Market power, Growth and Unemployment

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June 13, 2011

Abstract

I present a model where firms and workers set wages above the market-clearing level. Unemployment is thus generated by their exercise of market power. Because both the labor and product markets are imperfectly competitive, market power in the labor market interacts with market power in the product market. This interaction sheds new light on the effects of policy interventions on unemployment and growth. For example, labor market reforms that reduce labor costs reduce unemployment *and* boost growth because they expand the scale of the economy and generate more competition in the product market.
Keywords: Market Power, Market Structure, Endogenous Growth, Unemployment.
JEL Classification Numbers: E10, L16, O31, O40

1 Introduction

Traditional explanations of unemployment focus on labor market rigidities and ignore the characteristics of the product market. This leaves out important factors that should be included in the analysis of the effects of institutions and policies. In this paper, I exploit this argument, and recent developments in endogenous growth theory, to argue that unemployment and productivity growth are related because they both depend on the structure of the product market.

The source of the relation is the pricing behavior of agents with market power. Workers and firms have control over wages and prices; the exercise

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of market power in the product market interacts with its exercise in the labor market. Analysis of this interaction sheds new light on the effects on unemployment and growth of policy interventions in the two markets.

In order to focus on market power, I deviate from the existing literature on growth and unemployment that follows the "creative destruction" tradition.[1] I consider a model where growth is driven by the activities of firms that are not put out of business by outside innovators but are long-lived profit centers that innovate repeatedly in-house.[2] The main difference between the two approaches is that "creative destruction" models exhibit a *negative* relation between product market competition and growth, while the "creative accumulation" model that I consider exhibits a *positive* relation. This relation, supported empirically by the work of, among others, Nickell (1996) and Pagano and Schivardi (2003), has the important implication that a more competitive product market generates both faster growth and lower unemployment. Moreover, in "creative destruction" models the degree of competition is an exogenous parameter whereas in my "creative accumulation" model it depends on the mass of firms, which is endogenous.

Another important feature of the paper is that I consider an environment with endogenous labor supply: agents choose whether to participate to the labor market in the presence of unemployment risk. Specifically, unemployment is *involuntary*: households control the mass of members that supply labor but not their probability of employment. Thus, some of the participating members do not find employment even if at the going wage they wish to work. This approach allows me to identify separately supply-side and demand-side determinants of employment and unemployment and, more importantly, allows me to derive from the model's primitives a reservation wage that is decreasing in the unemployment rate.

This structure yields interesting results concerning institutions, tax policy and other factors that affect the labor market. Specifically:

- policies that reduce labor costs raise employment and growth and reduce unemployment;
- the benefits of these policies are larger when one considers their (indirect) effects on the structure of the product market.

[1] See Aghion and Howitt (1992 and 1998, chapter 4) and Mortensen (2005) for a review of recent results.

[2] See Peretto (1996, 1998, 1999) and Smulders and van de Klundert (1995) for a sample of early papers that developed this approach.

To illustrate, consider labor income taxes (unemployment benefits have similar effects). Given the structure of the product market, higher labor income taxes generate lower employment and higher unemployment via their traditional effect on the cost of labor. The economy then operates at a smaller scale. This results in lower returns to entry and less competition in the product market. Growth is lower because firms operate in a less competitive market. Moreover, employment and unemployment are, respectively, lower and higher than they would if the structure of the product market remained constant. This is consistent with the evidence discussed in Nickell and Layard (1997), who find that the total tax burden on labor has a negative effect on growth. It is also consistent with the evidence discussed in Daveri and Tabellini (2000), who show that the increase in unemployment and reduction in growth that occurred in the recent decades in the OECD is driven by the increase in labor income taxes. Finally, it is consistent with the evidence provided by Wu and Zhang (2000), who show that in the OECD countries there is a positive correlation between taxation and the mark-ups that firms charge over marginal cost.

It is also interesting to consider factors that raise the cost of innovation, reduce product substitution and thus price competition, or raise entry costs for entrants but do not affect incumbents. The analysis provides three results:

- lower costs of innovation raise employment and growth and reduce unemployment;
- tougher price competition raises growth and has ambiguous effects on employment and unemployment;
- lower barriers to entry reduce growth while do not necessarily raise employment and reduce unemployment.

These results emphasize the importance of the details of the pro-growth policy that a country adopts. Reducing barriers to innovation is the most effective policy because it reduces at the same time barriers to the creation of new firms and barriers to innovation within the firm. As a result, it fosters investment on both the intensive and the extensive margin and, more importantly, it exploits the positive relation between competition and growth. In contrast, promoting growth by protecting incumbents – which is fairly common in Europe where governments protect "national champions" – might reduce employment and raise unemployment by restricting competition.

I organize the paper as follows. In Section 2, I set up the model. In Section 3, I study bargaining over wages and employment at the firm level, the associated R&D policy, and characterize the relation between wages and R&D. In Section 4, I study the labor market and show how the exercise of market power over prices and wages generates unemployment. In Section 5, I study the general equilibrium of the model and determine unemployment, market structure, and growth. In Section 6, I discuss the effects of structural parameters and policy instruments. I conclude in Section 7.

2 The model

I consider a closed economy. A representative competitive firm assembles intermediate differentiated goods to produce a homogeneous final good that can be consumed or invested. The assembly technology is

$$Y = N^{-\frac{1}{e(N)-1}} \left[\int_0^N X_i^{\frac{e(N)-1}{e(N)}} di \right]^{\frac{e(N)}{e(N)-1}}, \quad e'(N) > 0 \tag{1}$$

where $e(N)$ is the elasticity of product substitution, X_i is the final producer's use of each differentiated good, and N is the mass of intermediate goods (the mass of intermediate firms). The elasticity of substitution is an increasing function of the mass of firms, bounded from above and from below, $\infty > e(\infty) > e(0) \geq 1$. This allows me to capture the role of endogenous market power while retaining the desirable features of a monopolistic competition model defined over a continuum of goods.

The final good is the *numeraire*. The final producer thus maximizes profits subject to the budget constraint $Y = \int_0^N P_i X_i di$, where P_i is the price of intermediate good i. This yields the demand schedule for good i,

$$X_i = \frac{Y}{N} \left(\frac{P_i}{P} \right)^{-e(N)}. \tag{2}$$

Notice that the price index of intermediate goods,

$$P = \left[\frac{1}{N} \int_0^N P_j^{1-\epsilon} dj \right]^{\frac{1}{1-\epsilon}},$$

which the atomistic intermediate firms take as given, must be equal to the price of the final good and thus is equal to one and can be omitted from (2) without loss of generality.

The typical intermediate firm produces with the technology

$$X_i = Z_i L_i^{\theta}, \quad 0 < \theta < 1 \tag{3}$$

where X_i is output, L_i is labor and Z_i is the firm's cumulated stock of cost-reducing innovations. The firm also runs in-house R&D facilities to produce a continuous flow of innovations according to

$$\dot{Z}_i = \alpha R_i, \quad \alpha > 0 \tag{4}$$

where $\dot{Z}_i$ is the flow of innovations generated by an R&D project employing R_i units of the final good for an interval of time dt.

Firms are created by entrepreneurs that develop new products and their manufacturing processes. The cost of entry is proportional to the entry level of productivity. Specifically, setting up a firm with initial productivity Z_i requires $\frac{\beta}{\alpha} Z_i$ units of final output. This captures two types of entry costs. First, the entrant needs to create the initial product-specific knowledge, and according to equation (4) creating a stock of knowledge Z_i requires $\frac{1}{\alpha} Z_i$ units of final output. Second, the entrant needs to pay additional costs, not related to R&D, that allow operations to begin. The parameter β captures this non-R&D component of the entry cost by reducing the overall productivity of resources devoted to entry. The important feature of this parameter is that it does not affect incumbents. Hence, it captures exogenous barriers to entry.

The economy is populated by a representative household with a continuum of mass λ of members. Each member is endowed with one unit of labor. The household maximizes

$$U(0) = \int_0^{\infty} e^{-\rho t} \lambda \left[\log\left(\frac{C}{\lambda}\right) + \psi \log\left(\frac{\lambda - L^s}{\lambda}\right)\right] dt, \quad \rho > 0, \ \psi > 0$$

subject to the flow budget constraint

$$\dot{A} = rA + L^s \left[W(1-\tau)(1-u) + Bu\right] + T - C, \quad 0 < \tau < 1$$

where ρ is the individual discount rate, C is consumption, L^s is the mass of household members that offer their labor for a wage (participate in the labor market), A is assets holding, and T is a lump-sum transfer from the government. The assets available to the household are ownership shares of firms. Hence, r is the rate of return on stocks.

Three features of this setup are important. First, the household controls the mass of members that supply labor but not their probability of employment. This is where the assumption that there is a continuum of agents within the household becomes very useful. By the law of large numbers I can equate the individual probability of unemployment to the economy's unemployment rate

$$u \equiv 1 - \frac{L}{L^s},$$

where $L = \int_0^N L_i di$ is aggregate employment. Similarly, with a continuum of firms the law of large numbers allows me to equate an employed worker's probability of being assigned to firm i with the firm's share of aggregate employment L_i/L. It follows that the pre-tax wage that the employed member earns is the weighted average

$$W = \int_0^N W_i \frac{L_i}{L} di,$$

where W_i is the wage paid by firm i. This approach implies a job rationing mechanism that takes the form of assigning job seekers at random to the unemployment pool and to the employment pool; those assigned to the employment pool are then assigned at random across the N existing firms and negotiate the terms of employment (see below).[3] Its main advantage is that it allows me to think of the term $1-u$ in the budget constraint as the fraction of the household members that participate to the labor market and earn the after-tax wage $W(1-\tau)$, while u is the fraction that earn the after-tax unemployment benefit B.

The second feature captures the basic trade-off that governs labor supply and thus determines workers' wage demands. The household's instantaneous utility contains a term that captures the role of household members that do not participate in the labor market; one can think of home production or other related activities the output of which is shared by all household members. This determines the opportunity cost of labor market participation, and thus contributes to determine the wage demands of employed workers. Participation takes 100% of the household's member time.

The third feature is that the household insures its members participating in the labor market against individual unemployment risk. This simplifies the analysis because all household members get the same flow of utility regardless of the outcome of the job rationing mechanism.[4] More importantly,

[3] One could think of this as a particular type of matching mechanism. With respect to the traditional approach in search theory (e.g., Pissarides 2002), it has two advantages. First, it does not imply unfilled vacancies and thus allows me to focus only on the supply side of the labor market as subject to rationing. Second, it does not require time and thus does not force me to model uemployment as a state variable, thereby reducing the dimensionality of the general equilibrium system (see below).

[4] Examples of previous work using this approach are Merz (1995) and Pissarides (2002).

it implies that each individual worker is indifferent between employment and unemployment in the bargaining process (see below).

The maximization problem outlined above yields well-known results with some novel features. The household follows the usual saving rule

$$\frac{\dot{C}}{C} = r - \rho \tag{5}$$

and equates the benefit from the marginal household member's participation to the cost. Formally,

$$W\left(1-\tau\right)\left(1-u\right) + Bu = \frac{\psi C}{\lambda - L^s}.$$

On the left-hand-side of this expression there is the expected income from participation, on the right-hand-side there is the expected cost – the foregone contribution of the marginal individual to household production. Participation therefore can be written

$$L^s = \lambda - \frac{\psi C}{W\left(1-\tau\right) - \left[W\left(1-\tau\right) - B\right]u}. \tag{6}$$

This is the economy's upward sloping labor supply curve. Consumption, C, enters negatively because it raises the opportunity cost of participation; the unemployment insurance benefit, B, enters positively because it raises the expected income from participation.

Labor supply depends on the unemployment rate via two effects. First, higher unemployment means that the participating individual is less likely to be employed and thus to earn the after-tax wage. This lowers the expected benefit of participation. Second, higher unemployment means that the individual is more likely to be unemployed and thus to draw the insurance benefit B. This raises the expected benefit of participation. The model's equilibrium conditions imply that the after-tax wage is higher than the unemployment benefit so that labor supply is *decreasing* in the unemployment rate (see below). This captures a "discouraged worker effect" whereby worse employment prospects in the labor market lower a worker's expected income and thus reduce participation.

3 Wages, prices and R&D at the firm level

The typical intermediate firm maximizes the present discounted value of net cash flow,

$$V_i\left(0\right) = \int_0^\infty e^{-\int_0^t r(v)dv} \Pi_i(t) dt,$$

subject to the demand schedule (2), the production function (3), the R&D function (4), $Z_i(0) > 0$ (the initial knowledge stock is given), $Z_j(t)$ for $t > 0$ and $j \neq i$ (the firm takes as given the rivals' innovation paths), and $\dot{Z}_j(t) \geq 0$ for $t > 0$ (innovation is irreversible).

Instantaneous profit is $\Pi_i = P_i X_i - W_i L_i - R_i$. The firm bargains with its workers over the wage and employment – this is equivalent to bargaining over the wage and the product's price since employment (the scale of activity of the firm) and the price are related through the demand curve. The firm then sets its R&D policy taking as given the instantaneous outcome of the bargaining process.

I model bargaining as

$$\max_{W_i, L_i} \quad \left[(1-\gamma) \log \Pi_i + \gamma \log \left(W_i \left(1-\tau\right) - W_a \right) L_i \right], \quad 0 < \gamma < 1$$

subject to the production function (3) and the demand curve (2). The parameter γ is the relative bargaining power of the workers. The firm and its workers maximize jointly the log-geometric average of profits and employees surplus. The firm and the workers take the alternative,

$$W_a = W\left(1-\tau\right)\left(1-u\right) + Bu = \frac{\psi C}{\lambda - L},$$

as given since it depends on aggregate variables. If negotiations break down, the worker can quit the firm and reenter the labor market, in which case he gets the expected labor income. Alternatively, he can allocate all of his time to household production, in which case he gets the value of his marginal contribution. These two options are equivalent because in deciding labor supply the household sets them equal (see above).

The solution of the bargaining problem yields (see the appendix for details on the derivation):

$$W_i = \frac{W_a}{1-\tau} + \frac{\gamma}{1-\gamma} \frac{\Pi_i}{L_i};$$

$$L_i = \frac{1-\tau}{W_a} \frac{\theta\left(e-1\right)}{e} P_i X_i. \tag{7}$$

The first expression is very important and quite general. It follows solely from the first-order condition for the wage and says that the workers get the reservation wage (adjusted for labor income taxation) plus a fraction of the firm's profit. The latter term establishes a connection between the wage and the firm's R&D policy. This is one of the most important features of the model and is worth exploring in detail.

The expression for firm employment (7) and the definition of profit allow me to write

$$\begin{aligned} W_i &= \frac{W_a}{1-\tau} + \gamma \frac{P_i X_i}{L_i} \left[\frac{e - \theta (e-1)}{e} - \frac{R_i}{P_i X_i} \right] \\ &= \frac{W_a}{1-\tau} (1 + m_i), \end{aligned} \quad (8)$$

where

$$m_i \equiv \gamma \frac{e}{\theta (e-1)} \left[\frac{e - \theta (e-1)}{e} - \frac{R_i}{P_i X_i} \right]. \quad (9)$$

This is the markup of the after-tax wage over the reservation wage that the firm and its workers agree on. It says that on top of the reservation wage, each worker gets a fraction of revenues given by the product of the bargaining power of workers, γ, times a term that results from subtracting R&D intensity from the margin of revenues over the reservation wage bill. This is important: the firm's R&D activity *reduces* the markup because R&D expenditure – which is a recurrent fixed cost – reduces the firm's cash flow and thus reduces what is available to distribute as extra wages to workers and as dividends to stockholders.[5]

The expressions for firm wage and employment yield the reduced-form profit function (see the appendix for details on the derivation)

$$\Pi_i = (1-\gamma) \left[P_i X_i \frac{e - \theta (e-1)}{e} - R_i \right], \quad (10)$$

where

$$P_i X_i = \left(\frac{Y}{N} \right)^{\frac{1}{e - \theta(e-1)}} \left[\frac{\frac{W_a}{1-\tau} e}{\theta (e-1)} \right]^{-\frac{\theta(e-1)}{e-\theta(e-1)}} Z_i^{\frac{e-1}{e-\theta(e-1)}}.$$

If the firm has no bargaining power, if $\gamma = 1$, reduced-form profit is zero because workers extract all rents in the form of higher wages. If the firm has all the bargaining power, if $\gamma = 0$, the firm captures all rents and the wage is set at the competitive level. The firm chooses R_i in order to maximize V_i evaluated using this reduced-form profit function.

The R&D strategy can be characterized in an intuitive way. Suppose that the firm finances R&D by issuing ownership claims on the flow of profits generated by cost-reducing innovations. Let the market value of such financial assets be q_i. The firm is willing to undertake R&D if the value of

[5] The markup is positive because of the non-negativity constraint on profits, which follows from the fact that firms can always choose to set R&D equal to zero.

the innovation is equal to its cost, if $q_i = \frac{1}{\alpha}$. If conditions are such that $q_i < \frac{1}{\alpha}$, the firm does zero R&D (see below). Situations with $q_i > \frac{1}{\alpha}$ cannot be equilibria because they entail infinite investment in R&D, which violates the economy's resources constraint. Since the innovation is implemented in-house, its benefits are determined by the marginal profit it generates. Thus, the value of the innovation must satisfy the arbitrage condition

$$r = \frac{\partial \Pi_i}{\partial Z_i}\frac{1}{q_i} + \frac{\dot{q}_i}{q_i}.$$

The marginal profit reads:

$$\begin{aligned} \frac{\partial \Pi_i}{\partial Z_i} &= (1-\gamma)\left(\frac{Y}{N}\right)^{\frac{1}{e-\theta(e-1)}}\left[\frac{\frac{W_a}{1-\tau}e}{\theta(e-1)}\right]^{-\frac{\theta(e-1)}{e-\theta(e-1)}} Z_i^{\frac{e-1}{e-\theta(e-1)}-1}\frac{e-1}{e} \\ &= \frac{(1-\gamma)(e-1)P_iX_i}{eZ_i}. \end{aligned}$$

Taking logs and time-derivatives of $q_i = \frac{1}{\alpha}$, substituting into the arbitrage condition and rearranging terms yields

$$r = \frac{\alpha(1-\gamma)(e-1)P_iX_i}{eZ_i}, \tag{11}$$

which defines the rate of return to in-house innovation.

To justify my focus on symmetric equilibria, I need to argue that the "economic" returns to the firm's R&D are diminishing. Otherwise, one firm could take over the whole market by exploiting "physical" increasing returns to knowledge and labor – the fact that cost falls linearly with Z_i. Intuitively, this involves a restriction on the price elasticity of demand such that marginal profit is monotonically decreasing in Z_i. A sufficient condition for this to happen is

$$\frac{e-1}{e-\theta(e-1)} < 1 \Longleftrightarrow e < \frac{1+\theta}{\theta},$$

which says that the marginal profit approaches infinity as the firm's knowledge stock approaches zero while it approaches zero as the firms' knowledge stock approaches infinity.[6]

[6] The reader familiar with this class of endogenous growth models might be interested to notice that this condition for symmetry does not require diminishing returns to knowledge or spillovers across firms. It solely follows from diminishing returns to labor, which yield

Entrants anticipate that once in the market they set wage, price and R&D spending according to the above characterization. The associated value of the firm must satisfy the arbitrage condition

$$r = \frac{\Pi_i}{V_i} + \frac{\dot{V}_i}{V_i}.$$

Entrants are active if the value of entry is equal to its cost, if $V_i = \frac{\beta}{\alpha} Z_i$. Taking logs and time derivatives and substituting into the arbitrage condition, I obtain

$$r = \frac{\alpha \Pi_i}{\beta Z_i} + \frac{\dot{Z}_i}{Z_i}.$$

Using the reduced-form expression for profits (10) and the R&D technology (4), I obtain

$$r = \frac{\alpha (1-\gamma)}{\beta} \frac{e - \theta (e-1)}{e} \frac{P_i X_i}{Z_i} + \frac{\alpha R_i}{Z_i} \left(1 - \frac{1-\gamma}{\beta}\right). \tag{12}$$

This equation holds as long as there is entry. If conditions are such that $V_i < \frac{\beta}{\alpha} Z_i$, there is no entry and the model works like one with an exogenous mass of firms (see below). Situations with $V_i > \frac{\beta}{\alpha} Z_i$ cannot be equilibria because they entail infinite investment in entry, which violates the economy's resources constraint.

Equations (11) and (12) define the returns to two types of investment. A standard arbitrage argument for the assets market requires that they yield equal rates of return. Hence,

$$\frac{R_i}{P_i X_i} = \begin{cases} 0 & 0 \leq N \leq N_0 \\ \left[\frac{e-1}{e} (\beta + \theta) - 1\right] \frac{1-\gamma}{\beta + \gamma - 1} & N > N_0 \end{cases}. \tag{13}$$

This equation determines the firm's R&D intensity as a function of product market competition, the entry cost and the firm's bargaining power.

To understand the properties of this equilibrium, one can represent the interaction of incumbents and entrants in a diagram with the rate of return, r, on the vertical axis and R&D, R_i, on the horizontal axis. The equilibrium

that the marginal cost is a convex function of output. The reason why this implies symmetry, if the price elasticity of demand is sufficiently low, is that expanding output too rapidly raises production costs and offsets the cost advantage stemming from knowledge accumulation. One can visualize this in a simple diagram with an increasing and convex marginal cost curve. Innovation shifts the curve down; the resulting output expansion involves a movement up along the new curve.

with positive R&D is at the intersection of the horizontal line (11) with the upward sloping line (12).[7] It exists if (11) is higher than the intercept of (12), otherwise (11) and (12) cross for a negative value of R_i, the non-negativity constraint on R&D is binding, and $R_i = 0$. Hence, there exists a threshold N_0, determined by $e(N) = 1 + \frac{1}{\beta+\theta}$, such that $R_i > 0$ for $N > N_0$ and $R_i = 0$ for $0 \leq N \leq N_0$.

According to equation (13), R&D is proportional to the firm's revenues, $P_i X_i$. To see why, note that the rate of return to R&D increases with the scale of production over which cost-reducing innovations apply. Similarly, the rate of return to entry increases with the anticipated scale of production of the firm. In both cases, the intuition is that R&D and entry costs are fixed costs that larger firms spread over larger volumes of production. Recent work by Cohen and Klepper (1996a, 1996b) and Adams and Jaffe (1996) shows that this cost-spreading mechanism is important in explaining the role of firm size emphasized in many empirical studies.

To characterize the labor market more sharply, it is useful to assume that the government cannot borrow and satisfies the budget constraint $T = \tau W L^d - B(L^s - L^d)$, which determines the lump-sum transfer, T, as the difference between tax revenues and expenditure on benefits.[8] It is also useful to assume that the unemployment benefit is a constant fraction of the wage. I thus posit $B = \sigma W$.

I now make use of the fact that symmetry implies that all firms pay the same wage so that $W_i = W$. The wage equation (8) yields

$$1 = \frac{(1-\tau)(1-u) + \sigma u}{1-\tau}(1+m).$$

This can be solved for

$$u = \frac{1-\tau}{1-\tau-\sigma}\frac{m}{1+m} \tag{14}$$

Notice that $u > 0$ because $m > 0$, while $u < 1$ if

$$1 + m < \frac{1-\tau}{\sigma}.$$

[7] This equilibrium is stable in the following sense: to its right the rate of return to R&D is lower than the rate of return to entry and investors wish to reduce growth since this reduces the rate of return to entry; to its left the rate of return to R&D is higher than the rate of return to entry and investors wish to raise growth since this raises the rate of return to entry.

[8] This setup keeps to a minimum the effect of the government on economic activity. Only two distortions matter: taxation, which lowers labor supply and raises the pre-tax wage that unions demand, and the unemployment benefit, which raises both labor supply and the pre-tax wage that unions demand.

This says that, given the markup m, if the replacement ratio is too high unemployment is 100%. To see what this means, use the wage equation (8) to rewrite the condition as

$$\sigma < \frac{W_a}{W} \Longleftrightarrow B < (1-\tau)\, W.$$

This is intuitive: a replacement ratio that is "too high" is one that makes unemployment a better outcome than employment.[9] To rule out situations like this it is sufficient to impose $\sigma < 1 - \tau$.

It is clear from the wage equation (8) that unemployment is decreasing in R&D intensity because the firm's R&D activity reduces the markup over the reservation wage. More importantly, the relation between unemployment and R&D activity is *invariant to the specifics of the determination of R&D intensity*. Hence, the implied negative relation between growth and unemployment is *causal* and *general*: however R&D intensity is determined, the higher is R&D intensity, the lower is the markup and the lower is unemployment. The specifics of the relation, on the other hand, depend on whether entrants are active or not. When entrants are active, equation (12) applies and R&D spending is determined by the arbitrage condition (13); when entrants are not active, equation (12) does not apply and R&D spending is determined by the economy's resources constraint. Thus, spelling out the details of the relation between unemployment and growth requires analysis of the economy's general equilibrium.

The expression for firm employment (7), the wage equation (8) and aggregation across firms yield

$$L = \int_0^N L_i di = \frac{1+m}{W} \frac{\theta\,(e-1)}{e} Y.$$

The assembly technology (1), the production technology (3) and symmetry yield the reduced-form production function

$$Y = ZN\left(\frac{L}{N}\right)^{\theta} = ZN^{1-\theta}L^{\theta}. \tag{15}$$

[9] This raises the question of how the government can pay for unemployment benefits if nobody works. In this paper's setup this is not necessarily a problem because the government pays (net) lump-sum transfers that can be converted to lump-sum taxes. The question, however, is really about how one can justify as an equilibrium a situation with 100% unemployment. One should also notice that the condition for $u < 1$ is surely satisfied if unemployment benefits are taxed at the same rate as wages. More generally, the condition should be that the replacement ratio be lower than the ratio $\frac{1-\tau_W}{1-\tau_B}$, where τ_W and τ_B are, respectively, the tax rate on wages and benefits.

Hence,

$$W = (1+m)\frac{\theta(e-1)}{e}Z\left(\frac{L}{N}\right)^{-(1-\theta)}.$$

The wage is increasing in product market competition e and the markup m, and is proportional to productivity Z. Employment per firm $\frac{L}{N}$ enters negatively because of diminishing returns to labor.

To calculate employment now observe that

$$\begin{aligned} L &= (1-u)L^s \\ &= \lambda\frac{1-\tau-\sigma(1+m)}{(1-\tau-\sigma)(1+m)}\left[1-\frac{\psi e\left(\frac{L}{N}\right)^{1-\theta}}{(1-\tau)\theta(e-1)}c\right], \end{aligned} \tag{16}$$

where $c \equiv \frac{C}{\lambda Z}$ denotes consumption per effective person (*not* worker). It is straightforward to show that L is increasing in N and decreasing in c. This is intuitive: higher consumption lowers labor supply and thus employment (holding constant the unemployment rate u which does not depend directly on c). The reason why employment rises with the mass of firms is twofold. First, a larger mass of firms disperses employment and reduces firm size. As a result, the marginal product of labor rises, the wage rises and labor supply rises. Second, a larger mass of firms raises the price elasticity of demand. This in turn has two effects: it raises the wage and thus labor supply, and it lowers the markup and thus unemployment.

4 General Equilibrium

To characterize the general equilibrium of this economy I impose output and capital market clearing. The partial equilibrium of the labor market affects the path of the economy through the reduced-form production function (15) which determines the resources constraint. (Notice that the mass of firms plays the role of capital in an otherwise standard reduced-form production function.) The saving schedule (5) determines the rate of return to saving that the household demands. The construction of the general equilibrium of this economy is then straightforward. There is an Euler equation characterizing the equilibrium of the assets market, whereby all rates of return are equalized, and an equation characterizing the equilibrium of the goods market, whereby output is allocated to consumption and investment. The latter equation is where this model deviates from the standard setup because the state variable of this economy is the mass of firms.

The phase diagram in Figure 1 and the following Proposition characterize dynamics in (N, c) space.

Proposition 1 *There is a unique perfect-foresight general equilibrium. If the initial mass of firms is smaller than N^*, the economy jumps on the saddle path and converges to the steady state (N^*, c^*). If the initial mass of firms is larger than N^*, the economy enters immediately a steady state with no entry.*

Proof. See the Appendix. ■

This proposition implies that there is a continuum of steady states to the right of N^* where the mass of firms is exogenous. This is the region of hysteresis where entry is not profitable and the mass of firms does not respond to parameter changes. To fully appreciate the model's implications, these must be taken into account.

Let $g \equiv \frac{\dot{Z}}{Z}$ be the rate of innovation, the rate of growth of labor productivity. To characterize the triple (g^*, u^*, L^*) associated to the steady state (N^*, c^*) it is useful to proceed as follows. The R&D intensity equation (13) and the R&D technology (4) yield

$$g = \begin{cases} 0 & 0 \leq N \leq N_0 \\ \frac{PX}{Z}\alpha\left[\frac{e-1}{e}(\beta+\theta)-1\right]\frac{1-\gamma}{\beta+\gamma-1} & N > N_0 \end{cases}. \tag{17}$$

Equation (11) yields the rate of return to investment (*both* in-house R&D and entry since arbitrage equalizes returns). Now notice that working with consumption per effective person implies that asset market equilibrium requires that the rate of return be equal to the discount rate plus the growth rate, $r = \rho + g$. Hence,

$$\rho + g = \frac{PX}{Z}\frac{\alpha(1-\gamma)(e-1)}{e}. \tag{18}$$

Solving this equation for $\frac{PX}{Z}$ and substituting into (17) yields an equation that describes growth as an increasing function of market competition,

$$g = \begin{cases} 0 & 0 \leq N \leq N_0 \\ \rho\frac{(\beta+\theta)\frac{e-1}{e}-1}{1-(1-\gamma+\theta)\frac{e-1}{e}} & N > N_0 \end{cases}. \tag{GG}$$

An important property of this equation is that the parameter α is missing. This is because its effects on the intensive and extensive margins are identical and thus cancel out in the arbitrage condition that equalizes the returns to R&D by incumbents and R&D by entrants.[10]

A similar equation characterizing equilibria with entry in (N, u) space obtains by evaluating the unemployment equation (14) at the relevant values of the markup. Substituting the R&D intensity equation (13) into the markup equation (9) yields

$$m = \begin{cases} \gamma \frac{e-\theta(e-1)}{\theta(e-1)} & 0 \leq N \leq N_0 \\ \gamma \frac{e-(1-\gamma+\theta)(e-1)}{\theta(e-1)\left(1-\frac{1-\gamma}{\beta}\right)} & N > N_0 \end{cases}.$$

Accordingly,

$$u = \frac{1-\tau}{1-\tau-\sigma} \frac{m}{1+m} \tag{UU}$$

defines a kinked curve that is monotonically decreasing in N.

The economy's resources constraint and the reduced-form production function (15) yield a relation between R&D intensity and consumption,

$$\frac{R}{PX} = 1 - \frac{\lambda c}{N} \left(\frac{L}{N}\right)^{-\theta}.$$

Solving the markup equation (9) for R&D intensity and substituting into this expression allows one to eliminate consumption from the employment equation (16) and write

$$L = \lambda \left[\frac{(1-\tau-\sigma)(1+m)}{1-\tau-\sigma(1+m)} + \frac{\psi}{1-\tau} \left(\frac{m}{\gamma} + 1 \right) \right]^{-1}. \tag{LL}$$

Evaluating this at the markup given above yields a kinked employment curve in (N, L) space that is monotonically increasing.

When entrants are not active, the rate of return to investment is given by the rate of return to R&D (11). Asset market equilibrium requires $r = \rho + g$. Hence,

$$g = \begin{cases} \frac{\alpha(1-\gamma)(e-1)}{e} \left(\frac{L}{N}\right)^{\theta} - \rho & 0 \leq N < N_1 \\ 0 & N \geq N_1 \end{cases}. \tag{HH_g}$$

[10] The reader should also note that the equation does not contain terms that measure the size of the economy. Hence, the economy's labor endowment affects growth only through its (positive) effect on the number of firms. As a result, the model exhibits a nonlinear scale effect, bounded from above. Since I have already discussed this property of this class of models in Peretto (1998, 1999), I do not examine this effect here and refer the reader to those papers for details.

One can characterize firm size $\frac{L}{N}$ as a function of the mass of firms N so that this equation describes a locus in (N, g) space.

To see this, observe that the procedure followed above yields

$$L = \lambda \left[\frac{(1-\tau-\sigma)(1+\tilde{m})}{1-\tau-\sigma(1+\tilde{m})} + \frac{\psi}{1-\tau} \left(\frac{\tilde{m}}{\gamma} + 1 \right) \right]^{-1} \qquad (HH_L)$$

and

$$u = \frac{1-\tau}{1-\tau-\sigma} \frac{\tilde{m}}{1+\tilde{m}}, \qquad (HH_u)$$

where the assets market equilibrium condition yields

$$\tilde{m} = \begin{cases} \gamma \left[\frac{e-(1-\gamma+\theta)(e-1)}{\theta(e-1)} + \frac{e}{\theta(e-1)} \frac{\rho}{\alpha} \left(\frac{L}{N} \right)^{-\theta} \right] & 0 \leq N < N_1 \\ \gamma \frac{e-\theta(e-1)}{\theta(e-1)} & N \geq N_1 \end{cases}.$$

These two equations determine employment L and the markup $\tilde{m}$ as functions of N. (The detailed analysis is available on request.) Accordingly, they determine the unemployment and employment equations, (HH_u) and (HH_L), that apply in the hysteresis region.

There are two effects of the mass of firms. The first is the standard one of tougher competition that reduces market power. The second is specific to equilibria with no entry wherein R&D is determined by the resources constraint and – contrary to equilibria with entry – is *decreasing* in N. As a consequence, a larger mass of firms *can* result in a higher markup. The appendix discusses a sufficient condition for the former effect to dominate and thus have the plausible property that the (HH_L) curve is upward sloping while the markup $\tilde{m}$ is decreasing in N. In this case, equation (HH_g) describes a monotonically decreasing curve in (N, g) space. It intersects the horizontal axis at point N_1, which means that R&D is zero whenever the mass of firms is too large. This is intuitive: when there are too many firms, each firm is small and the returns to innovation are low. As a result, firms set R&D to zero. Similarly, equation (HH_u) is downward sloping.

The values g^*, L^*, u^* associated to (N^*, c^*) are at the intersection of (GG) with (HH_g), (LL) with (HH_L), and (UU) with (HH_u). All points on the (HH_g), (HH_L) and (HH_u) curves to the right of N^* are steady states. These are situations where entry is not profitable and the mass of firms does not respond to shocks and changes in policy variables. Figure 2 illustrates. Comparative statics are as follows.

Proposition 2 *Growth g^* is increasing in α, β, ϵ, and decreasing in γ, τ, σ. The mass of firms N^* is increasing in α, decreasing in γ, τ, σ, β while* *the effect of ϵ is ambiguous. Employment L^* is increasing in α, decreasing in γ, τ, σ, while the effects of β and ϵ are ambiguous. Unemployment u^* is decreasing in α, increasing in γ, τ, σ, while the effects of β and ϵ are ambiguous.*

In the region $N_0 < N < N_1$, the figure emphasizes the underlying employment and unemployment curves for the case with zero R&D because comparing these curves to the other two highlights that there is more employment and less unemployment when there is growth – this is illustrated by the fact that the employment and unemployment curves for equilibria with R&D are, respectively, above and below the curves for the case without.

The positive relation between competition and growth captured by the (GG) locus determines the growth effects of policy interventions and exogenous shocks that affect the labor market. Specifically, changes in labor market equilibrium are transmitted to the product market through shifts of the (HH_g) locus that produce a movement along the (GG) locus. This happens, for example, in the case of reductions of the labor tax τ or the replacement ratio σ. Thus, policy interventions in the labor market that raise employment – because they lower unemployment, raise labor supply or do both – attract entry and, as a result of tougher competition, raise growth. This growth effect is larger the less competitive is the economy and vanishes when the economy approaches the upper bound for the elasticity of substitution.

The slopes of the (LL) and (UU) loci determine the employment and unemployment effects of policy interventions and exogenous shocks that affect the product market. Specifically, changes in product market equilibrium are transmitted to the labor market through shifts of the (HH_L) and (HH_u) loci that produce movements along the (LL) and (UU) curves. One can see that policy interventions in the product market that attract entry raise employment and reduce unemployment purely because they increase competition and thus reduce the wage premium .I discuss in detail the effects of interventions in the labor and product markets in the next section.

5 Implications for the analysis of reforms

The dynamic response of the economy to a change in parameters is subject to hysteresis since increases in the mass of firms are irreversible. It is thus necessary to distinguish between (a) results that characterize economies with different parameters (comparative statics results) and (b) results that characterize the response of one economy to a parameter change (comparative dynamics results).

5.1 Labor market reforms

Three parameters capture institutional features of the labor market that affect labor costs for firms: the tax on wages, τ, the replacement ratio, σ, and the bargaining power of workers, γ. This subsection makes three related points:

- policies that reduce labor costs raise employment – by raising labor market participation – and reduce unemployment;
- the rise in employment and the reduction in unemployment are larger when one considers the endogenous mass of firms;
- because these improvements in labor market conditions are associated to more competition, these policies raise growth.

To illustrate, I consider the effects of labor income taxes.

Proposition 3 *Effects of the labor income tax rate, τ. (a) An economy with higher τ converges to a steady state with lower growth, a smaller mass of firms, lower employment and higher unemployment than economies with lower τ. (b) In response to an increase in τ, the economy jumps to a steady state with lower growth, the same mass of firms, lower employment and higher unemployment. In response to a reduction in τ, the economy converges to a steady state with higher growth, a larger mass of firms, higher employment and lower unemployment.*

Consider Figure 3. Point A is the steady state reached by an economy with a high tax rate; point B is the steady state reached by an economy with a low tax rate. The arrows describe the shifts due to a reduction of the tax rate. Consider the economy at point B. If τ increases, the economy is in the hysteresis region and employment and growth fall immediately while unemployment raises. This is the jump from point B to point C on the hysteresis curves corresponding to the high tax rate. If τ returns to the original value, employment, output, growth, and unemployment return to the original values. Consider now the economy at point A. If τ decreases, the economy jumps on the saddle path that converges to point B.

The economics behind these results is as follows. The lower labor tax yields a higher after-tax wage for workers and a lower pre-tax wage for firms.

Hence, it raises labor supply (participation) and lowers the wage premium. As a result, given the mass of firms, it is associated to higher employment and lower unemployment. This is captured by the shift up of the (HH_L) curve and the shift down of the (HH_u) curve. These are just the traditional effects of lower labor income taxation on participation and unemployment. On top of these, there are the indirect effects due to the mass of firms. The higher level of activity due to higher employment means that firm size is larger. To keep the net rate of return equal to the discount rate, the mass of firms must be larger so that there is a compensating market share effect. The effect of the change in the mass of firms is captured by the movements along the (GG), (LL) and (UU) loci which incorporate entry. Since the (GG) locus does not shift, because it does not depend directly on the tax, growth is higher purely because the lower tax yields more competition. The (LL) and (UU) loci shift, respectively, up and down. As one can see, the lower tax is associated to higher employment and lower unemployment.

Consider now the dynamics. When the tax increases, the mass of firms does not change while unemployment rises. Holding constant labor supply, this reduces the firms' scale of activity and thereby reduces growth. Labor supply however is endogenous. The higher tax rate causes labor supply, and thus employment, to fall. These effects are in line with traditional intuition built on models that ignore the effects of the endogenous structure of the product market. Things are quite different when the mass of firms adjusts endogenously, as it happens when taxes are reduced. A lower tax generates a positive feedback through the product market that reinforces the benefits of lower taxation. These benefits are reaped over time as the mass of firms raises. Figure 3 illustrates this point by separating the *pro-competitive* or *product market effect* of the lower tax rate from its traditional *labor market effect*. Given the mass of firms, the lower tax rate yields a lower (HH_u) locus and a higher (HH_L) locus, and thus reduces unemployment and raises employment. These effects are captured in the figure by the movement from point A to point A'. The larger mass of firms then reduces unemployment further. This is captured by the movement from point A' to point B along the new (LL) and (UU) curves.

The asymmetric response of the economy to decreases and increases in the labor income tax rate requires one to distinguish the time-series implications of the model from its cross-section implications. The model predicts that countries with higher labor income taxes exhibit higher unemployment and lower growth. This is consistent with intuition. This correlation, however, is very hard to detect in studies that cover several countries at a moment in time because it is dominated by country-specific fixed effects in cross-sectional regressions. One then needs to check how variations of tax rates over time affect unemployment within a country (Daveri and Tabellini 2000). If labor taxation keeps increasing over a period of time, the time-paths of unemployment and growth track the time-path of the tax rate. More precisely, the model predicts that each time the tax rate rises, unemployment rises and growth falls. This is consistent with the empirical evidence provided by Daveri and Tabellini (2000) for the OECD countries. They show that the upward trend in labor income tax rates drives the upward trend in unemployment and the downward trend in growth.[11] On the other hand, the model predicts that the effects of tax breaks are spread over time and generate a protracted expansion of output accompanied by a falling rate of unemployment.

The replacement ratio has effects similar to those of the tax with the difference that the labor income tax reduces labor supply (because it reduces expected income) while the replacement ratio raises it. Hence, the tax is associated to less employment than the replacement ratio.

The parameter capturing the bargaining power of workers has intuitive effects that are similar to the ones outlined above. Because it raises the wage premium, it reduces employment and the mass of firms – two measures of the scale of economic activity – and through the associated anti-competitive effect rises unemployment and reduces growth.

5.2 Product market reforms

Several factors determine competition in the product market. The model allows me to consider the following:

- regulations/frictions that raise the cost of innovation can be modeled as a lower α;

[11] The model understates the negative effect of rising taxes because it does not allow for exit, and thus rules out the possibility that the upward trend in taxation lead to fewer firms and less competition. Including exit, for example by positing that firms incur instantaneous fixed costs, complicates the algebra but does not change the results discussed in the text. In particular, allowing for exit reduces the size of the region of hysteresis but does not eliminate it. The size of this region depends on how large is the entry sunk cost relative to the instantaneous fixed cost. If the latter is zero, as in this model, firms never exit and the region of hysteresis extends from the interior steady state to infinity; if it is positive, the region of hysteresis is a finite interval. In the latter case, the negative effect of taxation on firms' cash flow could be large enough to push them against the exit margin thereby triggering a feedback through the product market that reinforces the negative effects of taxation of labor by reducing competition.

- regulations/frictions that reduce product substitution and thus price competition can be modeled as a lower ϵ, where ϵ is a parameter that shifts up the function $e(N;\epsilon)$;

- regulations/frictions that raise entry costs for entrants but do not affect incumbents can be modeled as a higher β.

This subsection makes the following points, which illustrate the interactions between the labor and product markets:

- lower costs of innovation raise growth and employment and reduce unemployment;

- tougher price competition raises growth and has an ambiguous effect on employment and unemployment;

- lower barriers to entry reduce growth and ambiguous effects on employment and unemployment.

These results suggest that the details of the pro-competitive policy that a country adopts matter. In particular, *reducing barriers to innovation is the best policy because it reduces at the same time barriers to entry and barriers to innovation within the firm.* As a result, it fosters investment on both the intensive and the extensive margin and, more importantly, it exploits the positive relation between competition and growth and the negative relation between competition and unemployment. I now illustrate these results in some detail.

Proposition 4 *Effects of the R&D productivity parameter, α. (a) An economy with higher α converges to a steady state with higher growth, a larger mass of firms, higher employment and lower unemployment. (b) In response to an increase in α, the economy converges to a steady state with higher growth, a larger mass of firms, higher employment and lower unemployment. In response to a decrease in α, the economy jumps to a steady state with lower growth, the same mass of firms, and the same levels of employment and unemployment.*

It is simple to see what drives these results. The direct effect of the higher α is to shift up the (HH_g) and (HH_L) loci and to shift down the (HH_u) locus. Growth and employment rise while unemployment falls. The higher α also implies that to keep the net rate of return equal to the discount rate the mass of firms must be larger. The rise in the mass of firms feeds back positively on employment and growth and negatively on unemployment. The key intuition behind these results is that the higher α boosts productivity of investment on *both* the extensive and the intensive margin. Hence, the economy supports faster growth *and* a large mass of firms, with all the benefits that follow for the labor market.

Proposition 5 *Effects of the elasticity of product substitution, ϵ. (a) An economy with higher ϵ converges to a steady state with a smaller mass of firms. If the direct effect of ϵ dominates over the indirect effect, growth and employment are higher and unemployment is lower in the economy with higher ϵ. (b) In response to an increase in ϵ, the economy jumps to a steady state with the same mass of firms, higher growth and employment and lower unemployment. In response to a decrease in ϵ, the economy converges to a steady state with a larger mass of firms. If the direct effect of ϵ dominates over the indirect effect, growth and employment are lower and unemployment is higher in the new steady state.*

These results are relatively straightforward. Holding constant the mass of firms, in the product market the direct effect of tougher price competition is to raise growth while in the labor market it is to raise employment and lower unemployment. There are two conflicting effects on the mass of firms. The increase in the firms' scale of activity associated to higher employment implies that to keep the net rate of return equal to the discount rate the mass of firms must be higher. However, tougher price competition leads firms to spend more on R&D, which is a fixed cost that makes incumbency more costly. Firms, moreover, are less profitable because price-cost margins are lower. Both these forces tend to reduce the mass of firms. As a result of this conflict, the effect of ϵ on the mass of firms in ambiguous. If it is positive – if the mass of firms rises because the employment effect dominates over the incumbency cost and the profit margin effects – the overall effect of ϵ is to rise growth and employment and reduce unemployment because the pro-competitive indirect effects associated to the larger mass of firms work in the same direction as the direct effects associated to the lower price and wage markups.

Proposition 6 *Effects of the entry cost parameter, β. (a) An economy with higher β converges to a steady state a smaller mass of firms, lower employment and higher unemployment. If growth is very responsive to product market competition, it is lower in the economy with the smaller mass of firms. (b) In response to a reduction in β, the economy converges to* *a steady state with a larger mass of firms, higher employment and lower unemployment. If growth is very responsive to product market competition, it is higher in the new steady state. An increase in β has no effects.*

This case provides a surprise of sort in that lower barriers to entry are not necessarily associated to higher employment and lower unemployment. Here is why. The higher cost of entry yields *higher* growth. This is due to the *protection effect*: incumbent firms protected by high barriers to entry are larger and do more R&D. Quite important is the fact that faster growth is due to higher R&D intensity, which – as argued in detail in Section 4 – reduces the wage markup and thus is associated to higher employment and lower unemployment. Opposite these direct effects, there is the fact that higher barriers to entry are associated to fewer firms, which means weaker competition and a higher wage markup, a force that tends to lower employment and raise unemployment. The tension between the direct and indirect effects of barriers to entry gives rise to ambiguous results.

This ambiguity can be resolved if one can show that the (HH_L) is upward sloping and the (HH_u) locus is downward sloping, which is the case if there is a *sufficiently strong response of the elasticity of substitution to the mass of firms*. The appendix provides a formal analysis of the conditions under which this happens. Figures 2 and 3 illustrate this case.

An important point that emerges from this discussion is that preferential treatment of incumbents in order to boost growth – a policy that can be modeled as a high β – is potentially self-defeating because faster growth might come at the cost of worse conditions in the labor market. Given the importance that recent studies attach to the role of barriers to entry for labor market outcomes, two additional remarks concerning these results are in order.

First, the result that higher barriers to entry reduce the wage markup because they promote growth depends crucially on the assumption of efficient bargaining between firms and workers. If the wage setting process takes the form of a standard right to manage model with monopolistic unions, the wage follows

$$W_i = \frac{e_W}{e_W - 1}\frac{W_a}{1-\tau}, \quad e_W \equiv \frac{1}{1-\theta\frac{e-1}{e}}$$

which produces a markup that does not depend on R&D intensity. Breaking the link between the wage markup and R&D intensity has the crucial implication that the wage markup does not decrease directly with barriers to entry – like in equation (9) – and therefore the only effect of barriers to entry is through the mass of firms. It is then immediate to show that barriers to entry reduce employment and raise unemployment simply because they reduce product market competition. More generally, one should observe that the result that higher barriers to entry do not necessarily worsen labor market outcomes is predicated on (a) a strong response of the wage markup to R&D intensity and (b) a weak response of the wage markup to product market competition. Let me stress that the comparative statics results discussed above concerning the other parameters are robust to this change in the description of the bargaining process and thus do not depend on these two conditions. Barriers to entry, in contrast, appear to play a special role in this environment where firms undertake R&D investment, and their effects depend on the strength of the relationship between R&D intensity and the wage markup.

The second remark concerns the general implications of this line of analysis for the recent literature on the role of labor and product market reforms as different means to the same end of improving labor market performance. Since the effect of price competition and barriers to entry are potentially ambiguous, reforms of the product market do not substitute for reforms of the labor market. One could see in the recent literature on the labor market effects of product market deregulation an argument that the same desirable outcomes – higher employment, lower unemployment – could be accomplished by reforming the product market *instead of* the labor market. The analysis in this section suggests that the mechanisms involved are quite different. Reforming the labor market triggers indirect effects through the product market that work in the same direction as the direct effects because the transmission channel runs through larger market size (higher employment) that attracts entry and thus raises competition. This mechanism, moreover, applies to all the three dimensions of labor market reform considered here: taxation, unemployment benefits, bargaining power of workers. It follows that reforming the labor market is unambiguously good for employment and unemployment, with the additional bonus that it fosters growth. Reforming the product market instead triggers indirect effects that potentially offset the direct effects. More importantly, the overall effects are specific to the particular dimension that one wishes to pursue – lower costs of innovation for both incumbents and entrants, tougher price competition, lower barriers to entry – and to the particular form of the wage bargaining process. The robust result that emerges is that product market deregulation that reduces innovation costs for *both* incumbents and entrants boosts growth and produces better labor market performance.

6 Conclusion

The view that unemployment is high in economies where the welfare state provides long-lasting unemployment benefits that are unrelated to the individual's effort to find work, the labor force is organized in sectoral or firm-level unions that do not coordinate their activities, and taxation raises the cost of labor, is generally correct and supported by much of the available empirical evidence. It is, however, incomplete because it ignores the characteristics of the product market. There are good reasons, theoretical and empirical, to think that in addition to labor market frictions, unemployment depends on a broad class of factors that characterize the structure of the product market. An interesting implication of this argument is that there exists a relation between unemployment and growth. The reason is that growth is driven by firms' R&D investments, which are affected by the structure of the product market.

In this paper, I discussed a model where firms and workers set wages above the market-clearing level. Unemployment is thus generated by their exercise of market power. Because both the labor and product markets are imperfectly competitive, market power in the labor market interacts with market power in the product market. This interaction sheds new light on the effects of policy interventions on unemployment and growth. For example, labor market reforms that reduce labor costs reduce unemployment *and* boost growth because they expand the scale of the economy and generate more competition in the product market. Moreover, the reduction in unemployment is larger than one would expect if the reforms' effects in the product market were ignored. If such reforms are implemented jointly with a reduction of barriers to innovation an even larger reduction in unemployment is achieved.

The approach developed here lends itself easily to extensions and further analysis of important issues that are part of the current policy debate. First and foremost, it would be worthwhile to explore how different bargaining environments, or surplus sharing arrangements different from bargaining, might affect the results. For example, if the surplus sharing process is construed as bargaining between the firm and its unionized workforce, then it is possible to obtain different solutions according to whether one takes a right to manage approach or an approach where bargaining covers both employment and the wage. Even more interesting would be to investigate how the solution changes if the firm bargains with the workforce over the R&D strategy as well. Although rarely observed, such arrangements might yield surprises: in preliminary work, for example, I found that it would lead to higher R&D intensity and faster growth, suggesting a novel benefit of letting the workforce have a stake in the growth of the firm.

7 Appendix

7.1 The bargaining problem

The firm and its workers solve

$$\max_{W_i,L_i} \left[(1-\gamma)\log \Pi_i + \gamma \log \left(W_i\left(1-\tau\right) - W_a\right) L_i\right].$$

Using the production function (3) and the demand curve (2) profit becomes

$$\Pi_i = \left(\frac{Y}{N}\right)^{\frac{1}{e}} Z_i^{1-\frac{1}{e}} L_i^{\frac{\theta(e-1)}{e}} - W_i L_i - R_i.$$

At this stage, R&D spending R_i is taken as given – the assumption being that the firm's management sets R&D policy independently of its workers. Taking derivatives with respect to W_i and L_i:

$$(1-\gamma)\frac{L_i}{\Pi_i} = \gamma \frac{(1-\tau) L_i}{\left(W_i\left(1-\tau\right) - W_a\right) L_i};$$

$$(1-\gamma)\frac{-\frac{\theta(e-1)}{e}\left(\frac{Y}{N}\right)^{\frac{1}{e}} Z_i^{1-\frac{1}{e}} L_i^{\frac{\theta(e-1)}{e}-1} + W_i}{\Pi_i} = \gamma \frac{W_i\left(1-\tau\right) - W_a}{\left(W_i\left(1-\tau\right) - W_a\right) L_i}.$$

The first equation can be rearranged to obtain

$$W_i = \frac{W_a}{1-\tau} + \frac{\gamma}{1-\gamma}\frac{\Pi_i}{L_i}.$$

The ratio of the two first-order conditions yields

$$\begin{aligned} L_i &= \frac{\theta\left(e-1\right)}{e}\frac{1-\tau}{W_a}\left(\frac{Y}{N}\right)^{\frac{1}{e}} Z_i^{1-\frac{1}{e}} L_i^{\frac{\theta(e-1)}{e}} \\ &= \frac{1-\tau}{W_a}\frac{\theta\left(e-1\right)}{e} P_i X_i. \end{aligned}$$

7.2 The reduced-form revenue function

The production technology (3) and the expression for firm employment yield the price

$$P_i = \frac{W_a}{1-\tau} \frac{e}{\theta (e-1)} \frac{L_i^{1-\theta}}{Z_i}.$$

Using the demand curve (2) I can write

$$\begin{aligned} P_i X_i &= \frac{Y}{N} P_i^{1-e} \\ &= \frac{Y}{N} \left[\frac{W_a}{1-\tau} \frac{e}{\theta (e-1)} \frac{L_i^{1-\theta}}{Z_i} \right]^{1-e}. \end{aligned}$$

The expression for firm employment then yields

$$L_i = \frac{1-\tau}{W_a} \frac{\theta (e-1)}{e} \frac{Y}{N} \left[\frac{W_a}{1-\tau} \frac{e}{\theta (e-1)} \frac{L_i^{1-\theta}}{Z_i} \right]^{1-e}.$$

Solving for L_i yields

$$L_i = \left[\frac{Y}{N} \left[\frac{W_a}{1-\tau} \frac{e}{\theta (e-1)} \right]^{-e} Z_i^{e-1} \right]^{\frac{1}{e-\theta(e-1)}}.$$

The reduced-form revenue function then is

$$P_i X_i = \left(\frac{Y}{N} \right)^{\frac{1}{e-\theta(e-1)}} \left[\frac{\frac{W_a}{1-\tau} e}{\theta (e-1)} \right]^{-\frac{\theta(e-1)}{e-\theta(e-1)}} Z_i^{\frac{(e-1)}{e-\theta(e-1)}}.$$

7.3 Proof of Proposition 1

The output market clearing condition is

$$Y = C + NR + \frac{\beta Z}{\alpha} \dot{N}.$$

Since entry is non-negative, one has $\dot{N} > 0$ for $Y > C + NR$ and $\dot{N} = 0$ otherwise. This condition identifies two regions in (N, c) space: the entry region, where entry is profitable, and the hysteresis region, where entry is not profitable and the mass of firms is fixed.

Consider the entry region. Dividing through by Z, and using the R&D equation (13) and the reduced-form production function (15), I can write the resources constraint as

$$\dot{N}=\begin{cases}\frac{\alpha}{\beta}\left[N^{1-\theta}L^{\theta}-\lambda c\right] & 0\leq N\leq N_0\\ \frac{\alpha}{\beta}\left[N^{1-\theta}L^{\theta}\left(1-\left[\frac{e-1}{e}\left(\beta+\theta\right)-1\right]\frac{1-\gamma}{\beta+\gamma-1}\right)-\lambda c\right] & N>N_0\end{cases}.$$

Taking logs and time derivatives of $c\equiv\frac{C}{\lambda Z}$ and using the saving schedule (5), the rate of return to investment (18), the R&D equation (13), and the reduced-form production function (15) I obtain

$$\frac{\dot{c}}{c}=\begin{cases}\left(\frac{L}{N}\right)^{\theta}\frac{1-\frac{e-1}{e}\left(\theta-\gamma+1\right)}{\beta+\gamma-1}\alpha\left(1-\gamma\right)-\rho & 0\leq N\leq N_0\\ \left(\frac{L}{N}\right)^{\theta}\frac{1-\frac{e-1}{e}\theta}{\beta}\alpha\left(1-\gamma\right)-\rho & N>N_0\end{cases}.$$

Recall the employment equation (16)

$$L=\lambda\frac{1-\tau-\sigma\left(1+m\right)}{\left(1-\tau-\sigma\right)\left(1+m\right)}\left[1-\frac{\psi e\left(\frac{L}{N}\right)^{1-\theta}}{\left(1-\tau\right)\theta\left(e-1\right)}c\right],$$

where

$$m=\begin{cases}\gamma\frac{e-\theta\left(e-1\right)}{\theta\left(e-1\right)} & 0\leq N\leq N_0\\ \gamma\frac{e-\left(1-\gamma+\theta\right)\left(e-1\right)}{\theta\left(e-1\right)\left(1-\frac{1-\gamma}{\beta}\right)} & N>N_0\end{cases}.$$

These two equations jointly determine L as increasing in N and decreasing in c. It is useful to use the employment equation to analyze the effects of consumption and the mass of firms on employment per firm, $\frac{L}{N}$. One simply writes

$$\frac{L}{N}=\frac{\lambda}{N}\frac{1-\tau-\sigma\left(1+m\right)}{\left(1-\tau-\sigma\right)\left(1+m\right)}\left[1-\frac{\psi e\left(\frac{L}{N}\right)^{1-\theta}}{\left(1-\tau\right)\theta\left(e-1\right)}c\right].$$

This implicit equation in $\frac{L}{N}$ captures two effects of the mass of firms. First, there is the straightforward effect that more firms disperse *potential* labor supply; this is the term $\frac{\lambda}{N}$ reflecting the basic fact that – whatever the conditions of the labor market, i.e., whatever the fraction of the labor endowment that is actually employed – a larger mass of firms means smaller firm size. Second, a larger mass of firms raises the price elasticity of demand, e, and reduces the markup m. As discussed in the text, these effects tend to raise labor supply. One can show analytically, however, that the dispersion effect dominates so that the right-hand side of the equation is decreasing in N. The implicit function theorem then says that firm size $\frac{L}{N}$ is decreasing in both N and c.[12] With these results in hand, one can see that the two differential equations derived above fully describe dynamics in (N, c) space. The $\dot{c} = 0$ locus is

$$\begin{cases} \left(\frac{L}{N}\right)^{\theta} \frac{1-\frac{e-1}{e}(\theta-\gamma+1)}{\beta+\gamma-1} \alpha (1-\gamma) = \rho & 0 \leq N \leq N_0 \\ \left(\frac{L}{N}\right)^{\theta} \frac{1-\frac{e-1}{e}\theta}{\beta} \alpha (1-\gamma) = \rho & N > N_0 \end{cases}.$$

Since L is increasing in N and decreasing in c, this equation defines a downward sloping locus $c(N)_{entry}$ such that $\dot{c} \geq 0$ whenever $c \leq c(N)_{entry}$. Notice that the locus intersects the horizontal axis.

The hysteresis region is identified by the weak inequality

$$c \geq \begin{cases} \frac{N^{1-\theta}L^{\theta}}{\lambda} & 0 \leq N \leq N_0 \\ \frac{N^{1-\theta}L^{\theta}}{\lambda} \left(1 - \left[\frac{e-1}{e}(\beta+\theta) - 1\right] \frac{1-\gamma}{\beta+\gamma-1}\right) & N > N_0 \end{cases}.$$

Since L is increasing in N and decreasing in c, this says that $\dot{N} = 0$ whenever $c \geq c(N)_{border}$, where $c(N)_{border}$ is increasing in N.

Inside this region equation (13) does not hold and one must determine R&D effort through the resources constraint. Hence,

$$\frac{Y}{ZN} = \frac{\lambda}{N}c + \frac{R}{Z} \Rightarrow g = \alpha \left[\left(\frac{L}{N}\right)^{\theta} - \frac{\lambda}{N}c\right].$$

Equation (11) determines the rate of return to investment. The resulting asset market equilibrium condition reads:

$$\frac{\dot{c}}{c} = \frac{\alpha\lambda c}{N} - \left(\frac{L}{N}\right)^{\theta} \alpha \left[1 - \frac{(1-\gamma)(e-1)}{e}\right] - \rho.$$

Recall that L is determined by

$$L = \lambda \frac{1-\tau-\sigma(1+\tilde{m})}{(1-\tau-\sigma)(1+\tilde{m})} \left[1 - \left(\frac{L}{N}\right)^{1-\theta} \frac{\psi e}{(1-\tau)\theta(e-1)} c\right],$$

where

$$\tilde{m} = \begin{cases} \gamma \left[\frac{e}{\theta(e-1)} \left(\frac{N}{L}\right)^{\theta} \frac{\lambda}{N} c - 1\right] & 0 \leq N < N_1 \\ \gamma \frac{e}{\theta(e-1)} & N > N_1 \end{cases}.$$

[12] The key step in the proof is to show that employment rises less than linearly with the number of firms so that the ratio $\frac{L}{N}$ approaches infinity as N approaches zero. This analysis is available on request.

These two equations determine L as increasing in N and decreasing in c. Therefore, the asset market equilibrium condition reduces to an unstable differential equation in c. Specifically, $\dot{c} = 0$ whenever

$$\frac{\alpha}{N}\left(\lambda c - N^{1-\theta}L^{\theta}\left[1 - \frac{(1-\gamma)(e-1)}{e}\right]\right) = \rho.$$

Hence, $\dot{c} \geq 0$ whenever $c \geq c(N)_{hysteresis}$ where $c(N)_{hysteresis}$ is increasing in N and eventually intersects the feasibility constraint. This is the point N_1 where R&D becomes unprofitable because there are too many firms.

Observe now that the output market implies the feasibility constraint $Y \geq C$. In other words, the region of the state-space $C > Y$ must be ruled out because there the resources constraint is violated. This region can be specified as

$$\frac{N^{1-\theta}L^{\theta}}{\lambda} < c.$$

Since on this locus R&D is zero, L is determined by the employment equation as increasing in N and decreasing in c. It follows that the unfeasible region is $c > c(N)_{unfeasible}$ where $c(N)_{unfeasible}$ is increasing in N.

This information allows me to construct the phase diagram in Figure 1. The intersection of $c(N)_{entry}$ and $c(N)_{border}$ determines the steady state (N^*, c^*). The $\dot{c} = 0$ locus is the kinked curve formed by the portion of $c(N)_{entry}$ in the entry region to the left of N^*, the portion of $c(N)_{hysteresis}$ in the hysteresis region that lies to the right of N^* and to the left of N_1, and the portion of the feasibility constraint to the right of N_1. In the entry region to the left of (N^*, c^*) there is a saddle path leading to that point. All points on $c(N)_{hysteresis}$ to the right of (N^*, c^*) are steady states. The stable manifold of the system is the union of the saddle path in the entry region and the portion of $c(N)_{hysteresis}$ inside the hysteresis region. Paths above the stable manifold eventually violate the feasibility constraint and cannot be equilibria. Similarly, paths below the stable manifold cannot be equilibria because they eventually cross the horizontal axis and yield zero or negative c. Hence, whenever $N < N^*$ the economy jumps on the saddle path and converges to the steady state; whenever $N \geq N^*$ the economy jumps on the $c(N)_{hysteresis}$ locus and enters a steady state with no entry.

7.4 A condition for $\tilde{m}$ decreasing in N

Recall that L and $\tilde{m}$ obey

$$L = \frac{1-\tau-\sigma(1+\tilde{m})}{(1-\tau-\sigma)(1+\tilde{m})}\left[\lambda - L\frac{\psi}{1-\tau}\left(\frac{\tilde{m}}{\gamma}+1\right)\right].$$

and

$$\tilde{m} = \gamma \left[\frac{e - (1 - \gamma + \theta)(e - 1)}{\theta (e - 1)} + \frac{e}{\theta (e - 1)} \left(\frac{L}{N} \right)^{-\theta} \frac{\rho}{\alpha} \right].$$

(I consider only situations with positive R&D since those with zero R&D do not give rise to ambiguities.) These describe two downward sloping markup curves in $(\tilde{m}, L)$ space. The markup curve intersects the employment curve from below. Changes in N shift the markup curve and produce movements along the employment curve. A sufficient condition for $\tilde{m}$ decreasing in N, therefore, is that the markup curve shift down; that is, that holding constant L the effect of an increase in the mass of firms be negative. Formally,

$$\left[\theta (e - 1) - \frac{e' N}{e} \right] \left(\frac{L}{N} \right)^{-\theta} \frac{\rho}{\alpha} < \frac{e' N}{e}.$$

Recall now that positive R&D obtains if

$$\left(\frac{L}{N} \right)^{\theta} > \frac{\lambda c}{N} \Rightarrow \left(\frac{L}{N} \right)^{-\theta} \frac{\rho}{\alpha} < \frac{(1 - \gamma)(e - 1)}{e}.$$

The desired sufficient condition therefore is

$$\frac{(1 - \gamma)(e - 1)}{e} < \frac{\frac{e' N}{e}}{\theta (e - 1) - \frac{e' N}{e}} \Rightarrow \frac{e' N}{e} > \frac{\theta (e - 1)}{1 + \frac{e}{(1 - \gamma)(e - 1)}}.$$

This requires that the function $e(N)$ be sufficiently elastic over the range $0 \leq N < N_1$.

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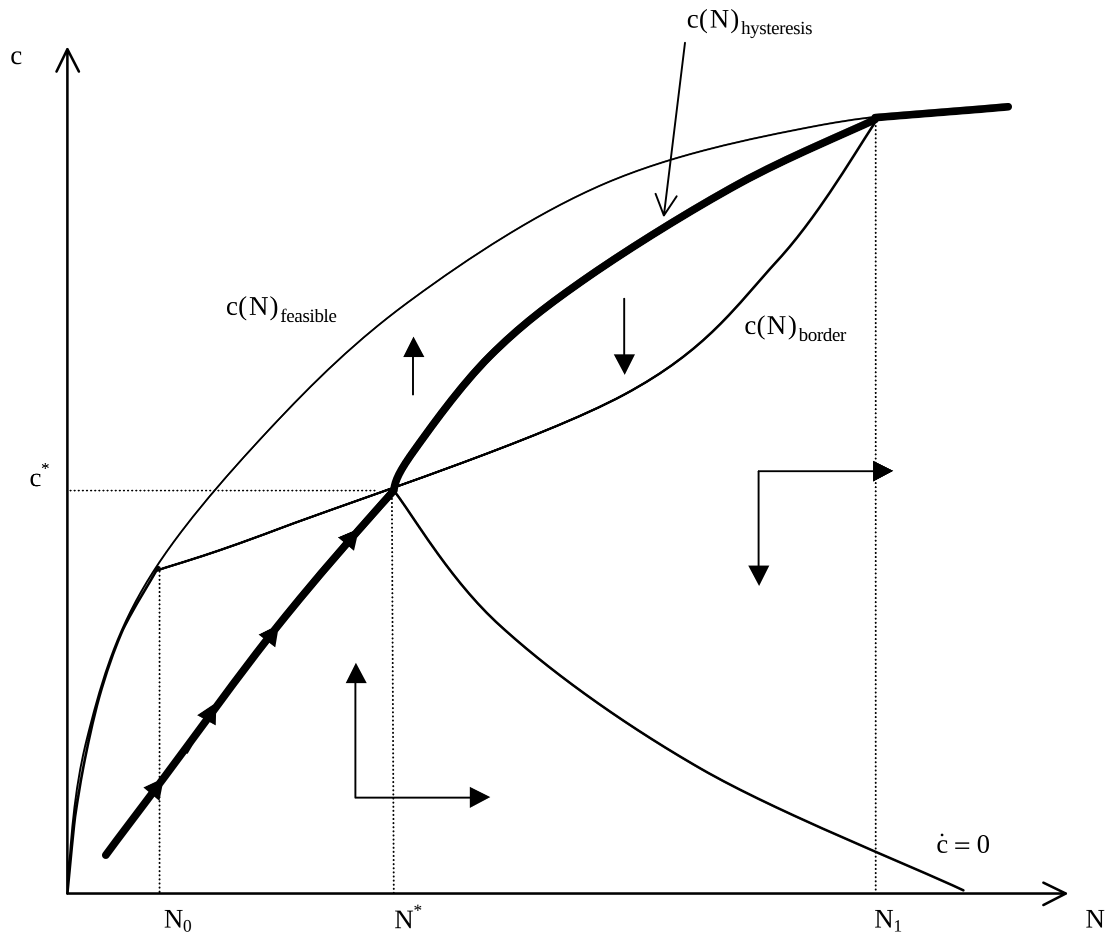

Figure 1: General equilibrium dynamics

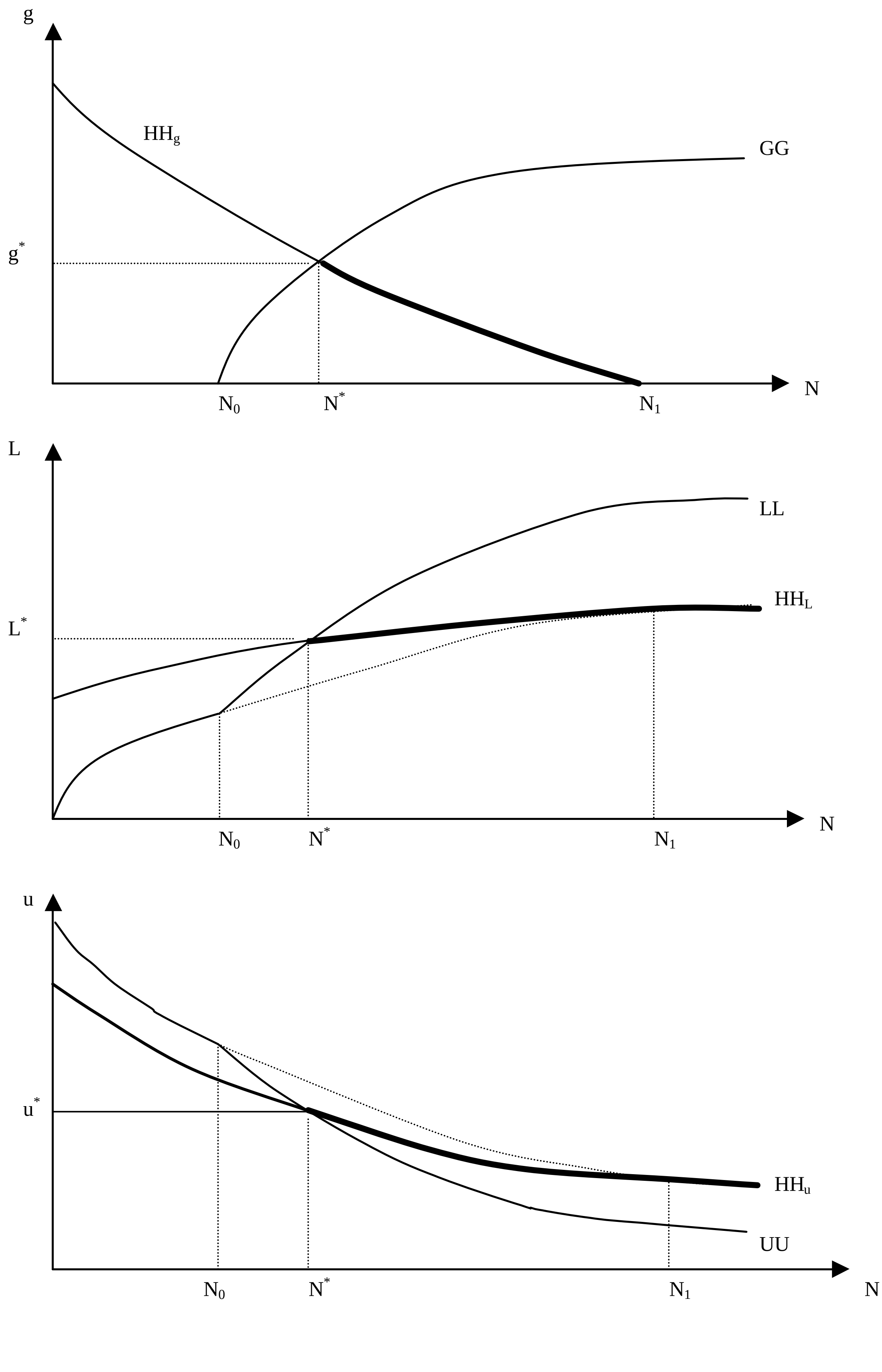

Figure 2: The set of steady-state equilibria

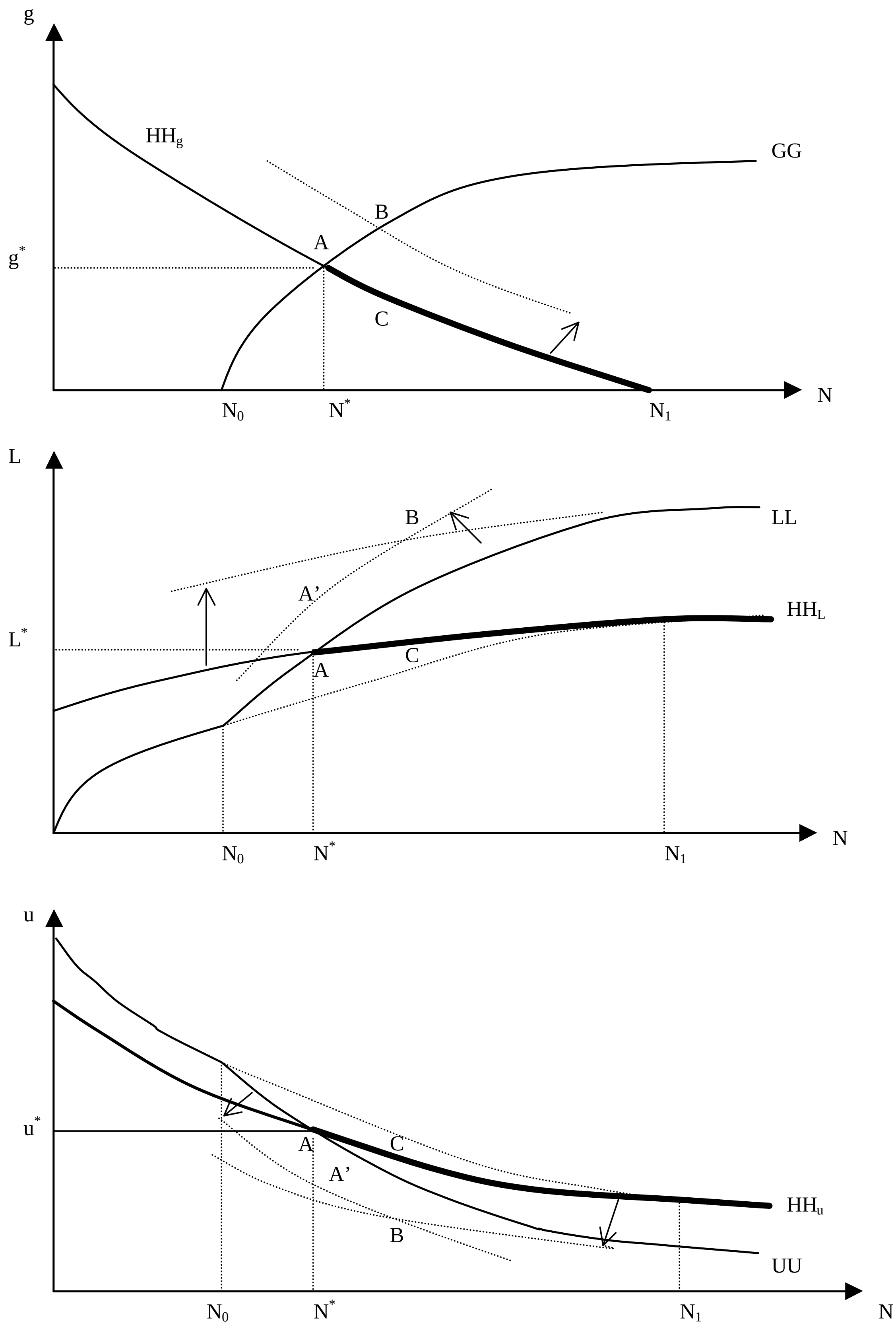

Figure 3: Effects of the labor income tax