarides, 1994). Although closer in spirit to the former, AV also pursue normative goals that have attracted special attention in the latter part of the literature. I find this modeling choice very appropriate for investigating the four labor-market policies of interest (albeit unions are better described as institutions than as policies).

The main innovation in AV is the simultaneous consideration of the three labor-market states—employment, unemployment, and non-participation—as well as of the elasticity of labor supply. Such ingredients appear in different combinations in previous contributions to the literature, but their full interaction with labor-market policies has hardly been explored from a quantitative viewpoint, in general equilibrium, or with heterogeneous production units. On methodological grounds, AV build upon a classical theoretical framework to obtain an efficient algorithm for quantitative analysis, fully illustrated in a companion paper (1999). The exercise presented here is elegant, well executed, and clearly explained.

I find the results of these experiments greatly informative as far as the minimum wage and, to a more limited extent, unions are concerned. The insights that this exercise offers are still limited on three dimensions. First, most interesting welfare effects of labor-market policies are shut down *ex ante.* Second, AV follow the literature and posit without regrets a random-matching technology, which appears somewhat artificial in the context of the economy they describe, and of course determines in part the outcome of the policy experiments. Third, the equilibrium that emerges from their simulations, meant to replicate salient aspects of the U.S. economy, looks "stiff": Compared with the magnitudes that macroeconomists have learned to consider normal, churning and ongoing reallocation appear subdued. The absence of aggregate shocks certainly plays a major role in this respect. In this comment I elaborate further on these three points, and then indicate how they affect the results of each policy experiment.

2. *Insurance and Welfare Analysis*

Simulations of a structural equilibrium model anchored to data have two advantages over standard econometric analysis: They avoid identification fallacies, and they allow welfare evaluation. Eventually, AV refer to the findings of some empirical literature to corroborate their results. But their most interesting message is the magnitude of welfare consequences. It is then unfortunate that they account for only part of the social costs and for none of the benefits of the labor-market policies in question.

Costs would be greatly enhanced by the presence of capital. The substitution of capital for labor by firms would amplify the impact of these policies on labor participation and unemployment. This is in fact a major theme of the current debate on Euorpean unemployment. It is fair to say, however, that such an extension would be highly nontrivial.

It is equally fair to say that the main goal of these institutions, at least in the minds of the policymakers who promote them, is to provide insurance against idiosyncratic labor-market uncertainty. In AV's world this is a nonissue, as workers have access to employment lotteries to diversify away this risk. I do not begrudge the tractability granted by this assumption, but one is left wondering about the meaning of the welfare analysis. AV claim to have dismissed important insurance effects in a companion paper; but this claim must depend on the degree of idiosyncratic risk that workers face, which is rather scant in the essay of this volume. The relevance of this issue is witnessed by the fast-growing literature on the macroeconomic consequences of uninsurable labor-market risk.

A similar role to lotteries is played by the assumption of competitive wage setting at the local (island) level, from Lucas and Prescott (1974). Without wage bargaining (the standard assumption in the other strand of equilibrium search literature), AV avoid altogether the familiar congestion-type externalities. To many readers, decreasing returns to scale and perfect competition may appear a virtue of the model. Yet, by their very nature, search frictions do generate rents, and labor-market policies appear more interesting in nonefficient scenarios. But this may be a matter of taste.

It is less disputable that competitive wage setting appears somewhat artificial in the absence of entry by firms into the island. It is natural to expect that, in each island, the fixed number of firms extract rents from the variable population of workers who happen to land there and then face a cost to move out. With no free entry, the value of a vacancy net of capital costs cannot be always zero. Indeed, workers effectively prepay for the firing tax through a 1:1 reduction in the competitive wage.

3. *Undirected Search*

Search models explicitly recognize the importance of heterogeneity in labor markets and have successfully accommodated increasing degrees of heterogeneity among agents and technologies. AV are no exception, allowing for idiosyncratic productivity shocks and uneven distribution of employment across islands, as well as for partial unionization and varying UI eligibility status among workers. This trend in the literature, however, has not been matched by a corresponding sophistication in the description of the search technology. In the model that AV propose, as in most of its predecessors, workers cannot direct their effort to locate more productive or unionized jobs, not even in a noisy way. This simplification, analogous to random matching, has served the equilibrium search literature well, but I take this occasion to say that it is time to move on and explore the implications of richer allocation mechanisms. The first attempts in this direction go back at least to Salop's (1973) discussion of systematic job search in partial equilibrium; Lucas and Prescott (1974) themselves sketch an analysis of directed search in general equilibrium. Since then, technical advances in the solution and simulation of equilibrium models have made it possible to manage successfully other projects of similar complexity, so I believe this exploration should now resume.

As for any polar case in theoretical analysis, undirected search provides useful insights into more realistic descriptions of the matching process. But, absent a comprehensive investigation, it is hard to conclude that partially directed search would simply result in a convex combination of Walrasian frictionless economies and random matching. The possibility of steering job search towards more attractive labor markets is an extra margin that responds autonomously to the introduction of the four policies and simply does not exist in either polar case. In Moscarini (1998) I investigate a frictional two-sector ecnomy where *ex ante* heterogeneous workers and firms may choose to be more or less selective in their search, both on and off the job. Agents on both sides of the markets adjust their search strategies to both sectoral and aggregate productivity shocks, and they do so in a systematic way that moderates the response of unemployment duration. For instance, in bad times workers become less selective and probe a wider range of jobs, reducing match quality but also the unemployment rate. It is reasonable to expect similar implications from the introduction of labor-market policies. I will discuss later in some detail the consequences of directed search in the AV model of unions.

4. *Churning Intensity and Other Calibration Issues*

The third major point I wish to raise concerns the amount of reallocation emerging from the numerical experiments. I find the choice of four months (17 weeks) for average unemployment duration too high in the light of available empirical evidence for the United States. The Bureau of Labor Statistics CPS series indicate 13 weeks for the whole postwar period, and 15 weeks for the post-oil-shock period. The upward trend in U.S. unemployment duration, documented by Murphy and Topel in the 1987 *NBER Macroeconomics Annual,* has since then leveled out and, if anything, mildly reversed, as manifest for example from the series mentioned above. The choice of 17 weeks is representative of the first half of the 1990s, and leads to a rather "stiff" picture of the economy. The other source of rigidity is the absence of search while employed, a major component of worker turnover. The very low incidence of unemployment that AV obtain from their experiments is the other side of the same coin. These choices thus imply a high persistence and low variance of idiosyncratic shocks, with intuitive consequences for policy evaluation that I will take up shortly.

The other open end of the calibration is the utility curvature parameter γ. A value $\gamma = 8$ may appear high, and indeed the results of the experiments conducted under this assumption are the least appealing, leading the authors to select $\gamma = 1$ as the benchmark value. But in fact the procedure that delivers $\gamma = 8$, based on equation (16), is perfectly reasonable and suggests an even higher number. Since $\tau/(1 - \tau)$ is a convex function of the labor tax rate $\tau \in [0,1]$, which is known to vary substantially across countries, by Jensen's inequality the implied value of γ is larger than the above value 8 obtained by simply substituting into equation (16) the empirical average of τ (50%). In any event, AV conduct an excellent robustness analysis on γ, but cannot find much robustness. Unfortunately, this brings us back to the beginning: we are left to evaluate the quantitative performance of a macromodel on the basis on a labor-supply-type preference parameter, which is hardly pinned down unambiguously by different calibrating procedures. In particular, as usual, micro and macro data suggest quite different numbers.

I now turn to policy modeling and numerical experiments. The minimum-wage exercise is quite convincing, both in its implementation and in its results, so I will limit my comments to the other three exercises.

5. *Unions*

I restrict attention to the coalition model of unions, which I consider the empirically relevant one. A union is a local monopolist of labor that sets quantity and lets the wage adjust. In the real world unions often bargain for a wage rate, conditional on securing employment for their members. The authors' choice shifts action from the employment margin to the wage margin, and yet the effects of unions on the former are "surprisingly large" in their experiments.

One way to dampen these effects is to introduce directed job search, which should drive union membership up and dilute rents. Suppose workers may direct their job search towards unionized islands, as long as a wage premium is paid there, still bearing the same opportunity costs of search, namely discounting and home production. The Bellman equation for the value of joblessness θ reduces to

$$\theta = \max\left\{ w^h + \beta\theta, \beta \int \frac{u(x,z)}{x} \mu^u(dx \times dz), \beta \int v(x,z)\mu(dx \times dz)\right\},$$

the three possibilities corresponding to home production, search for a unionized job, and search for a competitive job. *Ceteris paribus,* θ obviously rises (compare the Bellman equation above with the equation for θ in AV's Section 4.2). Labor participation also rises, as job search gains a "technological edge" over home production. The higher θ also sustains the value of being employed in both unionized [u; cf. AV's equation (9)] and competitive [v, equation (1)] islands, a familiar feedback that contributes to raising θ further. As a consequence, unemployed workers increase their reservation wage, and the marginal productivity of labor must rise in competitive islands. Workers must then relocate to unionized islands until indifferent between the two subsectors, as equilibrium requires continuous arrivals to competitive islands (see Alvarez and Veracierto, 1999). In conclusion, it is natural to expect a less dramatic employment reduction than the one we observe in the union experiment with undirected search.

Instead, a new distortion originates from the incentives that unions provide for outsiders to become insiders, rather than (say) pursue their natural talents or human-capital accumulation. Although outside the scope of this paper, this and other important consequences of labor-market institutions are obliterated by the assumption of undirected search.

6. *Firing Taxes*

Just as in Bentolila and Bertola (1990), firing taxes discourage firms from both firing and hiring, with opposite effects on unemployment, but the first effect always dominates. It is useful to learn that these well-known implications survive in a general-equilibrium context.

In quantitative terms, the benchmark configuration of parameters predicts a mild impact of empirically plausible firing taxes (cf. Section 7.3 of AV) on the unemployment rate, while again welfare changes are sizable but do not take insurance benefits into account. Hence, one would be tempted to deem excessive the time and energy currently spent in Europe debating the reform of firing restrictions.

I suspect that such weak unemployment effects depend to a large extent on the high persistence of idiosyncratic shocks, which skew toward zero the distribution of employment adjustments in the laissez-faire economy, thus reducing the "bite" of firing taxes. Indeed, a major concern in many European countries is that firing restrictions make firms totally unwilling to hire in the face of *temporary* and even predictable changes in profitability, choking off exit from unemployment and giving rise to long-term joblessness. Not surprisingly, proposals to reduce firing costs go hand in hand with the promotion of part-time jobs. In addition, both this model and Hopenhayn and Rogerson (1993), who found similar responses, abstract from aggregate shocks with their transitory components.

Although an average unemployment duration of 17 weeks may appear too low for several European countries, this number refers to an unobservable laissez-faire economy. The actual magnitudes could as well originate from less persistent shocks that amplify the impact of firing restrictions, a different image from the one depicted by AV.

7. *Unemployment Insurance (UI)*

In the absence of uninsured unemployment risk, unemployment benefits amount to search subsidies because employment is necessary to regain UI eligibility. The authors choose to fund unemployment benefits with a lump-sum tax levied on each worker irrespective of her labor-market status, rather than (more realistically) only on active jobs, say on wages and profits. This feature reduces the relative desirability of nonemployment over employment, understating the impact of UI on unemployment duration and rate. In spite of this bias, the model exaggerates the aggregate implications of UI vis à vis the available empirical evidence.

AV also show analytically that unemployment benefits and firing taxes offset each other. Again, an employment tax on wages and/or profits would compound, rather than neutralize, the incentives to unemployment provided by UI.

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Comment

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This paper provides a model with homogeneous production by homogeneous workers with homogeneous tastes on different islands that are hit by random shocks. In commenting on this paper, I have to confess that I feel a little like I've landed on a different kind of island—where the workers use a different production technology and possibly have different tastes. Nonetheless, I think it is healthy for the economic science to have many islands that employ different techniques, and to have the workers visit each others' islands from time to time.

I have two types of comments on this paper. The first concerns the modeling assumptions; I will try to relate what we've learned from micro studies about the type of model the authors have assumed, and the parameter values they build into the model. The second involves evaluating the models' predictions in light of the available evidence.

I have little quarrel with the elasticities the authors have assumed. If used in the right model, these seem quite sensible to me, and consistent with the consensus of thought among mainstream labor economists.[1] I also like the fact that the authors make employee search a prominent feature of their model; this also seems consistent with many of the findings in the labor literature. What seems more problematic to me, however, is that the authors have disregarded *employer search.* Workers are presumed to show up at employers' doorsteps without so much as a help-wanted ad. Firms never have vacancies in the model the authors employ. This seems inconsistent with an important feature of labor markets. Moreover, it is a modeling assumption that matters, because it implies that the elasticity of labor supply to firms is infinite. I think it would be more realistic and appropriate to model the labor market as entailing both employer- and employee-side search frictions, and to have the duration and incidence of vacancies at individual firms depend on the generosity of the compensation they offer.

Burdett and Mortensen (1998) and Dickens, Machin, and Manning (1999), for example, provide search models in which employers cannot instantly and costlessly fill their vacancies. As a result, these papers find that a wage floor that is modestly above the prevailing wage (e.g., imposed by a government minimum wage or union) can actually raise employment. In essence, the firm-side search costs bestow employers—even small employers—a small degree of monopsony power, since they can fill their vacancies more quickly if they pay a higher wage.[2] But, as in a static Joan Robinson monopsony model, employers would not choose to pay a higher wage voluntarily, because they already employ some workers, and it is not profitable to offer a higher wage to everyone. Also, as in static monopsony models, if the mandated wage is too high, employers would return to their demand curve and choose to fill fewer jobs. This type of model predicts an inverted-V-shaped pattern between employment and the wage floor and can explain other phenomena, such as a firm-size wage premium.

The asymmetric treatment of search frictions in this paper casts some of the policies the authors examine in as unflattering a light as possible. Nonetheless, the simulation results are rather encouraging for some of the policies. It is not unusual that I receive papers in the mail that report finding "very small employment effects of the minimum wage," as this paper does. But it is unusual that I receive such papers with return addresses in Chicago. Even setting the minimum wage at 85% of the average

1. For evidence on the consensus labor supply and demand elasticities, see Fuchs, Krueger, and Poterba (1998). The authors' assumed labor supply elasticity of 0.18, though low, is higher than the median estimate among labor economists.
2. One might think that the current model, with just one employer per island, would be a natural situation to consider firms as monopsonists.

wage (which is more than twice the U.S. level in 1998), the authors find that employment is unchanged from the no-minimum-wage counterfactual. And, as I stated above, the model the authors employ is likely to exaggerate the distortionary effect of a minimum wage. I think a valuable extension of this work would be to calculate the welfare effects of a minimum wage for workers and capital owners. My suspicion is that the authors will find that the minimum wage raises low-wage workers' welfare because their employment hardly changes, although their pay increases substantially.

An interesting implication of the authors' island-based model is that it implies a substantial spike at the minimum wage. Actual wage distributions clearly display such a spike. This finding, which only became known after microdata were available, was not predicted by George Stigler and early neoclassical critiques of the minimum wage. Stigler (1946), for example, expected wage distributions to be truncated at the minimum.

The analysis of unions could have benefited from a stronger connection to the previous literature. There is a tradition in labor economics of general-equilibrium analysis of unions (see, for example, Johnson and Mieszkowski, 1970), and I would have been interested in the authors' perspective on how their results extend this literature. Moreover, the union-boss model strikes me as equivalent to the efficient-bargains literature (see Oswald, 1985, for a survey). There are also additional alternative views of unions, such as the voice model.

In any event, the U.S. union penetration rate has been steadily declining for the last 25 years, and is currently below 10% in the private sector. The authors simulate the effect of unions on the economy, assuming a union penetration rate between 20% and 80%.[3] I would have found some simulation results for a union rate of around 10% useful, especially since the results presented suggest that the percentage of islands unionized has a nonlinear effect on the outcomes of interest. Cross-country studies often find that unions are associated with better macroeconomic outcomes when the institutional structure is such that unions bargain at a national level.

The assumptions of random eligibility for UI benefits and random duration of benefits strike me as more simplistic and artificial than necessary. For example, in the United States, a worker generally must work a certain number of quarters to qualify for 26 weeks of UI benefits. Why not build this into the model and allow for endogenous UI participation?

3. I presume that if *X*% of islands are unionized, approximately *X*% of workers are also unionized.

Furthermore, the split treatment of UI benefits and the firing tax strikes me as odd. Since in practice in the United States UI benefits are funded by an experience-rated tax on employers (akin to the firing tax in this model), it was not clear to me that anything is gained by treating UI benefits and firing costs separately.

In any event, my impression is that the generosity and duration of UI benefits are the only robust variables found in cross-country studies of unemployment. Layard, Nickell, and Jackman (1991), for example, find that countries with more generous UI benefits tended to have higher unemployment rates in the 1980s. And, unlike most of their explanatory variables, the UI variable tends to have a similar effect in later years (see Forslund and Krueger, 1996). Several compelling microeconometric studies (some involving randomized field trials) have also found that more generous UI benefits are associated with longer spells of unemployment.[4]

A few comments about the general approach taken in this paper are also called for. First, it seems to me that the piecemeal aproach (e.g., evaluate minimum wage, then unions, then UI) that the paper follows is sensible enough, but what would really be helpful would be to consider some policies in tandem. Policies have interactions that can either offset or exacerbate each others' distortions. For example, it is plausibly argued that an effect of the Earned Income Tax Credit is to lower market wages, and the minimum wage can offset this distortionary effect. The approach developed in this paper could be used to evaluate the optimal combination of policies designed to achieve a certain aim (in this case, raising the welfare of low-income workers).

Second, it is unclear to me how the results from the elaborate simulation exercise in this paper differ from a more simple (simple-minded?) partial equilibrium analysis. For example, with the parameters chosen, how different would the predicted effects of a minimum wage or union wage floor be in a textbook partial-equilibrium model? My guess is that the predictions would be quite similar, which makes me wonder whether the additional complexity that the authors introduce is worth the cost.

Third, and perhaps most importantly, it seems to me that we are a long way from being in a position where we know enough about the structure and operation of the labor market to model economic behavior with the fully specified general-equilibrium approach taken here. Personally, I think that the effort would be better spent identifying natural and actual experiments that yield insight into the modeling assumptions required for this type of work (estimating parameter values, understanding employer search behavior, etc.) than jumping to a full-scale model

4. See, for example, Meyer (1995), Solon (1985), and Katz and Meyer (1990).

based on an unknown set of primitives. But, as I noted earlier, I think there is benefit from diverse research methods, and it is reassuring to know that the machinery is available for the type of analysis in this paper when economics is in a position to model the labor market more confidently some time in the next millennium.

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Discussion

In response to the discussants, Veracierto said that they did not consider search by firms because they consider their work complementary to that of Mortensen and Pissarides, who emphasize very different margins. He defended the assumption of perfect insurance markets by citing other work by the authors, in which they consider the case of borrowing-constrained agents with no access to insurance markets. Although workers in this alternative model can only self-insure through saving, their behavior appears very similar to what is found under the assumption of complete markets. The reason for the similarity in results is that the average duration of unemployment in the United States is only about three months. The resulting risk is sufficiently small that it can be effectively handled through sef-insurance. Veracierto concluded that it is reasonable to abstract from borrowing constraints and market incompleteness, and that the main effects of policy appear to operate through search incentives (for workers) and hiring incentives (for firms).

Continuing his response, Veracierto conceded that undirected search is a strong assumption. He said, however, that experiments by the authors with directed search in the context of unemployment insurance actually strengthened the results. He also thought that including capital would enhance the effects that they find. Veracierto agreed with Krueger that their simulations are not successful in capturing the cross-sectional wage distribution, a result of their assumption of worker homogeneity.

Robert Shimer disagreed with the presumption that workers can effectively self-insure against unemployment, since even though spells are short on average they tend to be repeated and may lead to wage losses. He expanded on the criticism of complete markets by noting that several of the policies analyzed, such as unemployment insurance and firing taxes, make little sense in such a world. Effectively, in this setup, UI serves only as a subsidy for search. Several people noted that incorporation of permanent shocks, such as aggregate productivity shocks, would increase the need for insurance by workers. Mark Gertler suggested that self-insurance would work well only if agents were very long-lived, allowing them to spread the effects of shocks out over many periods. The authors replied that such long lives are necessary only if the shocks are relatively persistent.

Christopher Foote agreed with the authors that a general-equilibrium framework is necessary to think about firing taxes, since firing taxes reduce aggregate productivity and thus the return to work. He also pointed out that the welfare cost of firing taxes calculated here is very close to that found by Hugo Hopenhayn and Richard Rogerson in related work. The authors noted that their work differed from that of Hopenhayn and Rogerson mainly in that the latter allowed for entry and exit of firms.

Ben Bernanke suggested the incorporation into the model of two classes of workers of different productivity, or with different endowments of labor supply, in order to allow for a more realistic spread in the wage distribution. He thought that the analysis of the minimum wage would be particularly interesting in that extension. He also suggested supplementing the steady-state analysis with analyses of one-time shocks followed by transition to the steady state. The authors indicated an interest in doing future work that includes worker heterogeneity.