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POLICY ANALYSIS IN A MATCHING MODEL WITH INTENSIVE AND EXTENSIVE MARGINS

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ABSTRACT

The large differences in hours of work across industrialized countries reflect large differences in both employment to population ratios and hours per worker. We imbed the canonical model of labor supply into a standard matching model to produce a model in which both the intensive and extensive margins are operative. We then assess the implications of several policies for changes along the two margins. Firing taxes and entry barriers both lead to changes in hours and employment in opposite directions, while tax and transfer policies lead to decreases in both employment and hours per worker.

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1. Introduction

Hours of market work per person of working age exhibit dramatic differences across industrialized countries. For example, hours worked in continental European economies such as Belgium, France, Germany and Italy are roughly one third less than in the US. A growing literature seeks to understand the relative importance of the various factors that have been proposed as candidate explanations: tax and transfer programs, labor market regulations (e.g., employment protection and minimum wages), unions, preferences, and product market regulations (e.g., entry barriers).[1] Although one must ultimately carry out a quantitative assessment of a particular factor in order to argue that it is empirically relevant, when one is at the stage of contrasting alternative explanations, it is often useful at a qualitative level to note any differing implications across candidate explanations as a way to discriminate between them. A notable feature of the data is that differences in aggregate hours are due to quantitatively important differences along both the extensive margin (employment to population ratio) and the intensive margin (annual hours worked per worker in employment). Despite this, existing analyses have typically abstracted from modeling both margins. In this paper we argue that examining the implications of policies and institutions for differences in hours worked along these two margins can serve as a way to qualitatively distinguish between various explanations.

To pursue this, we develop a model that includes both extensive and intensive

[1] Recent contributions that argue in favor of particular factors include Prescott (2004) for taxes, Alesina et al (2005) for unions and labor market regulation, Fonseca et al (2003) for entry costs, and Blanchard (2004) for preferences.

margins by embedding a canonical model of labor supply into an otherwise standard Pissarides matching model. The former provides a theory of choice along the intensive margin, while the latter provides a theory of choice along the extensive margin. Although the preferences of workers in our model imply that workers would prefer to all be employed and work the same hours, matching frictions generate a nonconvexity, and this nonconvexity gives rise to interior solutions for both margins of labor supply. We provide a simple diagrammatic representation of steady-state equilibrium in our model and then use it to derive analytic results regarding the effects of several policies on the steady-state levels of hours and employment. Our analysis is perhaps of independent interest in that it can be interpreted as extending the Pissarides model to allow for strictly concave utility and endogenous choice of hours.[2] While the model is simple, we believe that it serves as a useful benchmark for assessing the effects of various labor market policies.

Allowing for both intensive and extensive margins turns out to have significant implications for the relative effects of various policies. Specifically, policies that have similar qualitative effects on aggregate employment in the standard Pissarides model when only the extensive margin is modeled, turn out to have very different effects on hours per worker in our model. For example, we find that while increases in either firing taxes or entry barriers can lead to reductions in employment, these policies necessarily lead to increases in hours worked along the intensive margin. In contrast, increases in labor income taxes that are used to

[2]Endogenizing the choice of hours in a model with linear utility is a simple extension of the standard Pissarides model. See, e.g., the survey paper of Rogerson et al (2005).

fund a lump-sum transfer lead to decreases in both employment and hours per worker. Policies that limit the length of the workweek necessarily lead to increases in employment. In the context of the model that we analyze, we conclude that it is less likely that entry barriers, firing taxes or exogenous workweek restrictions are the dominant source of differences in aggregate hours of work. More generally, we conclude that requiring any proposed theory of differences in aggregate hours of work to also confront the differences along the intensive and extensive margins is likely to be informative.

Although our results are obtained in the context of one particular model, we believe that the economic forces captured by our model are likely to apply much more broadly. The reason for this is that our model captures a very simple economic reality: from the perspective of producing output, the intensive and extensive margins are substitutes. Any policy that acts directly on one of these margins is likely to lead to adjustments along the two margins in opposite directions. For example, firing costs and entry barriers have a direct effect of making it more costly to use the extensive margin, and as a result lead to opposing effects on the intensive margin. Taxes, on the other hand, directly impact both margins, and hence lead to changes along both margins that are in the same direction.

The exercise that we carry out in this paper should be seen as an illustration of a much broader line of research. Even if our main goal is to understand the differences in certain aggregate variables across countries, it will typically be the case that disaggregated data will help to distinguish between competing mechanisms that can fit with the aggregate data. In the context of differences in aggregate hours of work, empirical work shows that there are some striking patterns at various levels of disaggregation.[3] Decomposing differences in hours worked into differences along the intensive and extensive margins is just one example of this broader point.

An outline of the paper follows. In the next section we document differences in hours worked between the US and several European countries and show how these differences can be decomposed into differences along the extensive and intensive margins. Section 3 presents the model, and Section 4 presents a characterization of the steady state equilibrium. In Section 5 we use the model to deduce the effects of several policies on steady state employment and hours per worker. Section 6 concludes.

2. Data

Although the analysis of this paper will be qualitative in nature, it is important to at least briefly present some of the evidence that serves to motivate the current analysis. on differences in hours worked across countries and the decomposition of these differences along extensive and intensive margins. Data on aggregate civilian employment relative to the size of the population aged 15-64 is taken from the OECD, while data on annual hours of work per person in employment is taken from the GGDC. The product of these two values provides a measure of market work per person of working age that can be compared across countries. Table 1

[3] Rogerson (2006) describes some of these differences. For example, he shows that differences in hours worked are dominated by differences in hours in the service sector, and that differences are much larger for younger and older workers than for prime aged workers.

presents data on these measures for the year 2003 for four European economies relative to the US.

Table 1

Market Work in Europe Relative to the US (2003)

	Belgium	France	Germany	Italy	Average
Hours per Person	.71	.68	.73	.69	.70
Employment/Population	.83	.88	.91	.79	.85
Hours per Employed Person	.86	.77	.80	.87	.83

The four economies that appear in this table are of particular interest since among OECD countries they exhibit the largest differences in hours worked relative to the US. It is important to note that differences in annual hours per person in employment reflects several factors, such as differences in the workweek for full time workers, the composition of full and part-time work, as well as differences in statutory holidays and vacation days. The model that we develop in the next section is aimed at understanding differences in hours for full time employees rather than the choice of part-time versus full time employment. France and Germany exhibit greater part-time employment than the US, so that part of the hours per employed person gap in this case is accounted for by the composition of full-time and part-time. In Italy, part-time work is less frequent than in the US. Alesina et al (2005) document that a large part of the differences in hours per employed person is due to differences in statutory holidays and vacation days for full time workers. While there is some variation across these four countries, the key pattern that we wish to emphasize is that the very large differences in hours of work per person of working age are due to large differences in both employment to population ratios as well as annual hours of work per person in employment. On average, differences in employment and hours per worker are of roughly equal importance in accounting for differences in total work between these countries and the US.

3. Model

The model is best characterized as embedding the canonical model of labor supply into a simple Pissarides matching model along two dimensions. Specifically, relative to the Pissarides model, we assume preferences are strictly concave in consumption and that employed workers make a decision about how many hours to work. The details of the environment follow.

3.1. Environment

There is a continuum of mass one of households. In order to avoid the issue of risk-sharing across households, we follow Merz (1994) and Andolfatto (1996) in assuming that each household in turn consists of a continuum of mass one of members. This assumption implies that households will not face any uncertainty. Each individual has preferences defined over consumption (c_t) and hours of work (h_t) given by:

$$\sum_{t=0}^{\infty} \beta^t [u(c_t) - g(h_t)]$$

where $u : R_+ \rightarrow R$ is increasing, twice continuously differentiable and strictly concave, $g : [0, 1] \rightarrow R$ is increasing, twice continuously differentiable and strictly convex. The function g represents the disutility of working, and we assume that each individual has a time endowment of one in each period. To guarantee interior solutions we make the standard assumptions:

$$\lim_{h \to 0} g'(h) = 0, \ \lim_{h \to 1} g'(h) = \infty, \ \lim_{c \to 0} u'(c) = \infty$$

A household seeks to maximize the average utility of its members.

The unit of production is a matched worker-job pair. Output from a matched pair is given by the function $f(h)$ where we assume that f is increasing, twice continuously differentiable, weakly concave and satisfies $f(0) = 0$. Any job-worker match that produces in period t faces a probability λ of becoming unproductive at the end of the period, i.e., output will be zero independently of h . The state of being unproductive is an absorbing state. Realizations of this shock are iid across all producing matches.

The process by which unemployed workers (u) and vacant jobs (v) come into contact with each other is specified by a matching function $m(u, v)$ that gives the number of matches that result from the given inputs into the search process. This function is assumed to be increasing in both arguments, weakly concave in both arguments jointly, strictly concave in each argument individually, exhibit constant returns to scale and to have the property that $m(u, v) \leq \min\{u, v\}$. As is standard, we assume that search for unemployed workers is costless, that employed workers are not allowed to search, but that it is costly for jobs to find workers. Qualitatively, it does not matter if this cost is modelled as a one time cost that is paid in order to create a vacant job, or as a flow cost associated with the process of searching for a worker. When we analyze the effects of entry barriers it will be convenient to have the cost modelled as an up front cost rather than a flow cost, so for simplicity we assume that there is a one time fixed cost κ, measured in units of output, in order to create an unfilled job. Given this fixed cost, the standard posting cost serves no important additional purpose, and so we set it equal to zero for simplicity. There is no limit to the number of jobs that can be created, and all created jobs are identical.

3.2. Equilibrium

Although the ingredients specified in the previous section are sufficient to define the set of feasible allocations and formulate a social planner's problem for the economy, in order to formulate our notion of decentralized equilibrium we will have to specify some additional aspects. As is standard in the literature, we will assume that wages are determined via generalized Nash bargaining between individual workers and their firms. We denote the bargaining weight of the worker by θ. The outside option of the worker is unemployment, while the outside option of the firm is an unfilled job. When bargaining, each worker-firm pair takes the outcomes in the rest of the economy as given. This implies that each individual worker bargains as if they are the marginal member of the household.

Firms in this model do not engage in consumption. Rather, in the spirit of modern general equilibrium theory, firms are simply economic agents that have access to technology and seek to maximize profits. We assume that the ownership of all firms is equally distributed among households. In equilibrium each firm takes the actions of all other firms as given when making its decisions. The theory laid out places no restrictions on how jobs will be distributed across firms in equilibrium, and so without loss of generality we normalize the number of firms to one.

It is well known that in matching models with linear utility it is equally easy to characterize both the steady state equilibrium and the dynamics out of steady state. This is no longer the case once one allows for strictly concave utility, since the interest rate is no longer constant outside of steady state. As a result, our analysis here will focus entirely on the steady state equilibrium.

We normalize the price of output to be equal to one. The remaining values that characterize a steady state equilibrium are c (consumption per individual), h (hours worked per matched worker), e (fraction of workers employed in each household) w (the payment from firms to workers), v (vacancies posted), u (number of unemployed workers), and π (total profits of the firm). Note that given u and v we can determine $p = m(u, v)/u$ (meeting rate for unemployed workers) and $q = m(u, v)/v$ (the meeting rate for unfilled jobs).

A steady state equilibrium is values for these variables such that:

(1) w and h are consistent with Nash bargaining

(2) the household budget constraint holds: $c = we + \pi$.

(3) profits satisfy: $\pi = e(f(h) - w) - \kappa\lambda e$.

(4) the return to creating an unfilled job is equal to zero.

(5) the level of employment is constant: $\lambda e = m(u, v)$.

(6) feasibility: $c = ef(h) - \kappa\lambda e$.

4. Characterizing Steady-State Equilibrium

In this section we show how to characterize the steady-state equilibrium. In the version of our model with linear utility one can reduce the conditions that characterize equilibrium to a single equation that determines the ratio v/u, and all other values can be determined given this value. With strictly concave utility we show that the conditions that characterize equilibrium can be reduced to a set of two equations in the values v/u and h, with all other values determined from these two values.

In order to solve the bargaining problem it is necessary to derive value functions for the household and the firm. The state variable for the household is e, the fraction of its members that are employed, and we denote the value function for the household in the steady state by $V(e)$. Denoting steady state values with asterisks, we know that in steady state $e^* = p^*/(p^* + \lambda)$ and that:

$$V(e^*) = u(w^*e^* + \pi^*) - e^*g(h^*) + \beta V((1-\lambda)e^* + p^*(1-e^*)) \tag{4.1}$$

The value of individual jobs to the firm are independent of how many jobs the firm has, so the key values are simply the value of a filled job and the value of an unfilled job, which we denote by J_e and J_u respectively. In steady state these values satisfy:

$$J^e = f(h) - w + \beta(1-\lambda)J^e \tag{4.2}$$

$$J^u = \beta[qJ^e + (1-q)J^u] \tag{4.3}$$

where we have made use of the fact that in steady state the interest rate satisfies $1/(1+r) = \beta$. We have also implicitly assumed that an unfilled job will necessarily post a vacancy. This will be true in any equilibrium with positive employment, which is the case of interest.

Rearranging the expression for J^e yields:

$$J^e = \frac{f(h) - w}{1 - \beta(1 - \lambda)}. \tag{4.4}$$

Also, in equilibrium the firm will create new unfilled vacancies as long as it is profitable, implying that in equilibrium it must be that $J^u = \kappa$.

We can now characterize the determination of equilibrium values for w and h. In steady state, the solution to the bargaining problem is to choose current values of w and h so as to maximize:

$$\theta \log(V'(e)) + (1 - \theta) \log(J^e - J^u),$$

taking as given that the bargains of all other household members in the current period are given by the steady state values, and that all future bargains will also be given by the steady state values. Note that with a continuum of members within a household, the difference for the household between having the worker employed and the threat point of having the worker unemployed is simply $V'(e)$. Assuming interior solutions, the first order conditions for the current period values for w and h are given by:

$$\theta \frac{V'_w}{V'} + (1-\theta)\frac{J^e_w - J^u_w}{J^e - J^u} = 0 \tag{4.5}$$

$$\theta \frac{V'_h}{V'} + (1-\theta)\frac{J^e_h - J^u_h}{J^e - J^u} = 0 \tag{4.6}$$

Recalling that future values are being held constant when bargaining over current values takes place, straightforward calculation yields:

$$V'_w = u'(c), \quad V'_h = -g'(h) \tag{4.7}$$

$$J^e_w = -1, \quad J^e_h = f'(h) \tag{4.8}$$

$$J^u_w = 0, \quad J^u_h = 0 \tag{4.9}$$

Using these values to substitute into equations (4.5) and (4.6) and rearranging terms yields the following two expressions:

$$\frac{g'(h)}{u'(c)} = f'(h) \tag{4.10}$$

$$w = \frac{\theta(1-\beta(1-\lambda-p))(f(h)-(1-\beta(1-\lambda))\kappa) + (1-\theta)(1-\beta(1-\lambda))\frac{g(h)}{u'(c)}}{1-\beta(1-\lambda)+\beta p\theta} \tag{4.11}$$

The first expression is the standard result that with Nash bargaining, hours will be set efficiently.

As is standard, given an expression for w and the expressions for the firm's value functions, the free entry condition $J_u = \kappa$ can be rewritten as:

$$\begin{aligned} 0 &= \beta q(1-\theta)(f(h) - \frac{g(h)}{u'(c)}) - ((1-\beta)\theta(1-\beta(1-\lambda-p)) \\ &\quad +(1-\theta)(1-\beta(1-\lambda))(1-\beta(1-q)))\kappa \end{aligned} \tag{4.12}$$

Feasibility requires that:

$$c = ef(h) - \lambda e \kappa, \tag{4.13}$$

but making use of the fact that in steady state we have $e = p/(p+\lambda)$, and $qv = \lambda e$, this can be expressed as:

$$c = \frac{p}{p+\lambda}[f(h) - \lambda\kappa] \tag{4.14}$$

The equations (4.10), (4.12), (4.14) represent a system of three equations in the three unknowns h, v/u, and c, and serve to characterize the steady state equilibrium. It is instructive to consider some special cases of the model. In the simplest Pissarides model, u is linear (i.e., u' is a constant) and h is exogenous, so equation (4.12) reduces to an equation in the single variable v/u. Given a solution for v/u, one can use equation (4.14) to solve for c. If one maintains linear utility but makes the value of h endogenous, then equation (4.10) can be used to solve for the equilibrium value of h independently of the values for v/u and c. Substituting this value into equation (4.12) we again have an equation in the single unknown v/u. Given the implied solutions for h and v/u, we can again solve for c from equation (4.14).

In the general case where u is not linear, the value of c does not drop out of equation (4.10), and the system of equations cannot be solved one at a time, so one must deal with a system of three equations in three unknowns. Although all of our results can be derived analytically by examining this system of three equations in three unknowns, given that equation (4.14) expresses c in terms of the other two variables, we can use it to substitute into the other two equations, thereby reducing the problem to a system of two equations in the two unknowns h and v/u. The resulting system permits a simple diagrammatic representation of the equilibrium outcomes. Each of these equations describes a locus of points in $h - v/u$ space. As shown in the appendix, some algebra reveals that both of these curves are downward sloping. Noting that in steady state, e is an increasing function of v/u, these two expressions both reflect the fact that in this model there is a fundamental trade off between e and h. From the household perspective, holding all else constant, higher e implies higher c, thereby decreasing the efficient level of h. It follows that equation (4.10) depicts a downward sloping relationship in $h - v/u$ space. We will refer to this as the optimal hours curve. From the firm perspective, a higher value of h holding all else constant leads to a higher equilibrium value of w and lower profit flow from a filled job, thereby leading to less incentive for job creation and lower steady state employment. This intuition lies behind the fact that equation (4.12) depicts a downward sloping curve in $h - v/u$ space. We refer to this curve as the free entry curve.

Given that the steady-state equilibrium is represented as the intersection of two downward sloping curves, there is the obvious possibility that there may be multiple intersections. We show in the appendix however, that at any point of intersection, the free entry curve is steeper than the efficient hours curve, implying that there is at most one steady state. Figure 1 shows the graphical determination of equilibrium in the model.

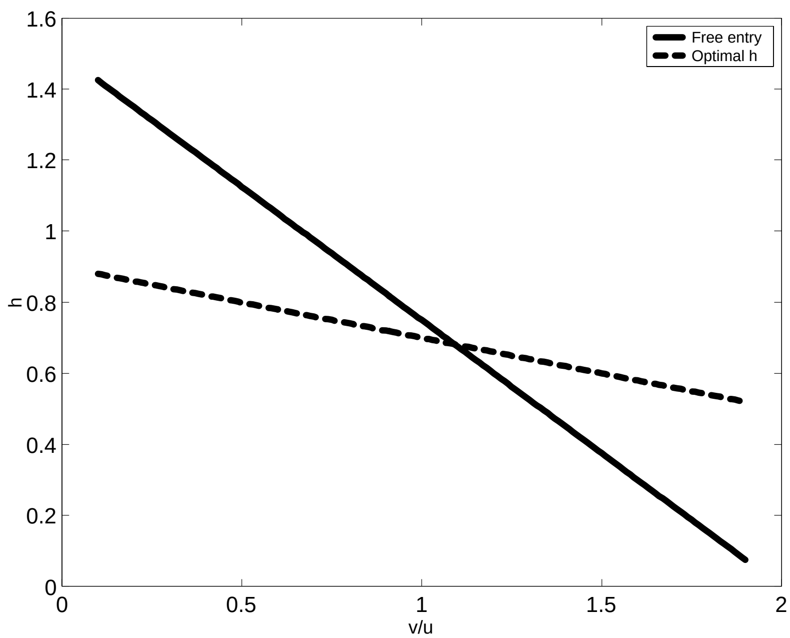

Figure 1: Determination of Steady-State Equilibrium

By way of comparison, we note that if we had assumed u were linear, then the optimal hours curve in Figure 1 becomes horizontal.

5. Policy Analysis

In this section we consider the effect of policies on the steady-state equilibrium, with particular focus on what these policies imply for relative changes in steady state hours per worker and employment. While the simplicity of the model limits the richness of the policies that can be analyzed, there are four policies which are of general interest that can be addressed within our framework: a proportional tax on labor income that funds a lump-sum transfer, a product market regulation that increases the fixed cost associated with job creation, and a labor market regulation that imposes a firing tax on firms whenever an employment position is destroyed.

We begin by describing in more detail the policies that we analyze. The tax-transfer program is characterized by a proportional tax τ on all labor earnings, and a lump-sum transfer T that is determined via a balanced budget constraint on the government. We model product market regulation in two different ways. The first approach assumes that regulation takes the form of an entry barrier that represents a cost κ_r, measured in units of output, that must be incurred when creating a job. Solving for the effects of this policy amounts to a comparative statics exercise in which the value of κ is increased from κ to $\kappa + \kappa_r$.[4] The second approach assumes that regulation takes the form of a per period cost κ_r that each producing match must pay. This amounts to changing the production function to $f(h) - \kappa_r$. Finally, we model employment protection as a cost ϕ, measured in units of output, that the firm must pay whenever a match is destroyed.[5] In this model, matches are destroyed whenever the idiosyncratic shock that hits with

[4]Many recent empirical studies have documented differences in entry barriers across countries and/or sought to assess their consequences for either employment or unemployment. See for example, Bertrand and Kramarz (2002), Blanchard and Giavazzi (2002), Djankov et al (2002) Boeri et al (2000), Lopez-Garcia (2003), Messina (2006), and Fang and Rogerson (2007).

[5]Earlier studies of firing costs include Bentolila and Bertola (1991) and Hopenhayn and Rogerson (1993).

probability λ occurs, so this policy amounts to the firm incurring a cost of ϕ in terms of output whenever this shock is realized. For the case of product and labor market regulations we will consider two cases, one in which the costs associated with the regulation are used to fund a lump-sum transfer, and one in which these costs are assumed to represent lost resources for the economy.

The next proposition summarizes the results of the policy analysis for the case of lump-sum transfers.

Proposition 1: Assume that the proceeds from labor market regulation and product market regulation are rebated lump-sum to households. Then (i) An increase in τ leads to a decrease in both e and h. (ii) An increase in κ_r corresponding to either type of regulation leads to a decrease in e and an increase in h. (iii) An increase in ϕ leads to a decrease in e and an increase in h.

The analytic proof is contained in the appendix. Here we discuss the results in terms of Figure 1. It is easy to see that for the cases of κ_r and ϕ, the efficient hours curve does not shift. One can also show that the free entry curve shifts downward. In both cases the policy change leads to lower employment and higher hours of work. These results are intuitive. Both types of regulations make it more costly to produce output by increasing hours along the employment margin, and therefore encourage a substitution of h for e in production. For the case of taxes, one can show that both curves in Figure 1 shift downward. Based on the diagrammatic analysis, this suggests that the effects are ambiguous, but in the appendix we show that the effects can be signed and are both negative.

The above result assumed that the costs associated with regulation were rebated lump-sum to households. In many cases these costs might better be thought of as representing real resource costs to the economy that are lost, in which case they would not be rebated. In this case the effects on h are as above, but the effects on e are ambiguous because of opposing income and substitution effects.

Proposition 2: Assume that the proceeds from labor market regulation and product market regulation are not rebated to households. Then (i) An increase in κ_r leads to an increase in h (ii) An increase in ϕ leads to an increase in h. Changes in e are ambiguous in both cases.

Our model also has a simple prediction regarding the implications of a policy that exogenously limits hours per worker. In this case the condition that characterizes efficient choice of working hours is dropped and the equilibrium is described by the downward sloping curve that depicts the free entry condition. It follows that such a policy will necessarily lead to an increase in employment. While this result is not surprising, we think it is important to note that such a policy does imply opposing movements along the two margins.

Lastly, our model has implications for the effect of a change in the bargaining parameter θ. Some researchers have used this comparative static exercise as a way to capture the effects of differences in union bargaining strength. In our model it is easy to show that holding h constant, an increase in θ leads to lower v/u, thereby implying both lower employment and lower consumption. But lower consumption implies a higher value of h via the first order condition for hours. It necessarily follows that employment decreases and hours increases.

6. Conclusion

The analysis of this paper suggests that explicit modeling of the intensive and extensive margins can provide very valuable additional information beyond that which is contained in a model with only one margin. In the specific context considered here, our work shows that such a model can play a role in qualitatively distinguishing between the impacts of various factors that have been proposed as candidates for accounting for the large differences in hours of work across economies. For example, for each of the variations that we have considered, higher levels of labor and product market regulations both lead to higher values for hours worked along the intensive margin. We conclude from this analysis that if the case is to be made for either product or labor market regulations as the dominant sources of differences in total hours worked across countries, then these policies must exert their influences through mechanisms other than those captured in the benchmark model that we have studied. Development of these alternative mechanisms is an important task.

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Appendix

Derivation of Diagrammatic Representation

Denote the ratio v/u by δ. Then the two equations of interest can be represented by:

$$\begin{aligned} A(h,\delta) &= 0 \\ B(h,\delta) &= 0 \end{aligned}$$

where the two functions A and B are defined by:

$$A(h,\delta) = g'(h) - u'(c)f'(h)$$

$$\begin{aligned} B(h,\delta) &= \beta q(1-\theta)(f(h) - \frac{g(h)}{u'(c)}) - \\ &\quad [(1-\beta)\theta(1-\beta(1-\lambda-p)) + (1-\theta)(1-\beta(1-\lambda))(1-\beta(1-q))]\kappa \end{aligned}$$

Note that both p and q are implicitly functions of δ, and c is implicitly a function of h and δ, given by:

$$c(h,\delta) = \frac{p}{p+\lambda}[f(h) - \lambda\kappa]$$

The derivatives of $c(h,\delta)$ with respect to its two arguments are given by:

$$\begin{aligned} c_h &= \frac{pf'(h)}{p+\lambda} > 0 \\ c_\delta &= \frac{\lambda}{(\lambda+p)^2}\frac{\partial p}{\partial \delta}[f(h) - \lambda\kappa] > 0 \end{aligned}$$

Note that the term in square brackets in the expression for c_δ is necessarily positive in any equilibrium with positive employment. Straightforward calculations allows one to derive and sign the partial derivatives of the A and B functions as follows:

$$
\begin{aligned}
A_h &= \underbrace{g''(h) - u'(c)f''(h)}_{A_h^1>0} \underbrace{-u''(c)f'(h)c_h}_{A_h^2>0} > 0 \\
A_\delta &= -f'(h)u''(c)c_\delta > 0 \\
B_h &= \beta q(1-\theta)\frac{g(h)u''(c)c_h}{u'(c)^2} < 0 \\
B_\delta &= \underbrace{\beta\frac{\partial q}{\partial \delta}(1-\theta)[f(h) - \frac{g(h)}{u'(c)} - (1-\beta(1-\lambda))\kappa] - [(1-\beta)\theta\beta\kappa]\frac{\partial p}{\partial \delta}}_{B_\delta^1<0} \\
&\quad \underbrace{+\frac{\beta q(1-\theta)g(h)u''(c)c_\delta}{u'(c)^2}}_{B_\delta^2<0} < 0
\end{aligned}
$$

We note that the term B_δ^1 can be signed as negative because the first term in square brackets $[f(h) - \frac{g(h)}{u'(c)} - (1-\beta(1-\lambda))\kappa]$ represents the implicit flow surplus measured in units of output taking into account the job creation cost and must be positive in any equilibrium with positive employment. Since both $-\frac{A_h}{A_\delta} < 0$ and $-\frac{B_h}{B_\delta} < 0$, it follows that each expression depicts a negatively sloped curve in $h-\delta$ space.

Proof of Unique Intersection

Noting that $A_\delta B_h = A_h^2 B_\delta^2$, we have

$$A_h B_\delta - A_\delta B_h = (A_h^1 + A_h^2)(B_\delta^1 + B_\delta^2) - A_\delta B_h = A_h B_\delta^1 + A_h^1 B_\delta^2 < 0$$

$A_h B_\delta - A_\delta B_h < 0$ implies $-\frac{A_h}{A_\delta} < -\frac{B_h}{B_\delta}$. It follows that the optimal hours curve is always flatter than the free entry curve, implying that there is at most one intersection.

Proof of Propositions 1 and 2

(i) Proportional income tax

Repeating the earlier analysis, and letting $\delta = \frac{v}{u}$, equilibrium can be represented as:

$$\begin{aligned} A(h, \delta, \tau) &= 0 \\ B(h, \delta, \tau) &= 0 \end{aligned}$$

where

$$\begin{aligned} A(h, \delta, \tau) &= g'(h) - (1-\tau)u'(c(h,\delta))f'(h) \\ B(h, \delta, \tau) &= \beta q(1-\theta)(f(h) - \frac{g(h)}{(1-\tau)u'(c(h,\delta))}) \\ &\quad -[(1-\beta)\theta(1-\beta(1-\lambda-p)) + (1-\theta)(1-\beta(1-\lambda))(1-\beta(1-q))]\kappa \end{aligned}$$

and $c(h,\delta) = \frac{p}{p+\lambda}[f(h) - \lambda\kappa]$. Note that taxes do not enter the expression for c since the revenues are rebated. As before, $c_h > 0$ and $c_\delta > 0$.

The following partial derivatives will be useful in the comparative statics results:

$$
\begin{aligned}
A_h &= \underbrace{g''(h) - (1-\tau)u'(c)f''(h)}_{A_h^1>0} \underbrace{-(1-\tau)u''(c)f'(h)c_h}_{A_h^2>0} > 0 \\
A_\delta &= -f'(h)(1-\tau)u''(c)c_\delta > 0 \\
B_h &= \beta q(1-\theta)\frac{g(h)u''(c)c_h}{(1-\tau)u'(c)^2} < 0 \\
B_\delta &= \underbrace{\beta\frac{\partial q}{\partial \delta}(1-\theta)[f(h) - \frac{g(h)}{(1-\tau)u'(c)} - (1-\beta(1-\lambda))\kappa] - [(1-\beta)\theta\beta\kappa]\frac{\partial p}{\partial \delta}}_{B_\delta^1<0} \\
&\quad \underbrace{+\frac{\beta q(1-\theta)g(h)u''(c)c_\delta}{(1-\tau)u'(c)^2}}_{B_\delta^2<0} < 0 \\
A_\tau &= f'(h)u'(c) > 0 \\
B_\tau &= -\frac{\beta q(1-\theta)g(h)}{u'(c)(1-\tau)^2} < 0
\end{aligned}
$$

Note that B_δ^1 can again be signed as negative if the expected flow surplus from a match expressed in units of output is positive. Standard analysis implies that comparative statics results are given by:

$$
\begin{aligned}
\frac{\partial h}{\partial \tau} &= -\frac{A_\tau B_\delta - A_\delta B_\tau}{A_h B_\delta - A_\delta B_h} \\
\frac{\partial \delta}{\partial \tau} &= -\frac{A_h B_\tau - B_h A_\tau}{A_h B_\delta - A_\delta B_h}
\end{aligned}
$$

Noting that $A_\delta B_h = A_h^2 B_\delta^2$, $A_\tau B_\delta^2 = A_\delta B_\tau$ and $A_h^2 B_\tau = B_h A_\tau$, we have:

$$
\begin{aligned}
A_h B_\delta - A_\delta B_h &= (A_h^1 + A_h^2)(B_\delta^1 + B_\delta^2) - A_\delta B_h = A_h B_\delta^1 + A_h^1 B_\delta^2 < 0 \\
A_\tau B_\delta - A_\delta B_\tau &= A_\tau (B_\delta^1 + B_\delta^2) - A_\delta B_\tau = A_\tau B_\delta^1 < 0 \\
A_h B_\tau - B_h A_\tau &= (A_h^1 + A_h^2) B_\tau - B_h A_\tau = A_h^1 B_\tau < 0
\end{aligned}
$$

It follows that $\frac{\partial h}{\partial \tau} < 0$ and $\frac{\partial \frac{v}{u}}{\partial \tau} < 0$.

(ii) Entry cost κ Without Rebating

This case is the same as the benchmark case with a higher κ. Thus, equilibrium conditions are the same. Proceeding as before, let $\delta = \frac{v}{u}$ and define the following expressions:

$$
\begin{aligned}
A(h, \delta, \kappa) &= g'(h) - u'(c) f'(h) \\
B(h, \delta, \kappa) &= \beta q (1 - \theta)(f(h) - \frac{g(h)}{u'(c)}) \\
&\quad -[(1-\beta)\theta(1 - \beta(1 - \lambda - p)) + (1 - \theta)(1 - \beta(1 - \lambda))(1 - \beta(1 - q))]\kappa
\end{aligned}
$$

where c is implicitly a function of h, δ, and κ given by:

$$
c(h, \delta, \kappa) = \frac{p}{p + \lambda}[f(h) - \lambda \kappa]
$$

The partials of A and B with regard to h and δ are exactly as before. The derivatives with regard to κ are given by:

$$\begin{aligned} A_\kappa &= f'(h)u''(c)\frac{\lambda p}{\lambda + p} < 0 \\ B_\kappa &= \underbrace{-[1-\beta)\theta(1-\beta(1-\lambda-p)) + (1-\theta)(1-\beta(1-\lambda))(1-\beta(1-q))]}_{B_\kappa^1 < 0} \\ &\quad \underbrace{-\frac{\beta q(1-\theta)g(h)u''(c)\lambda p}{u'(c)^2(\lambda+p)}}_{B_\kappa^2 > 0} \end{aligned}$$

We now have the following comparative statics results:

$$\begin{aligned} \frac{\partial h}{\partial \kappa} &= -\frac{A_\kappa B_\delta - A_\delta B_\kappa}{A_h B_\delta - A_\delta B_h} \\ \frac{\partial \delta}{\partial \kappa} &= -\frac{A_h B_\kappa - B_h A_\kappa}{A_h B_\delta - A_\delta B_h} \end{aligned}$$

Noting that $A_\delta B_h = A_h^2 B_\delta^2$, $A_\kappa B_\delta^2 = A_\delta B_\kappa^2$ and $A_h^2 B_\kappa^2 = B_h A_\kappa$, we then have:

$$\begin{aligned} A_h B_\delta - A_\delta B_h &= (A_h^1 + A_h^2)(B_\delta^1 + B_\delta^2) - A_\delta B_h = A_h B_\delta^1 + A_h^1 B_\delta^2 < 0 \\ A_\kappa B_\delta - A_\delta B_\kappa &= A_\kappa(B_\delta^1 + B_\delta^2) - A_\delta(B_\kappa^1 + B_\kappa^2) = A_\kappa B_\delta^1 - A_\delta B_\kappa^1 > 0 \\ A_h B_\kappa - B_h A_\kappa &= (A_h^1 + A_h^2)(B_\kappa^1 + B_\kappa^2) - B_h A_\kappa = \underbrace{A_h B_\kappa^1}_{<0} + \underbrace{A_h^1 B_\kappa^2}_{>0} \end{aligned}$$

It follows that $\frac{\partial h}{\partial \kappa} > 0$ and that $\frac{\partial \frac{v}{u}}{\partial \kappa}$ cannot be determined.

(iii) Entry Cost With Rebate

We now consider the case in which the entry cost is increased to $\kappa + \kappa_r$, where κ_r is the additional entry cost due to entry regulation. The free entry condition changes to $J^u = \kappa + \kappa_r$. Feasibility requires:

$$c = ef(h) - \lambda e \kappa$$

because the entry costs associated with κ_r are rebated back to consumers. Repeating the analysis one obtains that the equilibrium is characterized by:

$$\begin{aligned} g'(h) &= u'(c)f'(h) \\ 0 &= \beta q(1-\theta)[f(h) - \frac{g(h)}{u'(c)}] \\ &\quad -[(1-\beta)\theta(1-\beta(1-\lambda-p)) + (1-\theta)(1-\beta(1-\lambda))(1-\beta(1-q))](\kappa+\kappa_r) \end{aligned}$$

where c is given by $c = \frac{p}{p+\lambda}[f(h) - \lambda\kappa]$, since the proceeds associated with κ_r are rebated.

Defining the functions A and B as before, we now obtain:

$$
\begin{aligned}
A_h &= \underbrace{g''(h) - u'(c)f''(h)}_{A_h^1>0} \underbrace{-u''(c)f'(h)c_h}_{A_h^2>0} > 0 \\
A_\delta &= -f'(h)u''(c)c_\delta > 0 \\
B_h &= \beta q(1-\theta)\frac{g(h)u''(c)c_h}{u'(c)^2} < 0 \\
B_\delta &= \underbrace{\beta\frac{\partial q}{\partial \delta}(1-\theta)[f(h) - \frac{g(h)}{u'(c)} - (1-\beta(1-\lambda))(\kappa+\kappa_r)] - [(1-\beta)\theta\beta(\kappa+\kappa_r)]\frac{\partial p}{\partial \delta}}_{B_\delta^1<0} \\
&\quad \underbrace{+\frac{\beta q(1-\theta)g(h)u''(c)c_\delta}{u'(c)^2}}_{B_\delta^2<0} < 0 \\
A_{\kappa_r} &= 0 \\
B_{\kappa_r} &= -[(1-\beta)\theta(1-\beta(1-\lambda-p)) + (1-\theta)(1-\beta(1-\lambda))(1-\beta(1-q))] < 0
\end{aligned}
$$

The results of interest are given by:

$$
\begin{aligned}
\frac{\partial h}{\partial \kappa_r} &= -\frac{A_{\kappa_r}B_\delta - A_\delta B_{\kappa_r}}{A_h B_\delta - A_\delta B_h} \\
\frac{\partial \delta}{\partial \kappa_r} &= -\frac{A_h B_{\kappa_r} - B_h A_{\kappa_r}}{A_h B_\delta - A_\delta B_h}
\end{aligned}
$$

Noting that $A_\delta B_h = A_h^2 B_\delta^2$, we obtain:

$$\begin{aligned} A_h B_\delta - A_\delta B_h &= (A_h^1 + A_h^2)(B_\delta^1 + B_\delta^2) - A_\delta B_h \\ &= A_h B_\delta^1 + A_h^1 B_\delta^2 < 0 \\ A_{\kappa_r} B_\delta - A_\delta B_{\kappa_r} &= -A_\delta B_{\kappa_r} > 0 \\ A_h B_{\kappa_r} - B_h A_{\kappa_r} &= A_h B_{\kappa_r} < 0 \end{aligned}$$

We conclude that $\frac{\partial h}{\partial \kappa_r} > 0$ and $\frac{\partial \frac{v}{u}}{\partial \kappa_r} < 0$.

(iv) Firing Cost

Firing costs change the value function for J^e to:

$$J^e = f(h) - w + \beta[(1-\lambda)J^e - \lambda\phi]$$

The two equations that characterize equilibrium are:

$$\begin{aligned} g'(h) &= u'(c)f'(h) \\ 0 &= \beta q(1-\theta)(f(h) - \beta\lambda\phi - \frac{g(h)}{u'(c)}) \\ &\quad -[(1-\beta)\theta(1-\beta(1-\lambda-p)) + (1-\theta)(1-\beta(1-\lambda))(1-\beta(1-q))]\kappa \end{aligned}$$

If the firing cost is collected by the government and rebated to consumers, then the resource constraint is:

$$c = \frac{p}{p+\lambda}[f(h) - \lambda\kappa]$$

In this case, the comparative statics is similar to the case of entry barrier with rebating. Therefore, $\frac{\partial h}{\partial \phi} > 0$ and $\frac{\partial \frac{v}{u}}{\partial \phi} < 0$.

If firing cost represents a resource cost to the economy, then the steady state resource constraint is:

$$c = \frac{p}{p + \lambda}[f(h) - \lambda\kappa - \lambda\phi]$$

Comparative statics in this case are similar to the case of the entry barrier without rebating. Therefore, $\frac{\partial h}{\partial \phi} > 0$ and $\frac{\partial \frac{v}{u}}{\partial \phi}$ can not be determined.

(v) Per Period Regulatory Cost

Each production match must pay κ_r each period. This changes the value function for a matched firm to:

$$J^e = f(h) - w - \kappa_r + \beta(1 - \lambda)J^e$$

Note that κ_r acts similar to a firing cost if we set $\kappa_r = \beta\lambda\phi$. So, if the revenue from this regulation is rebated, we have $\frac{\partial h}{\partial \kappa_r} > 0$ and $\frac{\partial \frac{v}{u}}{\partial \kappa_r} < 0$. If the revenue from this regulation is not rebated, we have $\frac{\partial h}{\partial \kappa_r} > 0$ and $\frac{\partial \frac{v}{u}}{\partial \kappa_r}$ is not determined.