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Abstract. We explore to what extent di¤erences in employment and unemployment across economies can be generated by di¤erences in labor market policies. We use a version of the Lucas-Prescott equilibrium search model with undirected search and endogenous labor-force participation. Minimum wages, degree of unionization, …ring taxes, and unemployment bene…ts are introduced and their e¤ects analyzed. When the model is calibrated to US observations it reproduces several of the elasticities of employment and unemployment with respect to changes in policies reported in the empirical literature. We …nd that: i) minimum wages have small e¤ects; ii) …ring taxes have similar e¤ects to those found in frictionless general equilibrium models; iii) unions have large and negative effects on employment, unemployment, and welfare; and iv) unemployment bene…ts substantially increase unemployment and reduce welfare.

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1 Introduction

Labor markets perform quite di¤erently across countries. An often cited example is the sharp contrast in unemployment rates between Europe and the U.S. There are large and persistent di¤erences in labor market policies as well.[1] The goal of this paper is to explore to what extent di¤erences in labor market policies can generate di¤erences in labor market performance. In particular, the paper builds a general equilibrium model to evaluate the aggregate e¤ects and welfare consequences of a variety of labor market policies and institutions; mainly: minimum wages, …ring restrictions, unemployment insurance and unions. The model embodies a McCall search model in a general equilibrium production economy by modifying the Lucas and Prescott [15] islands 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 is a …xed number of …rms which share a common productivity shock. Productivity shocks follow a Markov process, and are identically and independently distributed 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 non-employed, or stay and work. Non-employed 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: …rms and workers take the process for spot wages as given. We also assume that …rms 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 …rms maximize the expected discounted value of their earnings. The model abstracts from any insurance role of labor market policies. In Alvarez and Veracierto [1] 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 e¤ects on productivity, search decisions and …rm dynamics. Those

[1] This has been documented in a number of OECD Jobs Studies and surveyed and analyzed by Nickel [5], among others.

[2] Also see Costain [10], Hansen and Imrohoroglu [12], and Valdivia [26].

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 [6], Bentolila and Bertola [4], Hopenhayn and Rogerson [13], Campbell and Fisher [7], and Veracierto [24]. 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 [17], Mortensen [20], Wolpin [25], and Lundqvist and Sargent [16].

Industry equilibrium models (e.g. Hopenhayn and Rogerson [13]) have typically abstracted from unemployment decisions, focusing on the employment /non-employment decision. Most equilibrium models of unemployment that have been used for policy analysis (e.g. Millard and Mortensen [19]) have abstracted from the employment/non-employment 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 to analyze labor force participation; and 3) the search decisions of workers, which allows to study unemployment.[3] In fact, the labor market policies that we analyze will have important consequences on 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 of 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

[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.

stationary equilibria only. We select parameters values by matching model moments with selected U.S. statistics under a stylized version of U.S. policies.

Minimum wages are introduced as in text-book 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 di¤erent ways of rationing the supply of workers. For instance, we allow for a distinction between "insiders" and "outsiders". We …nd that the aggregate e¤ects 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 di¤erent implications. In one version, a union is constituted by the coalition of all workers present in the island at a given period of time. The workers collude to extract rents from the …xed factor, sharing the bene…ts equally among themselves. In the other version, the union is dominated by a "union boss" who appropriates all the rents from the …xed factor, and pays workers their opportunity cost. We …nd that in the coalitions model of unions, higher degrees of unionization increases the unemployment rate and decreases welfare levels substantially. This is due to the incentives to search for a unionized island in order to appropriate rents. The rationing of employment in unionized islands contribute to larger ‡ows into unemployment as well.

Following Bentolila and Bertola [4] and Hopenhayn and Rogerson [13], we introduce …ring restrictions as a tax on employment reductions. This tax makes the …rms employment decision dynamic, since increasing current employment exposes …rms to future …ring costs. Firms react to the …ring taxes by …ring 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, …ring taxes reduce the unemployment rate in the economy. Similarly to previous studies, we …nd that …ring taxes equivalent to one year of wages have large negative welfare e¤ects. However, …ring taxes of similar magnitudes as the severance payments observed in OECD countries produce relatively small negative e¤ects.

Finally, we model unemployment insurance bene…ts as payments that accrue to workers after a job separation. In our model, unemployment bene…ts have similar e¤ects as …ring subsidies.[4] In particular, agents chose to stay out of the labor force and not search as long as they are eligible for UI bene…ts. We …nd that UI bene…ts have large e¤ects on unemployment rates since they increase both the duration and the incidence of unemployment. For instance, doubling the present value of UI bene…ts (from U.S. values) increases unemployment rates by about 1 per cent.

Our quantitative analysis indicates that the responses of the unemployment rate and employment to changes in UI bene…ts, degree of unionization, minimum wages and …ring taxes are broadly consistent with estimates in the empirical literature (Nickel [5], for example). This provides some con…dence 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 that laissez-faire equilibrium. Section 4 introduces di¤erent policies/institutions into the basic model. Section 5 explains our choice of parameter values. Section 6 describes the e¤ects of the di¤erent policies in the calibrated economy. Finally, Section 7 compares these e¤ects 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:

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

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:

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

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:

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

[4] In fact, they are completely equivalent when the UI bene…ts are small.

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

Home goods are produced in a non-market 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 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 non-employed.

A non-employed agent has two alternatives. First, he can leave the labor force and engage in home production during the current period. The following period the agent will remain non-employed. 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.

Hereon, 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 agents x 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:

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

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

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 equations 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.

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 expositional 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 that 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 non-employed and obtains a value of θ (to be determined below). His problem is then described by the following Bellman equation:

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

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,

(i) if $v(x; z) > \theta$ (agents are strictly better-off staying than leaving):

$$g(x; z) = x \quad (2)$$

(ii) if $v(x; z) = \theta$ (agents are indifferent between staying or leaving):

$$g(x; z) = \tilde{g}(z) \quad (3)$$

where $\tilde{g}(z)$ satisfies:

$$\theta = f(\tilde{g}(z); z) + \beta \int v(\tilde{g}(z) + U; z') Q(z; dz'): \quad (4)$$

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 or 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 $\tilde{g}(z)$: Otherwise, the equilibrium employment level is x.

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

Let now consider the problem of a non-employed agent who must decide whether to go home and obtain home production or search for a 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 non-employed 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 of islands μ. Thus the problem of a non-employed agent is described by the following equation:

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

If $w^h + \beta\theta < \beta \int v(x,z)\,\mu(dx,dz)$ (non-employed agents strictly prefer to search than stay at home) no one stays at home and employment feasibility becomes:

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

If $w^h + \beta\theta = \beta \int v(x,z)\,\mu(dx,dz)$ (non-employed 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 $w^h + \beta\theta > \beta \int v(x,z)\,\mu(dx,dz)$ implies that $U = 0$, which is inconsistent with an equilibrium (see Alvarez and Veracierto [2]). It follows that:

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

In Alvarez and Veracierto [2] 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 [13] 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 outweigh 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:

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

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 consumption, $c^{-\gamma}$. 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 [2] 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 non-employment decisions analogous to the ones just described.

[6] Prescott and Rios-Rull [23] 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 to 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 a minimum wage legislation. If equilibrium wages in an island are lower than the mandated minimum wage $\underline{w}$, 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 non-employed.[7] Throughout the section we denote $\hat{n}(z)$ to be the maximum employment level consistent with $\underline{w}$ and z, i.e.

$$\underline{w} = f(\hat{n}(z); z).$$

Let consider the problem of an agent that begins a period in an island of type $(x; z)$. If $g(x; z) < \hat{n}(z)$, 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 $g(x; z) = \hat{n}(z)$, 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 $\hat{n}(z)/x$. In that case he receives the minimum wage $\underline{w}$ during the current period and begins the following period in the same island. His expected value is then given by:[8]

$$v(x; z) = \frac{\hat{n}(z)}{x} \left[f(\hat{n}(z); z) + \beta \int v(\hat{n}(z) + U; z') Q(z; dz') \right] + \frac{x - \hat{n}(z)}{x} \theta$$

[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 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 [2] we discuss the more general case.

[8] In Alvarez and Veracierto [2] we show that $f(\hat{n}(z); z) + \beta \int v(\hat{n}(z) + U; z') Q(z; dz') > \theta$: agents always prefer to go through the employment lottery than to leave directly.

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 $\hat{x}(z)$ workers.

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

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 which there are $x - U$), are given priority over the ones that searched last period and just arrived ("the outsiders", of which 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 $\hat{x}(z) - x - U$ positions are rationed between the U "outsiders", or 2) the available $\hat{x}(z)$ positions are rationed between 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 [2].

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 agent to work in the island, there is a competitive market where workers are paid their marginal productivity. Agents that are restricted from entering this competitive labor market leave the island and become non-employed. 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 they 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 to 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:

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

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 new U 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 non-standard structure due to the endogenous discount factor $\beta \frac{g}{g+U}$: However, in Alvarez and Veracierto [2] 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 that 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 generate an invariant distribution μ. The decision problem of non-employed agents is then given by:

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

Note that agents that search have no control whether they will arrive to 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:

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

where g is the number of workers that he allows to work. Letting θ denote the equilibrium non-employment 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 only receive $\theta(1-\beta)$. In Alvarez and Veracierto [2] 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,

$$\theta = \max \left\{ \begin{array}{c} w^h + \beta\theta; \\ (1-\lambda)\beta \int v(x;z)\, \mu(dx;dz) + \lambda\beta\theta \end{array} \right\}$$

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

4.3 Firing taxes

In this section 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:

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

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 of the island $G(x;z)$, the equilibrium wage rate $w(x;z)$, and the number of agents that search U 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,

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

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:

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

where θ is the value of non-employment. The worker chooses to leave the island whenever the expected discounted value of wages in the island is less than the value of non-employment. 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 of agents that search U 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 particular, 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 …rms to hire or …re workers. For intermediate shocks, …rms will leave their labor force unchanged.

The decision problem of non-employed agents as well as 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, e¤ectively making workers pre-pay the …ring taxes.

In Alvarez and Veracierto [2] we show that a competitive equilibrium with …ring taxes coincide 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 su¢cient to exploit all mutually bene…cial trades, even in the presence of search frictions and …ring taxes. We also show that the equilibrium described above coincides (except for equilibrium wages) with a competitive equilibrium where the …ring taxes are paid directly by the workers. The advantage of this alternative decentralization is that it is much simpler to analyze, since it only requires a small variation on the arguments used in the laissez-faire case.

4.4 Unemployment Insurance

In this section we introduce an unemployment insurance system in which the government pays unemployment bene…ts b to eligible agents, …nancing the system with lump sum taxes. Non-employed agents may or may not be eligible for bene…ts. Whenever an agent leaves an island where he was employed during the previous period, he becomes eligible for bene…ts with probability ·. Eligible agents lose their eligibility for the following period with probability Ã. Agents that lose their bene…ts cannot regain eligibility within the same spell of unemployment.[9]

Given the nature of the unemployment insurance system we must keep track not only whether non-employed agents are out-of-the-labor-force or unemployed, but whether they are eligible for bene…ts or not.

Let $µ_0$ be the expected value of being non-employed without bene…ts, $µ_1$ the value of being non-employed with bene…ts, U_0 the new arrivals (i.e. the

[9] We model the eligibility and duration of the bene…ts as stochastic to reduce the dimension of the state in the agent's problem.

number of agents that searched during the previous period) which are not eligible for benefits during the current period, and U_1 the new arrivals which 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 that 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 that searched the previous period, has UI eligibility i and arrives to 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.

We now consider the non-employment 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 non-employed 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:

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

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;obtaining 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:

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

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 non-employed agents with eligibility $i = 0;1$ that decide to search. The equilibrium values of ϕ_i must be consistent with the optimal non-employment decision described above. In particular,

$$w^h + \beta\theta_0 > \beta \int u_0(x;z)\,\mu(dx;dz) \Rightarrow \phi_0 = 0$$

$$w^h + \beta\theta_0 < \beta \int u_0(x;z)\,\mu(dx;dz) \Rightarrow \phi_0 = 1$$

and correspondingly for ϕ_1:

To describe aggregate consistency, it is useful to introduce the following notation. Let H_i be the number of non-employed 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 that searched during the previous period, their benefits have not expired during the current period, and reject employment, and 2) all previously employed agents that decide to leave their islands and gain eligibility. In particular:[10]

$$\begin{aligned} D_1 &= \int \min[U_1; x - g(x;z)]\,\mu(dx;dz) + \\ &\quad \kappa \int \max\{\min[x - U_1 - U_0; x - U_1 - g(x;z)];0\} \end{aligned}$$

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

$$\begin{aligned} D_0 &= \int \max[U_0 - g(x;z);0]\,\mu(dx;dz) + \\ &\quad (1-\kappa) \int \max\{\min[x - U_1 - U_0; x - U_1 - g(x;z)];0\}: \end{aligned}$$

[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 that were employed the previous period, and the last agents to leave are those who have just arrived and are not eligible for benefits.

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

$$\begin{aligned}
U_0 &= \phi_0 (D_0 + H_0) + (1 - \psi)\, \phi_1 (D_1 + H_1)\,; \\
U_1 &= \psi \phi_1 (D_1 + H_1)\,; \\
H_0 &= (1 - \phi_0)(D_0 + H_0) + (1 - \psi)(1 - \phi_1)(D_1 + H_1)\,; \\
H_1 &= \psi (1 - \phi_1)(D_1 + H_1)
\end{aligned}$$

The market clearing condition is given by:

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

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 after a job separation, contingent on not becoming employed until the expiration of benefits, so that

$$p = \eta \frac{b}{1 - \psi \beta}. \qquad (13)$$

In Alvarez and Veracierto [2] we show that non-employed agents with benefits search ($\phi_1 > 0$) only if all non-employed agents without benefits search ($\phi_0 = 1$). Moreover, we establish that for small values of p, equilibria with UI benefits have $\phi_1 = 0$ and $0 < \phi_0 < 1$. In words, agents that receive UI benefits do not search, 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 from 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 eligibility η. Since agents eligible for benefits do not search, this results shows that in our model UI benefits are equivalent to a firing subsidy by the amount p.

The previous result has the following two important corollaries about the combined effects of firing taxes and UI benefits, whose proofs can be found in Alvarez and Veracierto [2]. 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 that with a …ring subsidy of p^0: Alternatively, if $p^0 < 0$ the equilibrium is the same than with a …ring tax of size p^0: Second, if we interpret severance payments as a tax to the …rms proportional to the employment reductions and a simultaneous subsidy to each worker that leaves the …rm, then one obtains that severance payments have no e¤ect. This is a known result for competitive markets, see for example Lazear [14]. What is interesting is that it holds even in the presence of the search frictions.

5 Calibration

To explore the e¤ects 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 ®, 2) the time discount factor ¯, 3) the home productivity w^h, 4) the curvature parameter in the utility function °, 4) the persistence of productivity shocks ½, and 5) the variance of the innovations ¾^2. Additionally we have to chose 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 to be able to match the short average duration of unemployment in the U.S.

A characteristic of the U.S. system is that it is …nanced by experience rated taxes. Experience rated taxes work as …ring taxes: they increase the tax liabilities of employers when workers are …red. Anderson and Meyer [3] 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 both with 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 …ring tax and set the UI bene…ts in the model to be equal to the present value of the UI bene…ts net of this …ring tax. In particular, we consider the "net" UI bene…ts to be 40 percent of the US unemployment insurance bene…ts.

In a sample of agents that collected UI bene…ts between 1978 and 1983, Meyer [18] 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: 26%. Meyer [18] 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 bene…ts do not search, we identify the 13 weeks with the average duration of UI bene…ts. Given a model period of 6 weeks, this translates to a persistence of UI bene…ts Ã of about 0.50.

The probability · that an agent becomes eligible for UI bene…ts at the start of an unemployment spell is chosen as follows. Let h be the escape rate from unemployment and I the ‡ow 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 bene…ts. Note that:

$$(1 \text{ ¡ } \tilde{A})H_1 = \cdot I; \tag{15}$$

since the ‡ow out of H_1 is given by the number of agents that lose their bene…ts, and the ‡ow into H_1 is equal to a fraction · of the ‡ow out of employment. At steady state both ‡ows must be equal. Substituting (14) in (15) we obtain:

$$\cdot = \frac{(1 \text{ ¡ } \tilde{A})}{h}\frac{H_1}{U}$$

Note that $\frac{H_1}{U}$ is the ratio of agents that receive UI bene…ts to the total number of agents that are unemployed. In OECD [21], Table 8.4, we …nd that this ratio is about 0.35 for the U.S. economy. On the other hand, a 4 months average duration of unemployment in the U.S. suggests a value of 1=h equal to 2.66 model periods. The value of · consistent with these magnitudes is 0.50.

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

Given the all the previous choices, the persistence of the productivity shocks ½ and the variance of its innovations $¾^2$ 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 …t was obtained.

In Alvarez and Veracierto [2] 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 U.S. (OECD [21], 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 effects 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:

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

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 [5], 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 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 hours worked have displayed no trend. To reconcile this observation with the theory, preferences where income and substitution effects cancel 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 is common in the macroeconomic literature), but is what Hopenhayn and Rogerson [13] 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]

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

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 effects on the unemployment rate, the average duration of unemployment, and the rate of incidence into unemployment are presented in the first panels of the tables since they are independent of γ. The second panels show results under $\gamma = 0$ (the case where home and market goods are perfect substitutes), the third panels report results under $\gamma = 1$ (our benchmark log utility case), and the fourth panels present results under $\gamma = 8$ (the low elasticity of labor supply case). For each of these panels we report the following: 1) total unemployment (i.e. the total number of agents U 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 describes the effects of minimum wages. The second column corresponds to laissez-faire, while the third and fourth 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 to 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 percent of average wages increases the unemployment rate only from 5.3 percent to 5.4 percent. Higher minimum wages can increase the unemployment rate further. But even a minimum wage which is large enough so that 27 percent of employed agents receive it, only increases the unemployment rate from 5.3 percent to 6.6 percent, a small e¤ect compared to other policies.

The minimum wage regulation has the e¤ect of increasing average wages. As a result, the number of agents that search for a job (U) increases until indi¤erence 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 (° = 0), a minimum wage equal to 90 percent of average wages increases the number of agents unemployed (U) by 24.7 percent. However, employment falls by 1.9 percent 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 percent and a decrease in market output of 0.5 percent.

On the other extreme when ° = 8, the e¤ects are quite di¤erent. The 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 e¤ects of minimum wages are extremely small. Even for a minimum wage equal to 90 percent of average wages, the welfare cost is only about 0.2 percent in terms of consumption.

In Table 2b we compute the e¤ects 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” –i.e. agents that search- are rationed more often. However the results are virtually the same: we still …nd small e¤ects of minimum wages.

6.2 Unions

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

We describe the coalition model of unions first. Recall that unions obtain 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 percent 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 then 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 3.a shows that the effects of unions are surprisingly large. When 60 percent of the islands become unionized the unemployment rate increases from 5.3 percent to 12.5 percent.

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 perfect substitutes and 60 percent of the islands become unionized, the number of agents unemployed (U) must increase by 115.9 percent 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 percent. 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 percent. Market output falls by 9.3 percent 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 a 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 percent. The increase in labor force is not enough to outweigh the higher unemployment rate, and employment still falls by 3.3 percent. However, market output now decreases only by 0.7 percent.

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

We now turn to the results under the union-boss model, as described in Table 3.b. We see that the effects are very different from the coalitions model: larger unionized sectors lead to lower unemployment rates. To understand this difference, notice that in this case it is the "union boss" the one who retains all monopolistic rents: workers in the union sector are merely paid 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 percent, the unemployment rate decreases from 5.3 percent to 3.5 percent.

When home goods and market goods are perfect substitutes ($\gamma = 0$), the fall in average wages is so large when 60 percent of the islands become unionized, that the number of agents that search (U) must fall by 53.9 percent 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 percent, despite the fall in the unemployment rate. The consequent reduction in labor force participation leads to an increase of 93.7 percent in home output. On the contrary, market output decreases by 21.4 percent.

When $\gamma = 8$, the fall in market output increases 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 percent, it is not enough to increase the labor force participation: home output still increases, but only by 3.6 percent. As a counterpart, market output decreases by merely 1.6 percent.

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

Since the two models of unions predict such di¤erent e¤ects on unemployment rates, it is important to discuss what evidence favors one type of model over the other. Note that in the coalitions 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 [8] provides such evidence. Using panel data from the 1987 and 1988 Current Population Surveys, he reported that the union wage premium is about 15 percent in the U.S. economy. The sign of this premium favors the coalitions 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 percent of the islands must be unionized (the generated wage premium is 12.5 percent). Under this degree of unionization we verify that 13 percent of the workforce is employed in the unionized sector. This is surprisingly close to the empirical counterpart of 15.6 percent reported by Nickell[5], providing additional con…dence about the quantitative relevance of the coalitions model of unions.

6.3 Firing taxes

Table 4 shows the e¤ects of …ring taxes that range between 3 months and 12 months of average wages. To understand these results, note that in the presence of …ring taxes …rms change their behavior in two important ways: 1) they become less willing to …re workers (as they try to avoid current taxes), and 2) they become less willing to hire workers (as they try to avoid future taxes). These e¤ects tend to reduce the incidence of unemployment and increase the average duration of unemployment, respectively. Depending on which e¤ect is larger, the unemployment rate can decrease or increase. Under our choice of parameter values we …nd that the e¤ect on the …ring rate dominates: the unemployment rate decreases from 5.3 to 3.7 percent with …ring taxes equal to 12 months of wages.

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

When ° = 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 only falls by 16.7 percent. This is a small decrease compared to the fall in the unemployment rate, leading to an increase in employment of 3.9 percent. Labor force participation increases so much that home output falls by 7.2 percent. As a counterpart, market output falls only by 0.8 percent.

It is interesting to compare our results with those obtained by Hopenhayn and Rogerson [13] who calculated the costs of …ring 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 ° = 1 case.

Table 3 in Hopenhayn and Rogerson [13] reports that a …ring tax equivalent to one year of wages lowers output by 4.6 percent, decreases employment by 2.5 percent, and lowers welfare by 2.8 percent in terms of consumption in their model economy. Table 4 in this paper shows that the same policy produces a fall of 4.5 percent in output, a decrease in employment of 2.1 percent and a welfare cost of 2.3 percent 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 °: As in Hopenhayn and Rogerson [13] the e¤ects of …ring taxes on employment and output depend on the income and substitution e¤ects on the labor supply. If the substitution e¤ect dominates –as in the ° = 0 case– employment decreases, if the income e¤ect dominates –as in the case ° = 8 case– employment increases.

6.4 Unemployment insurance

In Table 5 we analyze the e¤ect of introducing unemployment compensations with di¤erent expected discounted value of bene…ts into the laissez-faire economy. We measure the generosity of the UI system by the present value of UI benefits p, given by $\kappa \frac{b}{1-\beta\psi}$; where κ is the fraction of separations that qualified for UI benefits, b are the benefits per period, ψ is the per period probability of maintaining the UI benefits, and β is the reciprocal of the gross interest rate. In Table 5 we calculate the equilibrium for different values of p, starting with the one that corresponds to our depiction of U.S. policies (see the section on calibration for the details). Recall that for the U.S. we select p to be 0.28 of average model period 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 period of wages.

As the size of the UI benefits increase, 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 eligibility for UI benefits. This leads to a decrease 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 both 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 percent to 11.9 percent.

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 percent when 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 percent despite the increase in the unemployment rate. This leads to such an increase in labor force participation that home output falls by 73.5 percent. As a counterpart, market output increases by 12.1 percent.

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 percent and employment falls by 2.5 percent. The lower labor force participation dampens the fall in home output to only 17.5 percent. On the other hand, market output increases by merely 0.8 percent.

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 percent 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 [9]). The evidence that minimum wages affect adult employment is even weaker, suggesting that minimum wages have little impact on the aggregate unemployment rate and employment level.

Card and Krueger [9] observe that in the U.S. economy only 5 percent of workers are paid the minimum wage. Since in Table 2a the economy with a minimum wage equal to 80 percent of average wages generates a similar proportion of recipients, we identify it with the U.S.[12] Given the little 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, we consider that 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 too concentrated compared to the data (the standard deviation of wages in the benchmark US case is only 13%). To analyze distributional issues we

[12] In order for 5 percent of workers to be subject to the minimum wage, the minimum wage has to be 80 percent of average wages in the model economy. In the U.S. the minimum wage is only 26 percent of average wages (see Card and Krueger [9]). The reason for the difference is that the wage distribution is too concentrated in the model compared to the data. See the comments in the next paragraph.

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 coalitions model of unions over the union-boss model due to its ability to jointly generate 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 [5] reports that union densities vary widely across countries: from 9.8 percent in France and 11 percent in Spain, up to 72 percent in Finland and 82.5 percent in Sweden. Table 3.a. considered degrees of unionization within this empirical range and found that unions produce large variations in unemployment rates: from 7.1 percent to 16.3 percent. 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 3.a 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 [11] 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 percent to 3.7 percent and decreased employment by 2.1 percent 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 by tenure) as multiples of average

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

model period wages. According to this measure, one year of …ring taxes (equal to 8 model periods) is at the upper end of what is observed.[14]

The sign of the relation between unemployment rate and …ring taxes in the model economy is consistent with Nickell's results: in his regression of unemployment rate he …nds a negative coe¢cient on a measure of employment protection. On the other hand, Lazear [14] reports a positive coe¢cient for severance payments. Neither of the two coe¢cients are statistically signi…cantly di¤erent from zero. Di Tella and MacCulloch [11] …nd a negative e¤ect of labor market ‡exibility on unemployment rate controlling for random e¤ects, but the result are not signi…cant when they control for both country and year …xed e¤ects.

Nickell [5], Lazear [14] and Di Tella and MacCulloch [11] …nd 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 (° = 1) we …nd a negative relation. Lazear [14] reports that moving from laissez faire to three months of severance payments reduces the employment-population ratio by about 1 percent. In our benchmark case of ° = 1 we …nd that three months of severance payments reduce the employment to population ratio from 73.6 percent to 72.7 percent, which is consistent with Lazear's estimate.

7.4 Unemployment Insurance

Table 5 reported how changes in the present value of UI bene…ts a¤ect unemployment rates and employment levels. We found large e¤ects. 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 bene…ts, we consider that the responsiveness of the model to UI bene…ts is within what the empirical evidence suggests.

Nickell [5] reports regression coe¢cients that imply an elasticity of the

[14] Moreover, as explained at the end of the section on unemployment insurance, 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 …ring taxes would be lower than those shown in Table 6. For instance, if severance payments can be undone perfectly, …ring taxes would only include expected legal costs of litigation. For Germany, Italy, France and UK, Bentolila and Bertola [4] report that these costs are well below one month of wages.

unemployment rate with respect to UI benefits 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 benefits duration (see equation 13). The elasticity that Nickell reports with respect to benefits duration is about 0.20, which is lower than his estimated elasticity with respect to the replacement ratio. However, his coefficient on benefits 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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Table 1

Parameters

®	Cobb-Douglas parameter	0.64
¯	time preference	0.9951
°	substitution between market vs. home goods	1
½	persistence of z	0.98724
¾^2	innovation variance of z	0.00838
w^h	productivity at home	.817

US Observations

Labor Share	0.64
Interest Rate	4 % (annual)
Employment/Population	0.79
Average Duration of Unemployment	4 months
Unemployment Rate	6.2 %

US Policies

Average duration of U.I. bene…ts collected	3 months
U.I. recipients / Unemployed	35 %
Replacement Ratio	66 %
Experience Rating	60 %

TABLE 2.a. MINIMUM WAGES, NO PRIORITY (AS % OF AVG. WAGES)

	Laissez-Faire	MINIMUM WAGE 85%	MINIMUM WAGE 90%
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	2.6
Gamma = 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 (% of cons. vs. LF)	0.0	0.0	-0.2
Gamma = 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 (% of cons. vs. LF)	0.0	0.0	-0.2
Gamma = 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 (% of cons. vs. LF)	0.0	0.0	-0.1

TABLE 2.b. MINIMUM WAGES, PRIORITY (AS % OF AVG. WAGES)

	Laissez-Faire	MINIMUM WAGE 85%	MINIMUM WAGE 90%
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
Gamma = 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 (% of cons. vs. LF)	0.0	0.0	-0.2
Gamma = 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 (% of cons. vs. LF)	0.0	0.0	-0.2
Gamma = 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 (% of cons. vs. LF)	0.0	0.0	-0.2

TABLE 3.a. UNIONS AS COALITIONS

	Laissez-Faire	ISLANDS UNIONIZED 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 * (in %)		12.5	10.9	8.9	6.6
Gamma = 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 (% of cons. vs. LF)	0.0	-0.7	-1.9	-3.4	-5.3
Gamma = 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 (% of cons. vs. LF)	0.0	-0.7	-1.9	-3.5	-5.6
Gamma = 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 (% of cons. vs. LF)	0.0	-0.7	-1.8	-3.2	-4.8

* Average earning per union member / average competitive wages

Table 3.a. (cont.) COMPETITIVE vs. UNIONIZED ISLANDS

	ISLANDS UNIONIZED			
	20%	40%	60%	80%
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
WHOLE ECONOMY				
Unemployment Rate	7.1	9.5	12.5	16.3
Avg. Duration of Unemp.	3.0	3.6	4.5	5.5
Incidence of Unemp.	2.7	3.0	3.4	3.7

TABLE 3.b. "UNION BOSS" MODEL

		ISLANDS UNIONIZED			
	Laissez-Faire	20%	40%	60%	80%
Unemployment Rate	5.3	4.8	4.2	3.5	2.4
Avg. Duration of Unemp.	2.4	2.3	2.2	2.0	1.7
Incidence of Unemp.	2.3	2.2	2.1	1.9	1.5
Gamma = 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 (% of cons. vs. LF)	0.0	-0.3	-1.0	-2.2	-5.2
Gamma = 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 (% of cons. vs. LF)	0.0	-0.3	-0.7	-1.5	-3.7
Gamma = 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 (% of cons. vs. LF)	0.0	-0.2	-0.5	-1.1	-2.4

Table 3.b. (cont.) COMPETITIVE vs. UNIONIZED ISLANDS

	ISLANDS UNIONIZED			
	20%	40%	60%	80%
COMPETITIVE ISLANDS				
Unemployment Rate	4.6	3.8	2.9	1.7
Avg. Duration of Unemp.	2.2	2.0	1.8	1.5
Incidence of Unemp.	2.2	2.0	1.7	1.2
UNIONIZED ISLANDS				
Unemployment Rate	6.0	5.1	4.0	2.6
Avg. Duration of Unemp.	2.6	2.4	2.1	1.7
Incidence of Unemp.	2.4	2.2	2.0	1.6
WHOLE ECONOMY				
Unemployment Rate	4.8	4.2	3.5	2.4
Avg. Duration of Unemp.	2.3	2.2	2.0	1.7
Incidence of Unemp.	2.2	2.1	1.9	1.5

TABLE 4. FIRING TAXES (IN MONTHS OF AVG. WAGES)

		FIRING TAX		
	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
Gamma = 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 (% of cons. vs. LF)	0.0	-0.6	-1.2	-2.3
Gamma = 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 (% of cons. vs. LF)	0.0	-0.6	-1.2	-2.3
Gamma = 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 (% of cons. vs. LF)	0.0	-0.6	-1.1	-2.1

TABLE 5. UNEMPLOYMENT BENEFITS (PV, IN MODEL PERIODS OF AVG. WAGES)

		PV OF UNEMP.BENEFITS				
	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 Unemp.	2.4	2.7	2.9	3.4	4.1	5.0
Incidence of Unemp.	2.3	2.5	2.7	2.9	3.3	3.6
Gamma = 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 (% of cons. vs. LF)	0.0	0.0	-0.3	-1.2	-3.0	-5.6
Gamma = 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 (% of cons. vs. LF)	0.0	0.0	-0.3	-1.0	-2.5	-4.6
Gamma = 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 (% of cons. vs. LF)	0.0	0.0	-0.2	-0.8	-2.1	-3.6

Figure 1

Employment Determination, Laissez-Faire

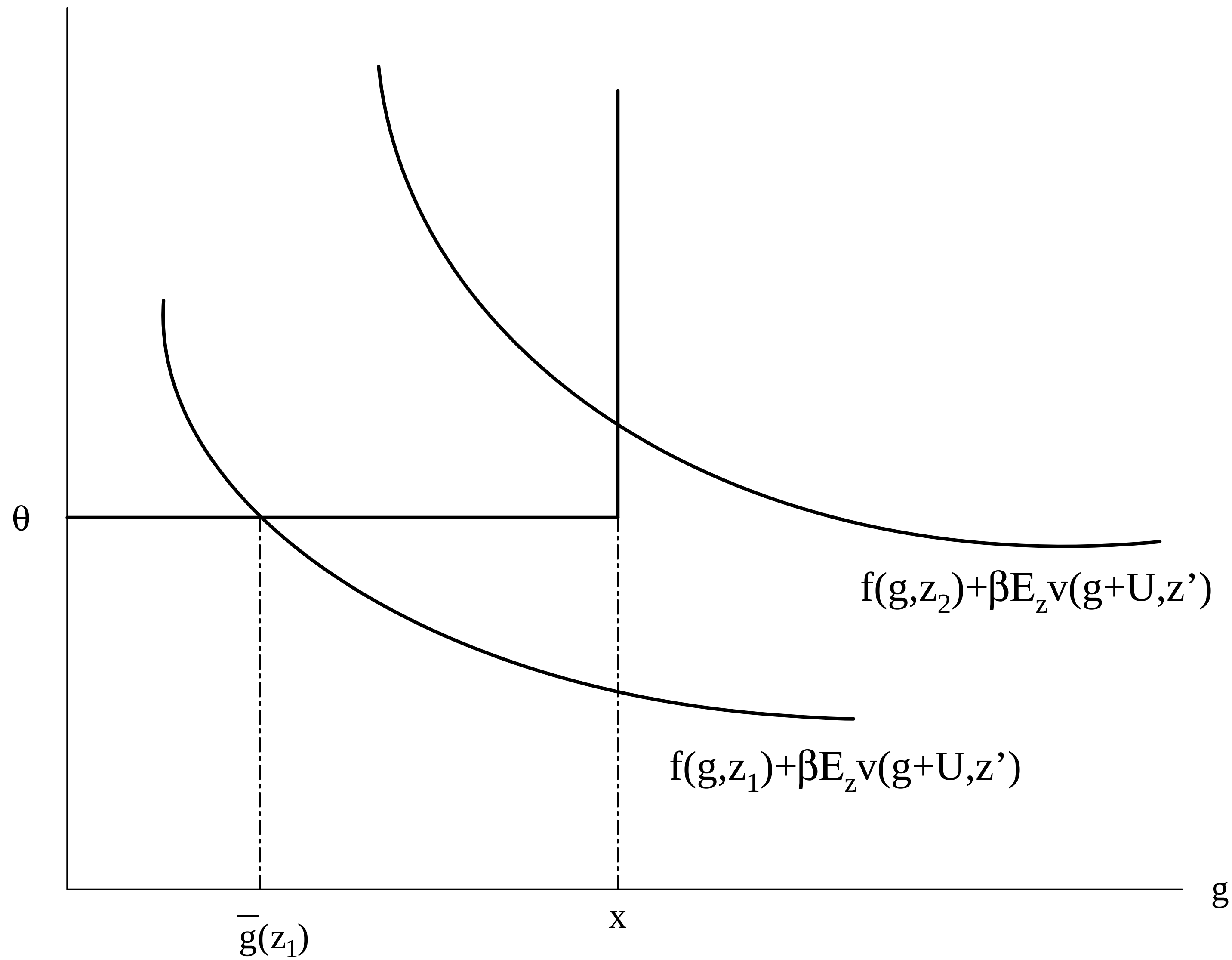


Figure 2
Value Function, Laissez-Faire

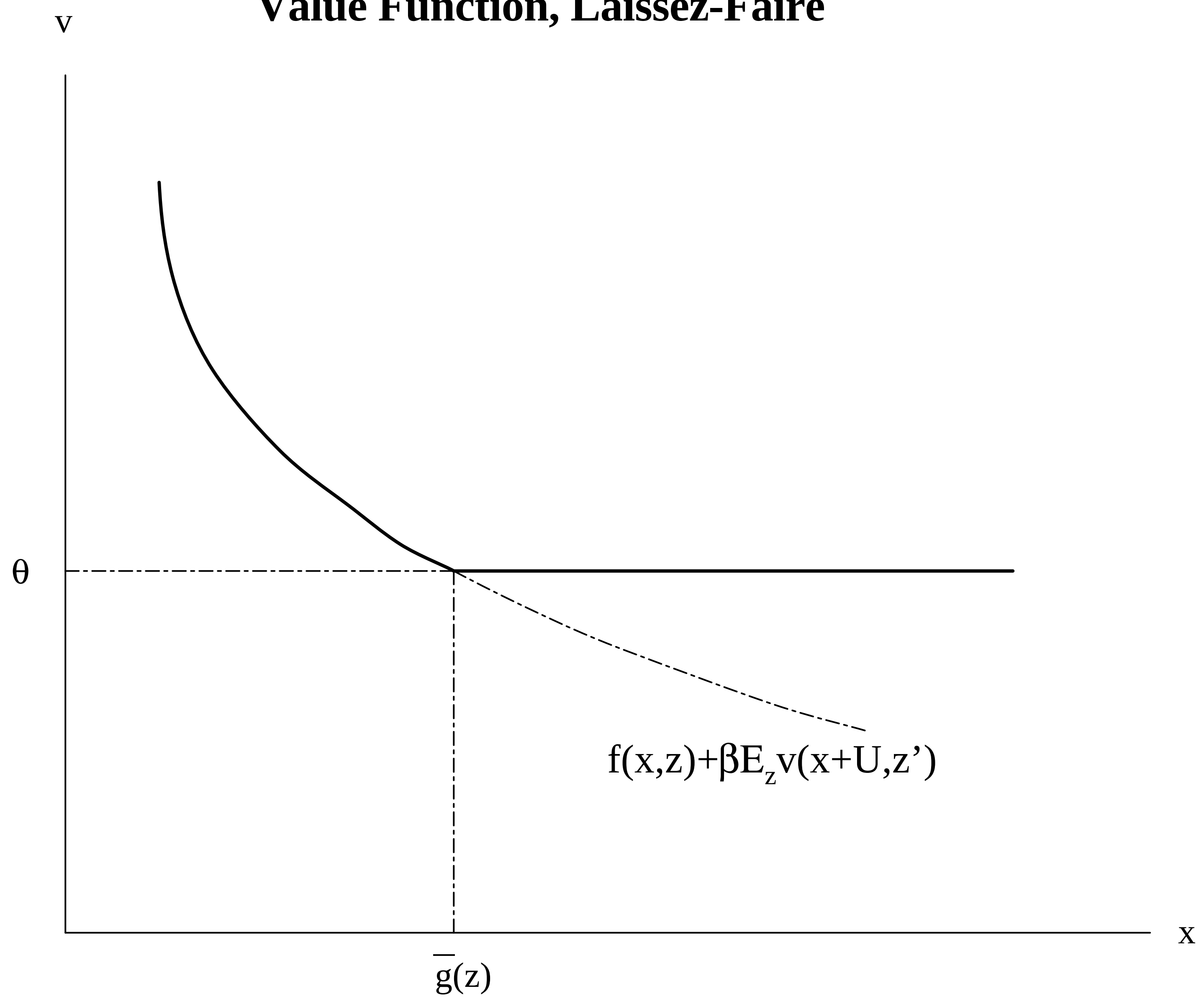


Figure 3

Employment Policy, Laissez-Faire

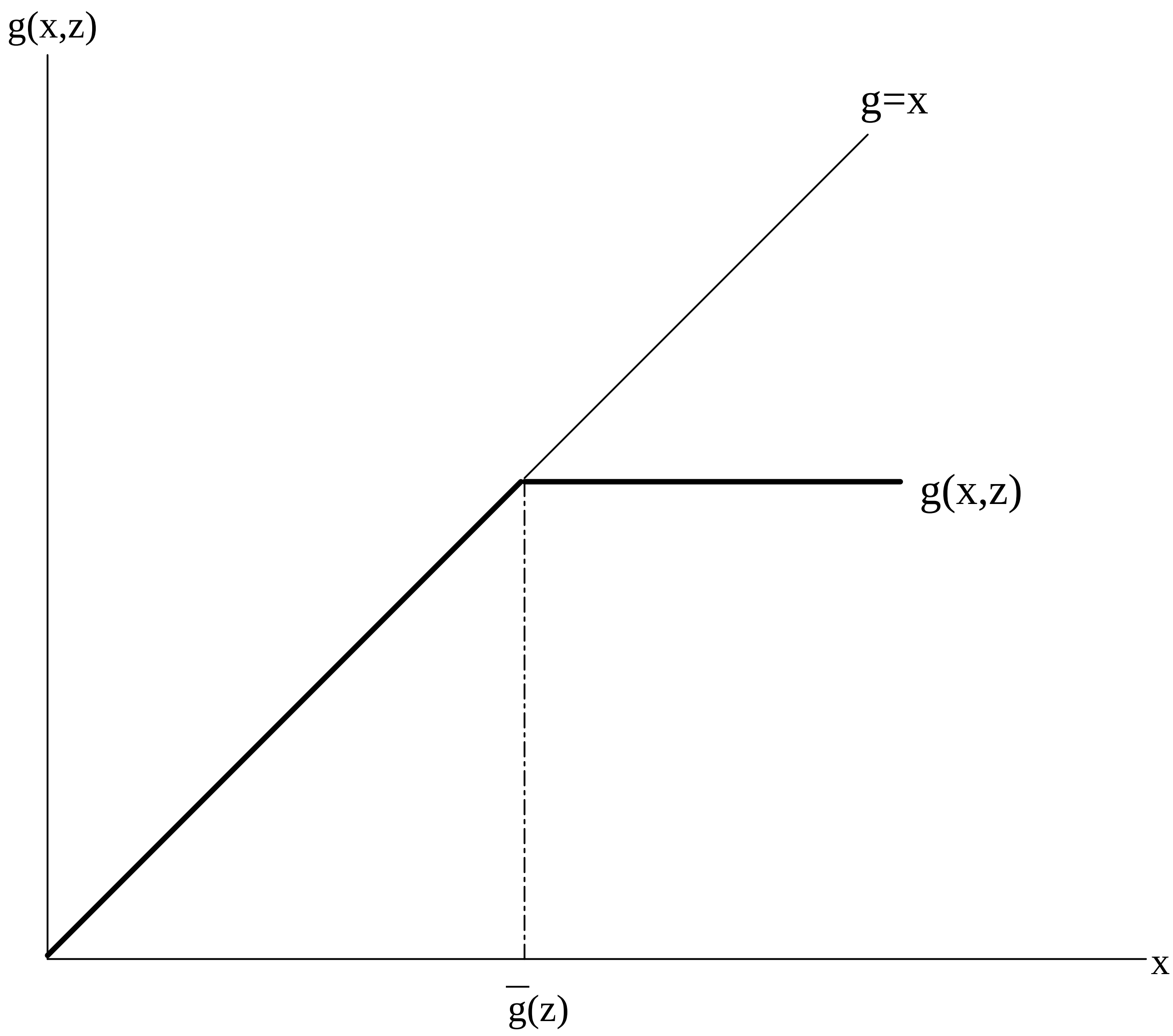


Figure 4

Employment Determination, Minimum Wages

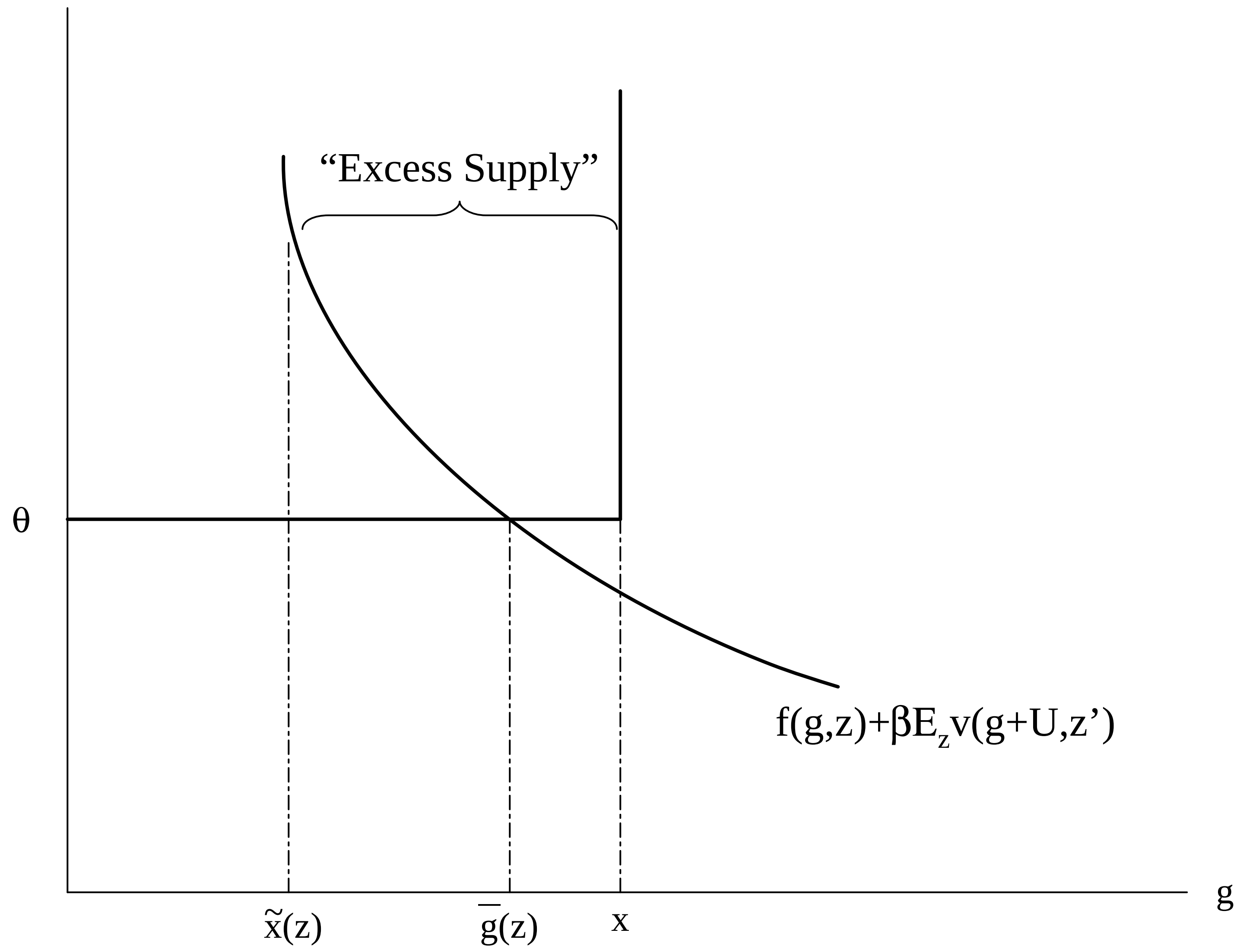
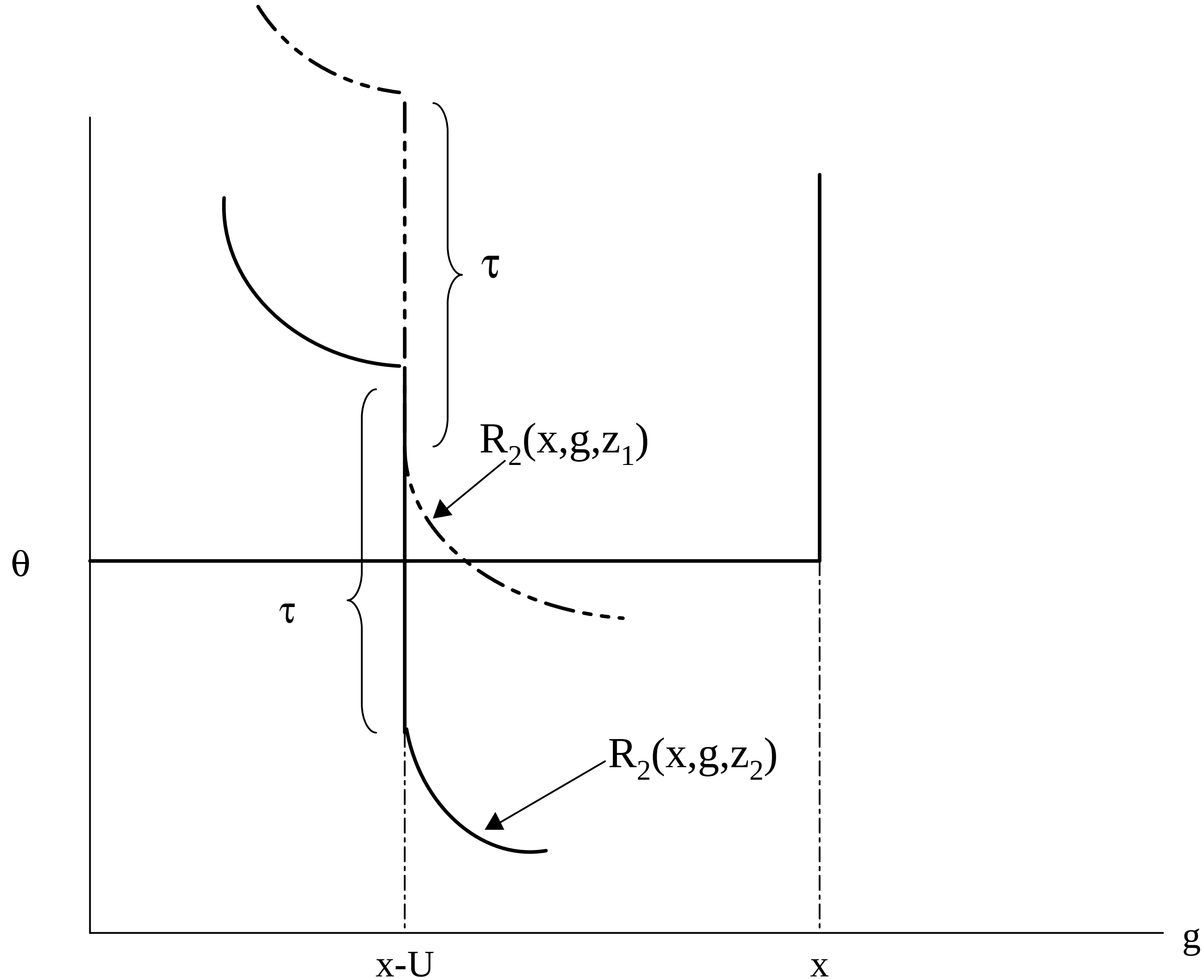


Figure 5
Employment Determination, Firing Taxes (firms pay tax)



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