Growth, Unemployment, and Labor Market Policy*

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1 Introduction

High rates of unemployment in E.U. countries, both in historical terms and relative to those the U.S., have been a major concern for European economic policy makers since the early 90s. Since the adoption of the Lisbon Strategy in 2000, the emphasis of the discussion has shifted to focus on policy reforms designed to raise growth in the per capita GDP in the E.U. The just published Sapir Report (2004), *An Agenda for a Growing Europe,* provides a survey of the economic performance history that led up to the Lisbon Strategy and sets out a set of recommendations designed to implement its goals of flexible labor markets and more rapid growth.

The role of passive labor market policy, specifically unemployment compensation, payrolls taxes and employment protection policy, as a possible cause of the run up in relative unemployment rates in Europe has been extensively studied in the academic literature. One major line of argument has been that these policies create rigidities that adversely affected the labor market's ability to adjust to trade and technology shocks.[1] The recent growth literature with its emphasis on the role of education and innovation as

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[1] This argument is made and explored by Krugman (1994), Ljungqvist and Sargent

a source of endogenous growth has also pointed out possible adverse effects of government policy on growth. The Lisbon strategy reflects these concerns by calling for reforms that ease market access, promote flexible labor markets, and simplify taxes and market regulation.

The principal purpose of this paper is build a simple model in which the possible effects of labor market and social welfare policies on both unemployment and growth can be isolated. The model is constructed of "off the shelf" parts found in the literatures on equilibrium unemployment based on search and matching models and endogenous growth of the Schumpeterian variety.

Equilibrium models of unemployment postulate a matching process that requires time to create new job-worker pairs and a job destruction process that guarantees a finite life for every existing match (See Mortensen and Pissarides (1999a) and Pissarides (2000) for an extensive treatment.) In that framework, equilibrium unemployment reflects the level that balances flows in and out of the state given individually rational behavior of the agents in the modeled environment. Although taste and technology shocks are postulated as reasons for match destruction, an explicit job destruction story is typically not incorporated into the model. In this paper, the process of "creative destruction" generates the need to reallocate workers from old to new economic activity.

The economy studied in this paper is characterized by the Schumpeterian model of endogenous growth as developed and studied in Grossman and Helpman (1991) and Aghion and Howitt (1998). The single consumption good is produced with a variety of intermediate goods and services. A new more productive or higher quality version of each intermediate input arrives from time to time at a rate endogenously determined by collective R&D investment. Labor is the only factor used in the production of intermediate goods and services. It can also be used to provide research effort. In the economy studied, a new firm with patent rights to its innovation forms to produce each new product. However, time is required to collect the labor force needed to create an operating production unit. The rate at which unemployed workers are matched with firms with job vacancies is determined by an increasing function of both quantities. The wage paid production workers is determined as the outcome of a bilateral bargaining problem. Subsequently, the firm collects monopoly rents until its product is in turn replaced by a better one. As

(1998), and Mortensen and Pissarides (1999b), Blanchard and Wolfers (2000) among others.

product replacement implies that the employees of the previous supplier lose their jobs, job creation and job destruction are two sides of the same coin.

The free entry condition, the equality of the expected cost of innovation with the expected present value of the future rents attributable to an innovation, requires that a negative relationship hold between market tightness and the rate of creative destruction. The sign of the slope reflects the fact that the future stream of rents, those that motivate job creation, are discounted at a rate that takes into account the probability that a new product will be replaced in the future by a better version. New firms with job vacancies flow into the stock of potential entrants at the rate of creative destruction and out of the stock at the rate at which firms with vacancies are matched with production workers. The steady state condition, which requires the equality of these two flows, and the labor force identity, which characterizes the fact that the available labor force must be divided between those who are employed in production, employed in research, and unemployed, require that a positive relationship holds between market tightness and the rate of creative destruction. An equilibrium solution to the model is a creative-destruction rate and a labor market tightness ratio that jointly satisfy these two conditions. Given the equilibrium creative-destruction and tightness pair, unemployment is determined by the labor market steady state conditions and the growth rate is the product of the rate of creative destruction and the log of the quality step size.

As unemployment and the aggregate growth rate are simultaneously determined in the model, there is no clear prediction about how the two should be correlated across countries or across time at low frequencies. As in the case of price and quantity in the supply and demand model, the theory suggests instead a list of joint determinants of both variables. An increase in the bargaining power of workers increases the worker's share of the profit earned by a producing firm. The rate of creative destruction and market tightness both fall with bargaining power as a result. Because the effect of the reduction in labor market tightness is sufficient to offset the effect of job destruction, the unemployment rate rises. Labor force shocks identify the positive relationship between unemployment and growth implied by the free entry condition while interest rate shocks identify the negative relationship implied by the labor market steady state condition and the employment identity. Finally, the equilibrium growth rate increases with R&D productivity but the net effects on labor market tightness and unemployment are unclear.

Labor market policy has effects on both unemployment and growth in the model. Because an increase in the either unemployment compensation or the payroll tax increases the cost of production labor, market tightness is adversely affected. This is a standard implications of equilibrium unemployment models. Because the demand for production labor decreases with both the tax and the generosity of the unemployment benefit, more workers are available for employment in R&D. Both effects increase unemployment but the net effect on the rate of creative destruction is ambiguous.

As is common in the literature, employment protection policy is modeled as a cost of terminating the employment of its workers. Because an increase in this cost reduces the return to job creation though innovation and entry, the growth rate is adversely affected by employment protection. Because the negative effect of employment protection on market tightness more than offset its negative effect on job destruction, the model also implies that unemployment rises.

The remainder of the paper is presented in five additional sections. The first contains a brief review of the related literature. The essential features of the Schumpeterian model of endogenous growth with a competitive labor market are presented in the second section. The notation used throughout the paper is also introduced in the section. In third section, a labor market with friction is incorporated into the model and conditions for existence and uniqueness of an equilibrium solution with positive rate of creative destruction are derived. The comparative static results, including those for the effects of labor market policies, are presented in the fourth section of the paper. The paper concludes with a brief summary of the its contributions and the author's suggestions for future research.

2 Related Literature

The bulk of the existing theoretical literature has focussed on the effects of growth, viewed as exogenous, on unemployment. Pissarides (1990) argues that a higher rate of growth in productivity will reduce unemployment through a positive "capitalization effect" on investment in job creation. Hoon and Phelps (1997) show that no relationship exists in the long run between the rate of growth and unemployment in their model but still use it to argue that those countries that experienced lower growth in factor productivity in the 70s and 80s should have suffered higher unemployment. In their Schumpeterian model of growth, Aghion and Howitt (1994) show that the process of "creative-destruction" can generate higher unemployment during periods in which new technologies and products replace old ones. Mortensen and Pissarides (1998) develop a model that has a capitalization and a creative-destruction effect. Which one dominates depends on the ease with which existing firms can move to the technology frontier. Although Aghion and Howitt (1998) do sketch a simple synthesis of the theory of unemployment and growth similar to the one presented here, they do not pursue its policy implications.

On the empirical side, there is no consensus regarding the sign of the correlation between growth and unemployment either across countries or across longer periods of time in the same country. Bean and Pissarides (1993) find no correlation between unemployment and measures of productivity growth across OECD economies. However, Hoon and Phelps (1997) report a strong positive association between the change in unemployment and the extent of the slow down in productivity growth over the same time period across the G7 countries. Caballero (1993) provides evidence of a weak positive time series relationship between growth and unemployment in the UK and US between 1966 and 1989 while Muscatelli and Tirelli (2001) find negative correlations for the other five G7 economies. Finally, Aghion and Howitt (1992) report that both high and low growth countries experience lower unemployment rate relative to those with intermediate rates of productivity growth among the 20 OECD countries included in their study. A simple scatter diagram of the average unemployment and average growth rate over the past ten years across 29 European countries is reported in Figure 1. (The specific country associated with each observation is reported in Table 1.) Consistent with the literature, the correlation is essentially zero.

Perhaps there is no consistent correlation between unemployment and growth because the two rates are simultaneous determined in market economies. If so, shocks to different common determinants in different countries and time periods can induce uncorrelated co-movements on average.

3 Creative Destruction with A Frictionless Labor Market

In this section, I restate the simplest Shumpeterian model of endogenous growth. The model borrows from both Grossman and Helpman (1991) and

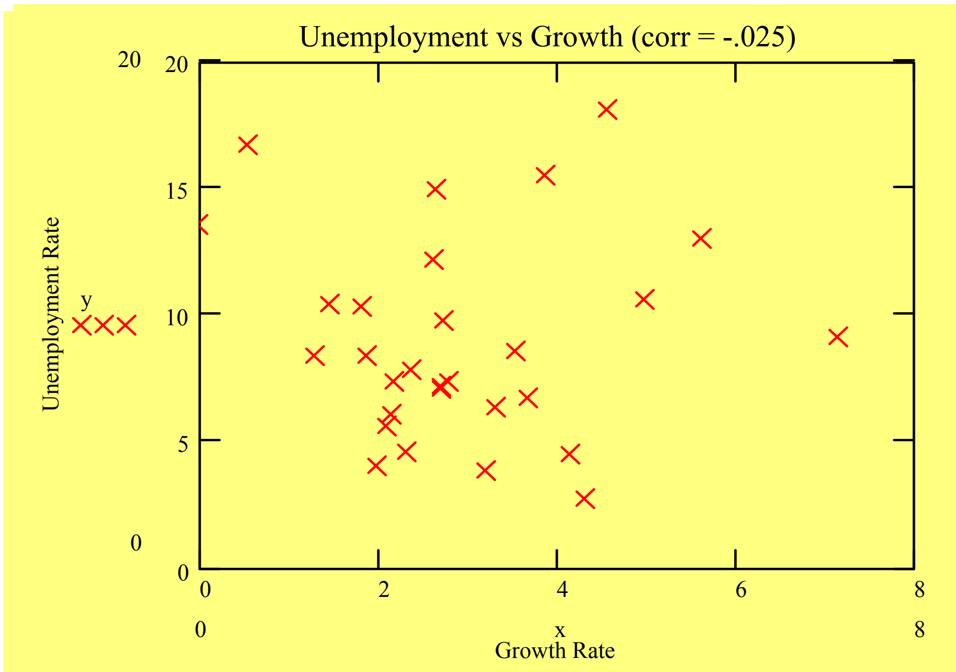


Figure 1: Unemployment vs GDP Growth (Source: EuroStat Structural Indicators)

Aghion and Howitt (1998). The purpose of the section is to layout notation and introduce the basic concepts.

3.1 Preferences and Technology

There is a unit continuum of identical households each with labor endowment ℓ. Intertemporal utility of the representative household at time t is

$$U = \int_t^\infty (\ln C_s - bn_s)\, e^{-\rho(s-t)} ds$$

where $\ln C_t$ denotes the instantaneous utility of consumption and n_t represents the measure of household members who are employed at date t. The discount rate is ρ and b denotes the disutility of work effort.

Each household is free to borrow or lend at interest rate r_t. Nominal household expenditure at date t is $E_t = P_t C_t$. Optimal consumption expenditure must solve the differential equation $\dot{E}/E = r_t - \rho$. Following

Grossman and Helpman (1991), I choose the numeraire. so that $E_t = E$ for all t without loss of generality, which implies

$$r_t = \rho \text{ for all } t. \tag{1}$$

Note that this choice of the numeraire also implies that price of the consumption good, P_t, falls over time at a rate equal to the rate of growth in consumption. Finally, every household supplies its entire labor endowment it the wage, w_t, exceed the opportunity cost of employment b.

The quantity of the consumption produced is determined by the quantity and quality of the economy's intermediate inputs. Specifically, there is a unit continuum of inputs and consumption is determined by the production function

$$\ln C_t = \int_0^1 \ln(A_t(j)x_t^\alpha(j))dj = \ln A_t + \alpha \int_0^1 \ln x_t(j)dj \tag{2}$$

where $x_t(j)$ is the quantity of input $j \in [0,1]$ at time t, $A_t(j)$ is the productivity of input j at time t, and $\alpha \in (0,1)$ is the elasticity of output with respect to every input. The level of productivity of each input is determined by the number of technical improvements made in the past. Specifically,

$$A_t(j) = q^{J_t(j)} \text{ and } \ln A_t \equiv \int_0^1 \ln A_t(j)dj = \ln(q) \int_0^1 J_t(j)dj$$

where $J_t(j)$ is the number of innovations made in input j up to date t and $q > 1$ denotes the quantitative improvement (step size) in productivity attributable to any innovation.

The model is constructed so that a steady state growth path exists with the following properties: Final output grows at a constant rate while the quantities of inputs produced and the endogenous innovation frequency are stationary and the identical across all intermediate goods. As a consequence of the law of large numbers, the assumption that the number of innovations to date is Poisson with arrival frequency δ for all intermediate goods implies

$$\begin{aligned} \ln C_t &= \ln A_t + \alpha \int_0^1 \ln x(j)dj = \ln(q) \int_0^1 EJ_j(t) \qquad (3) \\ &= \ln(q)\delta t. + \alpha \int_0^1 \ln x(j)dj. \end{aligned}$$

In other words, consumption grows at the rate of growth in productivity which is the product of the creative-destruction rate and the log of the size of an improvement in productivity induced by each new innovation. Furthermore, because the level of aggregate expenditure in terms of the numeraire, $E = P_t C_t$, is arbitrary, one can choose $P_t A_t = 1$ so that $E = \alpha \int_0^1 \ln x(j) dj$.

3.2 Firm Entry and Labor Market Clearing

Each incumbent firm is the sole supplier of a single intermediate good which it created at entry. It collects monopoly rents until its good is replaced in turn by a better one. Under the assumption that the final good sector is perfectly competitive, the price of each input is equal to the value of its marginal product. That is

$$p_t(j) = P_t \partial C_t / \partial x_t(j) = \alpha P_t A_t x_t^{\alpha-1}(j) = \alpha x_t^{\alpha-1}(j) \text{ for all } j \text{ and } t$$

from (3). Hence, the prices of intermediate goods are stationary if the quantity supplied is constant over time and the price of consumption good in terms of the numeraire depreciates at the rate of productivity growth. Each intermediate good is produced with labor services and labor productivity is the same across inputs. Without loss of generality, let labor productivity equal to unity. Hence, the demand for labor in the production of any input is

$$x_t(j) = \arg\max_x \{(p_t(j) - w_t)x\} = \arg\max_x \{\alpha x^\alpha - w_t x\}.$$

Note that this quantity is always the same over all input types but is also stationary if the wage is stationary. As these latter condition is satisfied along the steady state grow path of interest, aggregate labor demand for production purposes is

$$d(w) = \int_0^1 x_t(j) dj = \arg\max_x \{\alpha k x^\alpha - wx\} = \left(\frac{\alpha^2}{w}\right)^{\frac{1}{1-\alpha}}. \tag{4}$$

Finally, the common price charged for and the profit earned on each intermediate good are

$$p(w) = \alpha d(w)^{\alpha-1} = \frac{w}{\alpha} \tag{5}$$

and

$$\pi(w) = (p - w)d(w) = \left(\frac{1}{\alpha} - 1\right) \alpha^{\frac{2}{1-\alpha}} w^{-\frac{\alpha}{1-\alpha}} \tag{6}$$

respectively.[2]

The profit stream of any incumbent firm ends when its product is replaced by an improved version. Hence, the value of a continuing firm, its expected present value, is $V = \frac{\pi(w)}{r+\delta}$. The cost of innovation is the expected cost of the R&D effort required to discover and develop a new successful product. Hence, if a potential entrant obtains ideas for new products at frequency h per period, the expected opportunity cost of her effort per innovation realized is w/h, the expected earnings forgone during the required period of R&D activity. In the simple case in which every new innovation displaces an existing product, the rate of creative destruction is also the entry rate. Finally, because entry drives the value of a continuing firm down to its cost, the rate of creative destruction solves

$$\frac{w}{h} = V = \frac{\pi(w)}{r+\delta}. \tag{7}$$

The labor market is competitive. In equilibrium, workers are allocated across production and the R&D activities. Because a potential entrant innovates at frequency h, the total number workers engaged in R&D is δ/h since δ is the innovation frequency. The demand for production workers is $d(w)$. Hence, the equilibrium wage is the value that equates the total demand for labor to ℓ if larger than the opportunity cost b. Otherwise, the equilibrium wage is b. Formally,

$$\begin{aligned} d(w) + \frac{\delta}{h} &= \ell \text{ if } d(b) + \frac{\delta}{h} \geq \ell \\ \text{and } w &= b \text{ otherwise.} \end{aligned} \tag{8}$$

3.3 The Equilibrium Growth Path

A *equilibrium steady state growth path* is a stationary wage and creative destruction rate pair (w, δ) and an associated rate of growth in aggregate

[2] Of course, the previous supplier is a potential competitor. As the new product is q time more productive than the previous one, the discounted price of the old product is p/q. As the cost of production is w, the previous supplier is priced out of the market if and only if $p = \frac{w}{\alpha} \leq qw$ which requires $\alpha q \geq 1$. If this condition fails, then the innovator charges the limit price qw as Grossman and Helpman (1991) assume. Except for the effects of q on equilibrium quantities, the subsequent qualitative implications of the model are essentially the same in this case.

consumption, g, that satisfy the free entry condition (7), the labor market clearing condition (8) and

$$g = \delta \ln(q). \tag{9}$$

Since profit and the demand for labor are positive and strictly decreasing functions of the wage, a unique positive solution for the pair exists if and only if the solution to $rw_0 = h\pi(w_0)$ for w_0 exceed b, the opportunity cost of employment.

As is well known, off setting externalities exist in this model economy. Specifically, an innovation has a positive spill over benefit for consumers, a negative external effect on the supplier of the previous version of the product, and a positive knowledge spill over for future innovators. The net result can be either too much or too little creative destruction. Indeed, Aghion and Howitt (1998) show that the equilibrium rate of creative destruction is too low when the step size parameter q is large but is too high when the parameter is small relative to the value chosen by a benevolent social planner.

4 Growth and Unemployment

In this section, I incorporate labor market friction into the model along the lines reviewed in Pissarides (2000). Specifically, I assume that time is required to match workers and production job vacancies and that the wage paid a production worker is the outcome of bilateral bargaining that takes place only after the employer with a vacancy meets a prospective employee.

4.1 The Wage Bargain

In the standard model of labor market equilibrium with friction, workers cannot be instantaneously replaced and, as a consequence, workers have some market power. In the usual specification, the wage is regarded as the outcome of bilateral bargaining. As labor is the only input, the marginal revenue product of adding another worker, $p(x) = \alpha x^{\alpha-1}$, is the value of the marginal match. The employer has no immediate outside option and the only alternative open to the workers while bargaining is leisure activity. In this case, the outcome of a generalized strategic bargaining game is $w(x) = \beta p(x) + (1-\beta)b = \beta\alpha x^{\alpha-1} + (1-\beta)b$ where b is the value of leisure and β is a parameter reflecting the worker's relative bargaining power provided that the wage exceeds the flow value of unemployment.[3]

Given the bargaining outcome, each employer chooses the labor force size that maximizes profit taking the value of leisure as given. That is

$$x = \arg\max_x \{(p(x) - w(x))x\} = (1-\beta) \arg\max\{\alpha x^\alpha - bx\} = \left(\frac{\alpha^2}{b}\right)^{\frac{1}{1-\alpha}} \quad (10)$$

Of course, the associated price, wage, and profit flow are

$$p = \alpha x^{\alpha-1} = \frac{b}{\alpha} \quad (11)$$

$$w = w = \beta p + (1-\beta)b = \left(1 + \beta\frac{1-\alpha}{\alpha}\right) b \quad (12)$$

$$\pi = (p - w)x = (1-\beta)(1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}} b^{-\frac{\alpha}{1-\alpha}}. \quad (13)$$

The demand for production workers is independent of worker bargaining power because the profit maximizing labor force size also maximizes the total surplus captured by the firm and its workers. Indeed, the wage and firm size pair is the solution to the following generalized Nash bargaining problem over wage and employment:

$$(w, x) = \arg\max_{w,x}\{[(w-b)x]^\beta \left[(p-w)x\right]^{1-\beta}$$

Of course, the Nash solution is an efficient solution to the bargaining problem.

4.2 Innovation and Entry

Firm entry requires innovation. However, the acquisition of a production labor force takes time in a market with matching friction. Specifically, the value of the firm at the moment of discovery is determined by the asset pricing equation

$$rV = \eta\left(\frac{\pi}{r+\delta} - V\right)$$

[3] This is the solution to a non-cooperative bargain game of the Rubinstein type when it is impossible to search while negotiating. (See Binmore, et al. (1986)). In the models studied by Pissarides (2000), the outside option is typically assumed to be unemployed search. In that case the flow value of unemployment replaces b in the outcome equation. This alternative specification adds complexity but no new insight.

where the time required to fill its vacancies is exponentially distributed with expectation $1/\eta$.[4]

The expected labor time required per innovation is still $1/h$ as above. Any worker engaged in R&D is giving up the opportunity to search for a production job. In other words, each worker can choose between two activities, search and research in R&D. Both are investment opportunities that must yield the same expected present value of future income.[5] Hence, the expected investment cost is the product of the flow value of unemployment and the expected time required to innovate.

The asset pricing equations that determine the value of unemployed search, U, and the value of employment in a production job, W, are

$$rU = b + \lambda[W - U] \text{ and } rW = w + \delta[U - W]$$

where λ is the job finding rate and δ is the rate at which existing jobs are destroyed. As the free entry condition requires that expected cost equal the value of a firm at entry,

$$\frac{rU}{h} = \frac{(r+\delta)b + \lambda w}{(r+\delta+\lambda)\,h} = V = \frac{\eta\pi}{(r+\eta)(r+\delta)}. \tag{14}$$

Note that in the "frictionless" case in which no time is required for matching, $\lambda = \eta = \infty$, this condition reduced to equation (7).

4.3 Matching and Unemployment

As in the equilibrium unemployment literature, the aggregate rate at which vacancies are matched with workers in our economy is determined by a function of the numbers of unemployed workers and vacancies, denoted $M(v, u)$.

[4]Implicit in this specification is the assumption that a product cannot be replaced by a better one until after it appears on the market. This assumption is plausible because the technology of each innovation builds on the last one and reverse engineering is not possible until examples of the product or service are available for inspection.

[5]Many will view this assumption as unrealistic. Namely, in the real world R&D requires "skill" which is either an endowment that is distributed over the population or is acquired through education. Still these two alternative specifications require either that the marginal worker is indifferent between unemployed search and R&D activity or that the value of acquiring the needed education is equal to the value of unemployment respectively. My conjecture is that the comparative static implications of either specification are not materially different from those implied by the simpler model studied here.

By assumption the matching function is increasing, concave and homogenous of degree one in its arguments, vacancies v and unemployment u. As vacancies can be defined simply as the number of firms with job openings, the inflow into the stock of vacancies is the rate of creative destruction and the outflow is the rate at which vacancies are matched with workers. Given a linearly homogenous matching function, the steady state condition can be written as

$$\delta = M(v,u) = m(\theta)u \tag{15}$$

where $m(\theta) = M(v/u, 1)$ is the *job finding rate,* an increasing and strictly concave function of *market tightness,* defined as $\theta = v/u$.

Finally, unemployment is the difference between the labor force, which is taken as given, and the sum of workers employed in research and production activities by definition. Since the measure of products is unity and it takes x workers to supply each one, the employment identity requires

$$\ell = u + \frac{\delta}{h} + x. \tag{16}$$

4.4 The Steady State Growth Path

Because vacancies are filled at rate $\eta = M(v,u)/u = m(\theta)/\theta$ and the job finding rate is $\lambda = M(v,u)/u$, the free entry condition, equation (14), can be written as

$$b + \frac{m(\theta)(w-b)}{r+\delta+m(\theta)} = \frac{m(\theta)}{r\theta + m(\theta)} \times \frac{\pi h}{r+\delta} \tag{17}$$

The steady state matching condition, equations (15) and the employment identity, equation (16), require

$$\frac{\delta}{m(\theta)} = u = \ell - \frac{\delta}{h} - x. \tag{18}$$

An *equilibrium steady state growth path* is a vector (δ, θ, u, g) that satisfies equations (17), the two equations of (18), and equation (9) where (w, π, x) satisfies equations (12), (13) and (10)

Proposition 1 *Given $m(\theta)$ positive, increasing, concave, and $m(0) = 0$, a unique equilibrium with positive creative destruction exists if and only if*

$$\pi h > rb \text{ and } \ell > x. \tag{19}$$

Proof. Given that the job finding rate $m(\theta)$ is increasing and concave, the opportunity cost of innovation, the left side of (17), is increasing in labor market tightness while the right side, the value of research effort, is decreasing in θ. Although both decrease with the rate of creative destruction, the difference between the effect on cost, the partial derivative of the left with respect to δ, and the effect on return, the partial derivative of the right side, is positive. Formally, since $w > b$ from equation (12), it is

$$\begin{aligned} & -\frac{m(\theta)(w-b)}{(r+\delta+m(\theta))^2} + \frac{m(\theta)}{r\theta + m(\theta)} \times \frac{\pi h}{(r+\delta)^2} \\ = \quad & \frac{b}{r+\delta} + \frac{m(\theta)(w-b)}{r+\delta+m(\theta)}\left(\frac{1}{r+\delta} - \frac{1}{r+\delta+m(\theta)}\right) > 0 \end{aligned}$$

where the equality is obtained by substitution from (17). Hence, the entry condition defines a negative relationship between δ and θ. A unique positive solution to (17) for θ exists for every positive δ under the hypothesis if and only if profitability and research productivity are large enough relative to the discount rate and the opportunity cost of employment, i.e., $\pi h > rb$. In sum, the free entry condition, the restriction, and the implicit function theorem imply the existence of a strictly downward sloping relationship between the rate of creative destruction, δ, and market tightness, θ, which lies in the positive quadrant.

Equation (18) characterizes (δ, θ) pairs that equates the inflow of new vacancies with the flow of vacancies matched with workers. Since $m(\theta)$ is increasing and $m(0) = 0$ under the restrictions imposed on the matching function, this relationship has a positive slope and passes through the origin if and only if there are enough workers available to meet the production requirement at the outcome of the wage bargain, i.e., $\ell > x$. Along this curve, employment in research increases with θ because the expected time required to find a production job falls with labor market tightness.

The unique equilibrium lies at the intersection of the two curves implicitly defined by the entry and steady state matching conditions, equations (17) and (18) respectively. The properties of the two curves are illustrated in Figure 2 as EE and $0M$ respectively. ■

4.5 Equilibrium Growth and Unemployment

As before, the aggregate rate of growth, $g = \delta \ln q$, is solely determined by the rate of creative destruction while the steady state matching condition implies that the unemployment rate is given by $u = \delta/m(\theta) = g/\ln qm(\theta)$. Aghion and Howitt (1994) refer to the implication of this relationship that unemployment increases with the growth rate holding labor market tightness constant as the *direct creative destruction effect of growth on unemployment*. The negative slope of the curve representing the free entry condition, EE in Figure 2, reflects the effect of creative destruction on market tightness. Namely, a more rapid rate of job destruction reduces the value of innovation and entry. Hence, a decrease in labor market tightness, which both reduces the opportunity cost of research labor by lowering the value of unemployment and decreases the time required to fill a vacancy, is required to maintain the balance between the expected cost and return to entry as the rate of creative destruction increases. The negative effect of growth on unemployment implied by this relationship is referred to as the *indirect creative destruction effect* by the Aghion and Howitt (1994). Finally, Aghion and Howitt also point out in that paper, there is no *capitalization effect* of growth when the utility of consumption function is the log function as we have assumed.

The free entry condition is only part of the story. The remainder is embodied in the positive slope of the relationship between the creative-destruction rate and labor market tightness implied by the steady state condition and unemployment identity, represented as the $0M$ curve in Figure 2. Specifically, equation (18) implies that the rate of creative destruction must rise with θ because the demand for production workers is independent of both δ and θ. Since the labor force not employed in production is the divided between those doing research and those unemployed and unemployment falls with θ given δ, the rate of creative destruction must rise with market tightness along the $0M$ curve.

The following demonstration that the iso-unemployment curve defined by the steady state condition $\delta = m(\theta)u$ has a larger slope that the $0M$ curve formally implies that unemployment falls along the $0M$ curve as δ rises. Specifically, every such level curve intersects $0M$ only once and then from below. The expression for the derivative of an iso-unemployment curve is

$$\frac{\partial \delta}{\partial \theta}|_u = m'(\theta)u = \frac{\delta m'(\theta)}{m(\theta)}.$$

The derivative of the $0M$ curve is

$$\frac{\partial \delta}{\partial \theta}|_{0M} = \left(\ell - \frac{(1-\pi-\beta)}{(1-\beta)b}\right)\frac{h^2 m'(\theta)}{(h+m(\theta))^2} = \left(\frac{h}{h+m(\theta)}\right)\frac{\delta m'(\theta)}{m(\theta)} < \frac{\partial \delta}{\partial \theta}|_u$$

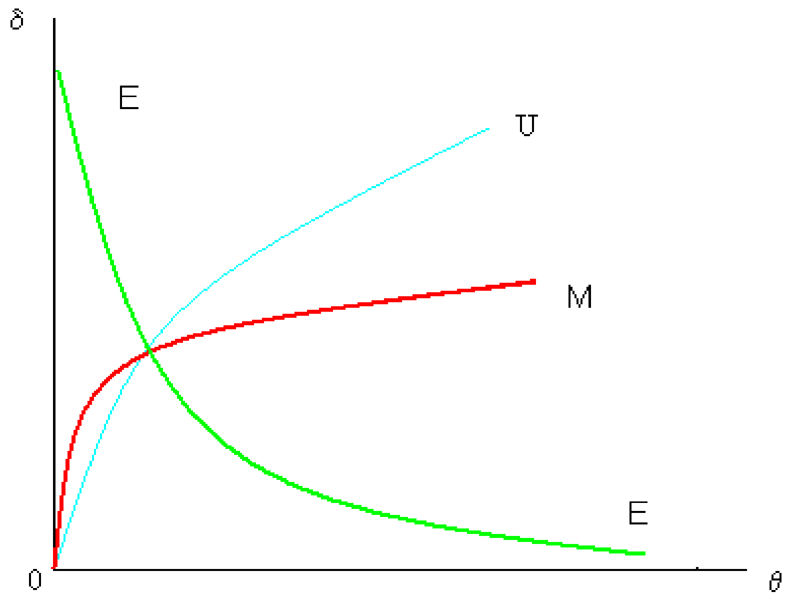


Figure 2: Equilibrium Creative-Destruction and Labor Market Tightness

when $\theta > 0$ where the second equality follows after substitution from equation (18). In sum, because the iso-unemployment curves cuts the $0M$ curve only once and from below, an increase in tightness more than offsets the negative effect of the rising value of the rate of creative destruction on unemployment.

This fact is also useful for determining how the equilibrium unemployment rate qualitatively depends on parameters of the model other than those that effect the matching function itself. In Figure 2, let the curve $0U$ represent the iso-unemployment curve defined by $u = \delta/m(\theta)$ and the equilibrium level of unemployment. It follows that any parameter change, other than a parameter of the matching function itself, with the property that the new equilibrium lies to the left (right) of $0U$ induces an increase (decrease) in equilibrium unemployment.

Since growth and unemployment are jointly determined in the economy studied, the model has no clear implication about how the two might be empirically correlated. Indeed, the fact that the $0U$ curve is more steeply sloped that the $0M$ curve implies that shocks to the $0M$ curve identify the positive relationship between the growth and unemployment implied by the entry condition while shocks to the EE curve trace out the negative relationship between the two implicitly defined by the steady state condition and employment identity. One needs to derive the relationships implied by the model between each of the endogenous variables and their joint determinants and use these implications to test the theory.

5 Comparative Statics

In this section, we study the factors that jointly determine growth and unemployment in our stylized environment when a strictly positive equilibrium solution to the model exists.

From equations, (12), (13), and (10), an increase in the worker's bargaining power, β, increases the wage and decrease profit, but has no effect on the number for production workers. Since an increase in the wage increases the cost of innovation and a decrease in profit decreases the return, equation (17) implies that the level of market tightness consistent with free entry decreases with the wage given the rate of creative destruction. In other words, the EE curve in Figure 2 shifts down in response to an increase in β. As the bargaining power parameter has no direct effect on any of the terms of equation (18), the OM curve is unaffected. Hence, the net result is a decrease in labor market tightness and a reduction in creative destruction. Because the new point of intersection is strictly to the left of the $0U$ curve, equilibrium unemployment rises.

Proposition 2 *An increase in β decreases both labor market tightness and the rate of creative destruction. Because the effect on market tightness more than offsets the effect on the rate of job destruction, unemployment rises.*

Labor force supply shocks identify the positive relationship between growth and unemployment associated with the entry condition while interest rate shocks trace out the negative relationship implicit in the steady state matching condition. Specifically, an increase in ℓ shifts the $0M$ curve up but has no effect on the entry condition. Hence, labor market tightness decreases while the equilibrium growth and unemployment rates both increase. Shifts in EE curve induced by interest rate shocks traces out the decreasing relationship between unemployment and growth implied by the $0M$ curve because the latter does not directly depend on r. Hence, an increase in the interest rate decreases the growth rate and increases the rate of unemployment as in the endogenous growth model without market friction and the matching model with exogenous growth respectively imply.

Proposition 3 *(i) An increase in the available labor force, ℓ, decreases labor market tightness and increases the rate of creative destruction. As a consequence, both unemployment and growth rise in response to a positive labor supply shock. (ii) A higher interest rate, r, decreases both labor market tightness and the rate of creative destruction. Furthermore, unemployment rises and the growth rate falls with a positive interest rate shock.*

From equations (17) and (18), an increase in research productivity as reflected in an increase in h shifts both curves upward in Figure 2. The value of δ required to solve the entry condition locus increases with h because the expected cost of entry through innovation decreases with h. The value required to solve the steady state condition shifts up because an increase in h reduces the demand for research labor given the rate of creative destruction. Holding labor market tightness constant, the creative-destruction rate must rise to maintain an equilibrium for both reasons, as the endogenous growth model with no market friction implies. Because the two effects on market tightness offset one another, the induced change in both tightness and unemployment are ambiguous in sign.

Proposition 4 *An increase in research productivity h induces an increase in the rate of creative destruction. However, the net effects on both labor market tightness and unemployment are both ambiguous.*

5.1 Labor Market Policy Effects

There is a substantial literature on the theoretical effects of passive labor market policies, specifically unemployment compensation, payroll taxes and employment protection policies, on unemployment in the setting of equilibrium unemployment models.[6] Studies of the effects of these policies on growth are less common. The fact that the model set out here can be used to gain insights into how these labor market policy affects both growth and unemployment represents an important contribution of the paper. In the model

[6] See Mortensen and Pissarides (1999b) for a more extensive discussion and literature review.

below, τ represents a proportional payroll tax paid by the employer and T denotes the cost of shutting down production at the end of a product's life implicit in the set of restrictions on worker termination imposed by contract and government mandate. At the level of abstraction built into this model, an increase in unemployment compensation is equivalent to an increase in the opportunity cost of employment, the parameter b in the model. However, since we have implicitly assumed that household can pool idiosyncratic unemployment risk, there is no economic role for unemployment compensation schemes in the model. Hence, one needs to be some what circumspect regarding its implied effects of unemployment compensation reform.

Consider a payroll tax. Although employers pay the tax, the Nash bargaining wage and employment outcome pair is

$$(w, x) = \arg\max_{w,x} \{ [(w-b)x]^{\beta} [(p - w(1+\tau))x]^{1-\beta} .$$

Because the first order condition for an optimal choice of the wage given x is

$$\frac{\beta}{w-b} - \frac{(1+\tau)(1-\beta)}{p - w(1+\tau)} = 0$$

and $p = \alpha x^{\alpha-1}$, the optimal production employment maximizes both profit and joint surplus. That is

$$\begin{aligned} x &= \arg\max_{w,x} \{ [(w-b)x]^{\beta} [(p - w(1+\tau))x]^{1-\beta} \\ &= \arg\max_{x} \{ (p - w(1+\tau))x \} \\ &= \arg\max \{ \alpha x^{\alpha} - b(1+\tau)x \} = \left(\frac{\alpha^2}{b(1+\tau)} \right)^{\frac{1}{1-\alpha}} . \end{aligned} \tag{20}$$

As a consequence,

$$p = \alpha x^{\alpha-1} = \frac{b(1+\tau)}{\alpha} \tag{21}$$

$$w = \beta \frac{p}{1+\tau} + (1-\beta)b = \left(1 + \beta \frac{1-\alpha}{\alpha} \right) b \tag{22}$$

$$\pi = (p - w(1+\tau))x = (1-\beta)(1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}} (b(1+\tau))^{-\frac{\alpha}{1-\alpha}} . \tag{23}$$

Because the price of intermediate goods is simply a markup over the total opportunity cost of the match, the net effect of the tax on the wage is zero.

Indeed, because the effect is equivalent to that of a tax on the value of the outside option, both employer profit and the number of workers employed for production purposes are adversely affected by it.

Given that cost of employment protection, T, represents the cost of shutting down a firm, the value of the firm once the production workers are hired solves $rV_1 = \pi - \delta(V_1 + T)$ which implies $V_1 = (\pi - \delta T)/(r + \delta)$. Because the expected value of the firm after an innovation but before its vacancies are filled is given by the solution to $rV = \eta(V_1 - V)$, the value of the firm at the moment of innovation is

$$V = \frac{m(\theta)}{r\theta + m(\theta)} \times \frac{\pi - \delta T}{r + \delta}$$

where the vacancy filling rate is $\eta = m(\theta)/\theta$.

The free entry condition takes the form

$$rU = b + \frac{m(\theta)(w-b)}{r + \delta + m(\theta)} = Vh = \frac{m(\theta)h}{r\theta + m(\theta)} \times \frac{\pi - \delta T}{r + \delta}. \tag{24}$$

in the extended model. The employment identity and the steady state matching condition imply

$$\frac{\delta}{m(\theta)} = u = \ell - \frac{\delta}{h} - x. \tag{25}$$

Now, the steady state equilibrium value of the vector (δ, θ, u) is determined as the solution to equation (24) and the two equations of (25) where the wage, profit, and employment in production are functions of parameters determined by equations (22), (23) and (20).

The existence and uniqueness result, Proposition 1, continues to hold as stated for this extension to the model. The qualitative properties of Figure 2 are also the same.

Because the payroll tax has no effect on the wage the worker receives but does decrease both profit and demand for production workers, an increase in the tax shifts the EE curve down and the $0M$ curve up in Figure 2. Hence, labor market tightness fall and unemployment rises but the net effect on the rate of creative destruction is ambiguous.

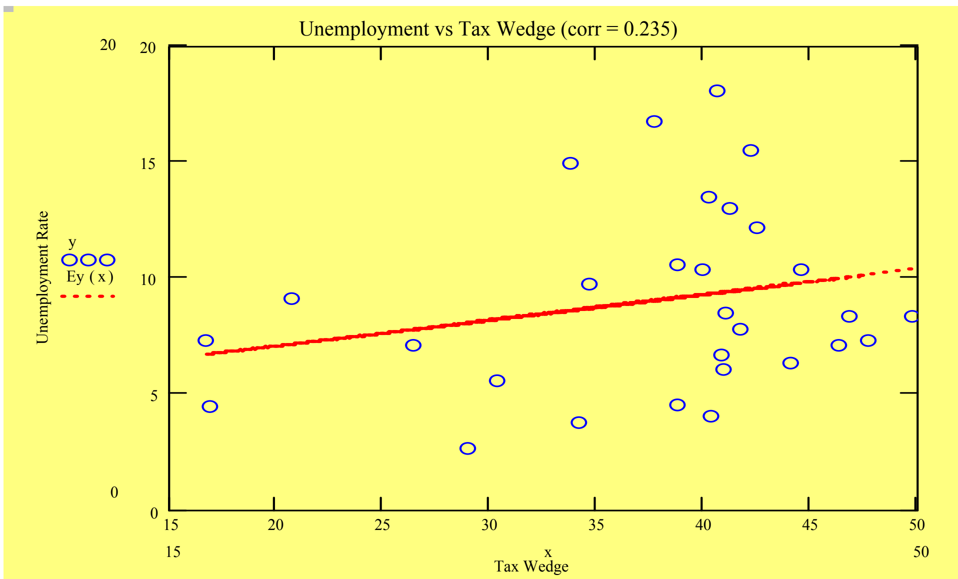
Proposition 5 *An increase in the payroll tax rate, τ, decreases market tightness and increases unemployment even though the sign of the net effect on the rate of creative destruction is ambiguous.*

By reducing the expected value of entry, employment protection shifts the entry locus EE down in Figure 2 but has no direct effect on either the steady state matching condition or the unemployment identity. The result is a decrease in both labor market tightness and the rate of creative destruction. Furthermore, because growth and employment move together along the $0M$ curve, the effect of employment protection is an increase in an unemployment as well as a decrease in the rate of growth.

Proposition 6 *An increase in the cost of employment protection, T, decreases both market tightness and the rate of creative destruction. Furthermore, the net effect on unemployment is positive.*

The model's implications for the effect of employment protection policy differ from those of related papers by Hopenhayn and Rogerson (1993) and by Mortensen and Pissarides (1994). In the Hopenhaym-Rogerson model, the job destruction rate is exogenous. Consequently, the only effect of a firing tax is on job creation which is negative. In contrast, the job destruction rate is endogenous in the Mortensen-Pissarides model but is independent of the rate of job creation. Because employment protection taxes the decision to layoff workers, job destruction falls with the cost of termination. As this effect can dominate the impact of employment protection on job creation, unemployment can fall with a firing tax in their model. In this model, the job destruction rate is the rate of creative destruction. It falls because the firing tax reduces the value of innovation. The rise in unemployment in the model is the consequence of the fact that the cost of production labor and, therefore, the demand for production workers is invariant with respect to a firing cost. Hence, the decrease in the demand for research workers associated with the negative effect of employment protection on the rate of creative destruction necessarily increases the aggregate level of unemployment.

The existing empirical literature neither confirms nor contradicts the implications of Propositions 5 and 6. Never the less, it is of interest to note that both are consistent with recent cross country experience for an extended set of European economics. In particular, Figures 3 and 4 contain scatter plots with average growth and unemployment rates over the past ten years represented on the vertical axes respectively and the Eurostat estimate of the tax wedge present in each of 29 European economies in their sample. As illustrated in the figures, unemployment is positively correlated and growth is negatively correlated with the tax rate on labor income. Similarly, the same growth and unemployment rate observations for a subsample of 17 countries are plotted against the OECD overall employment protection legislation (EPL) index in Figures 5 and 6.[7] In this case, the correlations are not only consistent with the model but are even larger in magnitude. Although cross county comparisons of these kind constitute the most naive evidence, there is no obvious alternative candidate explanation for these correlations.



28 European Countries (1992-2003)

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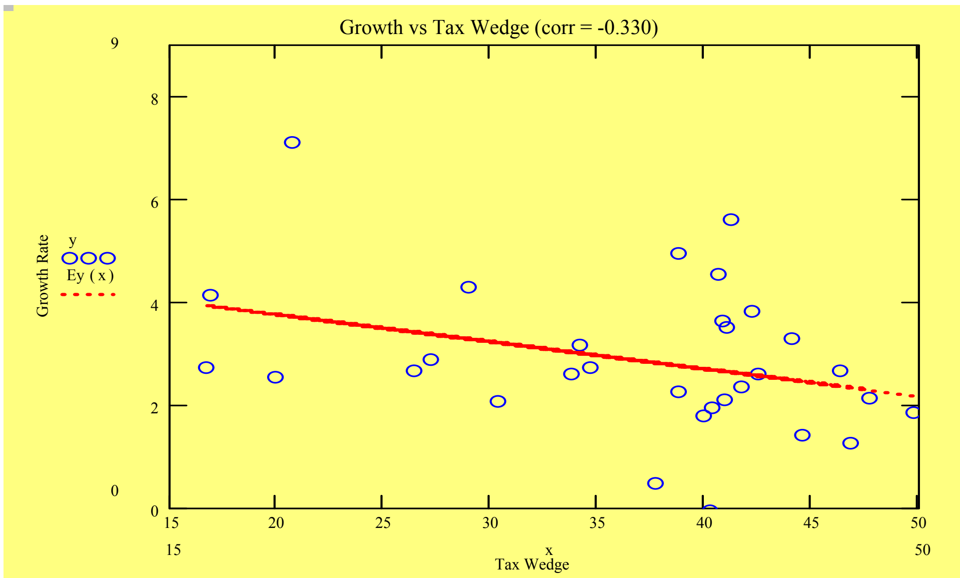
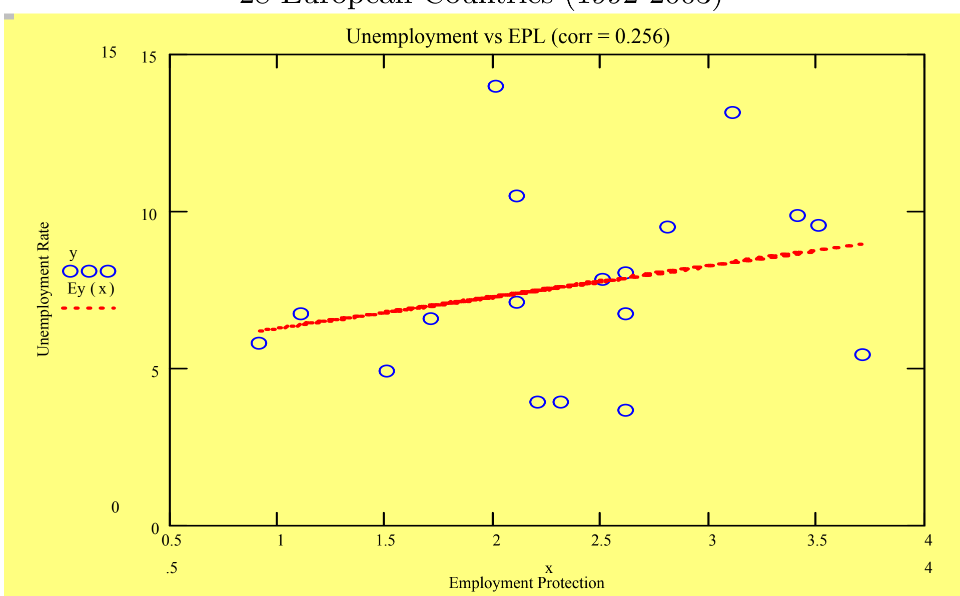
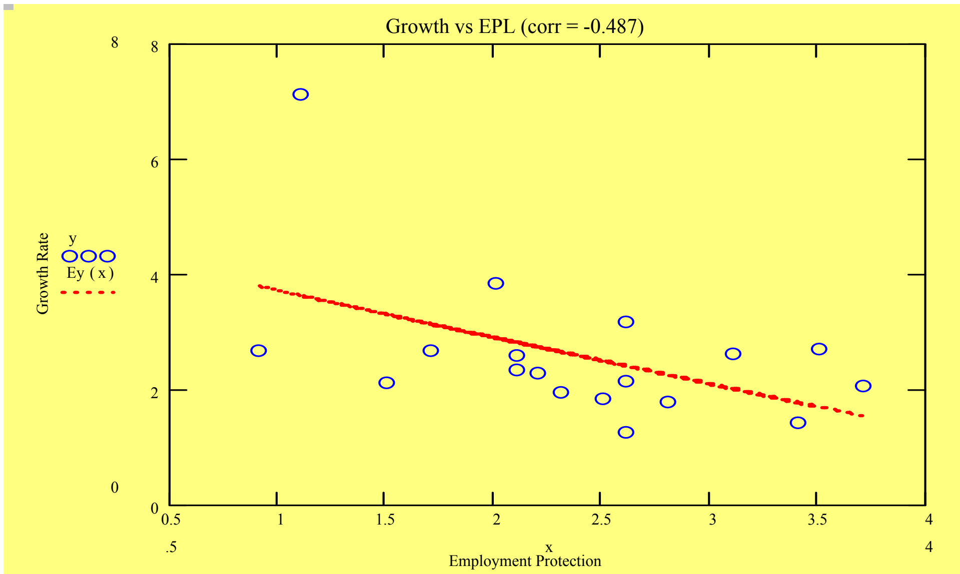
[7]The specific countries in each sample and the data associated with each are reported in tables found in the data appendex.



28 European Countries (1992-2003)



18 European Countries (1992-2003)



18 European Countries (1992-2003)

6 Conclusions and Suggestions for Research

The purpose of this paper is to sketch a simple model of endogenous growth and unemployment and to explore its implications for the effects of tax and employment protection policies. The implication of the model is that both policies increase unemployment. Although the effect of a tax on growth is qualitatively indeterminate, employment protection policy adversely affects the incentive to innovate. According to the model, then, reform efforts intended to improve labor market performance will reduce unemployment but may also encourage the investments in R&D needed for higher rates of long term growth. Cross country correlations between both unemployment rates and growth rates and measures that reflect labor taxes and the extent of employment protection are consist with these implications. I offer these results as a challenge to interested researchers and policy makers. Are the theoretical results and the empirical correlations robust? Will they hold for more realistic specifications of the model? Is there an obvious alternative interpretation of the cross country correlations that seem to characterize the data on the relationship between labor market and growth outcome to labor market policy measures?

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7 Data Appendix

Country	EPL Index**	GDP Growth*	Tax Wedge*	Un Rate*
Belgium	2.5	1.85	49.7	8.4
Czech Republic	2.1	2.36	41.6	7.8
Denmark	1.5	2.12	40.8	6.1
Germany	2.6	1.26	46.7	8.3
Estonia		4.95	38.7	10.6
Greece	3.5	2.72	34.6	9.8
Spain	3.1	2.62	33.7	15.0
France	2.8	1.80	39.9	10.4
Ireland	1.1	7.12	20.6	9.1
Italy	3.4	1.43	44.5	10.4
Cyprus		4.13	16.8	4.5
Latvia		5.61	41.1	13.0
Lithuania		-0.05	40.1	13.5
Luxembourg		4.30	28.9	2.7
Hungary	1.7	2.68	46.2	7.2
Netherlands	2.2	2.28	38.7	4.6
Austria	2.3	1.95	40.2	4.0
Poland	2	3.84	42.1	15.5
Portugal	3.7	2.07	30.2	5.6
Slovenia		3.64	40.7	6.7
Slovakia		4.55	40.5	18.1
Finland	2.1	2.61	42.4	12.2
Sweden	2.6	2.15	47.6	7.4
United Kingdom	0.9	2.68	26.3	7.1
Bulgaria		0.50	37.6	16.8
Romania		3.30	44.0	6.3
Turkey		3.52	40.9	8.5
Norway	2.6	3.18	34.1	3.8

Sources:
*Eurostat Structural Indicators (1992-2003) Averages
***OECD Employment Outlook (1999)*

Data for Figures 1, 3, 4, 5, and 6