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*“Searching, Matching and Education:
a Note”*

João Cerejeira Silva

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NÚCLEO DE INVESTIGAÇÃO EM POLÍTICAS ECONÓMICAS
UNIVERSIDADE DO MINHO

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Searching, Matching and Education: a Note

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July, 2005

Abstract

In this paper the individual optimal level of education is set in a frictional labor market, where matching is not perfect. Also search frictions are a function of the average education of the labor force. Therefore, an increase in the average education can improve economic efficiency, not only through improvements in workers productivity, but also making the matching process more efficient, and thus reducing the unemployment level.

Keywords: Education, Externalities, Search, Matching, Unemployment

JEL: I21, J41, J64

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In this paper the individual optimal level of education is set in a frictional labor market, where matching is not perfect. Also search frictions are a function of the average education of the labor force. Therefore, an increase in the average education can improve economic efficiency, not only through improvements in workers productivity, but also making the matching process more efficient, and thus reducing the unemployment level.

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1. Introduction

In modern economies, a large portion of human capital investments takes place in the form of education. While the main contributions of the role of education to economic outcomes are mainly in its importance to economic growth or to explain wage inequality, little has been done to understand how education choices interact with wage and unemployment determination in a frictional labor market, where matching is not perfect. As noted by Holzer (1987) and Montgomery (1991), informal networks are more important in generating job offers and acceptances than other formalized methods (such as job placement centers or newspaper advertisements), for low-skilled labor markets. Therefore, it may be possible that an increase on the education of the labor force could improve the efficacy of the matching process, decreasing the frictions in the labor market.

There are some papers that have analyzed the schooling and capital investments decisions in labor markets characterized by search. Acemoglu (1996) shows how the return to a worker can increase in the skill level of competing workers. Laing,

Palivos and Wang (1995) examine an endogenous growth model in which labor market frictions are an integral part of the economic environment. Acemoglu (1997) shows that in a frictional labor market, part of the productivity gains from general training will be captured by future employers.

Our paper closely follows the paper of Laing, Palivos and Wang (1995), however we consider a framework where education of the workforce not only affects the workers' productivity, but also can improve the efficiency of the matching process. We utilize the 'matching and bargaining' framework presented in Bagliano and Bertola (2004), which combines elements of the well known work of P. Diamond, D. Mortensen and C. Pissarides. Section 2 describes the basic economic environment, namely the educational sector and the labor market. In this section we also present the assumptions concerning the matching function. Section 3 describes the wage determination process and exploits the impact of the educational choices undertaken by the workers on some labor market outcomes. Finally, section 4 concludes.

2. Basic environment

This section describes the economic environment. The economy is populated by a continuum of identical agents, each possessing an identical instantaneous discount rate over consumption of r . Workers are endowed with a unit of labor which they can supply to firms without disutility from effort. There are two sectors: an educational sector and a frictional labor market, in which vacancies and job-searching unemployed workers are brought together via a stochastic matching technology.

2.1. The educational sector

Workers choose a level of schooling s , and their productivity is equal to their knowledge $\phi(s)$.

Assumption 1: The function $\phi : \mathbf{R}_+ \rightarrow [0, 1]$ is strictly increasing, strictly concave and twice differentiable in s , satisfying: $\lim_{s \rightarrow 0} \phi(s) > 0$ and $\lim_{s \rightarrow \infty} \phi(s) < \bar{\phi} < 1$.

This assumption implies that there are diminishing returns to investment in education with a boundary condition ruling out omniscience.

2.2. The labor market and the matching function

Once workers have completed their schooling, they enter the labor market, become unemployed and search for employment. We define labor force as the sum of the employed (E) workers plus the unemployed (U) workers which we assume to be constant and equal to L units. Unemployed workers (U) and unfilled vacancies (V) are brought together by a stochastic *matching technology* $mL = A(\bar{s})m(U, V)$, which describes the instantaneous flow meeting rate between searching workers U , and unfilled vacancies V . The matching technology parameter $A(\bar{s})$ captures the efficiency of the matching process, and we assume that is an increasing function of the average education of the labor force.

Assumption 2: The function $m, m : \mathbf{R}_+^2 \rightarrow \mathbf{R}_+$ is strictly increasing, strictly concave, twice continuously differentiable and constant-returns-to-scale function of U and V , satisfying the Inada conditions ($\lim_{j \rightarrow 0} m_j = \infty, \lim_{j \rightarrow \infty} m_j = 0$, $j = U, V$) and the boundary conditions $Lm(0, V) = Lm(U, 0) = 0$.

An increase in U or V increases the instantaneous number of matches, but at a diminishing rate. The CRS assumption follows the main findings of the empirical

studies of the matching technology. Therefore, dividing both sides by L , we can write m as $m = A(\bar{s})m(u, v)$, where $u = U/L$ denotes the unemployment rate and $v = V/L$ is the ratio between the number of vacancies and the total labor force.

Under CRS, the instantaneous probability p that a worker finds a job is:

$$p = \frac{A(\bar{s})m(u, v)}{u} = A(\bar{s})m\left(1, \frac{v}{u}\right) \equiv A(\bar{s})p^*(\theta), \quad (1)$$

where $\theta \equiv \frac{v}{u}$ denotes the tightness of the labor market, measured by the ratio between the number of vacancies and unemployed workers. We also assume that $\frac{\partial p(\cdot)}{\partial \theta} > 0$ and $\frac{\partial^2 p(\cdot)}{\partial \theta^2} < 0$. Similarly, the rate at which a vacant job is matched to a worker is expressed as:

$$q = \frac{A(\bar{s})m(u, v)}{v} = A(\bar{s})m\left(1, \frac{u}{v}\right)\frac{v}{u} \equiv \frac{A(\bar{s})p^*(\theta)}{\theta} \equiv A(\bar{s})q^*(\theta). \quad (2)$$

The severity of market frictions are represented by $A(\bar{s})$, implying that an increase in the average education level of the workforce skills leads to a more efficient matching technology. This assumption is consistent with some empirical studies that show that more skilled workers have more diverse sources of information about job offers than less skilled workers (see Holzer (1987) and Montgomery (1991)). Therefore, job searchers with any kind of schooling level benefit more from interacting with more educated people, because these individuals have more valuable information concerning non filled vacancies.

3. Wage determination

3.1. Wage determination with exogenous schooling effort

We now will analyze the determination of the wage offer function. The match between a job-searcher worker and a vacancy will lead to a positive surplus to

be divided between the two parties, according to their relative bilateral strength (exogenously given). Adopting the *Nash bargaining* assumption, we will assume that the surplus appropriated by the worker in the wage negotiations is thus equal to a fraction β of the total surplus of the job. This surplus is equal to the difference between the value that a firm attributes to a vacancy (V) and to a filled job (J). We can express these values as:

$$rV(t) = -c + A(\bar{s})q^*(\theta(t)) \left[J(t) - V(t) + \dot{V}(t) \right], \quad (3)$$

$$rJ(t) = [\phi(s) - w(t)] + d \left[V(t) - J(t) + \dot{J}(t) \right], \quad (4)$$

and therefore,

$$r [J(t) - V(t)] = [\phi(s) - w(t) + c] + [d + A(\bar{s})q^*(\theta(t))] [V(t) - J(t)] + [\dot{J}(t) - \dot{V}(t)]. \quad (5)$$

The flow return of the total surplus of the job is equal to the flow return of a filled job vacancy $[\phi(s) - w(t) + c]$, which is equal to the flow output minus the wage $\phi(s) - w(t)$ plus the saving of the cost of keeping a vacancy open c . To this, we have to add the net capital loss, in case the job is destroyed (with probability d) net of the capital gain in case the job is filled with a worker, which occurs with probability $A(\bar{s})q^*(\theta(t))$.

Focusing on steady state equilibria we can impose $\dot{J} = \dot{V} = 0$ and due to free entry assumption $V = 0$. Therefore, from 3 and 4, we get:

$$\begin{cases} J = \frac{c}{A(\bar{s})q^*(\theta(t))} \\ J = \frac{\phi(s) - w}{r + d} \end{cases}, \quad (6)$$

and combining both expressions we have:

$$\phi(s) = w(t) + (r + d) \frac{c}{A(\bar{s})q^*(\theta)}. \quad (7)$$

This equation means that the worker's marginal productivity $\phi(s)$ must compensate the firm for the wage w paid to the worker and for the flow cost of opening a vacancy $(r + d) \frac{c}{A(\bar{s})q^*(\theta)}$. Note that this cost is decreasing in $A(\bar{s})$, which means that as the labor force becomes more educated, the wage paid by the firm to the worker approximates its competitive level, which is equal to his marginal productivity.

Similarly, we can express the flow return to a worker from accepting a job as $r(E - U)$, where E and U denotes the value that a worker attributes to employment and unemployment, respectively. Thus:

$$rE(t) = w(t) + d \left[U(t) - E(t) + \dot{E}(t) \right], \quad (8)$$

$$rU(t) = z + A(\bar{s})p^*(\theta(t)) \left[E(t) - U(t) + \dot{U}(t) \right], \quad (9)$$

and

$$r[E(t) - U(t)] = [w(t) - z] + [d + A(\bar{s})p^*(\theta(t))] [U(t) - E(t)] + \left[\dot{E}(t) - \dot{U}(t) \right], \quad (10)$$

where z represents the value of the unemployment benefits or leisure.

Restricting attention to steady state equilibria, where $\dot{E} = \dot{U} = 0$, and keeping the other parameters constant over time, the above equation gives:

$$E - U = \frac{w - z}{r + d + A(\bar{s})p^*(\theta)}, \quad (11)$$

which means that the surplus of the worker depends positively on the difference $w - z$, and negatively on the separation rate d , on the tightness of the labor market θ and on \bar{s} , the average schooling of the workforce. This means that an increase on the instantaneous probability p that an unemployed worker finds a

job, reduces the average length of an unemployment spell, decreasing the surplus of the employment to the worker.

By the Nash bargaining assumption, we know that

$$E - U = \beta [(J - V) + (E - U)], \quad (12)$$

which means that the surplus appropriated by the worker is a fraction β of the total surplus. Therefore, using 11 and 6 and the above equation, we can obtain the following expression for the wage:

$$w = z + \beta(\phi(s) + c\theta - z). \quad (13)$$

The wage is the sum of the unemployment benefits or leisure z , plus the fraction β of the total surplus of a filled job $\phi(s) + c\theta - z$. It is important to note that education affects the equilibrium wage only through the worker productivity $\phi(s)$ and not through the efficiency of the matching process, because the effect of the average education on $E - U$ cancels out with the effect on $J - V$.

3.2. *Wage determination with endogenous schooling effort*

We now consider the optimal choice of education by workers in the economic environment described above. Investment in education raises the worker's stock of human capital, and therefore their productivity, but is a costly decision in terms of its effort disutility or direct pecuniary costs. Let $k(s)$ denote the utility cost to workers to acquire the level s of schooling. We assume that the function k is strictly increasing, twice continuously differentiable and convex in s . Note that once workers have completed their schooling, they enter the labor market, become unemployed, and search for employment. Therefore each individual, taking the

matching parameters β , θ and $A(\bar{s})$ as given, has to solve the following optimization problem:

$$\text{Max } [U - k(s)].$$

Through equations 9 and 8, we get:

$$U = \left[\frac{1}{r(r+d+A(\bar{s})p^*(\theta))} \right] [(r+d)z + A(\bar{s})p^*(\theta)w], \quad (14)$$

and we can characterize the first order condition as:

$$\begin{aligned} \frac{\partial U}{\partial s} - \frac{\partial k(s)}{\partial s} &= 0 \Leftrightarrow \\ \left[\frac{A(\bar{s})p^*(\theta)}{r(r+d+A(\bar{s})p^*(\theta))} \right] \left[\frac{\partial w}{\partial s} \right] &= \frac{\partial k(s)}{\partial s} \Leftrightarrow \\ \left[\frac{A(\bar{s})p^*(\theta)}{r(r+d+A(\bar{s})p^*(\theta))} \right] \left[\beta \frac{\partial \phi(s)}{\partial s} \right] &= \frac{\partial k(s)}{\partial s}. \end{aligned} \quad (15)$$

Individuals invest in education in order to increase their productivity $\phi(s)$ and hence their wage once employed. Factors which influence wage income (z , β , c or θ) or matching probabilities alter workers schooling effort.

The average level of education of the workforce also affects the individual schooling effort, because an increase in \bar{s} implies an increase in the ratio $\frac{A(\bar{s})p^*(\theta)}{r(r+d+A(\bar{s})p^*(\theta))}$. Note that $\lim_{A(\bar{s}) \rightarrow \infty} \frac{A(\bar{s})p^*(\theta)}{r(r+d+A(\bar{s})p^*(\theta))} = 1/r$, which means that without frictions in the searching process, the first order condition simplifies to

$$\frac{1}{r} \left[\frac{\partial w}{\partial s} \right] = \frac{\partial k(s)}{\partial s}, \quad (16)$$

which simply says that the optimal amount of schooling s^* is the one that equates the discounted total marginal wage income to the marginal cost of schooling $\frac{\partial k(s)}{\partial s}$.

Similarly, $\lim_{A(\bar{s}) \rightarrow 0} \frac{A(\bar{s})p^*(\theta)}{r(r+d+A(\bar{s})p^*(\theta))} = 0$, which means that there are no matches in the economy, and therefore individuals do not invest in their own education. Thus there exists a strategic complementarity between workers in this economy: an increase in the education of the others increases the marginal return of education of the worker, who will respond to this by raising his own educational level. The existence of multiple equilibria requires the condition $\frac{\partial s^*}{\partial \bar{s}} > 1$, which depends on features of the function $A(\bar{s})$. In this case, government can act as a ‘market-maker’, and keep the economy away from ‘poor’ equilibria, characterized by a low schooling effort and an inefficient labor market.

Average education also affects the unemployment level: from the steady state relationship between unemployment rate and $A(\bar{s})p^*(\theta)$, $u = d/[d + A(\bar{s})p^*(\theta)]$, we can infer that as \bar{s} increases, u decreases, because the unemployment spells become shorter.

As in Laing *et al* (1995), our results show that an increase in the average education of the labor force not only promotes their productivity, but also mitigates market frictions. As market frictions decrease, new generations of workers have more incentive to undertake schooling, which can raise the growth rate and decreasing unemployment.

4. Conclusion

In this paper we try to understand how education choices interact with wages and unemployment determination in a frictional labor market, where matching is not perfect. The individual optimal level of education is shown to be a function of the search frictions and on the educational choices of the others. An increase in the average education can improve economic efficiency, not only through improvements

in workers productivity, but also by making the matching process more efficient, and thus reducing the unemployment level.

There are many possible ways to expand this work. First, one interesting possibility is to more thoroughly explore the conditions under which multiple equilibria can occur. Secondly, a more dynamic framework might be considered, analyzing the case in which the stock of human capital grows, not only through education, but also through the worker's labor market experience. This would help us to better understand these channels of educational externalities, and give theoretical support to empirical analysis.

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