Matching, Education Externalities and the Location of Economic Activity

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Para Cordelia con todo mi amor

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Abstract

In this thesis we demonstrate how important the existence of a pool of qualified workers within the local labour market is for the process of job creation and the location of economic activity.

In chapter 1 the basic theoretical model is developed. Using a matching model it is shown that Job Creation will be higher if firms have a larger pool of qualified workers from which to fill their vacancies, since their expected profits per vacancy opened will be greater. At the same time, individuals have a higher incentive to invest in education if job creation is higher. The interaction between these two forces generates a pecuniary externality in the labour market.

In chapter 2, we extend the theoretical model by considering two regions and the possibility of migration. In equilibrium, areas where the pool of qualified workers is larger attract more jobs and skilled workers. Job Creation will be higher in such areas since firms located there are able to find a more qualified worker with greater ease. At the same time, given the sunk cost of moving, only the most skilled workers will find migration to these areas worthwhile. The interaction between these two forces generates a pecuniary externality that encourages concentration of economic activity in areas with a larger pool of qualified workers.

In chapter 3 we estimate the effect of the pecuniary education externality on the process of matching in the UK regional labour market in the 1990s. We find a significant effect of the average level of education in a region on the conditional probability of finding a job in that region using a duration model. This effect is positive for skilled occupations and negative for unskilled ones.

Finally, in Chapter 4 we estimate the effect of the education externality on the individual decision to stay-on in education. We find that the share of the region's working age population with degree has a positive and significant effect on the education decisions of sixteen and eighteen year-olds, while the share with high vocational has a similar effect for seventeen year-olds.

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Job creation and increasing returns to human capital

1.1 Introduction

In this chapter we show that the interaction between ex-ante investment decisions of heterogeneous individuals and firms in a labor market with search frictions generates a positive externality on the accumulation of human capital and the possibility of multiple equilibria. When individuals have to invest in education prior to entering the labor market and firms have to decide to open a vacancy before meeting a worker, in a labor market characterized by search frictions, there will exist a positive spill-over from each individual's investment in human capital to the rest of the society.

In general, individuals make their education decisions when young, well before entering the labor market. This decisions will thus be based on the expected probability to find a job and earn a wage. On the other hand, firms normally have to decide whether to incur in the cost of opening a vacancy or not, before knowing which worker they will be matched with. This means that they will base their decision on the expected profits from opening a vacancy, which will depend on the expected average of human capital among individuals. Therefore any exogenous change in the level of education of some workers will increase the expected profits per vacancy, augmenting job creation and the employment rate. This will improve every individual's expectations about the labor market and in turn will give incentives to everyone to increase his investment in human capital. At an aggregate level, the existence of increasing returns might generate different equilibria dependent on the underlying parameters. Some economies might get stuck at a low employment, low aggregate level of human capital equilibrium, while others will enjoy full employment and high skill level, depending on the underlying characteristics of each economy.

The interesting feature of this externality is that it does not depend on the existence of increasing returns to scale neither in the production function, nor in the matching function. It is only due to the combination of heterogeneity of workers and search frictions in the labor market.

This externality is generated by a similar mechanism to the one in Acemoglu (1996), which he called, pecuniary externality. Acemoglu shows that the interaction between ex-ante investment in human capital by individuals and in physical capital by firms in a labor market with frictions, generates increasing returns to human capital. The main difference with this work is that he assumes full employment, equal to the population size. We study equilibria with unemployment deriving richer results about the features of labour markets characterised with this externality. In addition, this model provides a simple reduced form expression which will be used in chapters 3 and 4 to test the existence of the externality in the individual education decisions and unemployment durations. This also allows for a fairly simple analysis of the social planner's solution.

When we introduce physical capital in the model, the positive externality on human capital accumulation is generated through two different sources: job creation and physical capital accumulation by the firms matched with the more skilled workers. When some individuals raise their investment in human capital, firms expect to be matched with a more skilled worker, so expected profits increase and they open more vacancies, raising the level of employment. At the same time, the firms which are matched with more skilled workers will increase their physical capital, increasing even further the expected profits and the number of vacancies. This will raise employment and education even further.

The derivation of an equilibrium with unemployment allows us to obtain a theoretical relation between aggregate employment, or unemployment, and the distribution of education in the labor force. This is particularly appealing, since it permits the analysis of processes related to changes in the size of the labor force[1]. The reason being that demographic or sociological changes may alter the distribution of human capital among workers, affecting job creation and unemployment.

The model developed in this chapter can also shed some light on the connection between individual education decisions and individual unemployment rates. Empirical evidence by Mincer (1991) suggests that people with higher educational levels suffer a lower risk of unemployment and a lower duration of unemployment. This can be explained within the model by endogenizing the intensity of search that each individual delivers. That is, individuals with higher education have higher ability and therefore search more efficiently, which increases their probability of employment.

However, this is not the only possible mechanism explaining education externalities. The endogenous growth literature, originated with the seminal papers by Lucas (1988) and Romer (1986), has shown that in an economy with a higher average level of education processes like the exchange of ideas, imitation or learning by doing are more likely to occur fostering technological progress. Since these externalities work through the improvement of technology in the process of production, are called technological externalities. Instead, the externality studied in the present work is generated in the labour market, due to the interaction between ex-ante heterogenous workers and search frictions. That is why it is called pecuniary externality. In addition, these literature does not study unemployment equilibria. Finally, Saint-Paul (1992) also derives pecuniary externalities from the accumulation of human capital but as a consequence of wage rigidities.

The rest of the chapter is organized as follows. In section 1.2 we start by describing the economy. In Section 1.3, we solve for the labor market equilibrium taking the average level of human capital as given. While in Section 1.4 the general equilibrium of the economy is obtained by endogeneizing the decision

[1]Demographic changes normally do not have any effect on the equilibrium of a labor market characterized by a matching process, because the matching function is assumed to have constant returns to scale.

to invest in human capital. The Social Planner's Solution is derived in section 1.5. Some extensions to the basic model are considered in sections 1.6 and 1.7. Finally, section 1.8 concludes.

1.2 Description of the Economy

1.2.1 Firms and Workers

This is an non-overlapping generations model, where individuals live one period only. That is, all individuals are born at the beginning of the period. First, they go to school and then they enter the job market simultaneously to search for a job. At the end of the period, end of workers' lives, all jobs are destroyed and firms and newborn workers start the search process again.

In the economy there are L individuals, each one born with a different ability (a_i). When young they attend full-time education and then enter the labor market with the human capital obtained (h_i). In the labor market individuals and firms engage in a search process, which produces a number of matches. Those individuals who find a job, produce and earn a wage, while the rest remain unemployed and earn a subsidy.

The number of firms active in the economy is variable. When a firm decides to enter the labor market opens a vacancy and starts looking for a worker. The cost of opening the vacancy is sunk, so the firm will only open one when expected profits are non-negative. Once a firm and a worker meet, the firm buys the appropriate technology for the worker's human capital level and the worker brings one unit of labor and his human capital. The result of the match is the production of y_i units of product using the following technology:

$$y_i = Ah_i^{\alpha} \tag{1.1}$$

where $A > 0$ is a constant representing the technological level and $1 > \alpha > 0$.[2]

[2]Physical capital is not introduced in this version of the model to simplify and emphasize the main mechanism studied.

1.2.2 Wage determination

When a match is realized, the occupied job will yield a return that is at least as high as the sum of the expected returns of a searching firm and a searching worker. The realized job match yields some pure economic rent which is equal to the sum of the expected search costs of the firm and the worker. Wages are set to share this economic rent according to the Nash Solution to a bargaining problem, as in Pissarides (2000). The wage rate will be the one that maximizes the weighted product of the worker's and the firm's net return from the job match. The worker will gain from the match a wage (w_i) and will give up the unemployment benefit (z). The firm will obtain from the match the product (y_i) minus the wage paid to the worker and will give up the expected profits of the vacancy, which are equal to zero in equilibrium. Therefore the wage for this job will satisfy

$$w_i = \arg\max(w_i - z)^{\beta} \, (y_i - w_i)^{1-\beta}$$

where $0 \leq \beta \leq 1$. The parameter β might be interpreted as the worker's relative bargaining power. The solution of this maximization problem gives us the following wage rule:

$$w_i = \beta y_i + (1 - \beta)z$$

The firm's net returns (π_i) are equal to the product minus the wage, namely

$$\pi_i = (1 - \beta)y_i - (1 - \beta)z$$

Throughout the rest of the chapter, the unemployment benefit is assumed equal to zero. This is only done for simplification purposes, since having a positive subsidy will not change the results, as long as the subsidy is independent of the productivity of the worker. Therefore the expression for the profits and wages we will use is the following:

$$w_i = \beta A h_i^{\alpha} \tag{1.2}$$

$$\pi_i = (1 - \beta)A h_i^{\alpha} \tag{1.3}$$

It is clear from these equations that the firm's and worker's returns from the match will be larger the higher the education level that the individual acquired when young.

1.2.3 Education Decisions

The acquisition of education level h_i requires effort e_i, which is increasing in the amount of education acquired and decreasing on each individual's ability.[3] A simple expression that satisfies these assumptions is:

$$e_i = \frac{h_i^{\Psi}}{a_i \Psi}$$

In order to decide how much to invest in human capital, each individual maximizes his utility subject to his resource constraint, taking the probability of employment as given ($\overline{q}$). The constraint only says that every person will consume according to her expected income, which is equal to the wage times the probability of finding a job ($\overline{q}$).

$$\begin{array}{lcl} \max\limits_{hi} \;\; u_i = & c_i - \dfrac{h_i^{\Psi}}{a_i \Psi} \\ s.t \quad : & c_i = w(h_i)\overline{q} \end{array} \tag{1.4}$$

Where the wage is given by equation (1.2). The solution to this maximization problem gives the individual's optimal human capital investment, which depends positively on the level of ability of the individual and on the probability of finding a job.

$$h_i = (\alpha A \beta a_i \overline{q})^{\frac{1}{\Psi - \alpha}} \tag{1.5}$$

where $\Psi > 1 > \alpha > 0$.

Lemma 1.1. *The individual's optimal investment in human capital increases with the probability of employment and with his own ability.*

Proof: From equation (1.5), the derivative of the optimal human capital with respect to q and with respect to a_i is positive as long as $\Psi > \alpha$. That is, as long as the elasticity of the expected wage with respect to human capital (α) is smaller than the elasticity of the utility cost of human capital (Ψ).

[3] In a different context it might be useful to define a_i differently - for example as the distance to the nearest education centre or as a higher opportunity cost of education for women. However, for the externality to exist it has to be an exogenous characteristic given before the entrance to the labour market.

This assumption is a necessary condition for the second order condition to hold and it includes the case of a quadratic cost function, generally used in the literature.

1.3 Labor Market Equilibrium

Trade in the labor market is considered a decentralized economic activity, mainly due to the existence of heterogeneities among workers, but also to frictions and information imperfections. Because of this, it becomes difficult for firms to find the appropriate worker and for workers to find a job, thus they have to spend resources searching before production takes place. This gives rise to unemployment in equilibrium (see Pissarides (2000), Pissarides (1992)).

The timing of events in the labor market is as follows. First, firms decide to open vacancies and then firms and workers engage in search. After a costly search process, a match is realized. Then production takes place using the firm's technology and the worker's human capital. At the end of the period all matches are destroyed. The labor market is therefore composed of L workers and V vacancies who engage in a search process by which N matches are created.

$$N = \min\{m(V, L), L\}$$

where $m(.,.)$ represents a matching function with standard properties, ie. increasing in both arguments, concave and homogeneous of degree one. The level of employment (N) should also be equal to the number of individuals looking for work times the probability that a worker meets a firm (q)

$$N = qL \ . \tag{1.6}$$

This implies that on average,

$$q = \frac{N}{L} = m(\frac{V}{L}, 1) \ . \tag{1.7}$$

It is assumed that q is also the transition probability for each worker. The average probability of filling a vacancy (p) has to be equal to the level of employment (N, equation (1.6)) over the number of vacancies opened.

$$p = \frac{N}{V} = \frac{qL}{V} \tag{1.8}$$

If we define market tightness as the ratio of vacancies opened to the number of searchers, , $\theta = \frac{V}{L}$, we can express the transition probabilities of workers and firms as a function of market tightness.

$$\begin{aligned} p &= m(1, \frac{1}{\theta}) \\ q &= m(\theta, 1) \end{aligned}$$

The dependence of these functions on the relative number of traders (tightness) shows the trading externality typical of matching models. This externality arises because price is no longer the only allocative mechanism, there is also stochastic rationing. There is a positive probability that a vacancy is not filled or that a worker does not find a job, which cannot be eliminated through price adjustments, but it can be improved or worsened by the relative number of traders in the market.

The expected profit of a firm from a vacancy ($E(\pi)$) will be equal to the probability of filling a vacancy (p) with a worker, times the profit obtained from employing that worker. Since the firm does not know which worker will arrive we have to integrate over all possible individuals.

$$E(\pi) = p\left\{\frac{p\int [y(h) - w(h)]\, f(h)dh}{L}\right\} \tag{1.9}$$

?

Substituting the equations determining p (equation (1.8)), y_i (equation (1.1)) and the wage (equation (1.2)) into this equation, we obtain the expected profit from a vacancy, as a function of the distribution of human capital.

$$E(\pi) = \frac{q}{\theta}(1-\beta)A\frac{\int h(a)^{\alpha} f(a)da}{L} \tag{1.10}$$

There is a fixed cost of opening a job equal to c, which is independent of the type of worker recruited. This implies that firms will open vacancies as long as the expected profit per vacancy is bigger than the cost of opening it.

$$E(\pi) \geq c$$

In equilibrium no firm can open a job and make a positive profit since there are no barriers to entry, therefore $E(\pi) = c$. Substituting the expected profits (equation (1.10)) in the free-entry condition and solving for the number of vacancies opened (over the population size), we obtain the first equilibrium condition of the labor market, which will be called "*Job Creation Condition*":

$$\theta = q\left[\frac{(1-\beta)A}{c}\right]\left[\frac{\int h(a)^{\alpha}f(a)da}{L}\right]$$

This means that in equilibrium market tightness depends positively on the employment rate, as well as on the distribution of human capital among the population. Therefore, if one of these factors increases, market tightness will be below its equilibrium level - there are too few vacancies - firms will expect positive net profits and will open more vacancies. As the number of vacancies increases, so does market tightness and the expected profits per vacancy decrease until they are equal again to the cost of opening a vacancy. The "*Job Creation Condition*" also shows that the probability of filling a vacancy (p) is independent of q or θ in equilibrium, since otherwise more vacancies would be opened.

$$p = \frac{q}{\theta} = \left\{\left[\frac{(1-\beta)A}{c}\right]\left[\frac{\int h(a)^{\alpha}f(a)da}{L}\right]\right\}^{-1}$$

Therefore the equilibrium value of p depends positively on the profit per worker and negatively on the cost of opening a vacancy. This is explained through a similar argument as before. When one of this factors increases, p will be above its equilibrium level, making the expected profits from opening a vacancy larger than the costs and firms will start opening more vacancies. As the number of vacancies increases, so does market tightness and the competition among firms in the search for workers. This will start reducing the expected profits until they become zero, where the equilibrium will be restored.

In order to solve for the equilibrium in the labor market we also have to determine the probability of finding a job (q). Using equation (1.7), we can obtain this probability as the number of matchings per person searching. Obviously, there has to be an upper-bound on q equal to 1.

$$q = \min\left\{m\left(\theta, 1\right), 1\right\}$$

Assuming a specific functional form for the matching function $m(V, L) = (bV)^{\phi}\ (L)^{1-\phi}$ we obtain the second equilibrium condition, which will be called "*Employment Rate Condition*".

$$q = \begin{cases} (b\theta)^{\phi} & if \quad (b\theta)^{\phi} < 1 \\ \\ 1 & otherwise \end{cases} \tag{1.11}$$

where $b > 0$ is a scaling constant and $0 < \phi < 1$ represents the relative efficiency of firms and workers in the search process. [4] Both, the "*Job Creation Condition*" and the "*Employment Rate Condition*" represent relations between market tightness and the probability of finding a job, for a given distribution of human capital. Therefore, the equilibrium values of this variables will be determined at the point in which the two curves cross, which is shown in figures 1.1 and 1.2.

Notice that we can define $\frac{\int h(a)\alpha f(a)da}{L}$ as $E[h^{\alpha}]$, which from now on will be called "average" education. However, this term depends on the whole distribution and can be shown to be approximately equal to the following:

$$E(h^{\alpha}) = \frac{\int h(a)^{\alpha} f(a)da}{L} \approx (\mu_h)^{\alpha} - \varphi\frac{\sigma_h}{\mu_h}$$

where μ_h and σ_h are the average and variance of the education distribution in the economy.

This market has a unique non-trivial equilibrium given h and the exogenous parameters of the economy. But this unique equilibrium may have different characteristics depending on the distribution of h and the exogenous parameters. When the "average" level of human capital is very high, or the cost of opening a vacancy is very low, an equilibrium with full employment and high tightness is more likely to prevail, otherwise unemployment and low tightness will be found in equilibrium. Which of this two unique equilibriums will exist depends on whether the two equations cross before they reach the upper bound of full employment or not, i.e. if the maximum value of θ from the "*Job Creation condition*" ($\theta_{\max} = \frac{\beta AL}{c} E[h_i^{\alpha}]$) is bigger than the maximum value of

[4]This is assumed to be equal for both, i.e.: $\phi = \frac{1}{2}$.

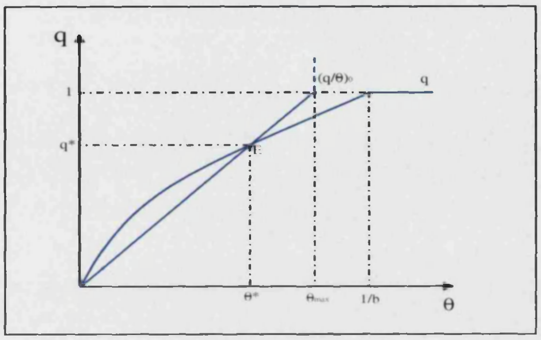


Figure 1.1: Labour Market Equilibrium case 1: $\theta_{max} < \frac{1}{b}$

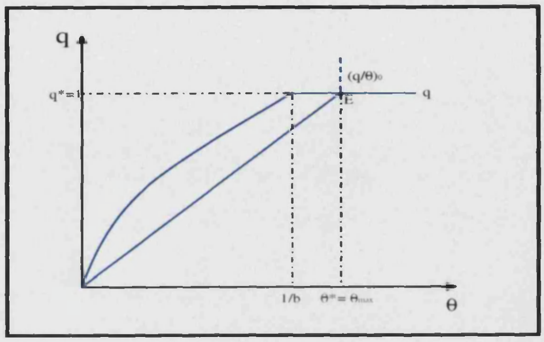


Figure 1.2: Labour Market Equilibrium case 2: $\theta_{max} > \frac{1}{b}$

θ from the "*Employment rate condition*" ($\theta = \frac{1}{b}$). The reason is that, when the "average" human capital in the economy is very large, the firms' expected profits are so big that they will keep on creating new jobs beyond the point in which market tightness is large enough to achieve full employment. This will happen until expected profits disappear and labour market equilibrium is achieved. This is defined in the following condition:

Condition 1.1. *An upper-bound to the education externality exists when "average" education is large enough. For the externality to affect the equilibrium employment rate the following condition must hold:*

$$E[h^\alpha] < \frac{c}{(1-\beta)Ab} \tag{1.12}$$

Otherwise "average" human capital is too large and job creation will be so strong that full employment will always be achieved.

Axiom 1.1. *The unique non-trivial equilibrium can have different characteristics depending on the distribution of human capital and the exogenous parameters of the economy:*

Case 1: if condition 1.1 holds an equilibrium exists with unemployment and low market tightness.

$$q = \left(\tfrac{b(1-\beta)A}{c} E[h_i^\alpha]\right)^{\frac{\phi}{1-\phi}} \quad ; \quad \theta = b\left(\tfrac{(1-\beta)A}{c}\right)^{\frac{1}{1-\phi}} (E[h_i^\alpha])^{\frac{1}{1-\phi}} \tag{1.13}$$

Case 2: if condition 1.1 does not hold there is full employment and market tightness is high in equilibrium.

$$q = 1 \quad ; \quad \theta = \tfrac{(1-\beta)A}{c} E[h_i^\alpha] \tag{1.14}$$

Both, the probability of finding a job and market tightness (number of vacancies opened) in case 1 depend positively on the distribution of human capital existent in the population, and the same happens with market tightness in case 2. These equilibrium values also depend positively on other parameters of the model like the bargaining power of firms or the technological progress and negatively on the cost of opening a vacancy.

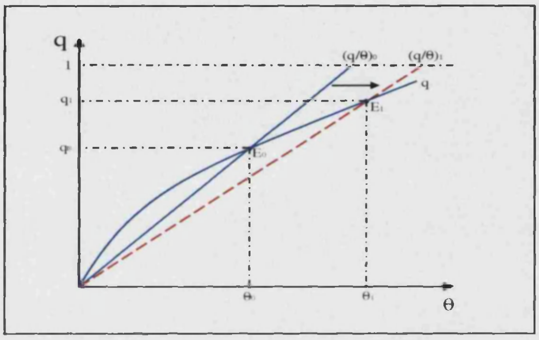
Lemma 1.2. *In equilibrium, both the probability of employment (if there is unemployment) and market tightness will increase if some or all the individuals in the labor market increase their investments in human capital, keeping the investment of the rest constant.*

Proof: From equation (1.13), we know that the equilibrium values of q and θ depend positively on $E[h_i^\alpha]$, since $1 \geq \phi \leq 0$. Thus, if h_i is increased for some individuals from h_i^0 to h_i^1 (where $h_i^1 > h_i^0$) [5] and remains constant for the rest, then $E\left[(h_i^1)^\alpha\right] > E\left[(h_i^0)^\alpha\right]$, since $1 > \alpha > 0$ and therefore $E[h_i^\alpha]$ is a convex function of h_i (see Aghion & Williamson for the mathematical theorem).

The reason is that the higher the $E(h_i^\alpha)$, the bigger the probability of employing a worker with more skills, obtaining a higher expected profit per vacancy opened. Therefore, the job creation condition will shift to the right and more vacancies will be opened increasing market tightness. The greater availability of vacant jobs makes it easier for unemployed workers to find a job and the probability of employment rises until it reaches the new equilibrium. Graphically this would correspond to the Job Creation Condition pivoting to the right, and cutting the Employment Rate Condition for a higher q and θ, as shown in figure 1.3.

[5] This increase may vary across individuals

Figure 1.3: Rise in $E[h^{\alpha}]$. Case 2: $\theta_{max} > \frac{1}{b}$



1.4 Equilibrium of the Economy

The equilibrium of this economy is fully described by the two variables determining the equilibrium in the labor market, i.e.: probability of employment and market tightness (equation (1.13) and (1.14)), plus the individual's optimal investment in human capital (equation (1.5)). In order to be able to analyze this equilibrium, we should express the human capital in the same functional form as it appears in the labor market conditions, i.e.: $E[h_i^{\alpha}]$. Therefore the three equations determining the equilibrium in the economy are the following:

$$E[h^{\alpha}] = (A\alpha\beta q)^{\frac{\alpha}{\Psi-\alpha}} E[a^{\frac{\alpha}{\Psi-\alpha}}] \tag{1.15}$$

$$q = \begin{cases} \left(\frac{b(1-\beta)A}{c} E[h^{\alpha}]\right)^{\frac{\phi}{1-\phi}} & if \quad q < 1 \\ \\ 1 & otherwise \end{cases} \tag{1.16}$$

$$\theta = \begin{cases} b\left(\frac{(1-\beta)A}{c}\right)^{\frac{1}{1-\phi}} E[h^{\alpha}]^{\frac{1}{1-\phi}} & if \quad q < 1 \\ \\ \frac{(1-\beta)A}{c} E[h^{\alpha}] & otherwise \end{cases} \tag{1.17}$$

This is a recursive system. First of all, we obtain the equilibrium values of the employment rate and aggregate human capital from the first two equations and then we substitute the human capital in the third equation to obtain the equilibrium value of the market tightness. The best way of understanding

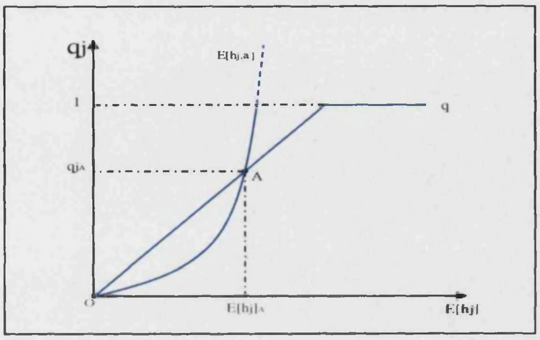


Figure 1.4: Equilibrium of the economy. Case 1: unemployment equilibrium

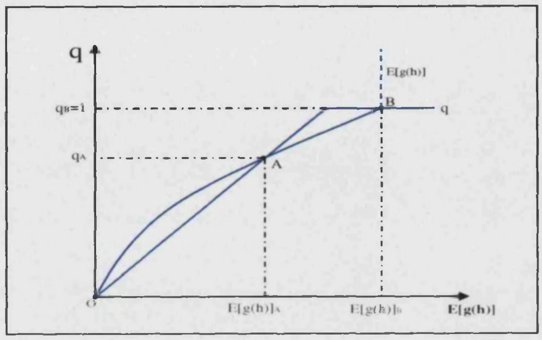


Figure 1.5: Equilibrium of the economy. Case 2: full employment

this equilibrium is graphically. In figure 1.4 we can see the equilibrium in the $\{q, E[h^{\alpha}]\}$ space.

A unique non-trivial stable equilibrium always exists, but it can have different characteristics depending on the concavity of the function determining the cost of education. We can have three different cases: one with unemployment, another with full employment and finally, the trivial case of a no-activity equilibrium. In the second case there is also another equilibrium with unemployment, but it is unstable. Which case prevails will depend on a condition determined by the underlying parameters of the economy, in particular by the distribution of abilities. Which case prevails will depend on the following two conditions determined by the underlying parameters of the economy:

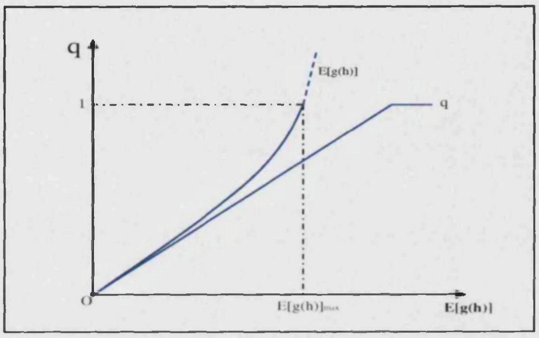
Condition 1.2. *An upper-bound to the education externality exists when the "average" ability amongst the population is large enough. For the externality to affect the equilibrium employment rate the following condition must hold:*

$$E[a_i^{\frac{\alpha}{\psi-\alpha}}] < \frac{c}{b(1-\beta)A^{\frac{\psi}{\psi-\alpha}}(\alpha\beta)^{\frac{\alpha}{\psi-\alpha}}} \tag{1.18}$$

Otherwise "average" ability is too large and therefore "average" human capital is also too large making job creation so strong that full employment is always achieved. This condition is equivalent to condition 1.1 but expressed in terms of ability instead of human capital.

Condition 1.3. $\Psi > 2\alpha$

Figure 1.6: Equilibrium of the economy. Case 3: no economic activity



This makes the second derivative of the "average" human capital equation with respect to the employment rate negative. That is, average human capital increases less than proportionally when the probability of employment raises. The intuition being that a higher ψ raises the rate at which the marginal cost of education increases while the rate at which the marginal benefits of education rises remains constant. Therefore individuals have a lower incentive to invest in education as the employment rate raises.

Axiom 1.2. *The unique non-trivial stable equilibrium can have unemployment or not depending on the concavity of the cost of education function, the distribution of abilities and the exogenous parameters of the economy:*

Case 1: if conditions 1.2 and 1.3 hold we have an equilibrium which is stable (point A in figure 1.4). This equilibrium will have unemployment with low "average" human capital and low market tightness.

$$\begin{aligned} q^1 &= \Lambda_1 \left(E[a^{\frac{\alpha}{\Psi-\alpha}}]\right)^{\frac{\Psi-\alpha}{\Psi-2\alpha}} \\ h_i^1 &= [A\alpha\beta\Lambda_1 a_i]^{\frac{1}{\Psi-\alpha}} \left(E[a^{\frac{\alpha}{\Psi-\alpha}}]\right)^{\frac{1}{\Psi-2\alpha}} \\ \theta^1 &= \frac{(\Lambda_1)^2}{b} \left(E[a^{\frac{\alpha}{\Psi-\alpha}}]\right)^{\frac{2\Psi-3\alpha}{\Psi-2\alpha}} \end{aligned}$$

where $\Lambda_1 = \left(\frac{b(1-\beta)}{c}\right)^{\frac{\Psi-\alpha}{\Psi-2\alpha}} (\alpha\beta)^{\frac{\alpha}{\Psi-2\alpha}} A^{\frac{\Psi}{\Psi-2\alpha}}$

Case 2: if neither condition 1.2 nor condition 1.3 hold there is a stable equilibrium with full employment and high investment in human capital (point B in figures 1.5 and A.1).

$$
\begin{aligned}
q^2 &= 1 \\
h_i^2 &= (A\alpha\beta a_i)^{\frac{1}{\Psi-\alpha}} \\
\theta_i^2 &= \frac{(1-\beta)L}{c}\left(A^{\frac{\Psi}{\alpha}}\alpha\beta a_i\right)^{\frac{1}{\Psi-\alpha}}
\end{aligned}
$$

In addition, if condition 1.2 is also fulfilled, we have a second equilibrium with some unemployment and low investment in human capital, but unstable (figure 1.5, point A).

Case 3: Otherwise, an equilibrium different from zero does not exist (figure 1.6).

The more interesting is case 1, in which an stable equilibrium with unemployment is obtained. This case results from the existence of a coordination failure problem, or externality in the accumulation of human capital. This externality results from the interaction between the search frictions in the labor market (trading externality) and the heterogeneity of individuals. When an individual (or rather a group of individuals) increases his human capital he knows he will obtain a higher wage if he finds a job. However, he cannot realize that the subsequent rise in the "average" level of education will increase expected profits and job creation, rising the employment rate. It is the failure to recognize this second effect that gives rise to the coordination failure. Therefore, if there are not enough incentives for the individual to invest enough in human capital, the firm will expect a less qualified worker and its expected profits will decrease, reducing job creation and the investment in human capital of all individuals. Then the economy may find itself at a situation with high unemployment, and a low level of human capital.

The intuition for case 3 is the following. When the "average" level of ability is too low or the parameters determining the cost (benefit) of opening a vacancy are too high (low), firms will have no incentive to open any vacancy and there will be no activity in the labor market. This corresponds to the case in the labor market equilibrium, in which the job creation curve has a bigger slope than the employment rate curve for all θ. This is an interesting result which may help to explain the lack of skill intensive sectors in developing economies or in deprived areas within a country.

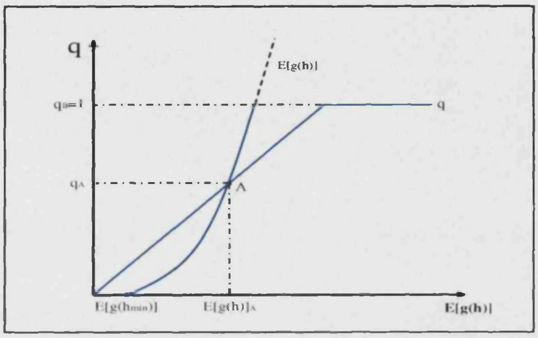
Proposition 1.1. *An increase in the education level of some individuals increases market tightness and therefore the probability to find a job. This increases the expected wage of every individual and thus his investment in human capital.*

Proof: From lemma 1.1 we know that the individual's investment in human capital increases with the probability to find a job. And from lemma 1.2 we know that the value of the market tightness that equilibrates the labor market depends positively on the "average" human capital existent in the economy. Therefore, the individual's optimal investment in education depends positively on the "average" level of education. This becomes clear by substituting the employment rate that equilibrates the labour market (equation 1.13) into the optimal investment in human capital (equation 1.15).

$$h_i = \begin{cases} \left[\left(\frac{b\alpha\beta(1-\beta)A^2}{c}\right) a_i E[h^\alpha]\right]^{\frac{1}{\Psi-\alpha}} & if \quad q<1 \\ (A\alpha\beta a_i)^{\frac{1}{\Psi-\alpha}} & if \quad q=1 \end{cases}$$

The equilibrium with unemployment described in case 1 and corresponding to point A in figure 1.4) is stable. To see why we can think of what would happen if the economy was below point A, with an employment rate and "average" human capital lower than in equilibrium. At that employment rate, the "average" level of education optimal for individuals is higher than the one which equilibrates the labor market. That is, it is higher than what firms expected. This implies that too few vacancies are opened and thus the competition between firms for the existing workers is not very intense, which makes the expected net profits per vacancy positive. Thus the number of vacancies starts augmenting and so does market tightness, increasing the probability to find a job. This augments the individuals' incentives to invest in education and eventually improves the "average" level of education, which in turn increases even further the net expected profits of firms. This process goes on until q and $E[h^\alpha]$ rise back to the equilibrium. A similar argument applies for the stability of the equilibrium with full employment described in case 2 (point B in figures

Figure 1.7: Case 3: Equilibrium of the economy with compulsory education



1.5 and 1.5).

The possibility of the market shutting down when the "average" level of education is too low is very worrying. However, this possibility can be reduced by introducing some compulsory education, so that all individuals acquire a minimum level of education even if there are no job opportunities at all. This is equivalent to assuming that the individually optimum level of investment in human capital has a lower bound equal to that compulsory education (h_{min}), which does not affect utility. That is:

$$h_i = (A\alpha\beta a_i q)^{\frac{\alpha}{\Psi-\alpha}} + h_{\text{min}}$$

If we take expectations we get

$$E[h^\alpha] = \left[(A\alpha\beta q)^{\frac{1}{\Psi-\alpha}} E[a^{\frac{1}{\Psi-\alpha}}] + h_{\text{min}}\right]^\alpha$$

This implies that now even in case 3 we can obtain a stable non-trivial equilibrium with unemployment (point A in figure 1.7). This shows that an education policy guaranteing a minimum level of compulsory education for all individuals, is not only important because of the individual gains in terms of future expected earnings but also because it helps to ensure the existence of labour markets.

1.5 Social Planner's Solution

The existence of a positive externality from education raises an important question about the social optimality of the individual decision. Individuals cannot internalize the externality in their optimal decisions, since they consider the employment rate as given, therefore their investment in education in equilibrium might be different from the socially optimal, and in fact it can be proven to be too low. The social planner knows that the investment decisions affect the equilibrium in the labor market, thus he will take this into account when deciding the optimal investment. He will maximize the following objective function:

$$\max_{q_i,h_i}\left\{m(\theta,1)L\int Ah(a)^{\alpha}f(a)da - cV - L\int \frac{h(a)^{\Psi}}{a\Psi}f(a)da\right\}$$

Solving this problem we obtain the socially optimal market tightness and human capital investment

$$q^{SP} = \left(\frac{\phi bA}{c}E[h^{\alpha}]\right)^{\frac{\phi}{1-\phi}}$$

$$h_i^{SP} = \left(A\alpha a_i q^{SP}\right)^{\frac{1}{\Psi-\alpha}} \tag{1.19}$$

where $\Psi > 1 > \alpha > 0$.

Proposition 1.2. *The socially optimal investment in human capital is higher than the individually optimal investment.*

Proof: Comparing the socially optimal level of investment (h_i^{SP}), with the privately optimal level (h_i^{p}), (equation (1.5)), we have that:

$$h_i^{SP} \geq h_i^{p} \qquad iff \quad q^{SP} \geq \beta q^{P}$$

which is always true since $q^{SP} > q^{P}$ in equilibrium (proof in the appendix).

This shows that there is scope for policy intervention. That is the government should subsidise individuals' investment in education to reach the socially optimal level. This could be done either by increasing the supply or the demand for human capital. An example of the importance of policy intervention was shown in the equilibrium of case 3 where a policy guaranteing a minimum level of education for every individual made sure that a labour market would always exist.

1.6 Physical Capital

In this section we consider the investment in physical capital by firms. We assume that a perfect market for capital exists where capital can be rented once the match is realized. That is, the capital investment by firms is not sunk, it can be recovered. The technology of production now will be:

$$y_{i,j} = Ak_j^{1-\alpha}h_i^{\alpha}$$

where i represents the individual and j the firm.

The introduction of physical capital in the model generates the following changes with respect to the basic model. First, the total match surplus now has to take into account the cost of renting the capital. Solving the Nash Bargaining problem in the same way as in section 1.2, we get the new wage and profit rules:

$$\begin{aligned} w_{i,j} &= \beta(Ak_j^{1-\alpha}h_i^{\alpha} - rk_j) + (1-\beta)z \\ \pi_{i,j} &= (1-\beta)(Ak_j^{1-\alpha}h_i^{\alpha} - rk_j) - (1-\beta)z \end{aligned}$$

Secondly, the firm's maximization problem has also changed. The firm now has to undertake two different investment decisions. It has to decide whether to open a vacancy or not, incurring in the sunk costs of advertising and recruiting, depending on the expected profits from opening it. Then, once the worker has been recruited, it has to decide what is the appropriate level of physical capital it needs to rent for the worker's level of human capital. That is, when the firm acquires the physical capital it already knows the level of human capital of the worker. This implies that we can determine the capital decision first, taking the worker's human capital as given, and then the job creation decision. The optimal level of physical capital will be equal to:

$$k_j = \arg\max \pi_{i,j} = \arg\max(1-\beta)(Ak_j^{1-\alpha}h_i^{\alpha} - rk_j - z) \text{ given } h_i$$

and solving we get,

$$k_j = h_i \left[\frac{A(1-\alpha)}{r}\right]^{\frac{1}{\alpha}}$$

This implies that the firm will acquire capital until the physical to human capital ratio is constant and equal for all firms, so we can drop the subscripts.

$$\frac{k}{h} = \left[\frac{A(1-\alpha)}{r}\right]^{\frac{1}{\alpha}}$$

The wage and profit rules can also be expressed in terms of this ratio:

$$\begin{aligned} w_i^k &= \alpha\beta A h_i \left(\frac{k}{h}\right)^{1-\alpha} + (1-\beta)z \\ \pi_i^k &= \alpha(1-\beta)Ah_i\left(\frac{k}{h}\right)^{1-\alpha} - (1-\beta)z \end{aligned}$$

Now, we can solve the rest of model in the same manner as before. The main difference with the basic model is that all equations will be multiplied by a factor which is a function of the physical to human capital ratio. The optimal investment in education by the individual will be:

$$h_i^k = \left[\alpha A\beta a_i q \left(\frac{k}{h}\right)^{1-\alpha}\right]^{\frac{1}{\Psi-1}} \tag{1.20}$$

where $\Psi > 1$. And the equilibrium of the economy with physical capital will be obtained by solving the following system of equations:

$$E[h^k] = [\alpha A\beta q]^{\frac{1}{\Psi-1}} E[a^{\frac{1}{\Psi-1}}] \left(\frac{k}{h}\right)^{\frac{1-\alpha}{\Psi-1}}$$

$$q^k = \begin{cases} \left(\frac{b(1-\beta)A}{c}E[h^k]\right)^{\frac{\phi}{1-\phi}} \left[\alpha\left(\frac{k}{h}\right)^{1-\alpha}\right]^{\frac{\phi}{1-\phi}} & \\ 1 & otherwise \end{cases}$$

The implications of including capital in the model are clear from the previous equations. Now the externality of education is potentiated by firms' investments in physical capital. As in the basic model, when some individuals invest more on education, they raise the economy's average level of education and the expected profits of firms from opening a vacancy. Increasing job creation and the probability of employment for all individuals. However, now we have a second mechanism. The firms matched with these more skilled individuals will invest more on capital, increasing even further the gains from the match. This provides an additional incentive for all individuals to invest in education. Now it is the exact average level of education what affects the employment rate, which is larger than the "average" human capital of the basic model ($E[h_i] > E[h_i^\alpha$ since $\alpha < 1$). The effect will be potentiated even further if the physical to human capital ratio is larger than one. This will happen when the cost of renting capital is low, and/or the technological level and the share of physical capital in production are high. The reason being that in this case for every unit of human capital the individuals contribute to the match, the firm contributes with more than one unit of physical capital.

With capital, the conditions for an equilibrium with unemployment to exist are slightly different:

$$E[a_i^{\frac{1}{\Psi-1}}] < \frac{c}{b(1-\beta)A^{\frac{\Psi}{\Psi-\alpha}}(\alpha\beta)^{\frac{\alpha}{\Psi-\alpha}}} \tag{1.21}$$

$$\Psi > 2 \tag{1.22}$$

Axiom 1.3. *A stable equilibrium with unemployment exists if both conditions hold equal to the following:*

$$\begin{aligned} q^1 &= \Lambda_1 \left(E[a^{\frac{\alpha}{\Psi-\alpha}}]\right)^{\frac{\Psi-\alpha}{\Psi-2\alpha}} \\ h_i^1 &= [A\alpha\beta\Lambda_1 a_i]^{\frac{1}{\Psi-\alpha}} \left(E[a^{\frac{\alpha}{\Psi-\alpha}}]\right)^{\frac{1}{\Psi-2\alpha}} \\ \theta^1 &= \frac{(\Lambda_1)^2}{b} \left(E[a^{\frac{\alpha}{\Psi-\alpha}}]\right)^{\frac{2\Psi-3\alpha}{\Psi-2\alpha}} \end{aligned}$$

where $\Lambda_1 = \left(\frac{b(1-\beta)L}{c}\right)^{\frac{\Psi-\alpha}{\Psi-2\alpha}} (\alpha\beta)^{\frac{\alpha}{\Psi-2\alpha}} A^{\frac{\Psi}{\Psi-2\alpha}}$

1.7 Different Unemployment Rates

It is a known stylized fact that individuals with higher levels of education face lower unemployment rate and this empirical fact seems to hold for most developed countries and education levels [6]. Mincer (1991) suggests that the differences in individual unemployment rates are mainly due to the fact that more educated workers are relatively more efficient in acquiring and processing job search information and that workers and firms search more intensively to fill more skilled vacancies. In this section I try to reconcile the basic model with this empirical fact by endogeneizing the individual's search efficiency.[7]

The basic model in this chapter assumes that all individuals face the same unemployment rate, this is because they all search with the same intensity. Instead, we may think that different individuals search with different intensity depending on their characteristics. The more intensively an individual searches, the higher the probability of finding a job. Then, the individual probability of employment will be equal to the number of search units that particular individual supplies (s_i) times the general employment rate prevailing in the economy. And the same will be true for the probability of filling a vacancy with individual i. Namely,

$$\begin{aligned} q_i &= s_i q \\ p_i &= s_i p \end{aligned}$$

The aggregate supply of search units (S) will be the sum of the efficient search units supplied by each individual:

$$S = \int sf(s)ds$$

In this case, each person has to make two decisions: the investment in education and the number of units of search to supply. It is assumed that the acquisition of s_i units of search and h_i units of education, requires an effort e_i, which is increasing in the amount of education or search units acquired and decreasing in the ability of each individual. A simple expression that satisfies

[6] In some developing countries, like India, this is not true

[7] This will be done using a similar method as in Pissarides (1992) and Pissarides (2000) chapter 5.

these assumptions is:

$$e_i = \frac{h_i^{\Psi}}{a_i\Psi} + \frac{s_i^{\Gamma}}{a_i\Gamma}$$

Therefore, the individual will solve the following maximization problem:

$$\max_{hi,si} u_i = \beta A h_i^{\alpha} s_i \overline{q} - \frac{h_i^{\Psi}}{a_i\Psi} - \frac{s_i^{\Gamma}}{a_i\Gamma}$$

Solving, we obtain the optimal search intensity as a positive function of education and the investment in education as a positive function of search intensity, while both are a function of ability and the employment rate.

$$h_i = (\alpha A \beta a_i s_i \overline{q})^{\frac{1}{\Psi-\alpha}} \quad (1.23)$$

$$s_i = (A\beta a_i h_i^{\alpha} \overline{q})^{\frac{1}{\Gamma-1}} \quad (1.24)$$

where $\Psi > 1 > \alpha > 0$ and $\Gamma > 1$.

The main difference with the basic model in the labor market is that now we have L workers, supplying S units of search, and V firms who engage in a search process. That is, we have to redefine the market tightness as the ratio of vacancies to the total supply of units of search: $\theta = \frac{V}{S}$. Solving in the same manner as in the basic model we get the "*Job Creation Condition*" and the "*Employment Rate Condition*":

$$\theta = q\left(\frac{(1-\beta)A}{c}\right)\frac{\int s(a)h(a)^{\alpha}f(a)da}{\int s(a)f(a)da}$$

$$q = \begin{cases} \left\{\left(\frac{b(1-\beta)A}{c}\right)\frac{\int s(a)h(a)^{\alpha}f(a)da}{\int s(a)da}\right\}^{\frac{\phi}{1-\phi}} & if \quad (b\theta)^{\phi} < 1 \\ 1 & otherwise \end{cases} \quad (1.25)$$

Then, the individual's probability of employment will be (if $(b\theta)^{\phi} < 1$):

$$q_i = s_i q = \left(\frac{s_i}{\int s(a)f(a)da}\right)^{\frac{\phi}{1-\phi}}\left\{\left(\frac{b(1-\beta)A}{c}\right)\int s(a)h(a)^{\alpha}f(a)da\right\}^{\frac{\phi}{1-\phi}} \quad (1.26)$$

From these equations it becomes clear that now in addition to the external effect there is another effect due to the search efficiency. When some individuals invest more in education, they increase the average level of education, but they also become more efficient in searching, rising aggregate search efficiency. This will increase expected profits per opened vacancy since firms now have a higher probability of finding those more skilled individuals and job creation goes up. However, at the same time, this has a negative effect on the rest of individuals searching for jobs, since they are now relatively less efficient in searching and therefore face higher unemployment rates. That is, a rise in average education generates two effects. On the one hand, it increases job creation, but at the same time it increases aggregate search efficiency reducing everyone else's chances of finding a job.

1.8 Conclusions

The main contribution of this chapter is to develop a theoretical model showing how an education externality might be generated exclusively from the process of matching in the labour market without the need of increasing returns to scale neither in the production function nor in the matching function. It is the interaction between the ex-ante decision to invest in education by workers and to open a vacancy by firms that gives rise to the externality. The model shows that when the economy is in an equilibrium with unemployment due to the education externality there is a connection between aggregate employment (or unemployment) and the distribution of education in the labour force.

The existence of the externality means that there is scope for intervention. Individuals cannot internalize the effect the externality has in their optimal decisions, since they take the employment rate as given, and therefore their equilibrium investment in education is lower than the socially optimal. This is particularly interesting in the case in which an economy finds itself in an equilibrium with no activity due to the low level of skills of its population. A clear example of this are the labour markets in many developing countries or the lack of specialized labour markets in certain areas of developed countries. The model developed in this chapter indicates that a solution to this problem might be to implement an education policy which guarantees a minimum level of compulsory education for all individuals. This will develop the skills of the population enough to provide incentives for firms to start creating vacancies in that area (or particular sector) and for workers to invest in education above the compulsory level. Eventually, both these forces will take the economy into an equilibrium with economic activity, reducing aggregate unemployment.

Finally, the theoretical model is extended to consider the effect of having physical as well as human capital. The introduction of both types of capital is shown to potentiate the education externality. Now in addition to the standard mechanism, by which a rise in the education investment of some individuals increases expected profits per vacancy and job creation, we have a second one. The firms matched with these more skilled workers will also invest more in capital increasing even further the gains from the match and providing with an additional incentive for workers to invest more in education.

The model is also extended to consider the possibility that different individuals face different unemployment rates, depending on their search efficiency, which is a function of ability. This will potentiate the effect of the externality for these individuals who have increased their education, but it will dampen it for the rest of individuals. The reason being that when some individuals increase their education, they improve the average level of education in the labour market, which has two opposite effects: it increases job creation, but at the same time it increases aggregate search efficiency reducing everyone else's chances to find a job.

Some of the interesting further work to be done in this area would consist in extending this model to consider other related mechanisms, like the possibility of migration between regions, which is studied in chapter 2. In addition, an empirical test of the empirical relevance of this mechanism is necessary. Two empirical tests of the theory are explained in chapters 3 and 4 of this thesis.

Chapter 2

Education matching externalities and the location of economic activity

2.1 Introduction

The analysis of the concentration of economic activity in specific geographic areas has been a very dynamic area of research since the seminal papers by Krugman (Krugman (1991a), Krugman (1991b)). But, as Krugman himself states, the basis of this analysis was developed much earlier. Alfred Marshall (Marshall (1920)) already identified three reasons to explain the concentration of economic activity in a certain geographical location: pooling of skilled workers, input-output linkages and technological spill-over effects. So far, this literature has centered its attention on the existence of pecuniary externalities in the production process, coming mainly from Marshall's second and third reason for concentration, but little attention has been paid to the first one. In general, these models have given a secondary importance to the labor market and the accumulation of skills. An exception being Rotemberg and Saloner (2000). They develop a model that explains concentration based on the existence of an externality coming from the supply of workers with the specific skills required by the industry. In their model, workers will only be willing to acquire these specific skills if there are enough firms wanting to employ them and vice-versa. But they concentrate on specific skills and do not consider the existence of unemployment, while most empirical studies show that this is one of the most important determinants of regional migration (see Greenwood

(1997)).

In addition, the analysis of the relationship between labor markets, skill accumulation and geographic concentration of economic activity seems specially relevant since differences across geographical areas in unemployment rates and average human capital are large and persistent for most developed countries.

In this chapter we propose a mechanism by which geographical concentration of economic activity may arise from a pecuniary externality originated exclusively in the labor market. This externality is due to the interaction between the firm's expected returns from opening a vacancy and the workers' decisions to invest in general skills and to search for work in a certain area. The idea is the following. Better off areas offer higher wages, more job opportunities and lower unemployment rates, thus attracting workers from other areas where labor markets are performing worse. But since moving to a different region implies an important sunk cost (housing, etc.) only the more skilled individuals will find migration worthwhile.[1] Therefore, migration favours the concentration of human capital in areas where labor markets are performing better. This will improve the profits firms expect to obtain when creating a job in these regions, fostering job creation and improving even further the performance of these regions' labor markets and the immigration of skilled individuals. Thus, there exists a positive feedback effect between the migration of highly qualified individuals into better off regions and job creation.

The existence of this pecuniary externality will result in the possible of multiplicity of equilibria in the economy, which can explain the concentration of economic activity in certain areas as well as the persistence of regional differences. That is, if a region is affected by a negative shock, strong enough to trigger migration of the more skilled individuals towards other regions, the human capital levels of the recipient regions will improve. Once the shock disappears, the economy may not return to the original situation, but instead it may converge to a new equilibrium, where regional divergences become permanent. Thus, migration produces concentration of human capital in those regions where labor markets are performing better, which improves economic

[1]This is a well known stylized fact of regional migration. See Greenwood (1997) for a survey of the empirical literature.

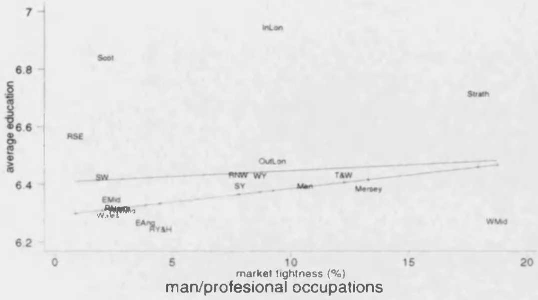


Figure 2.1: Average regional education duration vs labour market tightness

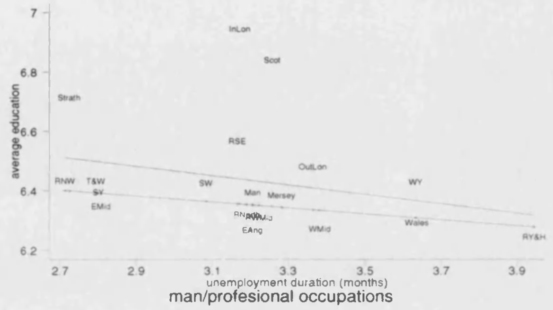


Figure 2.2: Average regional education duration vs unemployment duration

conditions in these areas, increasing migration even further. The process eventually stops because as more people search for work in these areas, the labor market becomes congested and work opportunities are reduced.

The real relevance of this mechanism is difficult to determine without serious empirical work which will be reported in chapters 3 and 4. However, as it is clear from figures 2.1 and 2.2[2], the skilled labour markets of the regions with highest average level of education have shorter unemployment durations and greater market tightness. This evidence seems to support the implications of this theory.

In the literature on returns to education there exist several empirical studies for US cities and UK travel to work areas showing the importance of human capital externalities. Rauch (1993) and Moretti (1998) find that a one-year increase in average years of schooling in a city generates an important social return, on top of the private return. While, Burgess and Profit (2001) show that there exist significant spatial externalities in British travel to work areas. The problem with this paper is that they do not take workers' education into account. They find that conditional on local labor market conditions, high unemployment levels in neighbouring areas raise the number of local filled vacancies but lower the local outflow from unemployment. The former suggests that local vacancies become more profitable since are filled quicker with people

[2]The line with crosses represents the trend when excluding the three top & bottom regions.

from this nearby areas. While the latter could be interpreted that the people from nearby areas applying to local vacancies are exhibiting a higher search intensity or they are offering better qualifications than the local unemployment pool. Both of these interpretations would justify the mechanism analyzed here.

There are other relevant articles related to this chapter in the literature. Burda and Wyplosz (1991) analyze the interaction between migration and human capital accumulation, but they consider only technological externalities and assume full-employment. Ortega (2000) uses a matching model related to the one used here to show that migration can be pareto improving, but he considers homogeneous individuals who do not invest in human capital. In addition, his mechanism comes from the distribution of rents between firms and workers, while the one here comes from the total size of the rents to be distributed. Finally, the externality analyzed in this chapter is based on Acemoglu (1996) and on the model of chapter 1.

The rest of the chapter is organized as follows. The economy is described in section 2.2. Section 2.3 describes the labor market equilibrium. Section 2.4 solves for the regional equilibrium taking the migration flows as given. Finally, in Section 2.5, we endogenize migration flows and solve for the general equilibrium of the economy. Section 2.7 concludes.

2.2 Description of the Economy

2.2.1 Firms and Workers

This is a non-overlapping generations model, where individuals and jobs live one period only. The economy is composed of two areas with the same initial population, L. These areas are identical in every aspect. Each individual is born with a different ability (a_i), but there is a similar distribution of abilities in each area, given by the cumulative distribution function $F(a)$. When young they attend full-time education. Then, they decide where to live and they enter the labor market of the area where they have settled down with the human capital acquired (h_i). In the labor market, individuals and firms engage in a search process, which produces a number of matches. Those individuals who find a job, produce and earn a wage, which depends on their education level.

The rest remain unemployed and earn a subsidy, which is independent of their qualifications. There is a sunk cost of migration, m, which represents the costs the migrant has to incur when settling down in a new area (eg. housing costs).

The number of firms active in each area of the economy is endogenous. When a firm decides to enter a region's labor market it opens a vacancy in one area, and starts looking for a worker. All firms are identical and the cost of opening the vacancy is sunk and equal across areas. Therefore, firms will open vacancies until the expected profits are equal to zero in each area. Once a firm and a worker meet, the firm buys the appropriate technology for the worker's human capital level and the worker brings one unit of labor and his human capital. The result of the match is the production of y_i units of product using the following technology, similar across areas:

$$y_{i,r} = Ah_{i,r}^{\alpha} \tag{2.1}$$

where the index i denotes the individual and index r the area. $A > 0$ is a constant representing the technological level, $1 > \alpha > 0$.

2.2.2 Wage determination

A realized job match yields some pure economic rent which is equal to the sum of the expected search costs of the firm and the worker. Wages are set to share this economic rent according to the Nash solution to a bargaining problem (as in chapter 1 and Pissarides (2000)). That is, the wage will satisfy the following:

$$w_{i,r} = \arg\max(w_{i,r} - z_r)^{\beta} \left(y_{i,r} - w_{i,r}\right)^{1-\beta}$$

where $\beta \in [0,1]$, which can be interpreted as the worker's relative bargaining power. The solution of this maximization problem gives us the following wage and profits rules:

$$w_{i,r} = \beta y_{i,r} + (1-\beta)z_r \tag{2.2}$$

$$\pi_{i,r} = (1-\beta)y_{i,r} - (1-\beta)z_r$$

The wage determination process is similar across all areas and independent of the worker's origin. This is true for native workers searching for a job in their own areas, since the returns from a match will be similar. But it is also true for migrants and natives working in the same area. The reason is that the cost of migration is independent of whether the worker finds employment or not and therefore it is not be considered when determining the wage. This does not mean that the actual wage will be of the same value. For a given ability, the actual wage might be different across regions, because the investment in education might also be different. However, migrants and natives living in the same region with similar ability earn the same wage.

2.2.3 Education Decisions

The acquisition of education level h_i requires effort e_i, which is increasing in the amount of education acquired and decreasing in the ability of each individual. A simple expression that satisfies these assumptions is:

$$e_i = \frac{h_i^{\Psi}}{a_i \Psi}$$

In order to decide how much to invest in human capital, an individual born in region j maximizes his utility subject to his resource constraint (which depends on whether he migrates or not), taking the probability of employment in the area where he will work as given ($\overline{q}_r$). The constraint only says that every person will consume according to her expected income, which is equal to the wage times the probability of finding a job ($\overline{q}$), minus the cost of migration.

$$\max_{hi,r} \quad u_{i,r} = \quad c_{i,r} - \frac{h_{i,r}^{\Psi}}{a_i \Psi} \qquad where \quad r = j, g$$

$$s.t \quad : \quad \begin{cases} c_{i,g} = w(h_{i,g})\overline{q}_g + z(1-\overline{q}_g) & if \quad stays\ in\ g \\ c_{i,j} = w(h_{i,j})\overline{q}_j + z(1-\overline{q}_j) - m & if \quad migrates\ to\ j \end{cases}$$

Where the wage is given by equation (2.2). The solution to this maximization problem gives the individual's optimal human capital investment, which depends positively on the ability of the individual and on the probability of finding a job in the area where he lives.

$$h_{i,r} = (\alpha A \beta a_i \overline{q}_r)^{\frac{1}{\Psi - \alpha}} \tag{2.3}$$

where $\Psi > 1 > \alpha > 0$.

Lemma 2.1. *The individual's optimal investment in human capital increases with the probability of employment and with his own ability. Therefore, it is higher when he decides to settle down in an area with a higher employment rate. But it is the same for a migrant and a native living in the same area, provided they have the same ability.*

Proof: From equation (2.3), the derivative of the optimal human capital with respect to q_r and with respect to a_i is positive as long as $\Psi > \alpha$, which is a necessary condition for the second order condition to hold. Therefore, if you decide to migrate to an area with a higher employment rate, you will acquire a higher level of education, since your expected lifetime income will be higher. The education decision is the same for migrants and natives due to the existence of perfect capital markets.

2.2.4 Location Decisions

Individuals decide where to live and work before (or at the same time as) making their education investments. An individual will settle down in the area where his expected lifetime income, net of migration costs, is higher. That is, an individual born in region g will migrate to region j if the following inequality holds:

$$w_{i,j} q_j + z(1 - q_j) - m \geq w_{i,g} q_g + z(1 - q_g) \tag{2.4}$$

It is clear from this expression that some people will migrate from region g to j only if labor market conditions are better in the latter region. That is, if the employment rate or the wage is higher in j than in g ($q_j > q_g$ and/or $w_{i,j} > w_{i,g}$). Substituting the wage and the investment in education, we obtain this inequality in terms of the individual's innate ability:

$$\left\{ A \left(\alpha A \beta a_i q_j \right)^{\frac{\alpha}{\Psi - \alpha}} - z \right\} \beta q_j - m \geq \left\{ A \left(\alpha A \beta a_i q_g \right)^{\frac{\alpha}{\Psi - \alpha}} - z \right\} \beta q_g$$

And solving for the ability of the individual, we obtain the marginal ability to migrate (a^*). This is the ability of the individual who is indifferent between migrating to j or staying in g:

$$a_i \geq a^* = \left[\frac{m + z\beta(q_j - q_g)}{\alpha^{\frac{\Psi-\alpha}{\alpha}} (\beta A)^{\gamma} (q_j^{\gamma} - q_g^{\gamma})} \right]^{\frac{\Psi-\alpha}{\alpha}}$$

where $\gamma = \frac{\Psi}{\Psi-\alpha}$. Therefore, all individuals born in region j with ability higher than a^* will migrate to region g, while the rest stay in region j. Since the people with higher ability are also the ones with higher education, only the most skilled individuals migrate. If we assume the unemployment benefit is equal to zero[3], the marginal ability simplifies to:

$$a^* = \frac{m^{\frac{\Psi-\alpha}{\alpha}}}{\alpha (\beta A)^{\frac{\Psi}{\alpha}} (q_j^{\gamma} - q_g^{\gamma})^{\frac{\Psi-\alpha}{\alpha}}} \tag{2.5}$$

Proposition 2.1. *Migration only happens from regions where labor markets are performing badly to regions where they are performing better. That is, in this model, there exists only one-way migration.*

Proof: The marginal ability to migrate from region j to region g (a'^*) can be obtained in the same manner as equation 2.5, to get:

$$a'^* = \frac{m^{\frac{\Psi-\alpha}{\alpha}}}{\alpha (\beta A)^{\frac{\Psi}{\alpha}} (q_g^{\gamma} - q_j^{\gamma})^{\frac{\Psi-\alpha}{\alpha}}} \tag{2.6}$$

An individual will migrate from region j to g only if the expected utility obtained from moving to g is higher than the one obtained from staying in j, which is only possible if $q_j < q_g$. Obviously, we cannot fulfill both this condition and the one to have migration from g to j ($q_j > q_g$) at the same time and therefore only one-way migration is possible.

With the ability of the marginal individual we can determine the size of the labor force in each region, that is, the number of people engaged in search in each labor market. The labor force in region j (L_j) will be equal to the native population (L) plus the migrants from g, i.e.: all individuals with ability higher than a^*. While the labor force in region g (L_g) will be equal to the native

[3]Throughout the rest of the chapter, the unemployment benefit is assumed equal to zero. This is only done for simplification purposes, since having a positive subsidy will not change the results, as long as the subsidy is independent of the productivity of the worker.

population minus the migrants.[4]

$$
\begin{aligned}
L_j &= L\left(1+\int_{a^*}^{1} f(a)da\right) \\
L_g &= L\int_{0}^{a^*} f(a)da
\end{aligned}
$$

Once we know who will live in each region, we can also determine the average level of education of the workers in that area.

$$E[h_r] = (\alpha A\beta q_r)^{\frac{1}{\Psi-\alpha}}\, E[a_r^{\frac{1}{\Psi-\alpha}}]$$

Where the "average" ability in each region ($E[a_r^{\frac{1}{\Psi-\alpha}}]$) is equal to:

$$
\begin{aligned}
E[a_j^{\frac{1}{\Psi-\alpha}}] &= \frac{\int_0^1 a^{\frac{1}{\Psi-\alpha}} f(a)da + \int_{a^*}^1 a^{\frac{1}{\Psi-\alpha}} f(a)da}{L\left(1+\int_{a^*}^1 f(a)da\right)} \\
E[a_g^{\frac{1}{\Psi-\alpha}}] &= \frac{\int_0^{a^*} a^{\frac{1}{\Psi-\alpha}} f(a)da}{L\int_0^{a^*} f(a)da}
\end{aligned}
\tag{2.7}
$$

These two equations determine what happens to "average" ability and subsequently average human capital as migration increases (or as a^* decreases).

Lemma 2.2. *The "average" ability and average human capital of a region increases for low levels of immigration, while it decreases for high levels of immigration. When everyone from region g migrates to region j the average level of human capital converges to the initial average level with no migration.*

Proof: The derivative of $E[a_j^{\frac{1}{\Psi-\alpha}}]$ with respect to a^* is:

$$\frac{\partial E[a_j^{\frac{1}{\Psi-\alpha}}]}{\partial a^*} = \frac{f(a^*)\,[2\,(B_1)-(B_2)]}{L\left[1+\int_{a^*}^1 f(a)da\right]^2}$$

where

$$B_1 = \left[\int_{a^*}^1 a^{\frac{1}{\Psi-\alpha}} f(a)da - (a^*)^{\frac{1}{\Psi-\alpha}}\int_{a^*}^1 f(a)da\right] \geq 0 \quad ; \quad \frac{\partial B_1}{a^*} < 0$$

[4] It is not necessary to indicate over which of the region's ability distributions we are integrating since they are identical. Therefore, we always integrate over da.

$$B_2 = \left[(a^*)^{\frac{1}{\Psi-\alpha}} \int_0^{a^*} f(a)da - \int_0^{a^*} a^{\frac{1}{\Psi-\alpha}} f(a)da\right] \geq 0 \quad ; \quad \frac{\partial B_2}{a^*} > 0$$

B_1 is positive or zero because the average $a^{\frac{1}{\Psi-\alpha}}$ over the interval $[a^*, 1]$ (LHS of the difference in brackets) is greater than or equal to this expression calculated at the lower bound of the interval times the population in the interval (RHS of the difference in brackets). A similar argument but using the upper bound of the interval explains why B_2 is also positive or zero. In addition, when there is no migration ($a^* = 1$) the derivative is negative ($B_1 = 0$ and $B_2 > 0$), while when everyone in region g migrates to j, the derivative is positive ($B_1 > 0$ and $B_2 = 0$). Then, as migration increases (a^* decreases), B_1 starts increasing and B_2 decreasing, until the derivative becomes positive (see figures 2.3 and 2.5).

Lemma 2.3. *The "average" ability and average human capital of a region decreases as emigration increases.*

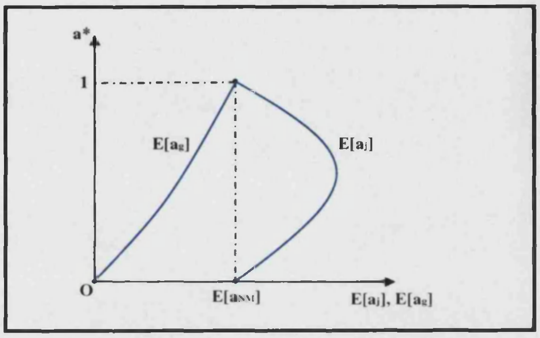
Proof: The derivative of $E[a_g^{\frac{1}{\Psi-\alpha}}]$ with respect to a^* is:

$$\frac{\partial E[a_g^{\frac{1}{\Psi-\alpha}}]}{\partial a^*} = \frac{f(a^*)\left[(a^*)^{\frac{1}{\Psi-\alpha}} \int_0^{a^*} f(a)da) - \int_0^{a^*} a^{\frac{1}{\Psi-\alpha}} f(a)da\right]}{L\left[\int_0^{a^*} f(a)da\right]^2} \geq 0$$

The numerator is equal to B_2 in lemma 2.2 and is therefore positive. In addition, when there is no emigration ($a^* = 1$) the derivative is positive. Then it decreases until it becomes zero when everyone has emigrated to the other region ($a^* = 1$) (see figures 2.3 and 2.5).

From these two previous lemmas it is clear that as the individuals with highest ability start migrating from region g to j, the regional difference in "average" abilities and average human capital will increase. However, as migration becomes more important and a larger part of the population of region g migrates to j (a^* is low), the average ability in j will increase less and eventually start decreasing. This means that regional differences will eventually start decreasing when the average ability in region j decreases at a faster rate than the average ability in region g. However, they never disappear.

Figure 2.3: Evolution of regional average ability as migration increases



Proposition 2.2. *Regional differences in average human capital and ability increase with migration. Eventually, for very high levels of migration, these differences start decreasing, but they always remain positive.*

Proof: Lemma 2.2 shows that $E[a_j^{\frac{1}{\Psi-\alpha}}]$ increases with high levels of migration, while it decreases with low levels of migration until it converges back to its initial level. Lemma 2.3 shows that as migration increases $E[a_g^{\frac{1}{\Psi-\alpha}}]$ decreases until it becomes zero. Therefore, the difference increases while $E[a_j^{\frac{1}{\Psi-\alpha}}]$ increases. If for high levels of migration $E[a_j^{\frac{1}{\Psi-\alpha}}]$ decreases at a faster rate than $E[a_g^{\frac{1}{\Psi-\alpha}}]$, then the difference will decrease. However, when everyone in region g migrates to j, the difference is positive. This can also be shown by calculating this difference:

$$E[a_j^{\frac{1}{\Psi-\alpha}}]-E[a_g^{\frac{1}{\Psi-\alpha}}]=\frac{2\int_{a^*}^{1}f(a)da}{L\left[1+\int_{a^*}^{1}f(a)da\right]}\left[\frac{\int_{a^*}^{1}a^{\frac{1}{\Psi-\alpha}}f(a)da}{\int_{a^*}^{1}f(a)da}-\frac{\int_{0}^{a^*}a^{\frac{1}{\Psi-\alpha}}f(a)da}{\int_{0}^{a^*}f(a)da}\right]\geq 0$$

Where the difference inside the brackets is positive because the "average" ability over the interval $[a^*,1]$ (LHS of the difference in brackets) will always be greater than or equal to the "average" ability over the interval $[0,a^*]$ (RHS of the difference in brackets) . When everyone migrates $(a^*=0)$ the difference remains positive.

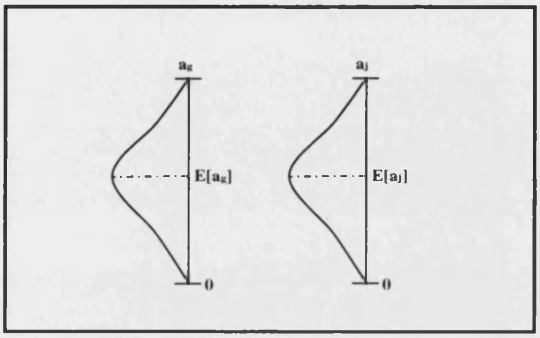


Figure 2.4: Distribution of ability before migration takes place

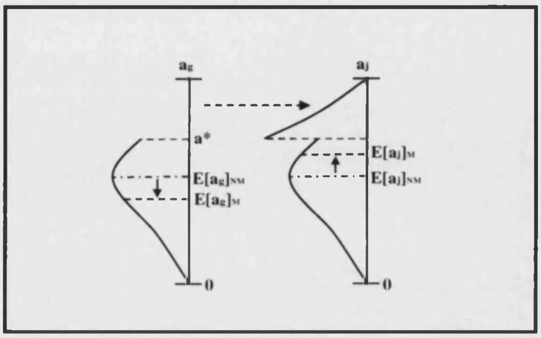


Figure 2.5: Distribution of ability after migration has taken place

2.3 Labor Market

The economy is divided into two separated regional labor markets. That is, individuals can only search for work in the region where they live (or where they plan to live).[5] Each regional labor market works similarly and in the same manner as the one described in chapter 1, section 1.3, therefore we will reduce its description here to the minimum. Trade in the labor market is considered a decentralized economic activity, which makes it difficult for firms to find the appropriate worker and for workers to find a job, forcing them to spend resources searching before production takes place. This gives rise to regional unemployment in equilibrium (see Pissarides (2000) & Pissarides (1992)).

The timing of events in the labor market is as follows. First, firms decide to open vacancies and then firms and workers engage in search. After a costly search process, a match is realized. Then production takes place using the firm's technology and the worker's human capital. At the end of the period all matches are destroyed. Each regional labor market is therefore composed of L_r workers and V_r vacancies who engage in a search process by which N_r matches are created.

$$N_r = \min\{m(V_r, L_r), L_r\}$$

[5]The mechanism explained here would prevail even if individuals searched for work from their region of origin, as long as they targeted only one market in their search. In that case we would have migration to jobs.

where $m(.,.)$ represents a matching function with standard properties and equal across regions. Then, on average, the probability of finding a job in region r (q_r) is equal to the employment level (N_r) over the number of people searching (L_r), while the probability of filling a vacancy in region r (p_r) has to be equal to the level of employment over the number of vacancies opened in that area (V_r).

$$q_r = \frac{N_r}{L_r} = m(\theta_r, 1) \tag{2.8}$$

$$p_r = \frac{N_r}{V_r} = m(1, \frac{1}{\theta_r})$$

Where market tightness (θ_r) is defined as the ratio of vacancies opened to the number of searchers, $\theta = \frac{V}{L}$.

The expected profit of a firm from a vacancy opened in region r ($E(\pi_r)$) will be equal to the probability of filling a vacancy (p_r) with a worker, times the profit obtained from employing that worker. Since the firm does not know which worker will arrive we have to integrate over all possible individuals searching in that area.

$$E(\pi_r) = p_r \left\{ \frac{\int [y(h)_r - w(h)_r] f(h) dh_r}{L_r} \right\} \tag{2.9}$$

Substituting the equations determining p_r, $y_{i,r}$ and the wage into this equation, we obtain the expected profit from a vacancy in region r, as a function of the distribution of human capital in that region.

$$E(\pi_r) = \frac{q_r}{\theta_r}(1-\beta) A \frac{\int h(a)^\alpha f(a) da_r}{L_r} \tag{2.10}$$

There is a fixed cost of opening a job equal to k, which is independent of the type of worker recruited and equal across regions. Therefore, firms will open vacancies as long as the expected profit per vacancy in the region is bigger than the cost of opening it. In equilibrium no firm can open a job and make a positive profit since there are no barriers to entry, therefore $E(\pi_r) = k$. Substituting the expected profits, equation (2.10), in the free-entry condition and solving for the number of vacancies opened in the region, we obtain the "*Job Creation Condition*":

$$\theta_r = q_r \left[\frac{(1-\beta)A}{k}\right] \left[\frac{\int h(a)^\alpha f(a) da_r}{L_r}\right] \tag{2.11}$$

This condition says that in equilibrium, market tightness in the region depends positively on the employment rate, as well as on the distribution of human capital among the labor force.

In order to solve the equilibrium in each regional labor market we also have to determine the probability of finding a job (q_r). Using equation 2.8 and assuming a specific functional form for the matching function $m(V, L) = (bV)^\phi \, (L)^{1-\phi}$ we obtain the "*Employment Rate Condition*".

$$q_r = \begin{cases} (b\theta_r)^\phi & if \quad (b\theta_r)^\phi < 1 \\ \\ 1 & otherwise \end{cases} \tag{2.12}$$

where $b > 0$ is a scaling constant and $0 < \phi < 1$ represents the relative efficiency of firms and workers in the search process. [6]

Both, the "*Job Creation Condition*" and the "*Employment Rate Condition*" represent relations between market tightness and the probability of finding a job in a region, taking the labor force and the distribution of human capital in that region as given.

2.4 Regional Equilibrium

The equilibrium of each region in this economy is described by the two variables determining the equilibrium in the labor market, the probability of employment and the market tightness in the region, plus the individual's optimal investment in human capital, taking the labor force of each region and the marginal ability to migrate as given. In order to be able to analyze this equilibrium, we express the human capital in the same functional form as it appears in the Job Creation Condition (equation (2.11)), i.e.: $\frac{\int h(a)^\alpha f(a) da_r}{L_r}$ or as $E[h_r^\alpha]$, which I will call "average" human capital. Therefore the three equations de-

[6]For simplicity, in some calculations ϕ is assumed to be equal for both, i.e.: $\phi = \frac{1}{2}$.

termining the equilibrium in region r, taking a^* as given, are the following:

$$E[h_r^\alpha] = (\alpha A \beta q_r)^{\frac{\alpha}{\Psi-\alpha}} E[a_r^{\frac{\alpha}{\Psi-\alpha}}]$$

$$q_r = \begin{cases} \left(\frac{b(1-\beta)}{k} E[h_r^\alpha]\right)^{\frac{\phi}{1-\phi}} & if \quad q_r < 1 \\ \\ 1 & otherwise \end{cases} \tag{2.13}$$

$$\theta_r = \begin{cases} b\left(\frac{(1-\beta)A}{k}\right)^{\frac{1}{\phi}} E[h_r^\alpha]^{\frac{1}{\phi}} & if \quad q_r < 1 \\ \\ \frac{(1-\beta)A}{k} E[h_r^\alpha] & otherwise \end{cases}$$

Where $E[a_r^{\frac{\alpha}{\Psi-\alpha}}]$ is the "average" ability of region's r labor force[7], which depends only on a^*.

There always exists a unique non-trivial stable equilibrium, but it can have different characteristics depending on the concavity of the function determining the cost of education and on the underlying parameters of the economy.

Condition 2.1. *A stable equilibrium with unemployment exists when the following conditions hold:*

$$\begin{aligned} \Psi &> 2\alpha \\ E[a_r^{\frac{\alpha}{\psi-\alpha}}] &< \frac{k}{b(1-\beta)A^{\frac{\psi}{\psi-\alpha}}(\alpha\beta)^{\frac{\alpha}{\psi-\alpha}}} \end{aligned}$$

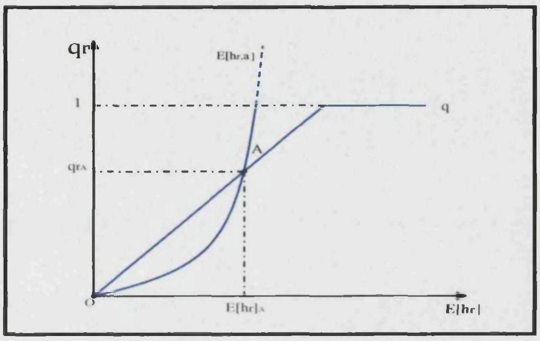
The first part of the condition is necessary for the stability of the equilibrium, while the second part guarantees that there is some unemployment in the region. [8]

Proposition 2.3. *A unique stable equilibrium with unemployment exists if*

[7] This expression can be approximated using a Taylor expansion by $E(a^{\frac{\alpha}{\Psi-\alpha}}) = \int a^{\frac{\alpha}{\Psi-\alpha}} f(a)da \approx (\mu_a)^{\frac{\alpha}{\Psi-\alpha}} - \varphi\frac{\sigma_a}{\mu_a}$, where μ_a and σ_a are the average and variance of ability, respectively

[8] If $\Psi < 2\alpha$, the human capital equation ($E[h_r^\alpha]$ curve in figure 2.6, will cut the employment rate equation (q_r curve) from above, making that equilibrium unstable. Then, the only stable equilibrium is the one with full-employment. For a more detailed discussion on this issue read section 1.4 in chapter 1.

Figure 2.6: Regional equilibrium with unemployment (given a*)



Axiom 1 is fulfilled, taking a^* as given. The equilibrium will be the following:

$$
\begin{aligned}
q_r &= \Lambda_1 \left(E[a_r^{\frac{\alpha}{\Psi-\alpha}}]\right)^{\frac{\Psi-\alpha}{\Psi-2\alpha}} \\
h_{i,r} &= [A\alpha\beta\Lambda_1 a_i]^{\frac{1}{\Psi-\alpha}} \left(E[a_r^{\frac{\alpha}{\Psi-\alpha}}]\right)^{\frac{1}{\Psi-2\alpha}} \\
\theta_r &= \frac{(\Lambda_1)^2}{b} \left(E[a_r^{\frac{\alpha}{\Psi-\alpha}}]\right)^{\frac{2\Psi-3\alpha}{\Psi-2\alpha}}
\end{aligned}
$$

where $\Lambda_1 = \left(\frac{b(1-\beta)}{c}\right)^{\frac{\Psi-\alpha}{\Psi-2\alpha}} (\alpha\beta)^{\frac{\alpha}{\Psi-2\alpha}} A^{\frac{\Psi}{\Psi-2\alpha}}$, *and* $E[a_r^{\frac{\alpha}{\Psi-\alpha}}]$ *is given by equation (2.7).*

The best way of understanding this equilibrium is graphically. In figure 2.6 we can see the equilibrium for a region, in the $\{q_r, E[h_r^\alpha]\}$ space. This stable equilibrium exists due to the existence of a coordination failure problem, or externality in the accumulation of human capital. This externality results from the interaction between the search frictions in the labor market (trading externality) and the heterogeneity of individuals. An individual (or rather a group of individuals) will not invest much in human capital if he expects a low probability of employment. At the same time, since the "average" level of human capital in the region is low, the expected profit from opening a vacancy will also be low and thus few vacancies will be opened. This will reduce market tightness diminishing the probability of employment for everyone in that region's labor market. Thus reducing everyone's investment in human capital. Then, the region may find itself at a situation with high unemployment, and a low level of human capital, for a given a^*.

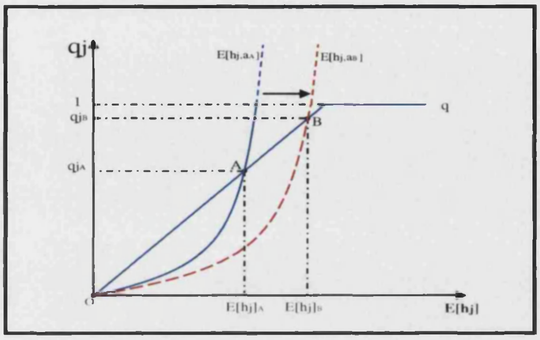


Figure 2.7: Effect of an increase in migration (reduction in a^*) in region j

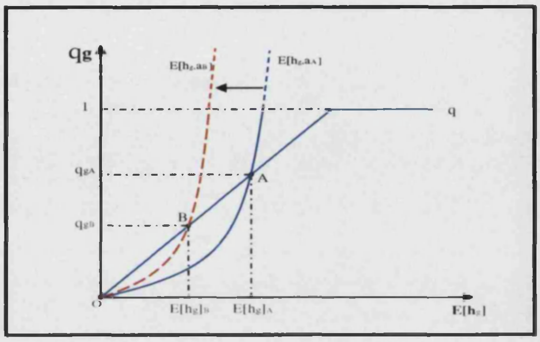


Figure 2.8: Effect of an increase in migration (reduction in a^*) in region g

Where exactly lies the regional equilibrium depends on the "average" ability of the labor force in the region, which depends on the marginal ability to migrate (a^*), as was shown in equation 2.7. From these equations it is clear that when a^* diminishes, the average ability of the labor force in the region receiving emigrants (j) increases (figure 2.7), while the one of the other region (g) goes down (figure 2.8). However, when migration becomes relatively large (a^* tends to zero), the "average" ability and human capital in the region receiving emigrants will start decreasing making the difference in regional average abilities decrease. Although this final effect never dominates and the regional differences in "average" abilities always remain positive.

Proposition 2.4. *An increase in the marginal ability to migrate (a^*) increases the average level of education and the probability to find a job in the region receiving emigrants. This augments the expected benefits from migration, reducing a^* even further and increasing more the number of migrants. The process will go on until a new equilibrium in the labor market is reached. The opposite happens in the migrants' region of origin. As migration increases, the average education in the region receiving emigrants starts to decrease and so does the probability to find a job, although, they always remain above the initial value with no-migration.*

Proof: It is clear from Proposition 2.3 that the equilibrium values of h_r and q_r depend positively on the average ability of that region's workforce ($E[a_r^{\frac{\alpha}{\Psi-\alpha}}]$). This in turn, for the region receiving emigrants depends positively on a^* for high values of a^*, but negative for low values of

a^*, while it depends negatively for the other region, as shown in Lemma 2.2 and 2.3. This can also be seen in figures 2.8 and 2.7.

2.5 Equilibrium of the Economy

The equilibrium of the economy is fully described by three equations: one for the employment rate of each region (q_j, q_g) plus another for the marginal ability to migrate (a^*). The problem is, that this system of equations can only be solved numerically. But since a^* is a function only of the difference between the regional employment rates $(q_j^\gamma - q_g^\gamma)$ (or market tightness $(\theta_j^{\phi\gamma} - \theta_g^{\phi\gamma})$), we can reduce this system to two equations and then solve it graphically. Namely,

$$(q_j^\gamma - q_g^\gamma) = \Lambda_1 \left\{ \left(E[a_j^{\frac{\alpha}{\Psi-\alpha}}]\right)^{\frac{\Psi}{\Psi-2\alpha}} - \left(E[a_g^{\frac{\alpha}{\Psi-\alpha}}]\right)^{\frac{\Psi}{\Psi-2\alpha}} \right\} \tag{2.14}$$

$$a^* = \frac{\Lambda_2}{(q_j^\gamma - q_g^\gamma)^{\frac{\Psi-\alpha}{\alpha}}} \tag{2.15}$$

where $\gamma = \frac{\Psi}{\Psi-\alpha}$; $\Lambda_1 = \left(\frac{b(1-\beta)}{c}\right)^{\frac{\Psi-\alpha}{\Psi-2\alpha}} (\alpha\beta)^{\frac{\alpha}{\Psi-2\alpha}} A^{\frac{\Psi}{\Psi-2\alpha}}$; $\Lambda_2 = \frac{m^{\frac{\Psi-\alpha}{\alpha}}}{\alpha(\beta A)^{\frac{\Psi}{\alpha}}}$. and the regional "average" abilities are equal to:

$$\begin{aligned} E[a_j^{\frac{\alpha}{\Psi-\alpha}}] &= \frac{\int_0^1 a^{\frac{\alpha}{\Psi-\alpha}} f(a)da + \int_{a^*}^1 a^{\frac{\alpha}{\Psi-\alpha}} f(a)da}{L\left(1 + \int_{a^*}^1 f(a)da\right)} \\ E[a_g^{\frac{\alpha}{\Psi-\alpha}}] &= \frac{\int_0^{a^*} a^{\frac{\alpha}{\Psi-\alpha}} f(a)da}{L\int_0^{a^*} f(a)da} \end{aligned} \tag{2.16}$$

In order to graph these two equations we need to know their first and second derivatives:

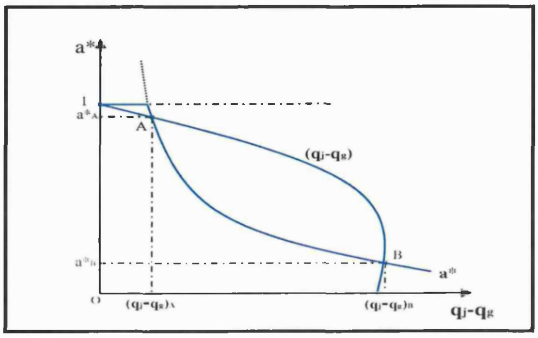
Lemma 2.4.

$$\frac{\partial a^*(eq(2.15))}{\partial(q_j^\gamma - q_g^\gamma)} < 0; \quad \frac{\partial^2 a^*(eq(2.15))}{\partial(q_j^\gamma - q_g^\gamma)^2} > 0$$

$$\frac{\partial a^*(eq(2.14))}{\partial(q_j^\gamma - q_g^\gamma)} \begin{array}{l} \leq 0 \quad for \quad a^* \quad high \\ \geq 0 \quad for \quad a^* \quad low \end{array} ; \quad \frac{\partial^2 a^*(eq(2.14))}{\partial(q_j^\gamma - q_g^\gamma)^2} \begin{array}{l} \leq 0 \\ \geq 0 \end{array}$$

Proof: The derivatives for each case are derived in Appendix B. It is difficult to find the sign of the derivatives of equation 2.14 with respect to a^* without specifying a particular distribution function for f(a). However,

Figure 2.9: Equilibrium of the economy



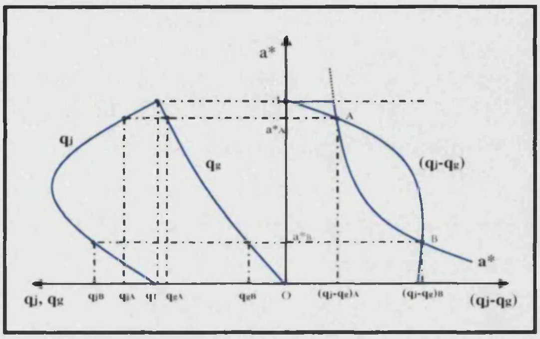
from lemmas 2.2 and 2.3 and proposition 2.2 it is clear that the regional difference in average ability will increase for high levels of a^* and decrease for low levels of a^*. Therefore, the first derivative of equation 2.14 has to be negative for low levels of migration, but as migration increases it goes down until it eventually becomes negative. In terms of the second derivative of equation 2.14, even though we cannot unambiguously find its sign, this does not affect the properties of the possible equilibria. Equilibrium B will be stable if, equation 2.14 cuts equation 2.15) from above, which is true independently of the second derivative of equation 2.14. For ease in the exposition below, I assume it to be positive.

The equilibrium can be seen in figures 2.9 and 2.10. It is clear from these figures that there may exist one, two or three equilibria in the economy, depending on whether the two curves cross, are tangent or do not cross. The most interesting case is the first one, depicted in the figures, where three equilibria exist: equilibrium 1, with no migration ($a^* = 1$) and equal economic characteristics in both regions ($q_j = q_g$); and equilibria A and B, where migration takes place and regional divergence prevails.

Lemma 2.5. *Equilibrium 1 and A are stable, while B is unstable.*

Proof: This can be shown using figure 2.9. If we have a marginal ability to migrate (a^*) larger than the one that equilibrates both regions' labor markets (a point to the right of B), that is, if entrepreneurs expect more people to migrate than what really occurs. Then the average human capital in the recipient region is lower than expected and there is less

Figure 2.10: Equilibrium of the economy comparing regional labour markets



job creation in that region, so the regional differences are lower as well ($\downarrow q_j - q_g$). This reduces even more the incentive to migrate, triggering an even higher a^* and reducing even further the incentives to create more jobs. The result is that a^* and $(q_j - q_g)$ increase until point B is reached. The opposite is true for a point to the left of B.

The most important implication from this case is the possible multiplicity of equilibria. If, for any reason, one region is affected by a negative shock strong enough to move this economy to a point to the right of A in figure 2.9, then, once the shock disappears the economy will not return to the original situation, but instead converge to a new equilibrium (B). That is, temporary regional divergences may become permanent if the initial regional shock is strong enough.

Proposition 2.5. *Possible multiplicity of equilibria. If a region is affected by a negative shock, strong enough to move this economy to a point to the right of A, when the shock disappears the economy may converge to a new equilibrium (B). At B regional divergences in employment rates, wages and human capital stocks become permanent.*

In the stable equilibrium with migration (B), the recipient economy (region j) has a labor market that is performing better, with a higher employment rate, market tightness and human capital stock, as is clear from figure 2.10 and Proposition 2.2. But, it is also true that this economy has a higher average expected wage and a higher real wage for all levels of qualification:

$$E[w_j] - E[w_g] = \beta A \left(E[h_j^\alpha] - E[h_g^\alpha]\right) \geq 0$$

Table 2.1: Comparative statics

	Parameters							
variables	m	b	L	c	β	A	ψ	α
a^*	+	−	+	+	−	−	+, −	+, −
$q_j^\gamma - q_g^\gamma$	−	+	−	−	−	+	+, −	+, −

NOTES: The derivative of each of the equilibrium equations with respect to the parameters are calculated in the appendix.

$$w_j - w_g = (\beta A)^\gamma a_i^{\frac{\alpha}{\Psi-\alpha}} \left(q_j^{\frac{\alpha}{\Psi-\alpha}} - q_g^{\frac{\alpha}{\Psi-\alpha}} \right) \geq 0 \qquad \forall i \quad if \quad q_j \geq q_g$$

Proposition 2.6. *An economy which in equilibrium receives immigrants, has a labor market that is performing better, with a higher employment rate, market tightness and human capital stock. In addition, this economy has a higher average expected wage and a higher real wage for all levels of qualification.*

2.5.1 Comparative statics

Table 2.1 summarizes the effect that changes in some of the parameters of the economy have on the equilibrium values of the marginal ability to migrate and the difference in regional employment rates.

A rise in the cost of migration (m) will reduce migration and the regional differences in employment. This is because a higher cost of migration reduces the incentive to migrate and the number of migrants for a given level of regional differences in employment, that is, it shifts upwards the migration curve (equation 2.15), as can be seen from figure 2.11. However, it does not affect the regional labour markets curve (equation 2.14). As a consequence, the economy moves along the regional labour markets curve towards the new equilibrium, where migration and regional differences in employment are lower (a^* is higher and $q_j^\gamma - q_g^\gamma$ is lower).[9]

An increase in the matching efficiency (b), a reduction in the costs of opening a vacancy (c) or a reduction in the population born in each area (L), all have a similar effect, increasing migration and regional differences. This change in the parameters increases the (ex-ante) expected profits[10] from opening a vacancy

[9]Regional differences could actually increase due to the shape in the regional labour markets curve, which has a negative slope for low levels of migration but a positive one for high levels of migration.

[10]Ex-post profits are always zero in equilibrium due to the free-entry condition.

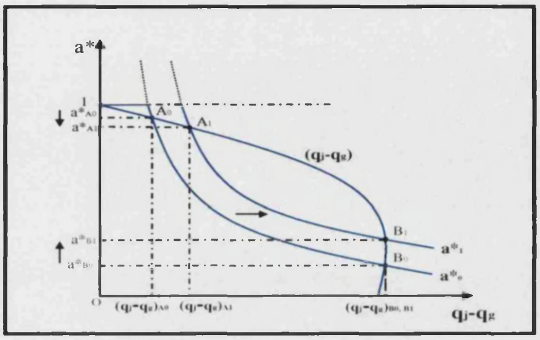


Figure 2.11: Increase in the cost of migration (m)

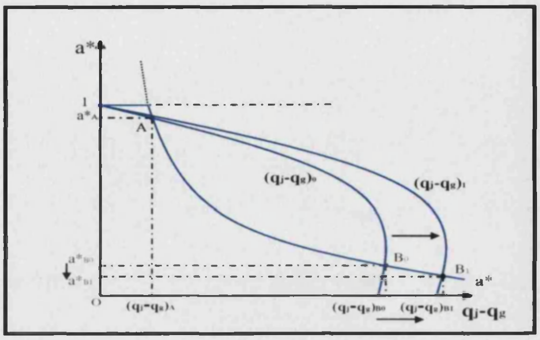


Figure 2.12: Increase in b, or decrease in L or c

and therefore rises job creation in each region, given the average ability of the population in the region. However, since the average ability was already higher in the region receiving migrants, (ex-ante) expected profits increase proportionally more in that region and so does job creation rising regional differences even further. This means that the regional labour markets curve (equation 2.14) shifts to the right, while the migration curve remains unchanged (see figure 2.12). Therefore, the new equilibrium lies to the right and below the original one, with a lower a^* and a higher $q_j^\gamma - q_g^\gamma$.

A rise in productivity (A) also increases migration and regional differences in employment, but in this case is as consequence of both curves shifting. On the one hand, a rise in these parameters increases the real wage in both regions and consequently the individual investment in education. This allows more people to migrate from the region with the lower employment rate to other one for a given difference in regional employment rates since they are earning more now while the migration costs have not changed. That is, we have a lower a^* for a given $q_j^\gamma - q_g^\gamma$, and therefore the migration curve has shifted down. In addition, the rise in education increases ex-ante expected profits in both regions, but proportionally more in the region with higher employment rate, rising even more regional differences in employment. This means that the regional labour markets curve has also shifted to the right, as shown in figure 2.13.

A rise in the bargaining power of workers (β) (rise in the share of rents from the match allocated to workers) increases migration but decreases regional dif-

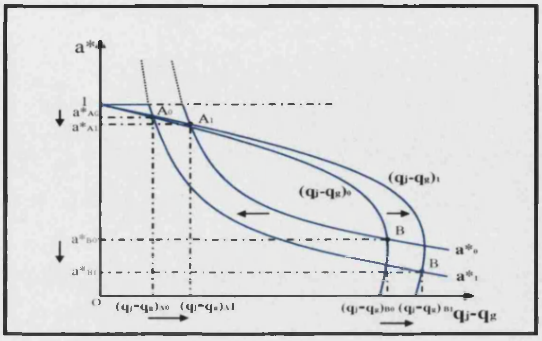


Figure 2.13: Increase in Productivity (A)

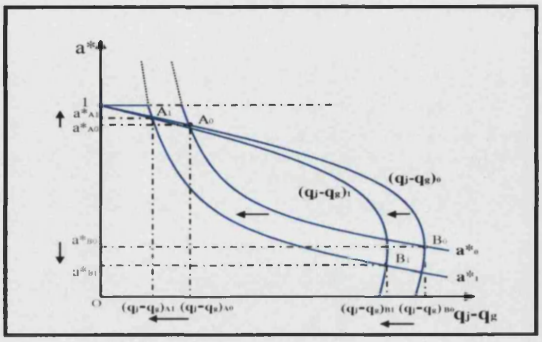


Figure 2.14: Increase in β

ferences in employment, as consequence of both curves shifting. On the one hand, a rise in these parameters increases the real wage in both regions and consequently the individual investment in education. This allows more people to migrate from the region with the lower employment rate to other one for a given difference in regional employment rates since they are earning more now while the migration costs have not changed. That is, we have a lower a^* for a given $q_j^\gamma - q_g^\gamma$, and therefore the migration curve has shifted down. On the other hand, the rise in education increases ex-ante expected profits in both regions, but proportionally more in the region with higher employment rate, rising even more regional differences in employment. However, a rise in the bargaining power of workers also implies a reduction in the bargaining power of firms $(1 - \beta)$ which reduces the firm's profits per vacancy opened and job creation. This last effect is stronger than the effect due to the increase in education, therefore the labour markets curve also shifts to the left, as shown in figure 2.14.

Finally, a change in the share of human capital in production (α) and of the parameter determining the concavity of the cost of education (ψ), has an ambiguous effect on the equilibrium of the model. The problem is that these parameters shift both curves and change their shape, making it very difficult to predict where the final equilibrium will be.

2.6 Welfare analysis

One would be very interested in the ranking according to a Pareto criterium of the different possible equilibria in this economy. However, the welfare analysis is not easy in this model since we cannot solve analytically for the equilibrium and most of the results depend on how much migration there is in equilibrium. In general, one can say that the stable equilibrium with migration can only increase overall welfare when migration is not very high (a^* away from zero).

The overall welfare of a region is equal to the total production in the region minus the costs to generate this product, which include the cost of opening vacancies, the cost of education and the cost of migration.

$$W_r = N_r E(y_r) - cV_r - L_r E(e_r) - mL \int_{a^*}^{1} f(a)da$$

Or if we express it in terms of welfare per individual:

$$w_r = \frac{W_r}{L_r} = q_r E(y_r) - c\theta_r - E(e_r) - m \frac{\int_{a^*}^{1} f(a)da}{\int_0^1 f(a)da + \int_{a^*}^{1} f(a)da}$$

Substituting into this expression the equations for the employment rate, labour market tightness, production and effort, and expressing the resulting equation in terms of the "average" ability in the region, we get the following equation determining regional welfare:

$$w_r = \Lambda_w E\left[a_r^{s\frac{\alpha}{\psi-\alpha}}\right]^{2\left(\frac{\psi-\alpha}{\psi-2\alpha}\right)} - m \frac{\int_{a^*}^{1} f(a)da}{\int_0^1 f(a)da + \int_{a^*}^{1} f(a)da}$$

where $\Lambda_w = (\Lambda_1 A)^{\frac{\psi}{\psi-\alpha}} (\alpha\beta)^{\frac{\alpha}{\psi-\alpha}} - \frac{c\Lambda_1^2}{b} - \frac{(A\alpha\beta\Lambda_1)^{\frac{\psi}{\psi-\alpha}}}{\psi}$, $r = j, g$ and $s = M, NM$. The index r represents the region, while the index $s =$ represents the equilibrium for which we are evaluating the welfare (M with migration, NM with no migration). That is, $E\left[a_r^{s\frac{\alpha}{\psi-\alpha}}\right]$ refers to the "average" ability of region r in equilibrium s. In an economy without migration or in a region with emigration the last element measuring the cost of migration will be equal to zero.

In order to see if migration increases the region's welfare, we compare the welfare obtained in the equilibria with and without migration (i.e.: $w_r^M - w_r^{NM}$).

For the case of the region receiving migrants (region j), this welfare difference will be:

$$w_j^M - w_j^{NM} = \Lambda_w \left\{ E\left[a_j^{M\frac{\alpha}{\psi-\alpha}}\right]^{2\left(\frac{\psi-\alpha}{\psi-2\alpha}\right)} - E\left[a^{NM\frac{\alpha}{\psi-\alpha}}\right]^{2\left(\frac{\psi-\alpha}{\psi-2\alpha}\right)} \right\} - m\frac{\int_{a^*}^1 f(a)da}{\int_0^1 f(a)da + \int_{a^*}^1 f(a)da}$$

Note that we have dropped the regional index for the "average" ability in the equilibrium with no migration since it is equal for both regions. It is clear from this expression that migration will not increase the welfare in a region receiving migrants for all levels of migration. The change in the region's welfare due to migration is composed of two opposing forces: the higher the average ability the greater the increase in welfare, while the higher the cost of migration the lower the increase. From lemma 2.3 we know that the average ability in the region receiving migrants increases for low levels of migration, while it decreases for high levels of migration. In addition, the cost of migration is always increasing with migration. Therefore, the welfare difference will be positive (and possibly increasing) for low levels of migration, but as migration becomes more important the difference will go down and eventually become negative. In the extreme, if every individual emigrated to this region, the "average" ability will be back to the level with no migration, and the difference in welfare will be negative and equal to the migration costs.

In the migrants' region of origin welfare will always decrease when migration occurs. From lemma 2.2, we know that the "average" ability in this region decreases with migration since the most able individuals will migrate first. If all individuals leave this region the average ability becomes zero and the difference in welfare is at its maximum.

Proposition 2.7. *Overall welfare in the economy will be greater in an equilibrium with migration if the optimal level of migration is not too high and the cost of education is not too concave, otherwise it will lower. For very high levels of migration, both the cost of migration becomes quite large and the "average" ability in the region receiving migrants becomes small, making overall welfare negative. In addition, when the function determining the cost of education is very concave ($\psi \geq 2$), the rate at which average ability decreases in region g is greater than the one at which it increase in region j making welfare always negative.*

2.7 Conclusions

The main contribution of this chapter is to highlight the importance of Marshall's first reason to explain geographical concentration of economic activity, that is, the existence of a large pool of skilled workers in the region. A simple model is developed to show that the labor market itself plus migration can generate an externality which potentiates the concentration of economic activity. Where exactly the activity is located will depend on history and expectations. This model can explain the persistent regional differences in human capital stocks, unemployment rates and wages across regions of developed countries.

In addition, we undertake some comparative statics analysis. We find that a higher bargaining power for workers in the wage setting process and a higher level of technology increase regional differences in the equilibrium with migration, while a lower migration cost, larger population (in both regions) and higher cost of opening vacancies reduces regional differences in equilibrium.

Finally, we also show that the equilibrium with migration and persistent regional differences can be Pareto improving but only for low levels of migration and low marginal cost of education in terms of effort.

Further work should consist in attempting an empirical test of the mechanism described above. This is undertaken in chapters 3 and 4 in this thesis. There we will show that a higher regional level of education reduces average unemployment duration and increases the individual probability to continue studying at sixteen, seventeen and eighteen years of age. In addition, we will also show that this mechanism seems to work through higher job creation, as implied by the theoretical model developed here, since we find that a higher regional average of education increases regional market tightness.

Chapter 3

An econometric analysis of education externalities in the matching process of UK regions (1992-99)

3.1 Introduction

This chapter studies the existence and the scale of regional education externalities in the unemployment durations suffered by workers in the UK. First, we develop a simple model, based on chapters 1 and 2, to address this issue theoretically. Then, we test it empirically using data from the UK Labour Force Survey for the 17 UK regions over the period 1992Q1-99Q4.

Education externalities have been at the heart of the economic and policy debate for the last two decades. Different theoretical explanations have been developed, and these can be grouped into two main categories: technological externalities (or non-pecuniary) and pecuniary externalities. Both these types of externalities were already mentioned by Alfred Marshall (1920) as reasons explaining the concentration of economic activity. However, they were not further developed until more recently.

The first type of externality was re-discovered by the works of Romer (1986) and Lucas (1988). They showed theoretically that, in an area with a higher average level of education processes like the exchange of ideas, imitation or learning by doing are more likely to occur, in turn fostering technological progress. These type of spill-overs have been explored in great detail by the endogenous growth literature. The second type of externality was re-discovered by the works of Krugman (1991a) and further developed by the new economic geography literature. However, these ideas have also been used in other areas of economic research. Acemoglu (1996) showed that, in a labour market were it is costly for firms and workers to find each other, if the average level of education of workers is high then firms will invest more in physical capital. This generates a pecuniary education externality which does not work through technology, but through improving the search process. Based on this idea, a similar type of externality is developed in chapters 1 and 2 of this thesis. There, it is shown that the average level of education of workers in a labour market affects job creation and the duration of unemployment.

However, despite these theoretical developments, there had not been any relevant empirical work on this area until fairly recently. Moreover, most of the existing work has concentrated on the estimation of the effect of average education in an area on individual wages, that is, on estimating the social returns to education. Rauch (1993) was the first attempt to estimate human capital externalities. He used data from the United States' 1980 Census to test the effect of average education in the Standard Metropolitan Statistical Areas on individual wages. He found that a one-year increase in average schooling in an area raises individual wages by between 3-5%. Moretti (1998) re-estimates this effect for US cities using instruments for the average level of education to avoid an omitted variable bias problem. He finds that a 1 percentage point increase in college share in a city raises average wages by 1.2%-1.4% above the private returns to education.

Other studies have found little evidence of significant external returns. Acemoglu and Angrist (2000) estimated the effect of average schooling in US states on individual wages, using the change in State compulsory attendance laws and child labour laws as instruments. They found modest external returns of 1-3%. Moretti (1998) indicated that the fact that average education affects wages does not necessarily imply the existence of education externalities. This result could be due to complementarities between high and low educated workers.

However, he argued that if different skills are perfect substitutes, the effect of an increase in the supply of educated workers on their own wage had to be an external effect. By doing this he found that a 1 percentage point increase in the labour force share of college graduates increases wages of college graduates by 1.2%, and therefore concluded that education externalities are important in US cities. Ciccone and Peri (2000) argued instead that if skills are imperfect substitutes, one cannot separately identify the external effect from the effect of the complementarity of skills using a regression of individual wages on average wages. They used a standard neoclassical growth model to identify external effects and found that these were negligible and insignificant. However, their methodology is completely dependent on the theoretical model used. In particular, they implicitly assume competitive labour markets and full employment.

Another line of empirical research has looked at the effect of education externalities on employment growth in cities. Simon (1998) found that a rise in the supply of high school and degree graduates in a US Standard Metropolitan Area in 1940 increases employment growth in the area and that this effect is persistent, lasting up to 40 years. Simon and Nardelli (1996) looking at English cities found that this effect could last up to a century. Glaeser, Hallal, Scheinkman and Schleifer (1992) studied the effect of knowledge spill-overs on employment growth in industries within cities. They found that these effects are more likely to occur between industries within a city and when competition between firms in an industry is strong.

In this paper we take a different approach - we test the existence of education externalities in the matching process. Firstly, a simple model showing the existence of a pecuniary education externality in the matching process is developed. In this model, human capital externalities arise when there are matching frictions in the labour market because firms have to decide whether to create a job or not before knowing who they will finally employ. Thus, a more educated labour force will increase the expected profits per vacancy opened and increase job creation in that area, at the same time increasing the worker's probability of finding a job. That is, if externalities exist in the matching process, one should find that unemployed individuals belonging to a local labour market where the labour force is better educated have a higher probability of moving from unemployment into employment than otherwise similar unemployed individuals in labour markets where the labour force is less educated. In addition, for a given average, the more equal the distribution of education the higher the probability of transition.

We test this theory by a maximum-likelihood estimation of a model of the duration of unemployment which assumes a discrete-time semi-parametric hazard function and allows the covariates to vary within each unemployment spell. The estimation shows that the higher the average and the more equal the distribution of education in a labour market, the higher the individual probability of transition from unemployment to employment. Both of these effects are statistically significant at the 10% level. The magnitude of the effect is in line with the findings in the literature. A 1% increase in the average education of the average labour market rises the probability of employment by 1.2%. This effect increases to 2.8% when we consider only intermediate and skilled occupations, while it is negative for the unskilled occupations.

Finally, an important issue in this literature, raised by Ciccone and Peri (2000), is whether these effects are due to education externalities or to complementarities in skills. It is difficult to apply their work to this model since they implicitly assume a competitive labour market with no unemployment. However, what their work shows is that there is a significant effect of an area's skill composition on wages paid, but this is not due to an externality that works through improvements in productivity. Then, using their model they conclude that their result has to be due to complementarity of skills. Alternatively, one could interpret this result as suggesting that it might be other types of externalities not working through productivity which are important. One such type could be the one studied in this research, which may affect wages through improving the matching process.

This chapter will be organised as follows. In section 3.2 the theoretical model is developed. The dataset used as well as some descriptive analysis of the distribution of education and its relation with labour market performance is described in section 3.3. The econometric methodology is explained in section 3.4. Section 3.5 outlines the estimation results and some robustness analysis. In section 3.6 we try to confirm the relevance of the results by estimating directly the effect of education externalities on job creation. Finally, section

3.7 concludes.

3.2 Theoretical model

The relationship to be estimated in this chapter is based on the theoretical models developed in chapters 1 & 2. In particular, I will use a simplified version of the model of chapter 1.

Consider an economy lasting one period composed of a continuum of workers and firms, both normalized to 1. Individual human capital h_i is a function of innate ability and assumed to be given (endogenized in chapter 1). Opening a vacancy is costly (assume it costs c) and firms have to decide whether to open it or not before searching for a suitable worker. Firms and workers are matched randomly in the labour market, but not every worker (firm) meets a firm (worker). Therefore, there is unemployment in equilibrium. This implies that total employment is equal to the number of people looking for a job times the probability of finding one. The probability that a worker (firm) meets a firm, q (worker, p), is equal to the number of matches N over the number of people searching L (vacancies V):

$$p = \frac{N}{V}; \; q = \frac{N}{L} \tag{3.1}$$

Once a firm and a worker are matched they have to decide whether to produce together or not to produce at all (since they live only one period). If they produce together, their output is $y_i = Ah_i^{\alpha}$, where $\alpha < 1$, and $A > 0$ represents aggregate productivity. Wages are set to share the rent generated by the match according to a Nash-bargaining rule. This means that the worker receives a share β of the output, while the firm receives the rest of the output, $(1-\beta)y_i$. Firms' expected profits are equal to the probability of meeting a worker p times the expected product from the match, minus the cost of opening and filling the vacancy.

$$p(1-\beta)AE[h_i^{\alpha}] - c \tag{3.2}$$

Since the firm does not know which worker it will be matched with, expected profits depend on the average level of education in the market. There is free entry into the market, thus in equilibrium firms will open vacancies until the expected profits are equal to zero.

Substituting equation 3.1 into 3.2 and solving we get the equilibrium expression for the probability of finding a job given that you are unemployed (hazard rate into employment):

$$q = \frac{(1-\beta)AE[h_i^{\alpha}]}{c} \tag{3.3}$$

Human capital externalities arise in this model because firms have to decide whether to create a job or not before knowing who they will finally employ. A more educated labour force will increase the expected profits per vacancy opened and increase job creation. If the labour market was perfectly competitive and there were no matching frictions, firms would be matched with workers until the worker's human capital made the firm's profits equal to zero. In this case, every firm knows who it will be matched with and therefore the job creation decision depends only on the individual's human capital. That is, in the competitive case aggregate employment is determined by the position of the marginal worker in the education distribution. With matching frictions it is determined by the whole distribution of education. This external effect has been named a pecuniary externality since it is generated in the matching process and is independent of the existence of increasing returns in the production function.

As was mentioned in the introduction, education externalities may also arise through the exchange of ideas, imitation or learning by doing (Romer (1986) and Lucas (1988)). These external effects have been called technological or non-pecuniary externalities because they are generated in the process of production. They can be captured in this model by allowing the aggregate productivity term A to depend on aggregate human capital in the following way:

$$A = E[h_i^{\delta}] \tag{3.4}$$

If we substitute this into equation 3.3 we have:

$$q = \frac{(1-\beta)E[h_i^{\delta}]E[h_i^{\alpha}]}{c} \tag{3.5}$$

From this equation it is clear that pecuniary and non-pecuniary externalities cannot be separately identified empirically using this model. Instead, in the empirical estimation we will control for the level of technology in the region by including the industrial structure of employment.

Up until now we have assumed that all individuals face the same probability of finding a job. However, this probability may vary across individuals if the individual search effort is endogenous, as was shown in chapter 1, section 1.7. In this case, the individual probability of finding a job (q_i) is equal to the aggregate probability (q) times the individual's search effort (s_i). If we solve the individual maximization problem we get the optimal level of search intensity as a function of the individual human capital, but also of his innate ability (a_i) and of the labour market conditions.

$$s_i = (A\beta a_i h_i^{\alpha} q)^{\frac{1}{\Gamma-1}} \tag{3.6}$$

where $\Gamma > 1$. Therefore, the individual probability of finding a job q_i will be:

$$q_i = s_i q = \{\frac{\beta(1-\beta)^{\Gamma} a_i h_i^{\alpha} E[h_i^{\delta}]^{\Gamma} E[s_i h_i^{\alpha}]^{\Gamma}}{(cs)^{\Gamma}}\}^{\frac{1}{\Gamma-1}} \tag{3.7}$$

Finally, taking logs in this equation we obtain the relationship we are trying to estimate in this chapter.

$$\ln q_i = \ln\{\frac{\beta(1-\beta)^{\Gamma}}{(cs)^{\Gamma}}\}^{\frac{1}{\Gamma-1}} + \frac{1}{\Gamma-1}\ln a_i + \frac{\alpha}{\Gamma-1}\ln h_i + \frac{\Gamma}{\Gamma-1}\ln E[h_i^{\delta}] + \frac{\Gamma}{\Gamma-1}\ln E[s_i h_i^{\delta}] \tag{3.8}$$

We will test whether the probability of finding a job given that you are unemployed for t periods (or unemployment duration) is positively related with the average level of education in the labour market after controlling for individual education and other individual and local characteristics - that is, whether $\frac{\Gamma}{\Gamma-1} > 0$.

3.3 The data

The data used in this chapter comes from the longitudinal Labour Force Survey (LFS). The LFS is designed to be representative of the total population in

GB[1], containing very detailed information on the labour force status of individuals as well as on family and individual characteristics. In addition, we use the non-longitudinal LFS to obtain aggregate variables reflecting the evolution of the British regional labour market over time.

The longitudinal LFS is conducted every quarter on all members of around 60.000 households. One fifth of the sample is renewed quarterly and hence we can observe any individual for a maximum of five quarters. It started in the first quarter of 1992 (march-may) and we use all waves up to the fourth quarter of 1999 (November-January)[2]. This period of nine years covers more than a whole cycle of the British Economy. The sample is constructed using only the unemployment spells taking place during the five quarters each individual is in the sample, to avoid a stock sampling bias problem. That is, spells which start not earlier than the quarter of the first interview. This means that the longest spell will be 14 months. This will avoid stock sampling biases. Spells will be measured in months[3]. The resulting sample consists of 15,974 unemployment spells with an average duration of 3.4 months. Out of these durations 40.8% finished with a transition into employment, 15.7% finished with a transition into inactivity and the remaining 43.5% did not conclude before the individual left the sample (see table 3.2).

Since the aim of this study is the estimation of the effect of education matching externalities on the transitions from unemployment to employment, the most important variables are the ones measuring the distribution of education in the local labour market. We assume that the distribution of education is perfectly described by its mean and standard deviation. The theoretical model predicts that what is important is the specific segment of the labour market the individual is participating in. The problem is how to define the relevant

[1]Northern Ireland is excluded from the study since the quarterly LFS was not introduced in this area until the winter of 1994-95.

[2]After 1999 regions are only reported using the new classification of regions (GOR). In addition, the county indicator is also dropped from the LFS at this moment which makes it impossible to construct comparable regions.

[3]In some estimations a sample including all unemployment spells reported by individuals is used. These can be obtained since individuals are asked in each interview how long have they been unemployed for, how long have they been actively looking for work if unemployed and when did they start to work. Due to the structure of these question spells may have the following length: 1 month, 3 months, 6 months, 1 to 5 years. When using this sample the Log-likelihood function is corrected for the stock sample bias

segment of the labour market in the data. In this paper we use occupation groups in each region. Using this definition, we calculate the average level of education as the mean education across all the individuals belonging to the same occupation group in a region at a moment in time. Every individual is attributed the average level of education of his own labour market segment - e.g. a manager is attributed the average level of education of the managers in his area in that quarter. We are only looking at direct spill-over effects, that is, within occupation spill-over. We do similarly for the standard deviation of education.

The education and occupation variables used are explained in table 3.1 [4]. The individual education variable has 9 levels going from low to high education. This classification distinguishes between academic and vocational qualifications. In addition, we have aggregated this variable into 4 education groups, where academic and equivalent vocational qualifications belong to the same category.

The regions considered are based on the Standard Statistical Regions classification, split into metropolitan and non-metropolitan areas whenever possible. This divides GB into 19 regions: Tyne & Wear, rest of Northern region, South Yorkshire, West Yorkshire, Rest of Yorkshire & Humberside, East Midlands, East Anglia, Inner London, Outer London, Rest of the South East, South West, West Midlands metropolitan, Rest of West Midlands, Greater Manchester, Merseyside, Rest of North West, Wales, Strathclyde and Rest of Scotland. [5]
The Occupation variable follows the 9 Major Occupation Groups defined by the new Standard Occupational Classification (SOC) introduced in 1991. This classification was designed so that the occupational groupings brought together jobs with similar requirements in terms of qualifications, training and experience. The ranking of these nine major categories from 1-9 was meant to reflect the progression of the occupations from those requiring a higher level of qualifications, training and/or experience down to those requiring a much

[4] A more detailed definition of the education variable can be found in appendix C.1, tablet-education-detail

[5] A detailed list of the counties included in each region can be found in Appendix B, table C.2.

Table 3.1: Categories of Education and Occupation variables

Education		**Occupation**	
9 groups	**4 groups**	**9 groups**	**4 groups**
Degree	Degree or equivalent	Managers	Managerial/ Professional
High Voc.		Professionals	
A Level	A Level or equivalent	Technicians	Technical
Mid. Voc.		Craft	
O Level	O Level or equivalent	Clerical	
Low Voc.		Personnel	Service
Other Acad.	Other Voc. & no qual	Sales	
Other qual		Operators	Manual
No qual		Others	

lower level of skill or experience. This is particularly relevant for this study since we are using occupation groups to identify segments of the labour market which are fairly homogeneous in terms of the education level (ability) of its workers. We have also constructed a more aggregated occupation variable with 4 groups, keeping the hierarchical structure of the SOC.

The other explanatory variables used in this study can be divided into three groups: personal, household and regional characteristics. The personal characteristics include: age, sex, education, last job's occupational group, being white, being married, having migrated in the last year, and whether receiving unemployment benefit or financial help from relatives. The household variables are: region of residence, whether receiving housing benefit, number of dependent children under 6 and between 6 and 16, number of people working in the household and whether it is a one-person-household or a two-person-household. The variables reflecting regional characteristics are obtained from the non-longitudinal LFS and include: average level and standard deviation of education within each occupation group in the region, unemployment rate by region, inactivity rate by region, vacancy rate by occupation and region, ratio of the flow of immigrants to the flow of emigrants and industry's share of employment in the region (10 industries). The migration data is derived from the National Health Service Central Register, provided by NOMIS. Finally, we also include time and region dummies. All the regional variables are included in the estimation in logarithms.

The household and regional variables are allowed to vary within each unemployment spell, except for the region of residence[6], while the personal characteristics remain unchanged[7].

Finally, since the theoretical model does not provide a way of distinguishing between technological and pecuniary externalities, the only possibility is to try to control for each region's technological level. We attempt this by including the industrial structure of employment in each region (using a 10-industry classification). The idea being that, for example, a region with a high share of employment in agriculture will have a low technological level, while another with a high share of employment in financial services will be quite advanced technologically.

Table 3.2: Sample means of individual characteristics by occupation group

Variables	all occup	high occup	low occup
Duration Characteristics			
% exit into employment	40.8	45.0	37.1
% exit into inactivity	15.7	12.5	18.6
% stay unemployed	43.5	42.5	44.3
average duration	3.36	3.31	3.41
Individual Characteristics (%)			
Male	56.1	62.7	50.4
16-24 years of age	35.0	26.2	42.6
25-34 years of age	24.5	25.6	23.5
35-49 years of age	27.7	31.9	24.0
50-59/64 years of age	12.8	16.3	9.9
Non-white	7.4	6.4	8.3
Married	45.0	51.7	39.0
Migrant	2.2	2.3	2.2
Head of Household	39.3	46.0	33.4

continued on next page

[6]The LFS is a survey of non-movers.

[7]Changes in some of the personal characteristics, like age (in years) or education, may occur during an unemployment spell. However, since the maximum spell is 14 months, the effects of these changes are likely to be small.

Table 3.2: *continued*

Individual's Education (%)			
Other Voc	9.1	8.0	10.1
Other Acad	7.8	5.8	9.6
Low Voc	16.9	22.1	12.4
O Level	18.9	17.1	20.4
Mid Voc	2.9	3.8	2.0
A Level	6.3	7.2	5.5
High Voc	4.1	6.2	2.3
Degree	6.7	11.9	2.2
Last Job's Occupational Group (%)			
Operator	14.2	0.0	26.6
Sales	11.5	0.0	21.6
Personal	11.4	0.0	21.5
Clerical	15.7	0.0	0.0
Craft	14.6	31.3	0.0
Technical	5.4	11.7	0.0
Professional	3.8	8.2	0.0
Manager	7.1	15.3	0.0
Household Structure			
no dep child < 6	0.29	0.27	0.31
no dep child < 16	0.81	0.70	0.91
no working	1.2	1.2	1.2
% one person house	12.9	15.2	10.9
% two person house	23.7	26.0	21.6
Benefits (quarter before exit (%))			
Housing benefit	7.3	5.7	8.7
Unemp benefit	52.8	59.9	46.6
Family credit	1.3	0.9	1.7
No of cases	15,974	7,459	8,515

NOTES: "high occup" denotes occupations 5-9 of the SOC classification, while "low occup" denotes occupations 1-4 (see table 3.1.

3.3.1 The distribution of education across regions

Looking first at GB as a whole (figure 3.1 & table 3.3). The level of education of the working age population has grown steadily during the 1990s at an aver-

Table 3.3: Average Education by 4 Occupation Groups

	Average Level			Growth
Occup	92-99	92	99	92-99
M/P.	6.4	6.2	6.7	1.2
Tech	4.9	4.6	5.2	1.7
Serv	4.2	4.0	4.5	1.8
Man	3.0	2.8	3.1	1.5
All	4.4	4.2	4.7	1.7

age annual rate of about 1.7%, from a situation where the average person had at least some low vocational qualifications in 1992 to near having O Levels in 1999. Although this great increase in qualifications has affected all occupation groups, it has been most important in the intermediate occupations (technical & services), with average annual growth rates of 1.7-2%. The highest and lowest occupations grew at an average annual rate of only 1.2%. Despite the differences in growth rates, the top occupations have the highest qualifications over the whole period.

At a regional level, the general trends pointed out above are still present. The highest average corresponds to the skilled occupations and the lowest to the unskilled (table 3.4). However, there are important differences across regions. The biggest differences occur in the unskilled occupations, where the level of education of the worst region is 25% lower than that of the top one, while the skilled occupation group is the most uniform across regions (the education of the worst region is 10% lower than the top one). This is also reflected in their respective standard deviations (0.073 vs. 0.03) and gini coefficients (0.039 vs. 0.015). The 19 regions considered might be classified into three groups according to their average level of education (table 3.4). First of all, there is a group of regions which have the highest level of education across all occupations: Scotland, the South East (including Great London) and the South West. Secondly, Metropolitan West Midlands and Rest of Northern Region have the lowest level of education across all occupations. Thirdly, there is a lot of variation across occupations for the rest of the regions. Some regions, like Tyne & Wear, have low qualified Manual, Service and Technical occupations but medium-high qualified Manager/Professional occupations. While for other regions, like East Anglia, Rest of Yorkshire & Humberside and the Rest

Figure 3.1: Average education by occupation (GB)

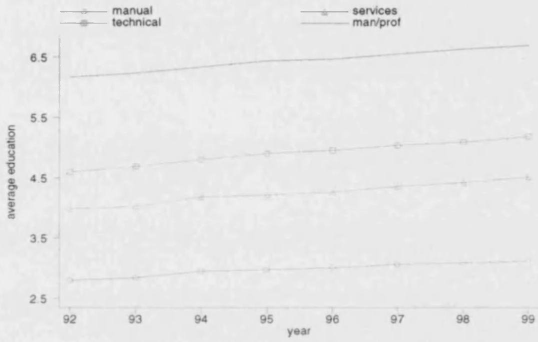


Figure 3.2: Average education vs average growth of education by occupation (line with crosses excludes 3 top & bottom regions)

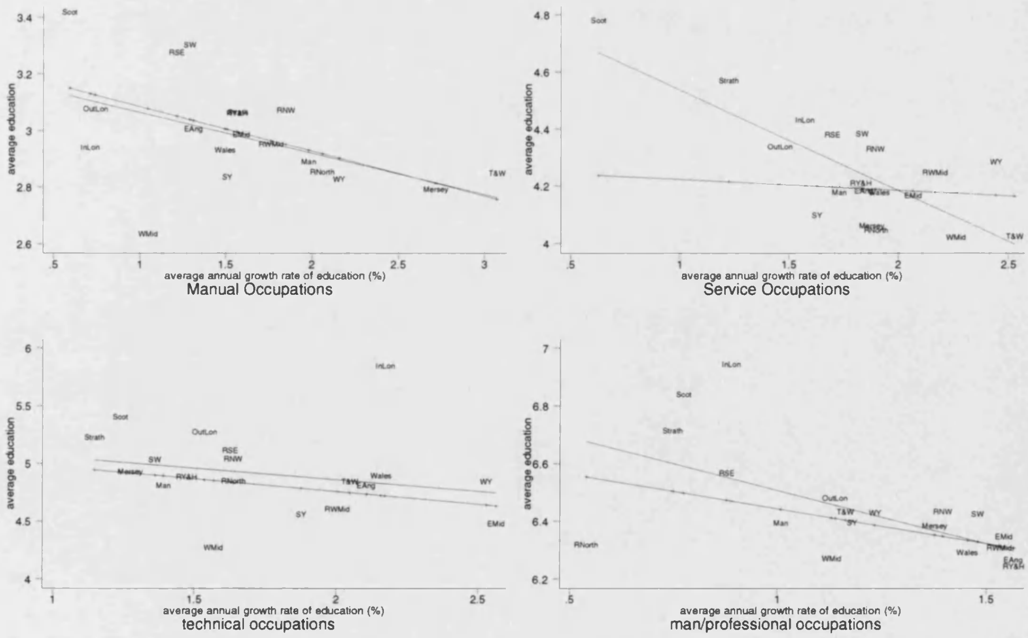


Table 3.4: Average Education by Region and Occupation Group, top 5 & bottom 5 regions

Manual		Services		Technicians		Man/Prof		All	
Reg	Ave	Reg	Ave	Reg	Ave	Reg	Ave	Reg	Ave
WM	2.67	WM	3.56	WM	4.25	RYH	6.23	WM	3.95
Mers	2.73	RN	3.74	EM	4.46	WM	6.26	SY	4.11
RN	2.78	SY	3.76	SY	4.53	EAng	6.26	T&W	4.14
T&W	2.78	T&W	3.79	RWM	4.58	Wal	6.28	Mers	4.15
SY	2.80	Mers	3.81	Man	4.78	RWM	6.30	RN	4.19
RNW	3.08	SW	4.13	RSE	5.09	OLon	6.47	SW	4.68
OLon	3.15	RSE	4.14	Strath	5.20	RSE	6.56	OLon	4.74
RSE	3.35	ILon	4.20	OLon	5.25	Strath	6.70	RSE	4.82
SW	3.36	Strath	4.22	Scot	5.38	Scot	6.83	ILon	4.85
Scot	3.48	Scot	4.43	ILon	5.82	ILon	6.93	Scot	4.90

of West Midlands, the opposite is true.

In terms of growth rates, the intermediate occupations have grown most across all regions, while the manual occupations have grown least (except for Tyne & Wear) (table 3.5). By occupation, in general the biggest growth has taken place in the areas with the lowest average education. In table 3.5 we can see that the most educated regions (Scotland and SE) are always amongst the worst regions in terms of growth (Inner london is the exception in Technical occupations). In addition, the regions with a very qualified workforce in certain occupations, have grown most in the other ones (Tyne & Wear in unskilled occupations, while East Anglia in skilled ones). However, this is not a feature of the extreme regions only, it is true for the middle ones as well. In figure 3.2, we can see that there is a clear negative relationship between the level of education and its growth rate across all occupations. This is still present when we exclude the best and worst regions (line with crosses in figure 3.2)[8].

[8]Scotland, South East, metropolitan West Midlands and rest of the Northern region

Table 3.5: Average Annual Growth Rate of Average Education by Occupation, top 5 & bottom 5 regions

Manual		Services		Technicians		Man/Prof		All	
Reg	Ave	Reg	Ave	Reg	Ave	Reg	Ave	Reg	Ave
WM	0.16	Scot	0.74	Strath	1.15	RN	0.54	Scot	0.96
OLon	0.35	OLon	1.57	Scot	1.24	Strath	0.75	OLon	1.34
Scot	0.43	Strath	1.70	Mers	1.27	Scot	0.77	Strath	1.36
ILon	0.44	ILon	1.78	SW	1.36	RSE	0.88	RSE	1.56
EAng	0.71	RSE	1.82	Man	1.39	ILon	0.89	RN	1.58
WY	1.85	EM	2.21	EAng	2.11	SW	1.48	Wal	1.87
Man	1.90	RWM	2.44	Wal	2.16	RWM	1.53	RWM	1.96
RN	2.03	WM	2.53	ILon	2.17	EM	1.54	EM	2.15
Mers	2.73	T&W	2.58	WY	2.53	EAng	1.56	T&W	2.17
T&W	3.26	WY	2.68	EM	2.56	RYH	1.57	WY	2.20
SD	0.80	SD	0.43	SD	0.42	SD	0.31	SD	0.30
GINI	0.33	GINI	0.11	GINI	0.13	GINI	0.15	GINI	0.09

3.3.2 Education, Survival rates and Vacancies.

The theoretical models of chapters 1 and 2 predict that regions with a relatively higher level of education will have higher job creation and lower unemployment durations. We can use the Kaplan-Meier empirical survival in unemployment to have an initial idea about the differences in unemployment durations across the UK local labour markets during the 1990s. The empirical survival is the fraction of unemployment spells ongoing at the start of a month which do not end during that month[9]. It represents the probability of remaining unemployed given that you have been unemployed for x months. In general, the most qualified occupations seem to have the lowest probability of remaining in unemployment for all durations (figure 3.3). An exception are the Service occupations which have the lowest survival for durations longer than two months.

If we now look across regions, we observe that the empirical survival in unemployment is greater in the region with the highest education level (Scotland) than in the one with the lowest level (Metropolitan West Midlands) (figure

[9]The empirical survivor for month t is equal to the number of spells which do not end during month t, divided by the size of the risk set at the beginning of month t. The size of the risk set at the beginning of month t is the number of people whose spells have not ended or been censored at the beginning of month t.

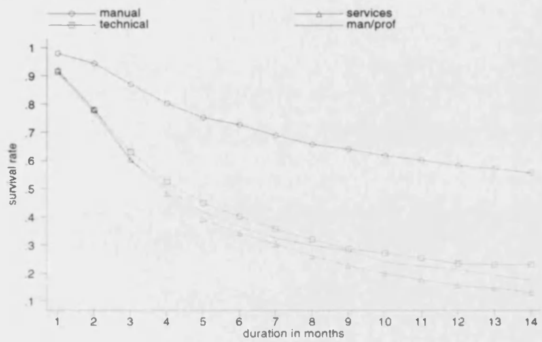


Figure 3.3: Survival by 4 occupations

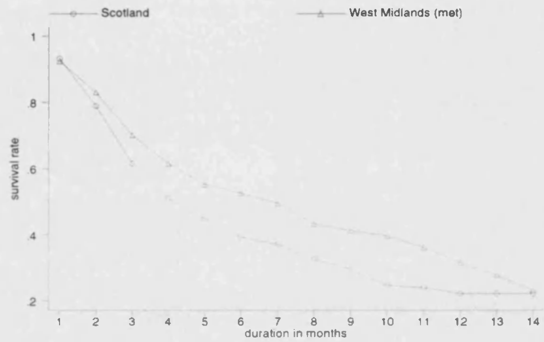
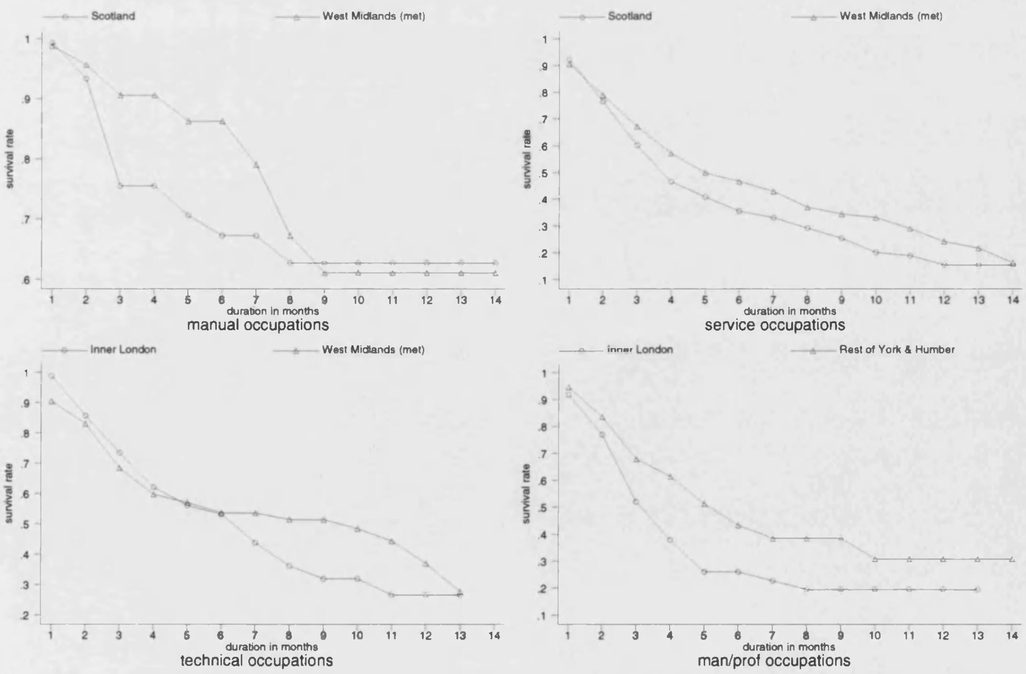


Figure 3.4: Survival of top & bottom regions

Figure 3.5: Survival in state of unemployment by occupation for top & bottom regions



3.4). This is not true for all regions. For example, Greater London has one of the highest survival rates for all durations of unemployment although it has one of the most qualified workforce, while Rest of Northern region has a medium survival rate but one of the lowest levels of qualifications. Finally, we can also look at different regions by occupation. In figure 3.5 we compare the empirical survival in unemployment state of the top and bottom regions in terms of qualifications by four occupation groups. It is clear from this figure that regions with a more qualified workforce enjoy lower probabilities of remaining unemployed.

A similar picture is obtained by looking at unemployment durations. The most skilled occupations have the lowest durations, while regional education by occupation is negatively correlated with unemployment duration (see figures C.1 and C.3 in appendix C.5).

Another important variable determining the performance of a labour market is labour market tightness, measured as the ratio of opened vacancies to the number of unemployed. Contrary to what was expected, figure 3.6 suggests that the most skilled occupations have the lowest market tightness. However, this is not longer true when we look at the relation between education and labour market tightness by occupational group and region. In figure 3.7, we see that there is a positive correlation between these variables for the more skilled occupations, but a negative one for the least skilled ones. This result is strongest when we drop the top and bottom regions in terms of education [10].

In conclusion, all the descriptive evidence points towards a positive relationship between regional education by occupation and labour market performance, confirming the conclusions of the theoretical model. Of course, it could be possible that the regions with the most qualified workforce have labour markets performing better simply because more qualified people face lower unemployment rates and shorter unemployment durations and not because of an external effect. That is why we now move to test this hypothesis using econometric techniques which allow us to control for the individual and regional characteristics which could be driving this result.

[10] Scotland, South East, metropolitan West Midlands and rest of the Northern region

Figure 3.6: Market tightness by occupation

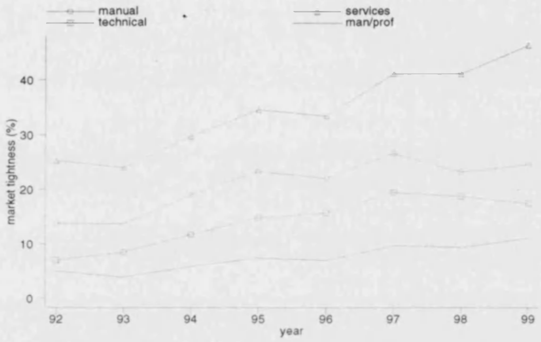
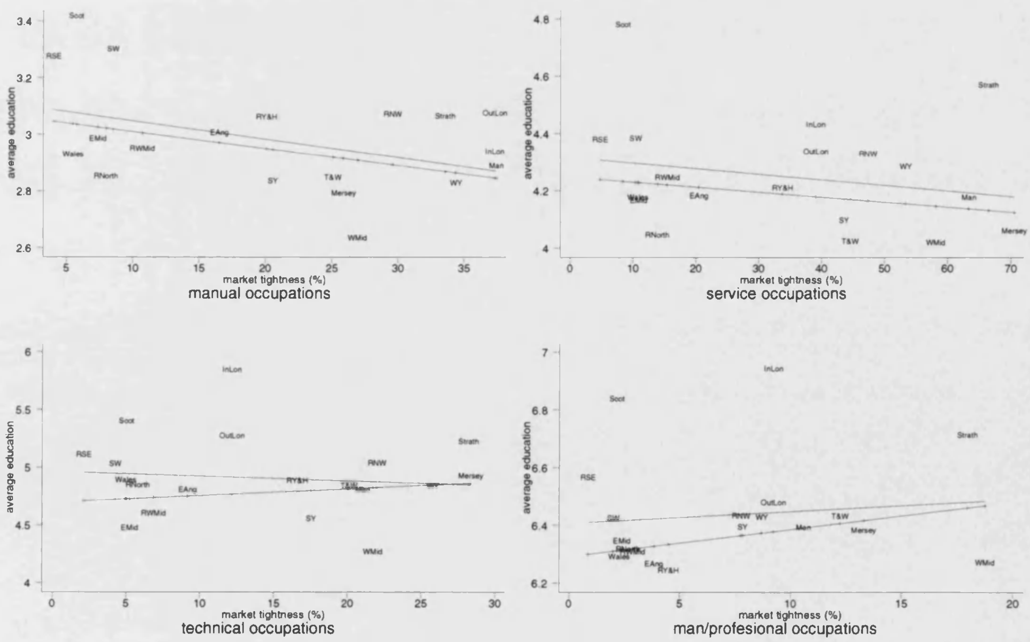


Figure 3.7: Average education vs labour market tightness by occupation (line with crosses excludes 3 top & bottom regions)



3.4 Econometric specification.

In order to study the determinants of the transitions from unemployment, we apply econometric duration models to the duration of unemployment spells.

The time to exit of unemployment can be thought of as a continuous random variable, T. This variable represents the duration of stay in the state of unemployment. The probability distribution of the duration of unemployment - the probability that the random variable T is less than some value t - can be specified by the distribution function $F(t) = \Pr(T < t)$. The corresponding density function is $f(t) = dF(t)/dt$.

Two other functions which are particularly relevant in studying duration data are the Hazard and the Survivor functions. The survivor function, $S(t)$, represents the probability of remaining in a specific state, i.e., the probability that the random variable T will equal or exceed the value t. It can be defined as $S(t) = 1 - F(t) = \Pr(T \geq t)$. The hazard function, $\lambda(t)$, is the rate at which unemployment spells will be completed at duration t, given that they last until t. It is defined as $\lambda(t) = f(t)/S(t)$. Both of these functions depend on a vector of explanatory variables $x(t)$ and some unknown coefficients β and λ_0.

We consider a proportional hazard model (Cox (1972)). This model separates the hazard function $\lambda[t, x(t), \beta, \lambda_0]$, into two parts in the following way:

$$\lambda[t, x(t), \beta, \lambda_0] = \lambda_0(t)\phi[x(t), \beta]$$

The first part, $\lambda_0(t)$, is called the "baseline" hazard and represents a functional form for the dependence of the hazard on duration t. The second part, $\phi[.]$, describes the way in which the hazard shifts between individuals endowed with different $x(t)$ at a given duration t. That is, the effect of explanatory variables is to multiply the hazard λ_0 by a factor ϕ which does not depend on duration t. A convenient specification of $\phi[.]$ is

$$\phi[x(t), \beta] = \exp[x(t)'\beta]$$

since it ensures the non-negativity of $\lambda[.]$ without constraining the parameter space for β. In addition, with this specification we can interpret the coefficient β as the proportional effect of $x(t)$ on the conditional probability of completing a spell. This is shown as follows:

$$\frac{\partial \ln \lambda[t, x(t), \beta, \lambda_0]}{\partial x(t)} = \beta$$

So far we have been considering the transition out of unemployment to be a continuous process, but in our dataset we only observe it on a monthly basis. Therefore, we have to use a discrete-time hazard function, $h_i(t)$. This function denotes the conditional probability that an unemployment spell lasts until time $t+1$, given that it has lasted until t. We will use a complementary log-log specification, which has been shown to be the discrete-time counterpart of an underlying continuous-time proportional hazard model (Prentice and Gloeckler (1978)).

$$\begin{aligned} h_i(t) &= \Pr[T_i = t+1 \mid T_i \geq t, x_i(t)] \\ &= 1 - \exp\left\{-\int_t^{t+1} \lambda_i(s)ds\right\} \\ &= 1 - \exp\left\{-\exp[x_i(t)'\beta] \cdot \int_t^{t+1} \lambda_0(s)ds\right\} \end{aligned} \tag{3.9}$$

given that $x_i(t)$ is constant between t and $t+1$. Equation (3.9) can be rewritten as

$$h_i(t) = 1 - \exp\{-\exp[x_i(t)'\beta + \gamma(t)]\} \tag{3.10}$$

where

$$\gamma(t) = \int_t^{t+1} \lambda_0(s)ds$$

denotes the integrated baseline hazard. We will estimate two different functional forms for this function. Initially, we do not assume a specific functional form for $\gamma(t)$ and estimate the model semiparametrically. This method estimates independently the value of each step in the baseline hazard. Then, in order to check the robustness of our results, we estimate the model parametrically assuming $\gamma(t)$ takes the following Weibull form (see Kiefer (1988))

$$\gamma(t) = \alpha_0 t^{\alpha_1} \tag{3.11}$$

The survivor function in discrete time can be shown to equal

$$S(t_i) = \Pr[T_i > t] = \prod_{t=1}^{t_i}[1 - h_i(t)] \tag{3.12}$$

The joint probability distribution of a sample of n observations of t_i can be represented by the log-likelihood function. Some of the n observations might be right-censored, that is, they represent uncompleted durations. These observations will contribute to the likelihood only with the survivor function since all we know is that the spell of unemployment has lasted until moment t_i. We can define a censoring indicator c_i, such that $c_i = 1$ if the ith observation is uncensored, and $c_i = 0$ otherwise. Therefore, the contribution to the log-likelihood of the ith individual with a spell of length t_i is given by

$$\ln L_i = c_i \ln f(t_i) + (1 - c_i) \ln S(t_i)$$

Substituting the definition of the hazard function and equation (3.12) into this expression we obtain the following

$$\begin{aligned}
\ln L_i &= c_i \left\{ \ln h_i(t_i) + \sum_{t=1}^{t_i-1} \ln[1 - h_i(t)] \right\} + (1 - c_i) \sum_{t=1}^{t_i} \ln[1 - h_i(t)] \\
&= c_i \left\{ \ln h_i(t_i) - \ln[1 - h_i(t_i)] \right\} + \sum_{t=1}^{t_i} \ln[1 - h_i(t)] \qquad (3.13)
\end{aligned}$$

Finally, substituting the discrete-time hazard function (equation 3.10), we get the likelihood function that will be estimated

$$\begin{aligned}
\ln L_i &= c_i \left\{ \ln\left[1 - \exp\left\{-\exp[x_i(t_i)'\beta + \gamma(t_i)]\right\}\right] - \exp[x_i(t_i)'\beta + \gamma(t_i)] \right\} \\
&\quad - \sum_{t=1}^{t_i} \exp[x_i(t)'\beta + \gamma(t)] \qquad (3.14)
\end{aligned}$$

In the above discussion, we have wrongly considered that there is only one possible transition out of unemployment. An unemployment spell can terminate when the individual finds a job, but also when he gives up searching and becomes inactive. Given that we are interested in the first type of transition, we need to estimate a competing risk model of duration that distinguishes exit into employment from exit into inactivity. Narendranathan and Stewart (1993) show that the parameters of the hazard into employment can be estimated by treating durations finishing for other reasons as censored at the time of exit. Having done this, the proportional hazard specification used for the single-risk model can be applied to the job-finding hazard.

Using this methodology we can control for unobserved heterogeneity by conditioning the hazard rate on an individual's unobserved characteristics, summarized in the variable v (Lancaster (1990), chapter 4). This is a random variable taking on positive values, with the mean normalized to one (for identification reasons) and finite variance σ^2. Then, the conditional hazard function (in continuous time) can be re-written as:

$$\lambda[t, x(t), \beta, \lambda_0] = \lambda_0(t) \exp[x(t)'\beta + v_i]$$

with v_i independent of x_i and t. Since each individual v_i is unobserved, we have to specify a distribution for v, so that we can write the unconditional hazard and the survivor function in terms of parameters that can be estimated and of the observable regressors included. This is known as "integrating out" the unobserved effect. In principle, one could use any continuous distribution with positive support, mean one and finite variance. However, in the case of the discrete time proportional hazard model that we are using in this work, the Gamma distribution has been the most popular choice in the empirical literature. This takes the form

$$f(v) \propto v^{\sigma^{-2}-1} \exp(-\sigma^{-2} v)$$

The resulting proportional hazard specification identifies three sources of variation among individual hazard rates: the duration of unemployment (t), the observable differences among individuals ($x(t)$) and the unobservable ones (v). In a competing risk framework like this one, we also have to impose the independence of these disturbance terms across the cause specific hazards. Under these assumptions, the log likelihood described in equation 3.14 becomes the following:

$$\begin{aligned}
\ln L_i &= \ln[(1+\sigma^2\sum_{t=1}^{t_{i-1}}\exp\{x_i'\beta+\gamma(t)\})^{-1/\sigma^2} \\
&\quad -c_i(1+\sigma^2\sum_{t=1}^{t_i}\exp\{x_i'\beta+\gamma(t)\})^{-1/\sigma^2}]
\end{aligned} \tag{3.15}$$

Finally, since the variable of interest, the mean and standard deviation of education, varies only across time, regions and occupation groups, when calculating the standard errors we have to allow for correlation of the errors between individuals belonging to the same cluster (see Moulton (1986) for a detailed analysis of this problem for the OLS case). This is done by estimating the robust $Var(\widehat{\beta})$ using White's method (White (1980) and White (1982)), substituting the score vector for the score vector corresponding to the whole cluster. These may be called super-observations and are obtained by summing the score vectors of all the individuals belonging to the same cluster. The score vectors corresponding to the super-observations are independent and therefore White's method still holds.

3.5 Results

We are now in a position to study the effect of education externalities in the matching process on the conditional probability of leaving unemployment. The theoretical model predicts that education matching externalities will affect positively the hazard of employment (re-employment probability), everything else equal, and this effect will be stronger the more qualified the segment of the labour market.

In the estimation we let local labour market variables vary quarterly, since that is the highest level of disaggregation that provides values of these variables which are representative of the total population.

The results of the estimation are reported in table 3.6. We estimate first the econometric model using a semi-parametric approach, where the hazard is left unspecified (columns I to III). Secondly, we re-estimate the model using a fully parametric approach, assuming the hazard takes a weibull form (columns IV to

VI). Each of the specifications is estimated first including all individuals in the sample (columns I & IV) and then splitting the sample into skilled (columns II & V) and unskilled occupations (columns III & VI).

The use of a proportional hazard model implies that the coefficients have a clear interpretation. If the sign is positive, an increase in the value of that variable has a positive effect on the baseline hazard. That is, it increases the probability of leaving unemployment for all durations. If it is negative, it will shift the baseline hazard down and reduce the probability of leaving unemployment.

Table 3.6: Maximum likelihood estimates of re-employment probabilities by occupation group

	semiparametric			weibull		
Variables	all	high	low	all	high	low
Regional Education Externalities						
Average education	0.509*	1.187***	−1.862**	0.602**	1.261***	−1.853**
s.d. of education	−0.454**	−0.650**	1.869***	−0.440**	−0.607**	1.960***
Regional Labour Markets						
Unemp rate	−0.618***	−0.418**	−0.957***	−0.619***	−0.407**	−0.978***
Vacancy rate	0.020	−0.026	0.023	0.030	0.011	0.025
Inactivity rate	1.108**	1.770***	0.511	1.017**	1.646***	0.463
Region's Migration ratio						
Migration ratio	0.077**	0.035	0.121***	0.073**	0.029	0.119***
Individual Characteristics						
Sex	−0.034	−0.067	−0.027	−0.055*	−0.085*	−0.046
16-24 years of age	0.116**	0.170**	0.081	0.115**	0.175**	0.066
25-34 years of age	0.465***	0.454***	0.486***	0.465***	0.464***	0.467***
35-49 years of age	0.346***	0.393***	0.279***	0.339***	0.390***	0.260***
White	0.235***	0.322***	0.130	0.228***	0.319***	0.123
Married	0.168***	0.124**	0.242***	0.156***	0.107*	0.232***
Migrant	0.057	0.029	0.088	0.062	0.031	0.096
Head of Household	0.147***	0.191***	0.097**	0.149***	0.197***	0.096**
Individual's Education						
Other Voc	0.145***	0.176**	0.129**	0.147***	0.171**	0.134**
Other Acad	0.019	−0.067	0.050	0.019	−0.070	0.052

continued on next page

Table 3.6: *continued*

Low Voc	0.139***	0.160***	0.141**	0.130***	0.144**	0.142**
O Level	0.039	0.101	0.017	0.046	0.102	0.031
Mid Voc	0.061	0.332***	−0.253	0.060	0.318***	−0.249
A Level	0.017	0.089	−0.035***	0.018	0.087	−0.034
High Voc	0.289***	0.413***	0.105***	0.281***	0.396***	0.110
Degree	0.176***	0.248***	0.103*	0.176***	0.245***	0.089
Last Job's Occupational Group						
Operator	0.893***		1.292***	0.877***		1.284***
Sales	0.889***		1.313***	0.885***		1.317***
Personal	0.919***		1.353***	0.916***		1.357***
Clerical	0.776***			0.715***		
Craft	0.884***	0.350**		0.873***	0.399**	
Technical	0.804***	−0.071		0.759***	−0.027	
Professional	0.714*	−0.567**		0.629*	−0.522**	
Manager	0.483	−0.749***		0.368	−0.747***	
Household Structure						
no dep child < 6	0.078***	0.337	0.087**	0.081***	0.347	0.089**
no dep child < 16	0.312***	0.048***	0.294***	0.326***	0.053***	0.312***
no working	1.070***	1.072***	1.088***	1.105***	1.103***	1.126***
one person house	1.765***	1.772***	1.748***	1.813***	1.813***	1.794***
two person house	1.089***	1.055***	1.136***	1.135***	1.089***	1.198***
Benefits						
Housing benefit	−0.305***	−0.325***	−0.265**	−0.298***	−0.314***	−0.266**
Unemp benefit	−0.129	−0.149***	−0.084*	−0.043	−0.066	0.002
Family credit	0.313***	0.119	0.389***	0.366***	0.230	0.403***
constant				−12.242***	−18.079***	−4.329***
α				0.055***	0.045***	0.070***
Log Likelihood	−16079	−8139	−7868	−16357	−8264	−8032
χ^2	33658	15967	26797	5129	2696	3921
No cases	15974	7459	8515	15974	7459	8515

NOTES: a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Region, Time and Occupation dummies and Industry's share of employment.

c) The robust standard errors are clustered by region, occupation and time period. This allows for correlation of errors between individuals in the same cluster.

3.5.1 Estimation Results for the Education Externality

We consider first the variables measuring the distribution of education: average education and standard deviation of education in the occupation group and region. The estimated coefficients have the expected signs, confirming the existence of a positive and significant effect of education externalities in the matching process in UK local labour markets (table 3.6 column I). The estimated coefficient for the average education in the occupation and region is positive and significant at the 10% significance level, while the coefficient for the standard deviation of education is negative and significant at the 5% significance level. This implies that the re-employment probability is higher for individuals belonging to a segment of the local labour market where the average level of education is higher and where the standard deviation is lower.

When we estimate the model separately for skilled and unskilled occupations we realize that this result is driven by the skilled occupations.[11] In table 3.6, columns II & III we see that a higher average level of education increases the probability of leaving unemployment for the skilled occupations but decreases it for the unskilled ones. That is, education externalities have a strong positive effect on the matching process of the skilled segments of UK local labour markets, whilst they have a negative effect on the matching process of the unskilled segments. The reason for this differential effect is that an increase in the average education level of a labour market generates two opposing forces affecting the matching process: a external effect and a competition effect. The external effect appears because a more qualified workforce increases expected profits by firms raising job creation and reducing unemployment duration. However, when average education is higher, the competition between unemployed individuals for the available vacancies will be more intense, increasing unemployment duration [12]. In the case of skilled jobs, where the worker's qualifications are very important for firms, one would expect the external ef-

[11] Skilled occupations correspond to occupations 5-9 of the SOC classification, while unskilled occupations correspond to occupations 1-4. We have tried different definitions of skilled occupations but this seems to be the relevant one.

[12] The theoretical model developed in this chapter only considers the external effect because it assumes random matching. This implies that firms will employ any worker they meet. If we relax this assumption to allow firms some directed search, the competition effect will appear, compensating part of the external effect. However, as long as firms cannot segment perfectly the labour market, the external effect will still be present.

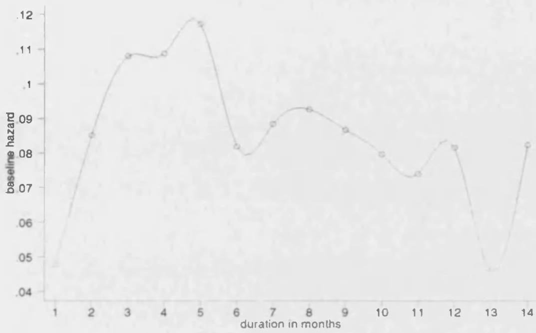


Figure 3.8: Baseline hazard all individuals

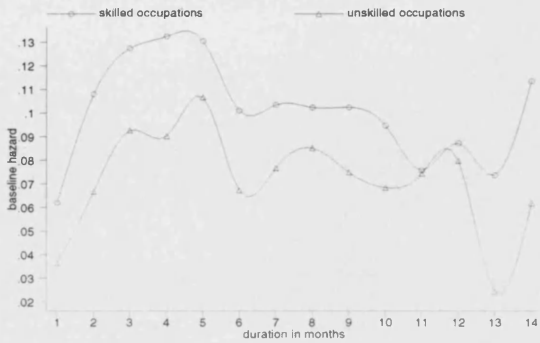


Figure 3.9: Baseline hazard by occupation group

fect to dominate the competition effect. In the case of unskilled jobs, firms might consider education as a minimum requirement but not as a fundamental determinant of the expected profits from the job. This means that job creation will react very little to a more qualified workforce and the competition effect will dominate the external effect.

Figure 3.8 shows the estimated baseline hazard of the representative individual for the standard model (table 3.6 columns I). The hazard of re-employment is increasing for durations up to 4-5 months and then decreasing, with some small peaks, which is consistent with the literature on unemployment duration (see Narendranathan and Stewart (1993) and Boheim and Taylor (2000)). The estimated baseline hazard for skilled and unskilled occupations shows a very similar picture (figure 3.9). The skilled occupations have a higher hazard than the unskilled ones for all durations. This means that individuals from the skilled occupations have a higher probability of leaving unemployment independently of how long they have been unemployed for

In order to have an idea of the magnitude of this on the probability of re-employment we look at the shift in the estimated baseline hazard of a representative person after a change in the average level of education. A 1% rise in average education shifts the hazard of the representative individual by 1.2% on average, while a 1% decrease in the standard deviation of education shifts the hazard by 0.5% on average (table 3.7). A similar pattern is obtained for the Skilled Occupations, although of a bigger magnitude - 2.8% and 0.7% for

Table 3.7: Average % change in baseline hazard of the representative individual

	All	Skilled Occup.	Unskilled Occup.
1% ↑ average education	0.95	2.65	-3.16
1% ↓ standard deviation of education	0.39	0.68	-1.41
average region to Scotland	6.04	7.53	-8.64
average region to West Mid (met)	-6.42	-22.27	13.28

a 1% change in the variables. The Unskilled Occupations show the opposite pattern. These numbers are comparable to those obtained by other studies in the literature. Moretti (1998) finds that a 1% rise in the share of college graduates increases wages of graduates by 1.2%, while Rauch (1993) finds that a one-year increase in average schooling raises individual wages between 3 and 5%.

One can also use this method to have an idea of the magnitude of the effect of regional differences in the distribution of education. A representative individual would experience an increase in the probability of finding a job of 20.6% if the regional level of education increased from the national mean to the level of the top region (Scotland). That same individual would experience a reduction in his probability of leaving unemployment of 8.9% if the level of education decreased from the mean to the level of the worst region (West Midlands Met.). That is, the regional differences in education could imply a difference in the probability of leaving unemployment of up to almost 30%. This number goes up to 33% when we consider the skilled occupations only, while it goes down to 21% for the unskilled occupations.

The model has also been estimated separately by sex and occupational group and by age group and occupational group (Tables 3.8 and 3.9).[13] The effect of the education externality in the matching process shows a similar pattern for all the categories, with a significant and strong effect for the skilled occupations and either negative or insignificant for the unskilled occupations. However, the magnitude of the effect is larger for men and older workers (the coefficient of

[13]The age groups are defined as follows: young = 16-34 & old = 35-59 if female and 35-64 if male. We run these estimations separately, not because we believe the externality should affect these groups differently, but because for other reasons, like female participation or youngsters' lack of job experience, these might be completely different labour markets.

the standard deviation of education is negative but insignificant).

Table 3.8: Maximum likelihood estimates of re-employment probabilities by sex and occupation group

		male			female	
Variables	all	high	low	all	high	low
Regional Education Externalities						
Average education	0.407	1.216***	−2.276**	0.822*	1.154**	−0.701
s.d. of education	−0.446*	−0.847**	2.183***	−0.466	−0.273	0.865
Regional Labour Markets						
Unemp rate	−0.758***	−0.584**	−1.090***	−0.348	0.048	−0.750**
Vacancy rate	0.016	0.101	−0.039	−0.013	−0.095	0.117
Inactivity rate	0.681	1.442*	−0.082	1.689**	2.519**	1.637*
Region's Migration ratio						
Migration ratio	0.125***	0.079	0.192***	0.013	−0.032	0.056
Log Likelihood	−6489	−2846	−3580	−9474	−5195	−4225
χ^2	17396	5540	14615	19604	11642	12525
No of cases	8963	4674	4289	7011	2785	4226

NOTES: a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Individual controls (see table C.5); Region, Time and Occupation dummies and Industry's share of employment.

c) The robust standard errors are clustered by region, occupation and time period. This allows for correlation of errors between individuals in the same cluster.

Table 3.9: Maximum likelihood estimates of re-employment probabilities by age group and occupation group

		16-34			35-59/64	
Variables	all	high	low	all	high	low
Regional Education Externalities						
Average education	0.485	1.302***	−1.671*	0.537	0.950**	−2.804***
s.d. of education	−0.259	−0.570	2.109***	−0.657**	−0.620	2.096**
Regional Labour Markets						
Unemp rate	−0.565***	−0.198	−0.932***	−0.686***	−0.601**	−1.027***
Vacancy rate	0.052	0.146	0.064	−0.072	−0.172	−0.064

continued on next page

Table 3.9: *continued*

Inactivity rate	0.821	1.842**	−0.026	1.585**	1.328***	1.708
Region's Migration ratio						
Migration ratio	0.079*	−0.030	0.154***	0.069	0.095	0.049
Log Likelihood	−9542	−4355	−5121	−6394	−3693	−2645
χ^2	19673	8301	17761	16481	9603	9010
No of cases	9495	3865	5630	6479	3594	2885

NOTES: a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Individual controls (see table C.6); Region, Time and Occupation dummies and Industry's share of employment.

c) The robust standard errors are clustered by region, occupation and time period. This allows for correlation of errors between individuals in the same cluster.

This is due to the fact that these two groups have more permanent links with the job market, while women and younger workers spend important periods inactive due to childbirth for the former and studies for the latter.

So far in this chapter we have looked only at unemployment durations with a maximum length of 14 months to avoid having a stock sampling bias problem. However, it would be interesting to know how important is the length of the unemployment duration for the matching education externality. One would expect that education externalities are more important for individuals who are well attached to the labour market, and on average that will be the case for the shorter durations. Firms searching for workers will most certainly discriminate against people who have been unemployed for long periods of time independently of the average quality of workers looking for jobs in that labour market segment. The main reason being that human capital depreciates and becomes obsolete very quickly after long spells of unemployment.

In order to test this hypothesis we have re-estimated the duration model using all the unemployment spells in the sample. The problem with using this sample is that the unemployment spells that started before the individual joined the survey are over-represented in it, since during that period of time other individuals included in the sample experienced shorter spells of unemployment, but they were not recorded because they finished before the survey started. However, this is solved by conditioning the log-likelihood function on the length of unemployment at the first interview date (seeLancaster and Chesher (1983) and Lancaster (1990))[14]. The results using this full sample (see table 3.10 are consistent in general with those for the standard sample. However, the effects are smaller in magnitude and insignificant for the unskilled occupations. We interpret this as a possible confirmation of the arguments explained above.

Table 3.10: Maximum likelihood estimates of re-employment probabilities by occupation group using all the durations in the sample, controlling for entrance to sample.

Variables	all occup		high occup		low occup	
	coef	s.e.	coef	s.e.	coef	s.e.
Regional Education Externalities						
Average education	0.295**	(0.143)	0.536***	(0.191)	−0.036	(0.273)
s.d. of education	0.036	(0.131)	0.209	(0.169)	0.243	(0.274)
Regional Labour Markets						
Unemp rate	−0.756***	(0.097)	−0.870***	(0.133)	−0.650***	(0.137)
Vacancy rate	0.094***	(0.027)	0.033	(0.047)	0.141***	(0.030)
Inactivity rate	−0.637***	(0.158)	−0.411*	(0.222)	−0.762***	(0.220)
Region's Migration ratio						
Migration ratio	0.178	(0.224)	0.113	(0.292)	0.198	(0.330)
Log Likelihood	−31110		−15461		−15568	
χ^2	39755		21116		25824	
No cases	40041		18258		21783	

NOTES: a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Individual controls (see table C.7); Region, Time and Occupation dummies and Industry's share of employment.

c) The robust standard errors are clustered by region, occupation and time period. This allows for correlation of errors between individuals in the same cluster.

Finally, we need to know how important are these matching education externalities with respect to technological externalities. As was mentioned earlier, the theoretical model does not provide a way of distinguishing between these two types of externalities. In this study we have tried to do this by including a variable in the estimation which acts as a proxy for the regional technological

[14]See appendix C section C.4 for a description of the econometric methodology.

level. These variables are the share of employment of each industry in each region over time. In table 3.11 we have the results of estimating the standard econometric model excluding the variables measuring technology. These estimation results are very similar to those of the standard estimation (including the regional technological level) although slightly smaller. This suggests that the technological externalities do not reduce the probability of leaving unemployment for all durations. If we accept this way of controlling for technology as correct, one should conclude that the most relevant type of externality in the matching process are the pecuniary externalities and not the technological ones.

Table 3.11: Maximum likelihood estimates of re-employment probabilities by occupation group dropping industrial share

Variables	all occup		high occup		low occup	
	coef	s.e.	coef	s.e.	coef	s.e.
Regional Education Externalities						
Average education	0.385	(0.284)	0.955***	(0.338)	−1.953***	(0.740)
s.d. of education	−0.424*	(0.222)	−0.597	(0.283)	1.930***	(0.578)
Regional Labour Markets						
Unemp rate	−0.681***	(0.153)	−0.584***	(0.199)	−0.908***	(0.218)
Vacancy rate	0.034	(0.041)	0.006	(0.073)	0.034	(0.051)
Inactivity rate	0.563	(0.429)	0.844	(0.550)	0.417	(0.611)
Region's Migration ratio						
Migration ratio	0.081**	(0.034)	0.063	(0.045)	0.108***	(0.040)
Log Likelihood	−16093		−8157		−7878	
χ^2	30291		14990		23190	
No of cases	15974		7459		8515	

NOTES: a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Individual controls (see table C.8); Region, Time and Occupation dummies and Industry's share of employment.

c) The robust standard errors are clustered by region, occupation and time period. This allows for correlation of errors between individuals in the same cluster.

3.5.2 Estimation Results for the regional labour market variables

The effect of regional labour market variables on unemployment duration in the standard model estimated are shown in the second and third parts of table 3.6.

The regional unemployment rate has a negative sign and is significant at the 1% significance level. This means that a rise in regional unemployment reduces the probability of leaving unemployment for all durations. The reason for this is that the bigger the number of people unemployed the greater the number of people looking for work and therefore the lower the market tightness, which reduces the probability of finding a job. This is an standard theoretical result of matching models (see Pissarides (2000) and Petrongolo and Pissarides (2001) for a survey of the literature) and is in accordance with the models of chapters 1 & 2. As one would have expected, the regional unemployment rate has the greatest effect in reducing the probability of staying unemployed of the individuals belonging to the unskilled occupations. The estimated coefficient is more than double that for the skilled occupations.

The vacancy rate has a positive sign, as expected from the theoretical model (see also Petrongolo (2001)). The larger the number of vacancies opened, the easier it is for unemployed individuals to find a job and therefore the shorter the average unemployment spell. However, it is not significant at the 10% level. This is most probably due to the fact that vacancies registered at job centers are known to under-represent the total number of vacancies. [15]

The inactivity rate has a positive and significant effect, indicating that the unemployed have a higher probability of finding a job in regions with high inactivity. This result is driven by the skilled occupations and unskilled women. Amongst the skilled, younger workers have a stronger effect. This result is in line with the theoretical model, since the more people inactive in an area, the less people looking for work (employed or unemployed) and the higher the

[15] There is an alternative explanation if the education externality works through vacancy creation, the vacancy rate might not have a significant effect because it is already proxied by the average level of education. However, this seems unlikely, since dropping the regional average and standard deviation of education from the estimation increases the significance of this variable only marginally.

market tightness, which increases the probability of finding a job. However, this result could also be indicating the existence of another external effect. The people who are more likely to withdraw from the active population are the long-term unemployed, who in general have less skills. Therefore, a lower participation might improve the average education of people looking for work and exert a positive education externality on the rest of the individuals. This would explain why it affects mainly the skilled occupations. Alternatively, it could simply indicate that the regions with better education systems have a more qualified workforce suffering less unemployment, but also more people studying and therefore a higher inactivity rate.

The theoretical model of chapter 2 shows that the migration of skilled workers might help the concentration of skilled workers in the best regions. This would imply a sorting process by which the best regions get the best people and could generate an endogeneity bias in the estimate of the education externality. In order to control for that bias we have included the migration ratio (number of immigrants / number of emigrants) by region and year.[16] The estimated coefficient is positive and significant suggesting that unemployed individuals in regions with high immigration (low emigration) suffer shorter durations, as predicted by the theoretical model. However, the coefficient is insignificant for the skilled occupations, where the sorting process ought to be strongest. This suggests that, although migration flows increase re-employment probabilities, the possible endogeneity bias is not an important problem in this case.

By sex and age group, we find that unemployment has a strong and significant effect for men and older workers of all occupations, while it has only a significant effect for low skilled women and young workers. This reflects the fact that men and older workers are more attached to the labour market, since more often they are heads of households and have to support their families economically. When active, skilled women and young workers suffer lower unemployment rates. Inactivity has a significant effect for women of all occupations and for skilled men and young workers. The migration ratio has a significant effect for unskilled male and young workers.

[16]It would be preferable to have the migration ratio by occupational group in each region, but this data is only available from the Labour Force Survey and the sample size is too small to draw any significant conclusions.

3.5.3 Estimation Results for individual and household variables

One would want to include as many individual and household characteristics as possible, in order to reduce the probability of having an omitted variable bias. The estimated coefficients of the individual and household variables in the standard model estimated are shown in the lower part of table 3.6. In general, these coefficients have the expected signs, which are consistent with the existing literature.

The main results for the individual variables are the following: Men have a higher probability of moving into employment than women. Age has a U-shaped effect: the age group 25-34 has the highest hazard rate into employment, followed by the group 35-49, then the younger group (16-24) and finally the older group (over 50) (see Narendranathan and Stewart (1993) & Arulamparan and Stewart (1995)). Individuals of white origin have higher hazard rates into employment. This result is probably due to the use of a white/not-white breakdown. Other studies using more detailed racial information (Boheim and Taylor (2000)) have found that individuals of Afro-Caribean origin have the lowest hazard rates into employment, while those of Pakistani and Indian origin have higher rates than whites. Married individuals and heads of households are more likely to find a job quicker. Migrants also have a higher hazard rate into employment, as was suggested by the theoretical model of chapter 2. However the estimated coefficient is not significant at the 10% level of significance. Finally, a higher level of education improves the re-employment probability of unemployed individuals, in particular if it is a vocational qualification or a degree. Having A levels only does not seem to contribute much to increasing the probability of leaving unemployment. The reason might be that employers see this qualification as a requirement towards a higher qualification level (degree or more) and therefore consider that they do not add anything on their own merit.

The variable measuring last job's occupation shows that the hazard of finding a job is quite similar across occupational groups. All the occupations have a higher hazard than the reference group, which includes other occupations and unknown. However, it is quite surprising that managers have a significantly lower probability of finding a job when unemployed. Also when looking only at skilled occupations, it seems that it is the craft and clerical occupations which have the highest probability of finding a job.

If we now look at the household variables, we observe that household composition has a fundamental effect on the probability of transition into employment. Having economically dependent members in a household increases greatly the individual hazard rate into employment, specially if they are over 5 years of age. Dependents under 6 years old increase the hazard for men but reduce it for women. On the other hand, individuals living on their own or as a couple have a much greater probability of leaving unemployment. The most probable reason for this is that they have to maintain themselves to live. However, it is also true that in order to afford your own accommodation you have to have a certain economic level, so this variable could be acting as a proxy for household income. We also find that there is a positive effect of belonging to a household where most of its members work. This may be due to the fact that the other household members working help to maintain a link with the labour market and create the right environment to look for work.

Finally, to have unemployment or housing benefits greatly reduces the probability of leaving unemployment. This is a well known stylized fact of the unemployment literature (see Narendranathan, Nickell and Stern (1985)). However, to have financial help from relatives has the opposite effect. The reason for this is that this source of income will obviously be limited and the money borrowed will probably have to be returned, which gives the individual an incentive to get a job as soon as possible.

3.5.4 Robustness of Results

We have undertaken two types of robustness checks. First, we have tried to challenge the empirical results by making alternative assumptions about the hazard function and the segmentation of the labour market. Then, we have also tried to take into account some of the standard problems of estimation in this literature.

First of all we have re-estimated the basic model of equation 3.14, changing some of the assumptions in order to be sure that the results are robust. In table 3.6 columns IV-VI, we re-estimate the basic model of equation 3.14 using a fully parametric approach assuming a Weibull hazard function (see equation 3.11). These estimations show that the results reported are consistent across different parameterizations of the hazard function. The average level of education and standard deviation have similar sign and significance, however the magnitude of the coefficient of average education is slightly smaller when we use a semi-parametric hazard function (0.51 versus 0.6). In addition, to make sure that it is not the level of disaggregation that is driving our results, we have re-estimated the basic model considering a more disaggregated definition of labour market segmentation. In particular, we assume that the local labour market is divided into 9 occupational groups (SOC 91). Again, the results are consistent with the basic model (table 3.12).

Table 3.12: Maximum likelihood estimates of re-employment probabilities by occupation group, more disaggregated.

Variables	all occup		high occup		low occup	
	coef	s.e.	coef	s.e.	coef	s.e.
Regional Education Externalities						
Average education	0.413*	(0.215)	1.031***	(0.294)	−0.193	(0.390)
s.d. of education	−0.302	(0.183)	−0.243	(0.224)	0.136	(0.388)
Regional Labour Markets						
Unemp rate	−0.631***	(0.157)	−0.455**	(0.206)	−0.862***	(0.226)
Vacancy rate	0.039	(0.040)	0.028	(0.068)	0.032	(0.051)
Inactivity rate	1.096**	(0.476)	1.708***	(0.657)	0.563	(0.668)
Region's Migration ratio						
Migration ratio	0.076**	(0.034)	0.026	(0.049)	0.120***	(0.045)
Log Likelihood	−16079		−8139		−7873	
χ^2	25539		13529		16101	
No cases	15974		7459		8515	

NOTES: a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Individual controls (see table C.9); Region, Time and Occupation dummies and Industry's share of employment.

c) The robust standard errors are clustered by region, occupation and time period. This allows for correlation of errors between individuals in the same cluster.

However, in this case the magnitude of the effect of average education is smaller than in the standard case (0.41 vs 0.5), and the effect of the variance of education is not statistically significant at the 10% level.

Finally, table 3.13 shows the results of re-estimating the basic case allowing for Gamma distributed individual unobserved heterogeneity, both for the semi-parametric and for the Weibull hazard function. This technique controls for individual omitted characteristics which are uncorrelated with the observed variables and time.

Table 3.13: Maximum likelihood estimates of re-employment probabilities by occupation group allowing for Gamma distributed individual unobserved heterogeneity

	Semiparametric			Weibull		
Variables	all	high	low	all	high	low
Regional Education Externalities						
Average education	0.389	0.883**	−2.125***	0.423	0.896**	−2.203***
Standard dev edu	−0.302	−0.530*	2.332***	−0.293	−0.558*	2.544***
Regional Labour Markets						
Unemp rate	−0.811***	−0.625***	−1.148***	−0.867***	−0.669***	−1.234***
Vacancy rate	0.025	−0.046	0.037	0.027	−0.062	0.045
Inactivity rate	1.147**	1.621**	0.707	1.147**	1.567**	0.768
Region's Migration ratio						
Migration ratio	0.078**	0.029	0.122**	0.082**	0.034	0.122**
constant				−12.940***	−17.370***	−5.607
α				0.660***	0.598***	0.732***
Gamma Variance	0.439***	0.412***	0.450***	−0.550***	0.598***	0.732***
Likelihood ratio st.	225.92	109.355	157.170	354.00	156.72	170.21
Log Likelihood	−15966	−8093	−7814	−16068	−8139	−7877
No of cases	15974	7459	8515	15974	6521	9453

NOTES: a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Individual controls (see table C.10); Region, Time and Occupation dummies and Industry's share of employment.

c) The robust standard errors are clustered by region, occupation and time period. This allows for correlation of errors between individuals in the same cluster.

Unobserved heterogeneity seems to be important in this empirical model. The likelihood ratio test indicates that we cannot reject the model with unobserved heterogeneity and the estimated gamma variance is significantly different from zero. The average level of education and the standard deviation of education still have a significant effect when we run the estimations separately for high and low occupations, although of smaller magnitude (a coefficient of 0.9 instead of 1.2). However, the external effect is not significant when we include all occupations. This indicates that part of the effect is due to unobserved characteristics. However, the fact that it is still significant for the skilled occupations means that there exist important education externalities in the matching process taking place in the UK local labour markets.

In addition, we have also tried to take into account some of the standard econometric problems one encounters when estimating external effects. In particular, we have worried about the endogeneity of independent variables, an omitted variable bias and the identification of the external effect (see Brock and Durlauf (2000) and Dietz (2001) for two excellent surveys about the literature dealing with these estimation problems).

The endogeneity of independent variables is a common problem to all studies of external and neighbourhood effects. The question is whether the area characteristics used to measure these effects are exogenous variables or not with respect to the formation of the area. If location was predetermined and fixed for all individuals there would not be a problem. However, we know that individuals are able to choose to a certain extent the area and group they belong to. This could generate a sorting process by which individuals with similar characteristics live together. This would then be problematic for the estimation of the external effects because the characteristics determining the group of interest are the same as those determining the problem we are studying, therefore generating biased and inconsistent estimators (Greene (1993)).

The omitted variable bias is another potential problem in this study. The problem is that there might be omitted variables which are correlated with both the dependent variable and the regressors measuring the distribution of education. This correlation would make these covariates wrongly significant.
Most studies in this literature solve both of these problems by using instruments for the variables measuring the distribution of education. We would

require a variable that is correlated with the distribution of education but is not correlated with the sorting process or any omitted variable. This is particularly difficult for our case since this variable would have to vary both across occupation groups within regions and over time. The previous studies in this literature which used instruments where cross-sectional and focused on education externalities by geographical area, not by occupational group. This allowed them to use instruments which vary across areas but not across time, like the demographic structure a decade before (Moretti (1998) & Ciccone and Peri (2000)). This leaves us with only one possible instrument, past values of the variables determining the education distribution. However, since the sorting process normally takes a long time, persistence is very likely and the endogeneity problem will not be solved by this method. The same would apply to the omitted variables bias if the omitted variables were persistent. Therefore, due to the difficulty of finding a good instrument, the relevant question that we should answer is how important is the endogeneity due to the sorting process in this particular study.

There are some reasons why the sorting process might not have an important effect on the estimation of external effects in this study. First of all, the areas used in this study - occupation group (4 groups) within each of 19 regions - are very large and heterogeneous. This would make a perfect sorting process almost impossible. Migration of skilled workers will generate a higher concentration of qualified individuals in the most skilled occupations of the best regions, but there will still be a large number of workers from all types in each region (eg. because of house ownership or housing benefit)[17].

Secondly, even if the sorting process is important, there is no reason to believe that it has has been increasing during the sample period or that it has been more acute than in the past. Thus, the effect of sorting would mainly be a level effect which should be captured by the region, occupation and time dummies.

Nevertheless, we have undertaken some simple tests to check the potential

[17]A clear example would be the Inner London area, where we will have some of the most qualified individuals. However, due to its size and to the existence of very poor neighbourhoods, there are also large groups of medium and low qualified workers in all occupations.

importance of endogeneity. One would expect the effects of the sorting process to be stronger in the areas at the extremes of the distribution - in the regions and occupations with the highest and lowest levels of education. However, when we run the regression excluding the regions that consistently have had the highest or lowest education level for the whole sample (Scotland, the South East, Metropolitan West Midlands and the Rest of the Northern region)[18] we find that the effect of the externality remains very significant and, if anything, is stronger (see table 3.14).

Table 3.14: Maximum likelihood estimates of re-employment probabilities by occupation group dropping top & bottom region in education

Variables	all occup		high occup		low occup	
	coef	s.e.	coef	s.e.	coef	s.e.
Regional Education Externalities						
Average education	1.095***	(0.426)	1.726***	(0.517)	−0.992	(1.022)
s.d. of education	−0.595	(0.344)	−0.926**	(0.428)	1.423*	(0.837)
Regional Labour Markets						
Unemp rate	−0.768***	(0.208)	−0.753**	(0.318)	−0.852***	(0.282)
Vacancy rate	−0.042	(0.063)	−0.203*	(0.114)	−0.012	(0.076)
Inactivity rate	1.621***	(0.592)	2.578***	(0.836)	0.877	(0.774)
Region's Migration ratio						
Migration ratio	0.134***	(0.050)	0.090	(0.067)	0.167***	(0.060)
Log Likelihood	−8287		−3927		−4315	
χ^2	17737		8430		16364	
No of cases	8129		3574		4555	

NOTES: a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.
b) Other variables included in the estimation: Individual controls (see table C.11); Region, Time and Occupation dummies and Industry's share of employment.
c) The robust standard errors are clustered by region, occupation and time period. This allows for correlation of errors between individuals in the same cluster.

Another option would be to try to understand the mechanism behind the sorting process. As was shown in the theoretical model of chapter 2, one of the most important sorting mechanisms in this analysis is regional migration. If

[18]See section 3.3.1 for a more detailed discussion on this issue

a large proportion of skilled workers move to the areas with highest wages and lowest unemployment rates, the average education of the workforce there will improve. At the same time, a high immigration rate will increase the demand for housing and raise the costs of living of the recipient area. This might push the least skilled individuals out of these areas, since they cannot afford to live there. Both of these forces increase the average education in the area, generating an even stronger education externality. In order to take into account this particular sorting mechanism we have controlled for people who have migrated into the region during the previous year but also for the aggregate migration flows in the region (ratio of immigrants to emigrants). The estimated coefficient is positive and significant when considering all occupations, but it is insignificant for the skilled occupations, where the sorting process ought to be strongest. This suggests that, although migration flows increase re-employment probabilities, the possible endogeneity bias is not an important problem in this case. Finally, if this type of sorting is present it should be strongest in the regions with the biggest migration flows. Therefore, we have re-estimated the model dropping the regions with biggest migration flows. The results remain unchanged.

We believe that all the above results indicate that, although there might be some endogeneity in the dependent variable, it is not having an important effect on the estimated coefficients.

It is not so easy to find simple tests to check the importance of a possible omitted variable bias. However, the fact that we include many individual, family and area variables in the estimation should reduce the importance of this effect. Moreover, in order to bias the coefficient measuring the external effect, the omitted variables have to vary both across groups and over time since the region, occupation and time dummies included in the estimation are already capturing any possible effect constant across groups or over time. One way of controlling for omitted variables in the estimation of a duration model is controlling for unobserved heterogeneity. However, this technique only controls for omitted variables which are uncorrelated with both the covariates and time. Nevertheless, one could use it as an indicator of the importance of this problem. As was mentioned above, controlling for unobserved heterogeneity (table 3.13) does not make the external effect disappear for the skilled occupations, although it reduces its magnitude. Therefore, even though it seems that this problem is not very important in this study, one should be aware that it could be biasing slightly the results.

Finally, the other important problem when estimating external effects is that of identification, also named the reflection problem by Manski (1993). This problem was first mentioned by Hauser (1970), but it was the work of Manski which provided a framework to understand it. This problem arises when a researcher observing the distribution of behaviour in a population tries to infer whether the average behaviour in some group influences the behaviour of the individuals that comprise the group. Manski shows that inference on endogenous effects is not possible unless the researcher has prior information specifying the composition of reference groups and if the variables defining reference groups and those affecting directly the outcomes are moderately related in the population. However, he also proved that identification is eased if the estimated model is non-linear, in particular for the binary response model. Brock and Durlauf (2000) extended that proposition to the case of duration models. The reason is that in a non-linear model, the external effect changes at a different rate than the direct effect of an individual's own characteristics and therefore both can be independently identified. In addition, Brock and Durlauf (2000) showed that this problem is further eased if there is within-group heterogeneity. Otherwise, if the neighbourhood is homogenous, it is impossible to distinguish between the individual and the group with respect to outcomes. Our study fulfills both of these properties and therefore we understand that identification of the external effects should not be a problem here.

3.5.5 Transitions into Inactivity

One would also be very interested in knowing what effect does the education externality have on the transitions into inactivity. Table 3.15 reports the results of the competing risk model, studying the transitions from unemployment into inactivity are reported. It is quite interesting to see that the externality still has a significant, but in this case negative effect, on the hazard into inactivity. This result is driven by the unskilled occupations, where the effect is strongest. Meanwhile the effect is negative but insignificant for the skilled occupations. This means that the higher the education level of your labour market segment, the least likely you are to become inactive for all unemployment durations.

A simple theoretical explanation for this result can be obtained by extending the model of chapter 1 to take into account labour market participation. Since an area with a highly qualified workforce benefits from high job creation, the individuals face a greater opportunity cost when inactive. In addition, if the greater job creation in the area attracts lots of migrants, the costs of living will increase, raising even further the opportunity cost of inactivity. These two forces will provide a greater incentive for individuals to participate in the labour market and continue looking for a job. This effect is stronger for the least skilled qualifications probably, because this group has the biggest incentives of becoming inactive.

Table 3.15: Maximum likelihood estimates of transitions to inactivity

Variables	all occup		high occup		low occup	
	coef	s.e.	coef	s.e.	coef	s.e.
Regional Education Externalities						
Average education	−0.729*	(0.410)	−0.821	(0.593)	−1.727**	(0.804)
s.d. of education	0.081	(0.365)	−0.099	(0.468)	1.151	(0.712)
Regional Labour Markets						
Unemp rate	0.163	(0.244)	0.200	(0.398)	0.112	(0.297)
Vacancy rate	0.031	(0.044)	0.071	(0.126)	0.006	(0.047)
Inactivity rate	0.043	(0.696)	0.164	(1.196)	0.108	(0.864)
Region's Migration ratio						
Migration ratio	−0.083*	(0.047)	−0.044	(0.086)	−0.091	(0.059)
Log Likelihood	−8785		−3540		−5159	
χ^2	72446		34634		47509	
No of cases	15974		7459		8515	

NOTES: a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Individual controls Individual controls (see table C.12); Region, Time and Occupation dummies and Industry's share of employment.

c) The robust standard errors are clustered by region, occupation and time period. This allows for correlation of errors between individuals in the same cluster.

3.6 Vacancy Creation and Education Externalities.

The theoretical models developed in this thesis showed that education externalities might have an important effect on the matching process. A higher level of education improves the expected profits per vacancy opened and there is higher job creation and market tightness. This effect will be stronger if there is migration of skilled individuals. Therefore, the external effect of education is always generated through a higher vacancy creation (market tightness). So far, we have shown that education externalities raise the probability of finding a job, but we have not analyzed the mechanism through which this effect is working. In this section we will try to do so, by using a quarterly panel on vacancies notified to UK job centers by occupational group (using the SOC 91 classification) and 19 regions for the period 1992-99. This data is obtained from job centers and is provided by NOMIS. We are conscious that the number of vacancies posted at job centers could be significantly lower than the real number of vacancies, especially for the most skilled occupations. This means that any result from this analysis should be considered as a lower bound of the total real effect of education externalities on vacancy creation. The covariates are obtained from the spring quarter of the non-longitudinal LFS.

We estimate a fixed effects panel using the log of market tightness in the local labour market as the dependent variable. This is defined as the number of vacancies notified divided by the number of unemployed by quarter, 9 occupational groups and 19 regions. The covariates are the average education and standard deviation of education of the occupation group within each region and quarter, the regional unemployment and inactivity rates and the annual immigration and emigration rates by region and occupation. The fixed effects used in the estimation are occupation, region and quarter.

The estimation results show that the education externality is an important determinant of market tightness in the UK local labour markets of the 1990s (table 3.16). The effect has a similar pattern to the one on the duration of unemployment. An increase in the average education of the local labour market raises market tightness, while an increase in the standard deviation reduces it.

This effect is strongest for the skilled occupations. However, in this model the average education also has a positive effect on the market tightness of the unskilled occupations but of smaller magnitude, while the standard deviation has a negative effect.

Table 3.16: Fixed Effects estimation of the Vacancy rate by quarter, region and occupation

Variables	Fixed Effects			I.V. Fixed Effects		
	all	low	high	all	low	high
Regional Education Externalities						
Av. education	0.895***	0.682***	1.374***	1.903***	1.596***	2.831***
	(0.162)	(0.198)	(0.251)	(0.251)	(0.303)	(0.391)
s.d. education	−0.313***	−0.180***	−0.190***	−0.483***	−0.286***	−0.318***
	(0.045)	(0.062)	(0.057)	(0.074)	(0.110)	(0.093)
Regional Labour Markets						
Unemp rt	−1.004***	−0.818***	−1.144***	−0.963***	−0.755***	−1.100***
	(0.033)	(0.042)	(0.046)	(0.035)	(0.045)	(0.050)
Inactivity rt	1.880***	1.683***	2.060***	1.856***	1.627***	2.078***
	(0.120)	(0.148)	(0.180)	(0.124)	(0.156)	(0.185)
Regional Migration by occupation						
Immigration rt	0.041***	0.031***	0.045***	0.042***	0.035***	0.042***
	(0.009)	(0.012)	(0.013)	(0.010)	(0.012)	(0.014)
Emigration rt	0.027***	0.016***	0.033	0.018**	0.005**	0.023
	(0.008)	(0.011)	(0.011)	(0.009)	(0.011)	(0.012)
No Observations	5798	2576	3222	5126	2276	2850

NOTES: a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Region, Time and Occupation dummies and Industry's share of employment.

c) The robust standard errors are clustered by region, occupation and time period. This allows for correlation of errors between individuals in the same cluster.

3.7 Conclusions

This study examines the effect of education externalities on the matching process taking place in UK local labour markets. First of all, we have shown theoretically that a higher level of education of the workers participating in the labour market raises the expected profits of opened vacancies, since firms expect to be matched with a more qualified worker. This increases job creation and reduces the unemployment rate. Then, we tested this empirically by estimating the effect of the education distribution in a labour market (measured by the average and standard deviation of education) on the probability of transition from unemployment to employment.

We found that, for individuals belonging to skilled occupational groups (managers/professionals and technical occupations), a higher average level of education increases the probability of transition from unemployment to employment, while a higher standard deviation, or a more unequal distribution, reduces it. However, the opposite is true for individuals belonging to less skilled occupational groups (technical, service and manual). The reason behind this is that in the latter case the increase in the competition for vacancies among unemployed workers due to the higher level of education more than offsets the effect of the education externality. When we also include longer durations (of up to five years) in the estimation, the effect of the externality on the hazard of skilled occupations is still significant but almost half the size of the coefficient in the standard estimation.

The effect of the education externality on the hazard into employment is not only statistically significant but also relevant in magnitude. A rise of 1% in the average level of education shifts up the baseline hazard of the representative individual by 1% on average if we include all occupations, and by 2.7% when we consider only the more skilled occupational groups. Regional differences in the distribution of education also have a very large effect shifting the baseline hazard by around 12% for all occupations and by 30% for the more skilled occupations.

The estimated baseline hazard of the representative individual is increasing for durations up to 5 months and then decreasing, with some small peaks.

This is true for all individuals and by occupational group. However, skilled occupational groups have a higher baseline hazard for all durations, indicating that they have a higher probability of leaving unemployment independently of how long they have been unemployed for.

The results remain equally significant when we estimate the model separately by sex and age group. However, as one would expect, they are stronger for men and older workers, since these two groups have more permanent links with the labour market.

Finally, the estimated results are very robust. They are still present when we estimate the model using different parameterizations of the hazard function, different definitions of labour markets within a region and also when controlling for unobserved heterogeneity. In addition, the results are also robust to the standard econometric problems considered in the literature.

Chapter 4

Education externalities and staying-on in education at 16, 17 and 18 years of age in the UK regions (1979-99).

4.1 Introduction

This chapter studies the existence and the scale of regional education externalities on the education decisions of teenagers in the UK. First, we develop a simple model, based on chapters 1 and 2, to address this issue theoretically. Then, we test it empirically using data from the UK Labour Force Survey for 17 UK regions over the period 1983-99.

The literature on education externalities has developed greatly since the seminal work by Romer and Lucas (Romer (1986), Lucas (1988)). They showed theoretically that, in an area with a higher average level of education processes like the exchange of ideas, imitation or learning by doing are more likely to occur, in turn fostering technological progress. From a different strand of economic literature, the one studying economic geography, Krugman (Krugman (1991a), Krugman (1991b)) showed that externalities can also appear in the market process of exchange. In an area with a greater concentration of population and therefore higher demand for products, there are higher incentives for industrial localization, and viceversa, generating important economies of scale. In chapters 1 & 2 of this thesis we show that a similar type of externality may exist in the labour market due to the interaction between the localization of the supply and demand of skilled labour. One of the main implications of these theories is that workers in an area where there are strong external effects will on average earn higher wages and suffer lower unemployment rates. The empirical literature has concentrated in testing the effect of externalities on wages (see Rauch (1993), Moretti (1998) and the introduction to chapter 3 of this thesis), while in chapter 3 of this thesis we have tested the effect of externalities on unemployment duration.

However, also embedded in any theoretical model studying the micro-foundations of education externalities is the result that young people will stay-on longer in education the stronger the external effect is. Young persons living in an area with a stronger external effect will accumulate more human capital because they will expect to earn higher wages and suffer lower unemployment rates when they enter the labour market. Nevertheless, very little empirical work has been done to study this externality[1].

In this chapter we attempt to estimate the effect of education externalities on education decisions by controlling for the distribution of education within a region. In practice, this is done by including as regressors in the estimation the share of the working age population for each level of educational attainment.

In order to be able to identify empirically the effect of education externalities on education decisions we need detailed micro data on individual education decisions, individual characteristics and family background covering a large time span. We also need macro data on the regional distribution of education and other labour market variables. Unfortunately, the datasets looking at education decisions, generally used by the education literature, are only available in the form of a few cross-sections of data. In addition, they do not

[1]There is a large literature studying the impact of the idiosyncratic characteristics of the area in which an individual lives on the economic decisions he makes - so called 'neighbourhood effects'. However, this area of research is interested in studying peer group effects, cluster effects and the failure of information mechanisms. Therefore, it looks at very reduced geographical areas (see Jenks and Mayer (1990) for a survey of the early literature, Crane (1991), Case and Katz (1991), Fernandez and Rogerson (1996b) and Fernandez and Rogerson (1996a))

allow for the construction of the aggregate series required by this study. An example of this approach is Rice (1999). She uses three waves of the Youth Cohort Survey to obtain a sample of 50.000 individuals covering the period 1988 to 1991 to study both the micro and macro components of the education decision. However, due to the short time span of the data she has difficulty in finding a significant impact of some of the macro variables, after controlling for individual characteristics and area effects.

An alternative approach is to use a general survey, which is available on a regular basis, to select those individuals who are in the process of making the decision whether to remain in the education system at the moment of the interview. In other words, to study the participation decision at sixteen one selects all the sixteen year olds within each wave of the survey. Potentially, this approach can provide the econometrician with a large source of data in both the cross-sectional and time dimensions. Using this approach Micklewright, Pearson and Smith (1990) obtain data on sixteen year olds' education decisions from the Family Expenditure Survey for the period 1978-84, to test the effect of unemployment on education decisions. However, due to the small number of cross sections of data used, they only find a significant and negative effect of the unemployment rate on education decisions when they exclude their full set of regional and time dummies.

In this work we follow the same approach as Micklewright et al. (1990) to construct our sample collecting the maximum time series of data available. Using 17 successive cross-sections of the Labour Force Survey (LFS) covering the period 1983-99 we obtain a sample including around 35,000 sixteen year olds, another with 34,000 seventeen year olds and finally one with 30,000 eighteen year olds. Furthermore, since the LFS also reports the number of years each person has been in full-time education we can estimate separately the determinants of the probability to participate in education at a particular age (the participation rate) and the probability of remaining in education for an additional year at a certain age (the staying-on rate). In addition, we can use the LFS to construct variables measuring the regional distribution of education, as well as labour market variables by level of educational attainment. Finally, since the LFS is a household based survey, i.e., the whole family is interviewed, we are able to control for a large number of individual and family characteristics.

The main results of this study can be summarized as follows. The probability of an individual staying-on in education after 16, 17 and 18 years of age is significantly influenced by the distribution of education within each region. We find that the higher the share of the population with a degree, the higher the probability of remaining in education at sixteen and eighteen years of age, with elasticities of 0.16 and 0.25, respectively; while the higher the share of the population with higher vocational qualifications, the higher the probability of continuing studying at seventeen, with an elasticity of 0.08. This effect may seem quite small in magnitude. However, with the large increase in qualifications over the sample period it implies a rise in the predicted probability of remaining in education of 8p.p., 7p.p. and 19p.p. for sixteen, seventeen and eighteen year olds, respectively. We interpret this result to indicate that the external effects have an important effect on education decisions.

Finally, we also use the fact that we have a large sample spanning over two decades to estimate the effect of regional labour market variables on the education decision. In particular, we look at the effect of the regional unemployment rate by educational attainment and of the returns to education.

There already exists a large literature looking at the effect of labour market variables on education decisions using aggregate UK data. [2] The fundamental conclusion of this research is that the state of the labour market plays an important role in determining participation rates in non-compulsory education, with the returns to education having a relatively large effect and the unemployment rate a relatively small effect.[3] However, there have been few attempts to study both the macro and micro components of the education decision. This is due to the great difficulty, already mentioned above, to obtain individual datasets spanning over a long period of time. Those who have attempted this

[2]This literature in the UK started with the work of Pissarides (Pissarides (1981), Pissarides (1982)), and continues to be an active area of research to this day (McVicar and Rice (2001)). Research has also focused on the variation in participation in education both across countries (McIntosh (1998)) and across regions (Clark (2001)).

[3]Typically, a 1% rise in the rate of return to education raises male (female) participation by 1.2% (0.1%) while a 1% increase in the youth unemployment rate increases the male (female) participation rate at sixteen years of age by only 0.06% (0.1%) (see McIntosh (1998)).

using the available data have generally found the macro variables to have an insignificant impact on the participation (although this may well reflect the limitations of their data). Rice (1999) using three waves of the Youth Cohort Survey between 1988 and 1991 finds that the local unemployment rate does not have a significant effect on individual's decisions whether to participate in post compulsory education. However, when she interacts the unemployment rate with the ability of the individual, she recovers a highly significantly role for the local labour market in determining educational participation.[4] The magnitude of the effect varies greatly with ability, but if we look at a male (female) with average GCSE attainment the estimated elasticity is 0.2 (0.1).[5] On the other hand, the rate of return to education for a male with average GCSE attainment has an elasticity of 1.5 (0.6 for females). Micklewright et al. (1990) using data from the Family Expenditure Survey for the period 1978-84 only find a significant and negative effect of the unemployment rate on education decisions when they exclude their full set of regional and time dummies.

The main results from the analysis of the regional labour market variables can be summarized as follows. The probability of an individual staying-on in education after 16, 17 and 18 years of age is significantly influenced by the state of the regional labour market. Young persons of all ages take into account the opportunity costs and expected gains from education when they decide whether to continue studying or not. They have a greater incentive to leave education if the labour market for unskilled workers in their region is buoyant, that is, if the unemployment rate for these workers is low and their expected lifetime earnings are high. On the contrary, the greater the gap between the state of the skilled and unskilled labour markets - i.e. the lower the unemployment rate of the skilled relative to the unskilled and the greater the gap between their expected lifetime earnings - the greater the incentive for them to remain in the education system. We find that at all ages the higher the unemployment rate faced by individuals with A Levels or less (unskilled plus semiskilled) and the lower the unemployment rate for individuals with degree or more (skilled),

[4]The fact that she splits the effect of unemployment into three coefficients corresponding to low, medium and high level unemployment area and that when she includes local labour market dummies the effect disappears demonstrates the practical difficulties in obtaining significant coefficients with samples covering such a short time span

[5]Although this value is about three times those obtained using macro data for males, it is not clear how much of it is due to ability and how much to unemployment.

the higher the probability of remaining in education. We find this effect to be quite small in magnitude, which is in line with the findings from the macro based research on aggregate labour market data, and only statistically significant for sixteen year olds, with elasticities of 0.07, 0.035 and -0.037 for the unskilled, semiskilled and skilled unemployment rate, respectively. A possible reason why this effect is only significant for sixteen year olds could be that those who leave at a later age will have some higher qualification and therefore face a much lower unemployment rate.

The returns to education (the ratio of the present discounted value of permanent earnings for those with and without higher qualifications) have a positive effect on the staying-on rate in education, with an elasticity of 0.4, 0.2 and 0.7 for sixteen, seventeen and eighteen year olds, respectively. This effect is statistically significant for sixteen and eighteen year olds. The magnitude of this effect is about a third of the estimated effects using aggregate data for sixteen year olds and about one half that for eighteen year olds. Nevertheless, our results imply that the rate of return on educational qualifications have a large impact on staying-on rates. During the sample period the returns to education have risen by around 29% which implies a rise in the predicted probability of remaining in education of 9p.p., 4p.p. and 17p.p. for 16, 17 and 18 year olds, respectively.

This chapter is organized as follows. In section 4.2 we introduce a theoretical model of the educational participation decision to motivate the research and then we explain our estimation strategy. Section 4.3 describes the dataset on which this research is based and the particular variables we will use. The results are discussed in section 4.4, while section 4.5 examines the robustness of our results. Finally, section 4.7 concludes.

4.2 Theoretical model

The theoretical framework we outline here has its origins in the classic human capital investment model pioneered by Becker (1964) and Ben-Porath (1967).[6] According to this model, an individual decides her optimal investment in education by comparing the present discounted value of expected net future earnings over the different alternatives she faces. If she invests in obtaining an educational qualification she will expect to be able to demand a larger stream of earnings in the future, since skilled individuals (skilled and educated are taken to be equivalent) to earn higher wages and face lower unemployment rates than the unskilled. However, investments in education are not costless - she must pay the direct costs of education: tuition fees and her costs of living, plus the indirect cost of education: the opportunity cost of foregone current earnings. She will invest in education if the expected benefits of that investment exceed the expected costs (leaving aside any consideration of the risk aversion of the individual - the costs of education are largely certain and must be paid today, while the benefits are uncertain and may not be realised for years, if not decades).

Individuals stay on in education in order to acquire the human capital that will reap a return once they enter the labour market. However, the stock of human capital they accumulate depends not only on the time spent in education but also on their innate ability to learn, which depends to a large extent on their family background and their environment.

Of course, most governments insist that all individuals remain in education until a given age (typically sixteen) in the hope that they will acquire some minimum level of human capital. However, when a young person reaches the end of compulsory education she then has to decide between two alternatives, to continue studying or to enter the labour market and look for a job. Consider the following expression:

$$V_i^u(t) = q_i^u[q(t), h_i^u(a_i)] * w_i^u[h_i^u(a_i)] + V^*\{q_i^u[q(t), h_i^u(a_i)] * w_i^u[w^u(t), h_i^u(a_i)]\} \tag{4.1}$$

[6] The following model draws not only upon the variant of the human capital model developed in chapter 1 but also upon the model presented in Rice (1999).

Let us define the stock of human capital with which an individual leaves education as h_i^u. She enters the labour market, where she will find a job with probability $q_i^u(t)$. Following the model developed in chapter 1, this probability is a function of the unskilled employment rate in her regional labour market ($q^u(t)$) and her own efficiency in searching for work, which depends on her ability. If she finds a job she will earn a wage which is a function of the human capital she accumulated and of the level of demand in her region. Finally $V^*[q_i^u * w_i^u]$ is the maximized present discounted value of expected net benefits from age t+1 onwards, conditional on the amount of human capital she accumulated at age t (h_i^u) and on the future conditions of the regional labour market for unskilled individuals.

If the young person decides to continue in full-time education, the present discounted value of future earnings is:

$$V_i^s(t) = -ce(t) + V^*\{q_i^s[q(t), h_i^u(a_i)] * w_i^s[w^s(t), h_i^u(a_i)]\} \tag{4.2}$$

That is, in period t she will have to bear the direct costs of full-time education ($ce(t)$). However, from the moment she leaves education and enters the labour market looking for a job ($t+1$), she will face a lower unemployment rate and higher wage because of the extra human capital she has accumulated ($V^*[q_i^s * w_i^s]$). The individual will therefore decide to continue in full-time education at time t if the difference in present discounted value of earnings from the two alternatives, $V^s(t) - V^u(t)$, is positive.

$$V^s(t) - V^u(t) = -ce(t) + q_i^u * w_i^u + (V^*[q_i^s * w_i^s] - V^*[q_i^u * w_i^u]) > 0 \tag{4.3}$$

Education externalities enter this equation in two ways. A higher Level of average education in the labour market fosters higher job creation, raising the employment rate, as was shown in chapters 1 and 2. In addition, a more educated workforce will improve the transmission of new information through the population fostering technological progress which in turn raises workers' productivity and wages. This means that the wage and employment rate in equation 4.3 depend also on the average level of education in the labour market ($E[h_i]$).

$$q_i^s\{q(t), h_i^u(a_i), E[h_i]\} \tag{4.4}$$

$$w_i^s\{w^s(t), h_i^u(a_i), E[h_i]\} \tag{4.5}$$

In order to be able to test this theory empirically, we have to express this equation in terms of observable variables and unobservable characteristics. The local labour market is taken to be the UK Standard Statistical region in which the individual resides, split into metropolitan and non-metropolitan areas where possible. Then, the difference in the present discounted value of earnings defined above for individual i in region j will depend on two sets of observable variables: the characteristics of individual i and her family(X_{ij}) and the characteristics of region j's labour market and education system (R_j) together with an unobservable random component (u_{ij}).

$$V^s(t)_{ij} - V^u(t)_{ij} = f(X_{ij}, R_j, u_{ij}) \tag{4.6}$$

For estimation purposes we assume that this expression follows a normal distribution:

$$(V_{ij}^s - V_{ij}^u) \sim N(Z_{ij}'\beta, \sigma^2) \tag{4.7}$$

where $Z_{ij} = [X_{ij}, R_j]$ and β and σ^2 are constant across the population. Then, the probability that the ith individual living in region j chooses to remain in full-time education will be the following:

$$Pr(V_{ij}^s - V_{ij}^u > 0) = (2\pi)^{-1/2} \int_{-\infty}^{Z_ij'\beta/\sigma} exp(-z_{ij}^2/2)dz_{ij} \tag{4.8}$$

The parameters of the probit function are estimated from the sample information on whether the individual is still in full-time education or not, p_i, and on the individual and regional characteristics Z_{ij}. As in all probit models the full set of parameters is not identified. This is solved by normalizing $\sigma = 1$. The likelihood function will then be the following:

$$L = \prod_{i=1}^{n} [\Phi(-\beta' x_i)]^{p_i} [1 - \Phi(-\beta' x_i)]^{1-p_i} \tag{4.9}$$

where Φ denotes the distribution function of a standard normal variable and p_i is the realization of the probability of staying-on in education.

Finally, since our variables of interest: the characteristics of region j's labour market and education system (R_j), vary only across time and regions, when we calculate the standard errors we have to allow for correlation of the errors between individuals belonging to the same cluster (see Moulton (1986)). This is achieved by estimating the robust $Var(\widehat{\beta})$ following White's method (White (1980) and White (1982)), substituting the score vector (or gradient vector) for the score vector corresponding to the whole cluster. These may be called super-observations and are obtained by summing the score vectors of all the individuals belonging to the same cluster. The score vectors corresponding to the super-observations are independent and so White's method holds.

4.3 The data

The data used is drawn from the yearly non-longitudinal Labour Force Survey (LFS) for the period 1983-1991 and from the spring quarter of the quarterly LFS for the period 1992-99[7]. The yearly LFS is designed to be representative of the total population in the UK, containing detailed information on the highest educational attainment of individuals and participation in education as well as family and individual characteristics. In addition, it allows us to obtain aggregate variables reflecting the evolution of the British regional labor market over time.

The non-longitudinal LFS is conducted in Spring every year on all members of around 60,000 households. Although the LFS started in 1975, the survey was biannual until 1983. In addition, there are no education variables until 1979. On the other hand, from 1999 regions are reported only using the new classification of regions (GOR).[8] For these reasons the period of study will be 1983-1999. This period of seventeen years covers most of the dramatic changes in education participation that have occurred in Great Britain in modern times: the explosion in education participation of the eighties and its halting in the mid nineties. Furthermore, almost two economic cycles occurred during this time in Britain.

The dependent variable is the staying-on rate in full-time education after the

[7] Although the LFS was published yearly for the period 1983-91 the data actually referred to the spring quarter.

[8] Although the previous classification (SSR) can still be recovered using county information, this variable was also dropped from 2000 onwards.

legal leaving age of sixteen. The law in the United Kingdom obliges individuals to stay in education until the end of the academic year in which they turn 16. In particular, it states that those born between September and January must wait until the following Easter to leave, whilst those born between January and August may leave in June. In Scotland, the individual may leave at the end of December if their sixteenth birthday is in September-February. Since the LFS undertakes all the interviews during the Spring quarter (March-May), it would be impossible to study the participation decision at the immediate moment in which they are legally free to leave school. Furthermore, what is relevant for education participation is whether they continue studying for another academic year or not. Therefore, the sample will include only those individuals who are interviewed during the academic year after the legal leaving age. That is, the individuals who are or will be seventeen during the academic year in which they are interviewed. This leaves us with a sample of 35,359 individuals - 18,314 males and 17,045 females.

Having determined who should be included in the sample, the dependent variable, "staying-on in education after 16" is defined as follows: a dummy equal to 1 if the individual remains in education in the academic year during which he will be seventeen and 0 otherwise. In our sample, on average 44% of children leave education by the end of the year in which they reach sixteen. This number rises to 48.8% for males, whilst is only 39% for females. This picture has changed dramatically during the sample period, with the staying-on rate at sixteen increasing from around 43% in 1983 to 70% in 1999.

Most UK studies on education have concentrated on 16 year-olds, since the UK has traditionally had a comparatively low participation rate compared to other developed countries. However, it seems particularly interesting to know what are the important factors determining the decision to stay on in education at later years and how they differ from the 16 year-olds case. Therefore, this study also looks at the decision to stay on in education after seventeen and eighteen years of age. The corresponding sample is obtained in the way described above, except that now we include only individuals who will be eighteen during the academic year in which they are interviewed (nineteen for those staying-on after eighteen years of age). In this case we also have to take into account the fact that some people left full-time education before they were 17

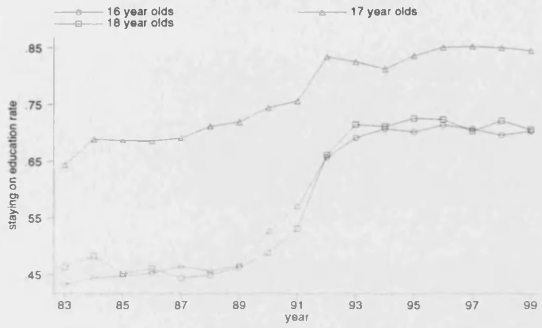


Figure 4.1: Staying-on in education rate

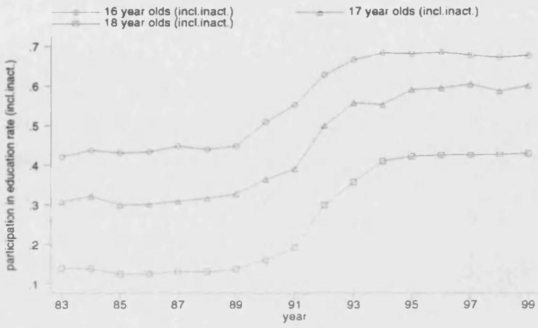


Figure 4.2: Participation in education rate

(18). These individuals are excluded since otherwise we would be underestimating the staying-on rate. The dependent variable is defined similarly. These samples include 18,688 and 12,187 people respectively, 47% and 48% of which are males, respectively.

The estimation of the model requires two types of explanatory variables, individual attributes and market characteristics. The first type includes personal and household characteristics. Both of them are obtained from the LFS since all members of the household are interviewed. However, it is possible that the individual has left the family home and is living on his/her own. In this case we would not have information on the family background. Since there is no easy solution for this problem and there are very few individuals in this situation, we drop them[9].

The main focus of this paper is on the effect of regional variables on the staying-on rate. Therefore, one would want to control for as many individual characteristics as possible to correctly identify the regional effects. Previous studies have shown that family background is one of the main determinants of the children's decision to study (Rice (1987), Micklewright (1989) and Andrews and Bradley (1997)). This effect might come through different mechanisms. If ability is transmitted through the genes then one would expect children of skilled parents to have a higher staying-on rate, simply because they are

[9]There are only 234 individuals in this situation at 16 years of age, which represent less than 0.7% of the sample. This number is 1.2% (220) and 4.6% (538) for 17 and 18 year-olds respectively (265 out of 18.984 (1.4%) and 591 out of 12.824 (4.8%) if inactive are included)

more able. Since controlling for individual ability is not easy to implement, we include parents' education. In addition, we control for individual ability by including the individual's educational attainment until the interview date. This variable may be endogenous since an individual that is planning to leave school might not have the incentive to obtain the highest education level possible at his age. However, if the child is planning to start working, the qualifications obtained will be very important to get a job, which might provide the right incentives to study[10]. On the other hand, household and parents' characteristics also reflect the environment the child is growing up in and this ought to have a great effect on the decision to study. In addition, in the UK education has been markedly different across different social classes. We try to capture this effect with the socioeconomic group and labour force status of the parents and by controlling for single parents. Finally, children's education is a costly investment and parents will be constrained by their income. We do not have information on family income but the socioeconomic group, labour force status and number of older and younger siblings should be good proxies for it.

The variables reflecting regional market characteristics are the share of working age population by 9 levels of education, the unemployment rate and present discounted value of permanent earnings by education[11], the pupil/teacher ratio and the industry's share of employment. Most of these are obtained by aggregating the individual LFS data, except for the permanent earnings, which come from the New Earnings Survey (NES) and the pupil/teacher ratio that is obtained from Regional Trends. The regions considered are based on the Standard Statistical Regions classification, split into metropolitan and non-metropolitan areas whenever possible. This divides the UK into 17 regions: Tyne & Wear, rest of Northern region, South Yorkshire, West Yorkshire, Rest of Yorkshire & Humberside, East Midlands, East Anglia, Greater London, Rest of the South East, South West, West Midlands metropolitan, Rest of West Midlands, Greater Manchester, Merseyside, Rest of North West, Wales

[10]We also report the results without controlling for individual ability table D.5 in appendix D

[11]The way permanent earnings are calculated is explained in appendix D

and Scotland. [12] [13]

The education classification used divides qualifications into 9 levels (see appendix C). It distinguishes between academic and vocational qualifications. In addition, we have aggregated this variable into 4 groups, where academic and equivalent vocational qualifications belong to the same category, and 2 groups -below A level, A level or more. The socio-economic group of the head of household includes the following categories - Employers/Managers/Professional, Intermediate occupations, Personal Service, Manual skilled occupations, Partly skilled occupations, Unskilled occupations, Unknown.

The literature on education externalities has used different variables to describe the distribution of education in an area. Most studies use the share of population with a certain level of education - Moretti (1998) and Ciccone and Peri (2000) use share with college degree, while Acemoglu and Angrist (2000) and Rauch (1993) use share of population with at least secondary schooling. Other studies, like the one of chapter 3 use average education in the area. However, it is not clear what is the most appropriate variable. In this work I have tried different measures, concluding it is most informative to include information about the whole education distribution, that is, the share of working age population for each level of education (excluding the lowest level). This will allow us to observe not only possible positive spill-over effects from the skilled groups but also negative effects from the unskilled groups.

[12] A detailed list of the counties included in each region can be found in Appendix B, table C.2. Although in this chapter we have two regions less since we cannot divide neither the Greater London region (into Inner and Outer London), nor the Scotland region (into Strathclyde and Rest of Scotland).

[13] Northern Ireland is not included because of the difficulty of getting data on wages by education (occupation) since the NES only covers Great Britain. The only suitable survey would be the Family Expenditure Survey, but because of its small sample size (around 85 observations per year) we are inclined not to use it

Table 4.1: Sample means of variables by staying-on

Variables	16year olds		17year olds		18year olds	
	stayer	leaver	stayer	leaver	stayer	leaver
Prob(staying)	54.0		76.7		60.2	
Regional Education Externalities						
Share Other Voc	7.2	6.3	7.4	6.6	7.8	7.0
Share Other Acad	4.6	4.7	4.6	4.5	4.5	4.7
Share Low Voc	14.0	13.3	14.1	13.3	14.5	13.5
Share O Level	17.7	17.0	17.8	17.2	17.8	17.7
Share Mid Voc	2.5	2.3	2.5	2.3	2.6	2.4
Share A Level	6.7	6.2	6.7	6.6	7.0	6.6
Share High Voc	5.5	4.8	5.5	5.0	5.9	5.2
Share Degree	10.9	9.6	11.1	10.3	11.5	10.7
Regional Labour Markets						
Unemp Unskilled	9.9	10.7	9.7	10.4	9.8	9.8
Unemp Semiskill	6.5	6.8	6.4	6.8	6.5	6.4
Unemp Skilled	3.6	3.8	3.6	3.8	3.6	3.6
Earnings Unskilled	100,418	98,328	101,384	100,669	102,381	101,557
Earnings Skilled	168,594	157,747	171,690	164,369	177,045	168,698
Earnings ratio	1.7	1.6	1.7	1.6	1.7	1.7
Region's Education Quality						
Pup/teach primary	22.3	22.2	22.4	22.1	22.4	22.3
Pup/teach 2ndary	15.9	15.7	15.9	15.7	15.9	15.9
Individual Ability						
Other Voc	0.5	2.0	0.6	1.9	0.9	1.5
Other Acad	6.7	20.8	2.9	8.7	1.7	2.8
Low Voc	0.9	2.4	3.8	8.5	4.0	9.6
O Level	78.8	42.2	77.3	51.3	25.4	22.4
Mid Voc			1.6	4.4	5.0	8.2
A Level					58.0	43.8
High Voc					1.3	2.6
More	3.7	2.1	10.3	11.6	0.1	0.1
Individual Characteristics						

continued on next page

Table 4.1: *continued*

migrant	16.4	24.2	15.3	25.3	17.7	21.5
sex	52.3	43.4	53.0	52.6	49.3	55.5
notwhite	9.7	4.8	10.1	7.9	13.4	8.0
Head of Household's Education						
Other Voc	7.9	9.0	7.9	8.3	8.6	7.9
Other Acad	1.0	1.4	0.9	1.6	0.6	1.0
Low Voc	20.4	22.5	19.0	22.2	16.8	20.3
O Level	10.6	6.8	11.2	9.3	9.3	10.5
Mid Voc	2.4	1.6	2.6	2.6	2.7	2.5
A Level	5.1	1.7	5.7	3.7	11.0	5.0
High Voc	6.8	2.8	7.0	4.4	7.5	5.8
Degree	19.1	3.0	22.0	7.4	21.3	14.2
Head of Household's Socio-economic Group						
Man Unsk	3.2	6.4	2.8	4.1	2.9	3.6
Man Semisk	6.3	10.8	5.5	8.5	5.1	6.9
Man Skilled	24.8	36.6	22.1	30.8	19.3	25.2
Non-man Unsk	2.1	2.2	2.1	2.6	2.8	2.2
Non-man Semisk	17.2	10.8	18.1	14.4	18.6	16.9
Non-man Skilled	37.1	16.8	40.1	25.7	37.4	32.7
Head of Household's Labour Force Status						
unemployed	16.6	21.7	16.8	21.1	24.4	20.7
inactive	4.7	8.6	4.1	5.7	4.2	4.8
Household Structure						
single parent	11.1	16.8	11.6	15.1	19.2	14.7
youngsibl	82.0	81.2	79.9	75.9	74.2	71.4
oldsibl	39.7	51.3	31.1	38.3	24.2	30.3
No Observations	19,083	16,276	14,327	4,361	7,342	23,149

4.3.1 The distribution of education across regions

Since one of the main contributions of this chapter is the analysis of the effects of education externalities on education participation, it is useful to describe the education distribution in the UK regions.

The UK's average level of education has been constantly growing since 1983 at an average annual growth rate of 2.45% (see table 4.2). This growth has been

Table 4.2: Education's share of UK's working age population

	Average level			Annual Growth rate		
	83	90	99	83 − 90	90 − 99	83 − 99
Average Education	3.23	3.75	4.58	2.01	2.20	2.45
Share of UK's working age population						
No Qual	46.78	33.14	18.59	−3.65	−4.39	−3.54
Other Voc	4.97	6.90	10.03	4.84	4.54	5.98
Other Acad	4.52	4.10	3.88	−1.17	−0.53	−0.83
Low Voc	10.04	15.24	15.22	6.46	−0.01	3.03
O Level	14.68	17.79	18.47	2.65	0.39	1.52
Mid Voc	1.50	2.64	3.89	9.50	4.71	9.35
A Level	5.23	6.43	8.02	2.86	2.48	3.14
High Voc	3.62	4.26	7.48	2.21	7.53	6.26
Degree	8.64	9.51	14.43	1.26	5.17	3.94
Share of UK's working age population with some qualification						
Other Voc	9.35	10.32	12.32	1.30	1.94	1.87
Other Acad	8.49	6.13	4.77	−3.48	−2.22	−2.58
Low Voc	18.87	22.79	18.69	2.59	−1.80	−0.06
O Level	27.59	26.60	22.69	−0.45	−1.47	−1.04
Mid Voc	2.82	3.95	4.77	5.01	2.08	4.08
A Level	9.83	9.61	9.85	−0.28	0.25	0.01
High Voc	6.81	6.38	9.18	−0.79	4.40	2.05
Degree	16.24	14.23	17.72	−1.55	2.46	0.54

driven by two main factors - the drastic reduction in the number of individuals without any qualification from 47% in 1983 to 19% in 1999 and the growth in all the most qualified groups, from Middle Vocational qualifications to Degree or more. Amongst these, the Middle Vocational group has grown most, mainly because it started at a very low level; but the High Vocational and Degree groups have also grown greatly[14]. This is still the case when looking only at the shares of each qualification group amongst the population with some skills. The three top qualifications have constantly gained ground against all other qualifications. At the same time, the groups with the lowest qualifications have reduced in size relative to other qualifications.

When we look at the distribution of education by regions (tables 4.3 & 4.4[15]), we can see that there is great persistence in the distribution. The five regions at the top and bottom of the distribution in 1983 are still in the same position in 1999. This result holds whether we look at the average level of education or at the share of the working age population with degree or more. However, things vary much more when we look at the intermediate qualifications. In addition, the dispersion of the distribution has decreased slightly both in terms of the average level of education and of the share of population with degree.

Amongst the top regions (see table 4.3), Greater London and East Anglia seem to have specialized in skilled academic qualifications, with a very low share of high and middle vocational qualifications, while the other regions on the top have remained more diversified (Scotland, Rest of South East and South West)[16].

If we now look at the 5 regions at the bottom of the distribution in table 4.4, we can divide them into two groups. The first group, Metropolitan West Midlands and South Yorkshire, have a very unskilled population with a very low share of the top three qualifications and very high of the bottom four. The second group, Merseyside, Tyne and Wear and Rest of Northern region,

[14]They have increased from 3.6% to 7.5% and from 8.6% to 14.4% respectively, with most of this growth taking place in the 1990s

[15]Also see the rankings in tables D.2 and D.3 in appendix D

[16]A surprising feature is that Greater London and Scotland have very few people with only O levels, possibly because people in these areas tend to stay longer in education until they achieve a higher academic qualification.

Table 4.3: Education's share of working age population by 5 top regions

	No qual		Other Voc		Other Acad		Low Voc		O Level	
region	83	99	83	99	83	99	83	99	83	99
GrLon	44	16	5	15	4	3	7	10	16	16
RSE	39	14	6	9	5	4	10	14	17	21
EAng	46	18	7	11	5	5	9	14	14	20
Scot	47	18	4	10	1	2	12	15	14	15
SW	43	15	5	9	5	5	11	16	17	20

	Mid Voc		A Level		High Voc		Degree		Average edu	
region	83	99	83	99	83	99	83	99	83	99
GrLon	1	3	8	8	3	6	12	22	3.7	5.0
RSE	2	4	6	9	4	8	12	17	3.8	5.1
EAng	1	3	5	6	3	7	8	14	3.3	4.6
Scot	2	4	9	12	4	10	9	14	3.6	4.9
SW	2	4	5	8	4	9	9	14	3.5	4.9

Table 4.4: Education's share of working age population by 5 bottom regions

	No qual		Other Voc		Other Acad		Low Voc		O Level	
region	83	99	83	99	83	99	83	99	83	99
SY	54	22	4	9	5	6	10	18	12	18
RN	50	21	5	9	5	5	11	20	14	18
WMid	56	25	5	12	5	5	9	13	12	17
Mersey	50	27	5	7	5	4	10	16	15	18
T&W	50	21	6	10	6	5	11	20	13	17

	Mid Voc		A Level		High Voc		Degree		Average Edu	
region	83	99	83	99	83	99	83	99	83	99
SY	1	4	4	6	4	6	6	11	3.0	4.3
RN	2	5	3	6	3	7	6	10	3.0	4.4
WMid	1	4	4	6	3	6	6	10	2.8	4.1
Mersey	1	4	4	7	3	7	6	10	3.1	4.3
T&W	1	4	3	7	3	7	6	9	3.0	4.3

Table 4.5: Education decisions in the UK

	Average level			Annual Growth rate		
	83	90	99	83 – 90	90 – 99	83 – 99
Education decisions						
stay on edu 16	43.26	52.65	70.23	2.94	3.38	3.19
stay on edu 17	64.36	74.45	84.51	2.13	1.47	1.76
stay on edu 18	46.29	48.83	70.59	0.85	4.47	2.89
part. In edu 17	30.78	36.43	60.06	2.56	6.05	4.52
part. In edu 18	13.94	16.02	42.95	2.28	12.74	8.16

seem to have compensated for the lack of skilled academic qualifications with a slight specialization in skilled and semi-skilled vocational qualifications.

The staying-on rate has risen dramatically over the sample period for 16, 17 and 18 year-olds, from 43%, 64% and 46% in 1983 to 70%, 85% and 71% respectively in 1999 (see table 4.5). The same is true for participation in education rates for 17 and 18 years olds, with an increase from 31% and 14% to 60% and 43% respectively. However, this transformation of the education decision has taken place in three different phases - in the first (1983-89), the staying-on rate at sixteen grows slowly reaching 52%, then in the second (1990-94) it explodes reaching its peak at 71% in 1994, and finally, in the third it stabilizes and even decreases slightly to around 70%. The fact that the staying-on rate is highest at 17 is due to the characteristics of the British curriculum. In the UK most young persons choose the academic route, whose intermediate qualifications (O and A level) are mainly considered as steps towards the attainment of a degree. Therefore, the people at highest risk of leaving education at seventeen are those undertaking vocational qualifications, which only account for 13% of seventeen year olds.

If we now look at the education decision by regions, we notice that the regions with the most qualified workforce also have the highest participation rates (see figures 4.3, 4.6 and 4.7). Exceptions to this are Merseyside and metropolitan West Midlands, which have one of the least skilled workforces but a very high participation rate. This is probably because they have had an important rise in middle and high vocational qualifications during the period, as well as A levels. However, when we look at staying-on rates at 17 and 18 years of age things

Figure 4.3: share with degree vs staying-on rate at 16

Figure 4.4: share with degree vs staying-on rate at 17

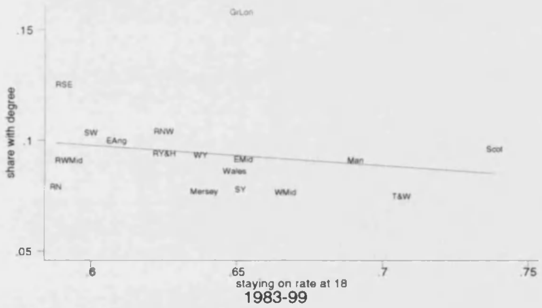


Figure 4.5: share with degree vs staying-on rate at 18

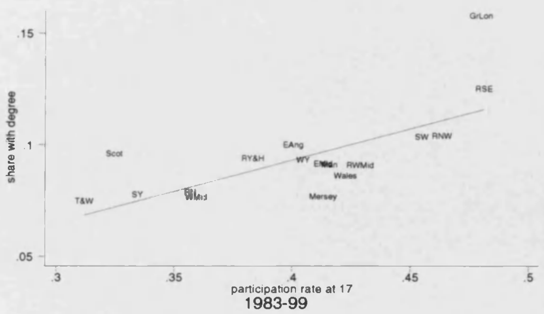


Figure 4.6: share with degree vs participation rate at 17

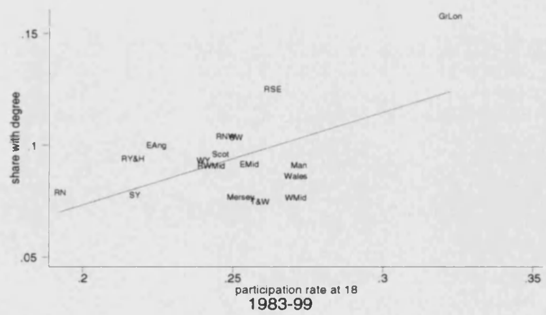


Figure 4.7: share with degree vs participation rate at 18

are not so clear. While some of the most skilled regions (Greater London, Rest of South East and Rest of North West) remain in the top or middle of the distribution, the other top regions (Scotland for 17 year olds, South West and East Anglia) have quite low participation rates. However Scotland has the highest staying-on rate at 18 years of age.

4.4 Results

As explained in section 4.2, the results were obtained by estimating the probability of staying-on in education by maximum likelihood using a Probit model. In this model, unlike in the linear probability model, an estimated coefficient, β_k, does not represent the total effect of the covariate, x_{ik}, on the dependent variable. Instead, one has to calculate the derivative of the likelihood function with respect to that covariate to obtain its marginal value:

$$\frac{\partial}{\partial x_{ik}}\Phi(x_i'\beta) = \phi(x_i'\beta)\beta_k \tag{4.10}$$

Therefore, we report both the estimated coefficients and the marginal values for the reference individual. For the labour market variables we report the elasticity instead.

The reference individual has the following characteristics: Male, white, non-migrant, with O level as the highest qualification attained so far, lives with both of his parents, the head of his household has O Level or Middle vocational qualifications and is working in a skilled manual or unskilled non-manual position, resident in the East Midland region. The rest of the covariates are calculated at mean value.

Four sets of regional variables are included in the estimation: the education distribution, unemployment rate by qualification, present discounted value of expected lifetime earnings by qualification and number of pupils per teacher. All these variables are included as logarithms.

Table 4.6: Probit estimation of the individual's probability of staying-on in education

Variables	16year olds		17year olds		18year olds	
	Coef	Mg V	Coef	Mg V	Coef	Mg V
Regional Education Externalities						
Share Other Voc	−0.205***	−0.093	−0.180**	−0.054	−0.148	−0.058
Share Other Acad	0.024	0.011	0.240***	0.072	−0.028	−0.011
Share Low Voc	0.041	0.019	0.399**	0.119	−0.082	−0.032
Share O Level	0.065	0.030	0.459*	0.137	0.402	0.158
Share Mid Voc	0.051	0.023	0.037	0.011	−0.015	−0.006
Share A Level	−0.141	−0.064	−0.108	−0.032	−0.043	−0.017
Share High Voc	−0.071	−0.032	0.275*	0.082	0.024	0.009
Share Degree	0.353***	0.160	−0.096	−0.029	0.629***	0.247
Regional Labour Markets						
Unemp Unskilled	0.156*	0.071	0.119	0.035	0.103	0.040
Unemp Semiskill	0.078***	0.035	0.022	0.007	−0.008	−0.003
Unemp Skilled	−0.082***	−0.037	−0.026	−0.008	−0.005	−0.002
Earnings Unskilled	−2.011***	−0.911	0.084	0.025	−1.595**	−0.628
Earnings Skilled	0.347	0.157	0.998*	0.298	1.909***	0.752
Region's Education Quality						
Pup/teach primary	−0.822**	−0.372	0.019	0.006	−0.324	−0.127
Pup/teach 2ndary	0.817*	0.270	0.090	0.022	0.169	0.051
Individual Ability						
Other Voc	−0.192***	−0.067	−0.042	−0.011	−0.003	−0.001
Other Acad	−0.022	−0.007	0.092	0.022	0.195**	0.055
Low Voc	0.007	0.002	0.209***	0.047	0.027	0.008
O Level	0.872***	0.332	0.918***	0.313	0.720***	0.262
Mid Voc			0.187**	0.042	0.172*	0.049
A Level					0.633***	0.145
High Voc					−0.009	−0.003
> O Level	0.956***	0.212				
> Mid Voc			0.780***	0.126		
> High Voc					0.738**	0.160
Individual Characteristics						
migrant	−0.083*	−0.028	−0.194***	0.011	0.086	0.025

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Table 4.6: *continued*

sex	0.212***	0.065	0.046**	−0.053	−0.129***	−0.041
notwhite	0.739***	0.182	0.412***	0.083	0.554***	0.132
Head of Household's Education						
Other Voc	0.080***	0.026	0.116***	0.027	0.144***	0.041
Other Acad	−0.090	−0.031	−0.218**	−0.060	−0.198	−0.064
Low Voc	0.129***	0.041	0.074**	0.018	0.065	0.019
O Level	0.305***	0.109	0.221***	0.061	0.116**	0.037
Mid Voc	0.311***	0.111	0.112	0.029	0.189**	0.061
A Level	0.606***	0.159	0.370***	0.076	0.550***	0.131
High Voc	0.447***	0.125	0.312***	0.066	0.251***	0.069
Degree	0.937***	0.209	0.633***	0.111	0.343***	0.090
Head of Household's Socio-economic Group						
Man Unsk	−0.197***	−0.069	−0.083	−0.021	−0.104	−0.033
Man Semisk	−0.152***	−0.053	−0.148**	−0.040	−0.105	−0.033
Man Skilled	−0.114***	−0.036	−0.127***	−0.030	−0.090*	−0.026
Non-man Unsk	0.039	0.013	−0.071	−0.017	−0.010	−0.003
Non-man Semisk	0.126***	0.040	0.058	0.014	−0.047	−0.014
Non-man Skilled	−0.122***	−0.042	−0.137	−0.036	0.027	0.008
Head of Household's Labour Force Status						
unemployed	−0.163***	−0.056	−0.041	−0.010	−0.094	−0.028
inactive	0.200	0.062	0.060	0.015	−0.008***	−0.003
Household Structure						
single parent	−0.039***	−0.013	0.031***	0.008	0.150	0.043
youngsibl	−0.002	−0.001	0.012	0.003	−0.006	−0.002
oldsibl	−0.105***	−0.035	−0.066***	−0.017	−0.094***	−0.028
Constant	17.686**		−9.105		−0.720	
Prob(staying)	0.73		0.83		0.77	
Log Likelihood	−19084		−8769		−7255	
χ^2	10499		4972		3415	
Pseudo R^2	0.218		0.136		0.114	
No Observations	35359		18688		12187	

NOTES

a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Region and year dummies and Industry's share of employment.

continued on next page

Table 4.6: *continued*

b) Standard errors are clustered by region and year. This allows for correlation of errors between individuals in the same cluster.

4.4.1 Estimation Results for the education externality

The estimated coefficients in table 4.6 show that the variables measuring the distribution of education (the workforce's shares by education) have an important effect on education decisions. However, these effects seem to come through different mechanisms at different ages. At sixteen and eighteen years of age the share of the region's working age population with degree has a positive and significant effect on the probability of staying-on in education, with elasticities of 0.16 and 0.25, respectively. Meanwhile, at seventeen years of age, it seems that the positive external effects of education are coming primarily from the high vocational qualifications, with an elasticity of 0.08, but also from the low and middle qualifications (other academic, low vocational and O levels). In addition, at sixteen and seventeen the share of population with the lowest qualification (other vocational) has a negative and significant effect.

The differences across age groups are probably a consequence of the different characteristics of the academic and vocational education-paths. The academic education-path is mainly built with the aim of reaching university and it has two main break-points, at 16 and 18 years of age, when children take their O Level and A Level examinations, respectively. This means that the main group at risk of leaving education at 16 and 18 years of age is the one with academic qualifications. Therefore, it is not surprising that it is precisely at these ages when the external effect comes from a high share of population with degree. Meanwhile, the vocational qualifications are much more self-contained. Although most of these qualifications are split into levels, each of them is valued by employers on its own merit, allowing the children to find a job if they leave education. This means that young persons trying to attain vocational qualifications may leave at the end of any course and therefore they are the ones most at risk of leaving education at seventeen years of age. This could also explain why at this age the external effect does not come through one qualification but is more widespread across several of them.

Table 4.7: Change in expected probability of representative individual after a change in the workforce's share by education (percentage points)

	workforce's share		staying-on rate		
	Initial	Final	16	17	18
rise in of workforce's share over period 83-99					
High Vocational	4.26	7.48	−2.27	7.28	0.81
Degree	9.51	14.43	7.54	−1.60	13.55
increase in workforce's share from mean to top region					
High Vocational	5.15	6.48	−0.75	2.42	0.27
Degree	10.33	15.65	8.28	−1.76	14.89
reduction in workforce's share from mean to bottom region					
High Vocational	5.15	4.08	0.32	−1.02	−0.11
Degree	10.33	7.34	−2.10	0.45	−3.78

To have an idea of the magnitude these numbers imply, in table 4.7 we have calculated the effect that the rise in the workforce's share with degree or high vocational qualifications over the sample period would have on the predicted probability of staying-on in education for the representative individual. During the sample the workforce's share with degree (high vocational) increased from 9.5% to 14.4% (4.3% to 7.5%). This increase in the top qualifications would have implied a rise in the predicted probability of remaining in education of 8p.p., 7p.p. and 14p.p. for sixteen-, seventeen- and eighteen-year-olds, respectively. That is, although the magnitude of the estimated elasticities might seem small (table 4.6), due to the big rise in qualifications over the sample, they actually imply a large increase in the probability of staying-on in education.

This exercise can also be done to analyze the effect of regional differences in the education distribution. The second and third parts of table 4.7 report the effect of a change in the share of population with degree (high vocational) from the mean value to the rate prevalent in the best and worst regions in terms of this variable. According to this, an increase in the workforce's share with degree from the level of the worst region to the level of the best region would increase the probability of staying on in education by 10p.p. and 19p.p. for sixteen- and eighteen-year-olds, respectively. However, the small regional differences in the share with high vocational qualifications imply a minor effect on the staying-on rate at seventeen years of age.

The external effects might only be a reflection of the quality of the education system or of the region's expenditure on education. In order to control for this we have included the number of pupils per teacher in primary and secondary schools in each region. Both of these variables are statistically significant at sixteen years of age, but insignificant for the rest. As expected, the more pupils per teacher in primary schools, the worse is the quality of the region's education system and this reduces the probability of staying-on in education at sixteen. On the contrary, the measure for secondary schools has the opposite effect. This result might reflect an endogeneity bias. If the budget for education of a local education authority is based on the population at schooling age living in the area, then the higher the share staying in secondary schooling, the higher the pupil-teacher ratio will be. This would not be true if schools' budgets were based on the actual number of students. Obviously, this could not happen for the ratio in primary schooling, since everyone in the area is legally bound to attend school. A different interpretation could be that this variable is capturing a peer group effect - you are more likely to stay in secondary schooling if most of your peers stay.

4.4.2 Estimation Results for the regional labour market variables

The individual probability of staying-on in education at all ages is significantly influenced by the state of the regional labour market. Young persons of all ages are taking into account the opportunity costs and expected gains from education when deciding to continue studying or not. They have a greater incentive to leave education if the conditions of the region's unskilled labour market are good for them, that is, if the unemployment rate is low and the expected lifetime earnings are high. On the contrary, they prefer to continue studying if they expect to encounter better conditions in the region's skilled labour market- low skilled unemployment rate and high skilled lifetime earnings.

The estimated coefficients in table 4.6 show that at all ages the higher the unemployment rate faced by individuals with O Levels or less and with A Levels or less (unskilled and semi-skilled) and the lower the unemployment rate for

Table 4.8: Change in expected probability of representative individual after a change in the unemployment rate by education (percentage points)

	unempl. rate		staying-on rate		
	Initial	Final	16	17	18
rise in unemployment over period 90-93					
unskilled rate	8.40	11.35	1.92	1.04	1.16
semi-skilled rate	5.28	7.03	0.78	0.18	−0.09
skilled rate	2.45	4.19	−2.14	−0.46	−0.10
increase in unemployment from mean to top region					
unskilled rate	10.25	7.05	−2.01	−1.09	−1.22
semi-skilled rate	6.64	4.67	−0.81	−0.19	0.09
skilled rate	3.72	3.02	0.69	0.15	0.03
reduction in unemployment from mean to bottom region					
unskilled rate	10.25	16.59	2.65	1.43	1.60
semi-skilled rate	6.64	9.39	0.75	0.18	−0.09
skilled rate	3.72	4.77	−0.66	−0.14	−0.03

individuals with degree or more (skilled), the higher the probability of staying-on in education. This effect is quite small in magnitude and only statistically significant for sixteen year olds. The elasticities for sixteen-year-olds are 0.07, 0.035 and -0.037 for the unskilled, semiskilled and skilled unemployment rate, respectively. That this effect is only significant for sixteen-year-olds may be because those who leave at a later age most certainly have some higher qualification and therefore face a much lower unemployment rate.

To have an idea of the magnitudes these numbers imply, in table 4.8 we have calculated the effect that the rise in unemployment during the last economic crisis 1990-93 would have on the predicted probability of staying-on in education for the representative individual. During this period, the unemployment rate increased from 8.4% to 11.4% for the unskilled, from 5.28% to 7.03% for the semi-skilled and from 2.45% to 4.19% for the skilled. The rise in unskilled and semi-skilled unemployment would have increased the predicted staying-on rate by 1.9 p.p and 0.8 p.p respectively. The rise in skilled unemployment would imply a reduction in the staying-on rate of 2.1 p.p. Regional differences in unemployment rates also imply large differences in the predicted staying-on rates. A reduction in the unskilled and semi-skilled unemployment rate from the level of the worst region to the level of the best region would reduce the probability of staying-on in education at sixteen by 4.7 and 1.6 p.p., respectively. A similar decrease in the skilled unemployment rate would increase the predicted staying-on rate by 1.4 p.p. The effects of the unskilled and semi-skilled unemployment are clearly larger since it is for these groups where regional differences are larger. These results suggest that the main effects of the unskilled and semi-skilled unemployment rates are due to regional differences, while the main effect of the skilled unemployment rate comes from the economic cycle.

The permanent earnings by education level or returns to education[17] have a great effect on education decisions at all ages. The elasticities for unskilled and skilled earnings are -0.9 and 0.16 at sixteen, 0.03 and 0.3 at seventeen and -0.63 and 0.75 at eighteen (see table 4.6). However, the skilled earnings at sixteen and the unskilled earnings at seventeen do not have a statistically significant effect on staying-on rates. These elasticities imply a very large effect on staying-on rates. The rise in permanent earnings of unskilled workers by 9.8% during the sample period would have reduced the predicted probability of staying-on in education at sixteen by 7.5p.p. and at eighteen by 5 p.p. (see table 4.9). Meanwhile the rise in earnings of skilled workers by 42% would have increased the predicted staying-on rate at seventeen by 10.5p.p and at eighteen by 25.9p.p.[18]. The regional differences in permanent earnings imply an even larger effect. The differences in unskilled earnings reduce the predicted staying-on rates at sixteen by 31.3p.p. and at eighteen by 20.8p.p. While the differences in skilled earnings increase the probability of remaining in education by 15p.p. at seventeen and by 37p.p. at eighteen.

Finally, following previous studies (Rice (1999), Raffe and Willms (1989)) we interact the labour market variables with individual's ability. In particular, we look at the effect of regional unemployment and lifetime earnings on young persons with less than O Level or O Level or more. Table D.7 in appendix

[17] In the estimation of the model (table 4.6) we have included the permanent earnings separately by education instead of the ratio of skilled to unskilled earnings (also called rate of return to education) since they are more informative of the incentives faced by young persons at different ages. However, we have also estimated the model with the rate of return obtaining elasticities of 0.37, 0.17 and 0.71 for sixteen, seventeen and eighteen year olds, respectively. These effects are significant for sixteen and eighteen year olds.

[18] The returns to education have risen by around 29% implying a rise in the predicted probability of remaining in education of 9p.p. and 17p.p. for sixteen and eighteen year olds, respectively

Table 4.9: Change in expected probability of representative individual after a change in permanent earnings by education (percentage points)

	earnings		staying-on rate		
	Initial	Final	16	17	18
rise in earnings over period 83-99					
unskilled	94686	103919	−7.52	0.20	−5.01
skilled	135970	193120	6.54	10.45	25.85
ratio	1.43	1.85	9.33	4.02	16.69
rise in earnings from mean to top region					
unskilled	100175	131693	−29.18	0.79	−19.44
skilled	164937	238745	9.16	14.64	36.21
ratio	1.64	1.81	4.47	1.93	8.00
reduction in earnings from mean to bottom region					
unskilled	100175	92963	2.09	−0.06	1.39
skilled	164937	147297	−0.31	−0.49	−1.22
ratio	1.64	1.53	−1.16	−0.50	−2.08

D shows that in general, labour market variables have a significant effect on individuals with higher ability, but an insignificant one on low ability individuals. An exception is the effect of permanent unskilled earnings for 16 year olds, and of permanent skilled earnings for 18 year olds, which are both very significant and of greater magnitude than for more able individuals. This results contradicts the previous findings in the literature, which suggested that labour market variables affected more the unskilled. This is most certainly due to our poorer measure of ability.

4.4.3 Estimation Results for individual and household variables

In general, the estimated coefficients for the individual and household variables are all in line with previous studies using micro-data. Individual's ability, as measured by the education attainment at the time of the interview, seems to be a very important determinant of the decision to stay on in education at all ages. As expected, individuals with the lowest qualifications (Low vocational, although not statistically significant for sixteen- and seventeen-year-olds, and other qualifications) have a lower probability of continuing studying, while O level or higher academic qualifications have the opposite effect. What is some-what more surprising is that middle and high vocational qualifications have a negative and significant effect. A possible reason could be that most vocational courses are self-contained, providing a qualification widely accepted by employers, while most academic courses are steps towards a higher qualification. Therefore, an individual studying a vocational qualification has a greater incentive to leave education after finishing the course[19]. A concern about controlling for individual ability using education attainment is that this variable may be endogenous. An individual that is planning to leave school might not have the incentive to obtain the highest education level possible at his age. On the other hand, if the child is planning to start working, the qualifications obtained will be very important to get a job, which might provide the right incentives to study. In order to see the importance of this problem we have also estimated the model without controlling for individual ability (see table D.5 in appendix D). The estimated coefficients do not vary significantly, suggesting that even if there is any endogeneity in the way ability is measured, it is not affecting the results.

With respect to other individual characteristics, we find that women have a higher probability than men of continuing in education at 16 and 17 years of age. However, men are more likely to stay at 18 years of age. Children of white origin have a higher probability of staying-on at all ages. Both of these results are common findings in the literature (see Micklewright (1989) or Rice (1999)). The interpretation is that women and non-white persons feel that in order to succeed in their careers they will have to prove they are better than their white-male peers and, therefore, they start by acquiring more education.

The results also show the relevance of the family background in the child's decision to stay on in education. The educational attainment of the head of the household increases the child's probability of continuing in full-time education. This effect is stronger, the higher the education level. However, except for the lowest qualifications, it is higher for academic than for vocational qualifications. A similar pattern is obtained for 17- and 18-year-olds, with one exception - for 18-year-olds the strongest effect is when the head of household

[19]It is also quite surprising that the effect of A level is not statistically significant for eighteen-year-olds. This contradicts the generally accepted idea that this qualification is a mere requirement to go to university and not valued by employers

has A Level as the highest education attainment.

The socio-economic group of the head of household also has an important effect on the child's decision to continue studying. Being a manual worker reduces that probability, whilst being a non-manual worker increases it. However, for 17- and 18-year-olds, the latter effect is not significant. A reason for this might be that when the individual is older his decisions are less influenced by his parents or by the social class they belong to, as long as the family has an economic status that enables them to pay for the education.

The other variables proxying for family income have the expected signs. Children with single-parents have a lower probability of staying-on in education at 16 and 17 years of age. However, this effect is insignificant for 18-year-olds. The head of household being unemployed always has a negative effect on staying-on rates, although it is only significant for 16-year-olds. Being inactive has a positive and significant effect for 17 and 18 year olds. Finally, having older siblings always reduces the probability of staying-on in education. This reflects the fact that families have to distribute their scarce resources amongst their children and the first ones get the bigger share.

Very similar results are obtained when we use the probability of participating in education instead of the staying-on rate (see table D.4).

4.5 Robustness of Results

In this section we have tried to take into account some of the standard econometric problems one encounters when estimating external effects. In particular, we worry about the endogeneity of independent variables and the identification of the external effect[20]. The existing literature studying the effects of regional labour market variables on education participation in the UK has normally not taken this problem into account. However, since we believe it might be a very important issue if one wants to study these factors, we will discuss them here.

[20]See Brock and Durlauf (2000) and Dietz (2001) for two excellent surveys about the literature dealing with these estimation problems

The endogeneity of independent variables is a common problem to all studies of external and neighborhood effects. The question is whether the area characteristics used to measure these effects are exogenous variables or not with respect to the formation of the area. If location was predetermined and fixed for all individuals there would not be a problem. However, we know that individuals are able to choose to a certain extent the area and group they belong to. This could generate a sorting process by which individuals with similar characteristics live together. This would then be problematic for the estimation of the external effects because the characteristics determining the group of interest are the same as the ones determining the problem we are studying, generating biased and inconsistent estimators (Greene (1993)).

One possible way of dealing with this problem is to use instruments for the potentially endogenous variable. We would require a variable that is correlated with the distribution of education but is not correlated with the sorting process. This is particularly difficult for our case since this variable would have to vary both within regions and over time. Most previous studies in this literature which have used instruments where cross-sectional. This allowed them to use instruments which vary across areas but not across time, like the demographic structure a decade before (Moretti (1998) and Ciccone and Peri (2000)). Some other studies have sorted out this problem by constructing instruments such us the variation in child labour laws and compulsory attendance across US states (Acemoglu and Angrist (2000)), but this is not possible for a country like the UK where most of the legislation is nationally based. This leaves us with one possible instrument - past values of the variables determining the education distribution. However, since the sorting process normally takes a long time, persistence is very likely and the endogeneity problem will not be solved by this method.

Due to the difficulty of finding a reliable instrument, the relevant question that we should answer is how important is the endogeneity due to the sorting process in this particular study. There are some reasons why we believe the sorting process might not have an important effect on the estimation of external effects. First of all, the areas used in this study, 17 regions, are very large and heterogeneous. This would make a perfect sorting process almost impossible. Migration of skilled workers will generate a higher concentration of qualified individuals in the best regions and therefore their children will have a greater probability of remaining in education longer. However, we already control quite extensively for the characteristics of the child's family background and for whether they have migrated in the last year. In addition, there will still be a large number of workers from all types in each region (for example because house ownership or housing benefit reduces mobility). Secondly, even if the sorting process is important, there is no reason to believe that it has been increasing during the sample period or that it has been more acute than in the past. Thus, the effect of sorting would mainly be a level effect, most of which should be captured by the region and time dummies.

We have undertaken some simple tests to check the potential importance of endogeneity. One would expect the effects of the sorting process to be stronger in the areas at the extremes of the distribution. That is, in the regions with the highest and lowest levels of education. However, when we run the regression excluding the regions that consistently have had the highest education level (South East including London) and those with the lowest (Metropolitan West Midlands and Merseyside) for the whole sample we find that the effect of the externality remains similar in magnitude and statistically significant (see table D.6). These results lead us to conclude that although some endogeneity might exist, it does not seem to affect significantly the estimation of the external effect of education, or of the other regional variables.

Finally, the other important problem when estimating external effects is the one of identification, also named the "reflection problem" by Manski (1993). This problem arises when a researcher observing the distribution of behaviour in a population tries to infer whether the average behaviour in some group influences the behaviour of the individuals that comprise the group. Manski shows that inference on endogenous effects is not possible unless the researcher has prior information specifying the composition of reference groups and if the variables defining reference groups and those affecting directly the outcomes are moderately related in the population. However, he also proved that identification is eased if the estimated model is non-linear, in particular for the binary response model. The reason is that in a non-linear model, the external effect changes at a different rate than the direct effect of an individual's own characteristics and therefore both can be independently identified. In addition, Brock and Durlauf (2000) showed that this problem is further eased if there is within-group heterogeneity. Otherwise, if the neighbourhood is homogenous, it is impossible to distinguish between the individual and the group with respect to outcomes. Our study fulfills both of these properties and therefore we understand that identification of the external effects should not be a problem here.

4.6 Participation rate in education

So far in this study we have looked at the probability of staying-on in education at different ages. However, a large part of the existing literature looks at the probability of participating in education. That is, they study how many people are in education at a certain age, including those who return to full-time education after having worked for some time. This issue is only relevant for seventeen- and eighteen-year-olds, since in the UK it is illegal to leave education before sixteen. One of the practical advantages of this approach is that sample sizes are much larger - more than 30,000 individuals - since we include everyone at each age. The disadvantage might be that the differences in effects between sixteen-year-olds and older children are not so easy to disentangle.

Table D.4 reports the result of estimating a probit for the probability of participating in education. The main conclusion is that the regional effects have the same sign and significance as with staying-on rates but are larger in magnitude. The only difference is that skilled earnings do not have a significant effect on the participation decision of seventeen-year-olds, while the unskilled rate of unemployment has a significant effect.

4.7 Conclusions

This study examines the effect of education externalities on the probability of staying-on in education at sixteen, seventeen and eighteen years of age, controlling for many individual and family characteristics. The length of time covered and the size of the sample allows a study of the existence of external effects from the regional distribution of education.

We find that there are important positive external effects of education. However, these effects seem to come through different mechanisms at different ages. At sixteen and eighteen years of age, the share of the region's working age population with degree has a positive and significant effect on the probability of staying-on in education. At seventeen years of age, the positive external effects of education are coming from the high vocational qualifications. This difference might be due to the structure of the UK academic curriculum.

In addition, we look at the effect of regional labour market variables on the probability of staying-on in education. Previous work had identified regional effects of unemployment only when interacting it with individual ability and not including regional dummies. Here we argue that this is due to the short time span covered by their samples. Our analysis shows that the individual probability of staying-on in education at all ages is significantly influenced by the state of the regional labour market. Young persons of all ages are taking into account the opportunity costs and expected gains from education when deciding to continue studying or not. They have a greater incentive to leave education if the conditions of the region's unskilled labour market are good for them, that is, if the unemployment rate is low and the expected lifetime earnings are high. On the contrary, they prefer to continue studying if they expect to encounter better conditions in the region's skilled labour market-low skilled unemployment rate and high skilled lifetime earnings. The effect of unemployment is significant only for sixteen-year-olds, while the effect of earnings is significant at all ages. This reflects the fact that unemployment impacts more strongly on low skilled individuals, while earnings become more important as they acquire some higher qualifications. The magnitude of these effects is quite important, especially due to regional differences.

Appendix A

Appendix for Chapter 1

A.1 Level of education in the Social Planner's solution

In equilibrium we have the following levels of employment for the private (q^P) and social planner solutions ($q^S P$):

$$q^P = \left(\frac{b(1-\beta)}{c}\right)^{\frac{\Psi-\alpha}{\Psi-2\alpha}} (\alpha\beta)^{\frac{\alpha}{\Psi-2\alpha}} A^{\frac{\Psi}{\Psi-2\alpha}} \left(E[a^{\frac{\alpha}{\Psi-\alpha}}]\right)^{\frac{\Psi-\alpha}{\Psi-2\alpha}}$$

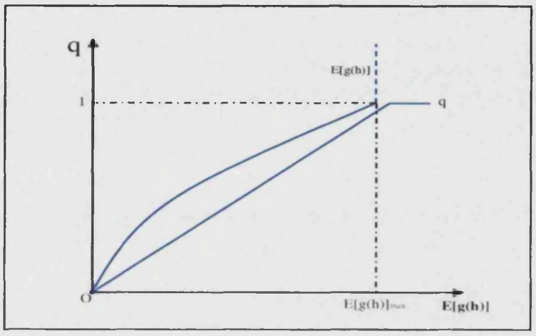
$$q^{SP} = \left(\frac{b}{2c}\right)^{\frac{\Psi-\alpha}{\Psi-2\alpha}} \alpha^{\frac{\alpha}{\Psi-2\alpha}} A^{\frac{\Psi}{\Psi-2\alpha}} \left(E[a^{\frac{\alpha}{\Psi-\alpha}}]\right)^{\frac{\Psi-\alpha}{\Psi-2\alpha}}$$

Re-arranging the expression for the social planer we get the following:

$$q^{SP} = \frac{q^P}{\left[2(1-\beta)\beta^{\frac{\alpha}{\Psi-\alpha}}\right]^{\frac{\psi-\alpha}{\Psi-2\alpha}}}$$

From this expression it is clear that $q^{SP} > q^P$ for all all values of β.

Figure A.1: Equilibrium of the economy. Case 2a: full employment equilibrium



A.2 Additional Figures of chapter 1

Appendix B

Appendix for Chapter 2

B.1 Derivatives of equilibrium equations

Equation (2.15):

$$\begin{aligned}
\frac{\partial a^*(eq2.15)}{\partial(q_j^\gamma - q_h^\gamma)} &= -\frac{m^{\frac{\Psi-\alpha}{\alpha}}}{\alpha^2(\beta A)^{\frac{\Psi}{\alpha}}(q_j^\gamma - q_h^\gamma)^{\frac{\Psi}{\alpha}}} < 0; \\
\frac{\partial^2 a^*(eq2.15)}{\partial(q_j^\gamma - q_h^\gamma)^2} &= \frac{m^{\frac{\Psi-\alpha}{\alpha}}}{\alpha^3(\beta A)^{\frac{\Psi}{\alpha}}(q_j^\gamma - q_h^\gamma)^{\frac{\Psi+\alpha}{\alpha}}} > 0
\end{aligned}$$

since $q_j \geq q_h$.

Equation (2.14):

$$\frac{\partial(q_j^\gamma - q_h^\gamma)(eq2.14)}{\partial a^*} = \frac{\Lambda_1 \Psi}{\Psi - 2\alpha}\left\{ E[a_j^{\frac{2\alpha}{\Psi-2\alpha}}]\frac{f(a^*)\,(2B_{1\prime} - B_{2\prime})}{L\left[1 + \int_{a^*}^1 f(a)da\right]^2} - E[a_g^{\frac{2\alpha}{\Psi-2\alpha}}]\frac{f(a^*)B_{2\prime}}{L\left[\int_0^{a^*} f(a)da\right]}\right\}$$

$$\frac{\partial(q_j^\gamma - q_h^\gamma)(eq2.14)}{\partial a^*} = \begin{matrix} \leq 0 & for \quad a^* \quad high \\ \geq 0 & for \quad a^* \quad low \end{matrix}$$

where

$$B_{1\prime} = \left[\int_{a^*}^1 a^{\frac{\alpha}{\Psi-\alpha}} f(a)da - (a^*)^{\frac{\alpha}{\Psi-\alpha}}\int_{a^*}^1 f(a)da\right] \geq 0 \quad ; \quad \frac{\partial B_{1\prime}}{a^*} < 0$$

$$B_{2\prime} = \left[(a^*)^{\frac{\alpha}{\Psi-\alpha}} \int_0^{a^*} f(a)da - \int_0^{a^*} a^{\frac{\alpha}{\Psi-\alpha}} f(a)da \right] \geq 0 \quad ; \quad \frac{\partial B_{2\prime}}{a^*} > 0$$

$B_{1\prime}$ is positive or zero because the average $a^{\frac{\alpha}{\Psi-\alpha}}$ over the interval $[a^*, 1]$ (LHS of the difference in brackets) is greater than or equal to this expression calculated at the lower bound of the interval times the population in the interval (RHS of the difference in brackets). A similar argument but using the upper bound of the interval explains why $B_{2\prime}$ is also positive or zero. In addition, when there is no migration ($a^* = 1$) the derivative is negative ($B_{1\prime} = 0$ and $B_{2\prime} > 0$), while when everyone in region g migrates to j, the derivative is positive ($B_{1\prime} > 0$ and $B_{2\prime} = 0$). Then, as migration increases (a^* decreases), $B_{1\prime}$ starts increasing and $B_{2\prime}$ decreasing, until the derivative becomes positive (see figures 2.3 and 2.5).

B.2 Derivatives of equilibrium equations with respect to the parameters of the economy

Cost of migration, m***:***

$$\frac{\partial a^*(eq2.15)}{\partial m} = \left(\frac{\psi - \alpha}{\alpha m} \right) \frac{\Lambda_2}{(q_j^\gamma - q_g^\gamma)^{\frac{\Psi-\alpha}{\alpha}}} > 0 \quad if \quad q_j > q_g; \qquad \frac{\partial (q_j^\gamma - q_h^\gamma)(eq2.14)}{\partial m} = 0$$

Matching efficiency, b***:***

$$\frac{\partial a^*(eq2.15)}{\partial b} = 0$$

$$\frac{\partial (q_j^\gamma - q_h^\gamma)(eq2.14)}{\partial b} = \frac{\psi - \alpha}{b(\psi - 2\alpha)} \Lambda_1 \left\{ \left(E[a_j^{\frac{\alpha}{\Psi-\alpha}}] \right)^{\frac{\Psi}{\Psi-2\alpha}} - \left(E[a_g^{\frac{\alpha}{\Psi-\alpha}}] \right)^{\frac{\Psi}{\Psi-2\alpha}} \right\} > 0$$

Initial population size in both regions (overall population $2L$***) ,*** L***:***

$$\frac{\partial a^*(eq2.15)}{\partial L} = 0$$

$$\frac{\partial (q_j^\gamma - q_h^\gamma)(eq2.14)}{\partial L} = \frac{-\psi}{L(\psi - 2\alpha)} \Lambda_1 \left\{ \left(E[a_j^{\frac{\alpha}{\Psi-\alpha}}] \right)^{\frac{\Psi}{\Psi-2\alpha}} - \left(E[a_g^{\frac{\alpha}{\Psi-\alpha}}] \right)^{\frac{\Psi}{\Psi-2\alpha}} \right\} < 0$$

Cost of opening a vacancy, *c*:

$$\frac{\partial a^*(eq2.15)}{\partial c} = 0$$

$$\frac{\partial(q_j^\gamma - q_h^\gamma)(eq2.14)}{\partial c} = \frac{-(\psi-\alpha)}{c(\psi-2\alpha)}\Lambda_1 \left\{ \left(E[a_j^{\frac{\alpha}{\Psi-\alpha}}]\right)^{\frac{\Psi}{\Psi-2\alpha}} - \left(E[a_g^{\frac{\alpha}{\Psi-\alpha}}]\right)^{\frac{\Psi}{\Psi-2\alpha}} \right\} < 0$$

Bargaining power of workers, β:

$$\frac{\partial a^*(eq2.15)}{\partial \beta} = \left(\frac{-\psi}{\alpha\beta}\right)\frac{\Lambda_2}{(q_j^\gamma - q_g^\gamma)^{\frac{\Psi-\alpha}{\alpha}}} < 0$$

$$\frac{\partial(q_j^\gamma - q_h^\gamma)(eq2.14)}{\partial \beta} = \frac{-(\beta\psi-\alpha)}{\beta(1-\beta)(\psi-2\alpha)}\Lambda_1 \left\{ \left(E[a_j^{\frac{\alpha}{\Psi-\alpha}}]\right)^{\frac{\Psi}{\Psi-2\alpha}} - \left(E[a_g^{\frac{\alpha}{\Psi-\alpha}}]\right)^{\frac{\Psi}{\Psi-2\alpha}} \right\} < 0$$

since we assume $\psi > 2\alpha$ to obtain an stable equilibrium with unemployment and $\beta = 1/2$ is an standard assumption in this type of models.

Productivity level, *A*:

$$\frac{\partial a^*(eq2.15)}{\partial A} = \left(\frac{-\psi}{\alpha A}\right)\frac{\Lambda_2}{(q_j^\gamma - q_g^\gamma)^{\frac{\Psi-\alpha}{\alpha}}} < 0$$

$$\frac{\partial(q_j^\gamma - q_h^\gamma)(eq2.14)}{\partial \beta} = \frac{\psi}{(\psi-2\alpha)A}\Lambda_1 \left\{ \left(E[a_j^{\frac{\alpha}{\Psi-\alpha}}]\right)^{\frac{\Psi}{\Psi-2\alpha}} - \left(E[a_g^{\frac{\alpha}{\Psi-\alpha}}]\right)^{\frac{\Psi}{\Psi-2\alpha}} \right\} > 0$$

Appendix C

Appendix for Chapter 3

C.1 Definition of Education Variable.

Table C.1: Education Variable

Education level	Composition
Degree or more	Higher degree, First degree or other degree, teaching (all levels)
High Vocational	Nursing, NVQ levels 3-5, HNC, HND, BTEC higher, RSA higher diploma, other higher education qualifications below degree
A Level or equivalent	A Level, Scottish 6th year Certificate, AS Level, SCE higher
Middle Vocational	NVQ level 3, GNVQ advanced, RSA advanced diploma, ONC, OND, BTEC and SCOTVEC national.
O Level or equivalent	O Level, GCSE grade A-C
Low Vocational	NVQ level 2, GNVQ intermediate, RSA diploma, City & Guilds advanced & craft, BTEC/SCOTVEC general diploma and completed apprenticeship
Other academic	CSE below grade 1, GCSE below grade C
Other vocational	NVQ level 1, GNVQ/GSVQ foundation level, BTEC/SCOTVEC general certificate, SCOTVEC modules, RSA other, City & Guild other, YT/YTP certificate, other vocational/professional qualifications
No qualifications	

C.2 Definition of the variables used in the estimation.

REGIONAL VARIABLES:

Average education: Average value of education variable (defined above) across all individuals of working age by occupational group (4, as defined in table 3.1), region and quarter.
s.d. of education: Standard deviation of education variable (defined above) across all individuals of working age by occupational group (4), region and quarter.
Unemp rate: Unemployment rate across all active individuals by region and quarter.
Vacancy rate: Vacancy rate (number of vacancies notified to job centers / number of unemployed) by occupational group (4, as defined in table 3.1), region and quarter.
Inactivity rate: Inactivity rate across all individuals of working age by region and quarter.
Migration ratio: Migration ratio (number of immigrants / number of emigrants) by region and year.

INDIVIDUAL CHARACTERISTICS:

Sex: 1 male, **0** female.
Age: 16-24, 25-34, 35-49 years of age: 1 age group, **0** otherwise. (50-64 (59 female) reference category.)
Ethnic origin: 1 white, **0** otherwise.
Married: 1 married, **0** otherwise.
Migrant: 1 if migrated from another region since last year, **0** otherwise.
Head of Household: 1 head of household, **0** otherwise.
Individual's Education: Other Voc - Degree: 1 level of highest educational attainment, **0** otherwise.
Last Job's Occupational Group: Operator - Manager: 1 occupational group in last job, **0** otherwise.
no dep child< 6: number of dependent children under the age of six living

in the household.
no dep child< 16: number of dependent children under the age of sixteen living in the household.
no working: number of members of the household working at the time of the interview.
one person house: household made of one person only.
two person house: household made of a couple.
Housing benefit: receiving housing benefit during unemployment.
Unemp benefit: receiving unemployment benefit during unemployment.
Family benefit: receiving financial help from relatives during unemployment.

C.3 Classification of regions.

Table C.2: Classification of regions

Region	Counties
Rest of Northern Region	Cleveland, Cumbria, Durham, Northumberland
South Yorkshire	South Yorkshire
West Yorkshire	West Yorkshire
Rest of Yorkshire & Humberside	Humberside, North Yorkshire
East Midlands	Derbyshire, Leicestershire, Lincolnshire, Northamptonshire, Nottinghamshire
East Anglia	Cambridgeshire, Norfolk, Suffolk
Inner London	Inner London
Outer London	Outer London
Rest of South East	Bedfordshire, Berkshire, Buckinghamshire, East sussex, Essex, Hampshire, Hertfordshire, Isle of wight, Kent, Oxfordshire, Surrey, West sussex
South West	Avon, Cornwall, Devon, Dorset, Gloucestershire, Somerset, Wiltshire
West Midlands Metropolitan	West midlands Metropolitan
Rest of West Midlands	Hereford & Worcester, Shropshire, Staffordshire, warwickshire
Greater Manchester	Greater Manchester
Merseyside	Merseyside

continued on next page

Table C.2: *continued*

Rest of North West	Cheshire, Lancashire
Wales	Clwyd, Dyfed, Gwent, Gwynedd, Mid Glamorgan, Powys, South Glamorgan, West Glamorgan
Strathclyde	Strathclyde
Rest of Scotland	Borders, Central, Dumfries & galloway, Fife, Grampian, Highland, Lothian, Northern & western isles, Tayside

C.4 Econometric Method to correct for stock sampling bias.

The standard econometric model explained in section 3.4 would not be correct when we use the full sample of unemployment durations, since it also includes unemployment spells that started before the survey period. The problem is that these spells are over-represented in the sample, since during that period of time other individuals included in the sample experienced shorter spells of unemployment, but they were not recorded because they finished before the survey started. This is solved by conditioning the log-likelihood function on the length of unemployment at the first interview date (see Lancaster and Chesher (1983) and Lancaster (1990)). Suppose that an individual i enters the survey after j_i periods of unemployment, remains unemployed for another k_i periods, for a total duration $t_i = j_i + k_i$, that can be either censored or uncensored. The individual likelihood contribution is therefore

$$\ln L_i = c_i \left\{ \ln h_i(j_i + k_i) + \sum_{t=1}^{j_i+k_i-1} \ln[1 - h_i(t)] \right\} + (1 - c_i) \sum_{t=1}^{j_i+k_i} \ln[1 - h_i(t)]$$

and substituting the discrete-time hazard we get the log-likelihood to be estimated using the full sample of unemployment spells:

$$\begin{aligned} \ln L_i &= c_i \{\ln [-\exp \{-\exp[x_i(j_i + k_i)'\beta + \gamma(j_i + k_i)]\}] - \exp[x_i(j_i + k_i)'\beta + \gamma(j_i + k_i)]\} \\ &\quad - \sum_{t=1}^{j_i+k_i} \exp[x_i(t)'\beta + \gamma(t)] \end{aligned} \tag{C.1}$$

C.5 Additional tables & figures of Chapter 3.

Table C.3: Average Education by Region and Occupation Group

Manual		Services		Technicians		Man/Prof		All	
Reg	Ave	Reg	Ave	Reg	Ave	Reg	Ave	Reg	Ave
WM	2.67	WM	3.56	WM	4.25	RYH	6.23	WM	3.95
Mers	2.73	RN	3.74	EM	4.46	WM	6.26	SY	4.11
RN	2.78	SY	3.76	SY	4.53	EAng	6.26	T&W	4.14
T&W	2.78	T&W	3.79	RWM	4.58	Wal	6.28	Mers	4.15
SY	2.80	Mers	3.81	Man	4.78	RWM	6.30	RN	4.19
WY	2.84	Wal	3.82	EAng	4.79	RN	6.31	Wal	4.27
Man	2.91	Man	3.83	RN	4.82	EM	6.34	Man	4.31
Wal	2.93	EM	3.83	T&W	4.82	Mers	6.37	EM	4.33
ILon	2.95	RWM	3.85	WY	4.82	SY	6.38	WY	4.34
RWM	2.99	EAng	3.86	RYH	4.86	Man	6.38	RWM	4.38
EM	3.00	WY	3.88	Wal	4.87	T&W	6.42	RYH	4.40
Strath	3.01	RYH	3.9	Mers	4.91	WY	6.42	EAng	4.40
EAng	3.02	RNW	4.00	RNW	5.01	RNW	6.42	Strath	4.54
RYH	3.05	OLon	4.11	SW	5.01	SW	6.42	RNW	4.56
RNW	3.08	SW	4.13	RSE	5.09	OLon	6.47	SW	4.68
OLon	3.15	RSE	4.14	Strath	5.20	RSE	6.56	OLon	4.74
RSE	3.35	ILon	4.20	OLon	5.25	Strath	6.70	RSE	4.82
SW	3.36	Strath	4.22	Scot	5.38	Scot	6.83	ILon	4.85
Scot	3.48	Scot	4.43	ILon	5.82	ILon	6.93	Scot	4.90

Table C.4: Average Annual Growth Rate of Average Education by Occupation

Manual		Services		Technicians		Man/Prof		All	
Reg	Ave	Reg	Ave	Reg	Ave	Reg	Ave	Reg	Ave
WM	0.16	Scot	0.74	Strath	1.15	RN	0.54	Scot	0.96
OLon	0.35	OLon	1.57	Scot	1.24	Strath	0.75	OLon	1.34
Scot	0.43	Strath	1.70	Mers	1.27	Scot	0.77	Strath	1.36
ILon	0.44	ILon	1.78	SW	1.36	RSE	0.88	RSE	1.56
EAng	0.71	RSE	1.82	Man	1.39	ILon	0.89	RN	1.58
RSE	0.91	SY	1.82	RYH	1.47	Man	1.01	RYH	1.60
SW	0.96	SW	1.89	OLon	1.54	WM	1.13	ILon	1.61
RYH	1.07	Man	1.92	WM	1.57	OLon	1.14	SY	1.63
Strath	1.12	RYH	1.96	RSE	1.63	T&W	1.16	WM	1.64
Wal	1.15	EAng	2.04	RNW	1.64	SY	1.18	SW	1.64
EM	1.16	Wal	2.07	RN	1.64	WY	1.23	Man	1.69
RWM	1.37	RN	2.10	SY	1.88	Mers	1.38	RNW	1.80
SY	1.41	Mers	2.11	RWM	2.00	RNW	1.40	EAng	1.81
RNW	1.56	RNW	2.11	T&W	2.05	Wal	1.45	Mers	1.84
WY	1.85	EM	2.21	EAng	2.11	SW	1.48	Wal	1.87
Man	1.90	RWM	2.44	Wal	2.16	RWM	1.53	RWM	1.96
RN	2.03	WM	2.53	ILon	2.17	EM	1.54	EM	2.15
Mers	2.73	T&W	2.58	WY	2.53	EAng	1.56	T&W	2.17
T&W	3.26	WY	2.68	EM	2.56	RYH	1.57	WY	2.20
SD	0.80	SD	0.43	SD	0.42	SD	0.31	SD	0.30
GINI	0.33	GINI	0.11	GINI	0.13	GINI	0.15	GINI	0.09

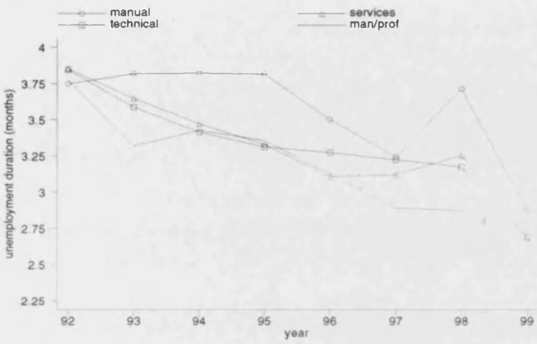


Figure C.1: Unemployment duration by occupation

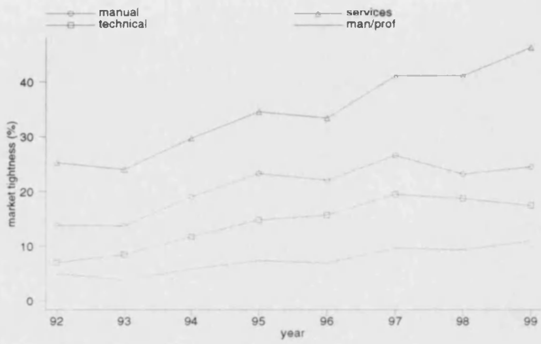
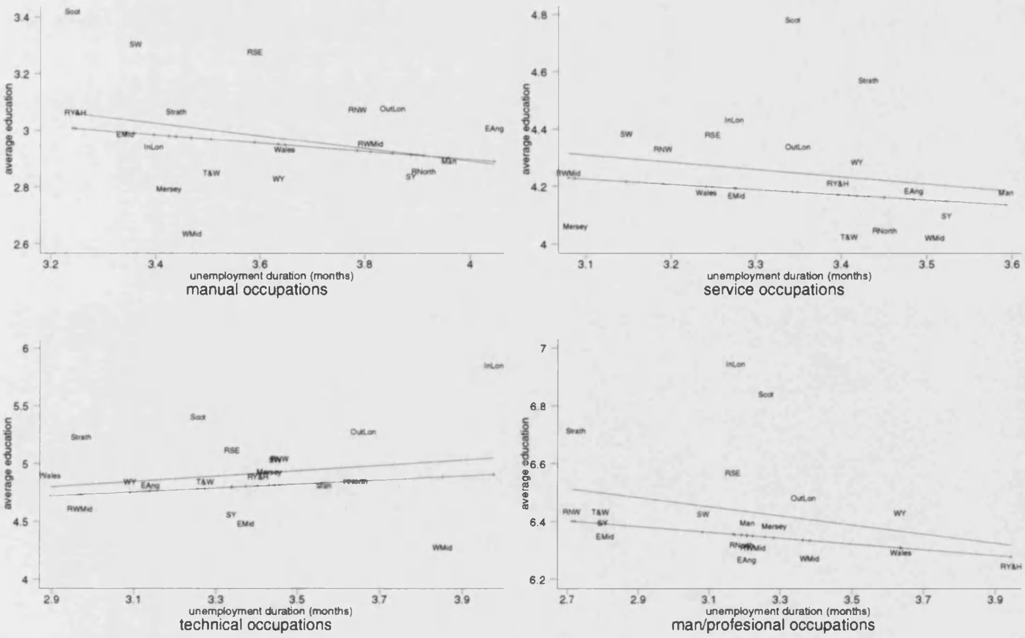


Figure C.2: Market tightness by occupation

Figure C.3: Average education vs unemployment duration by occupation(line with crosses excludes 3 top & bottom regions)



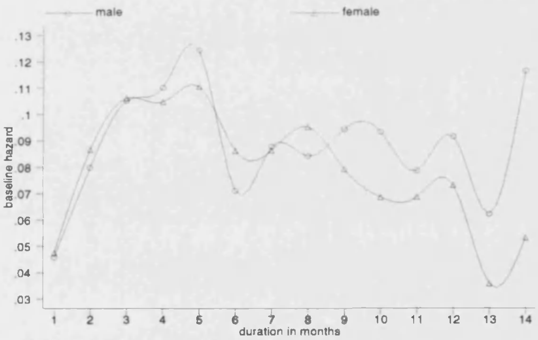


Figure C.4: Baseline hazard by sex

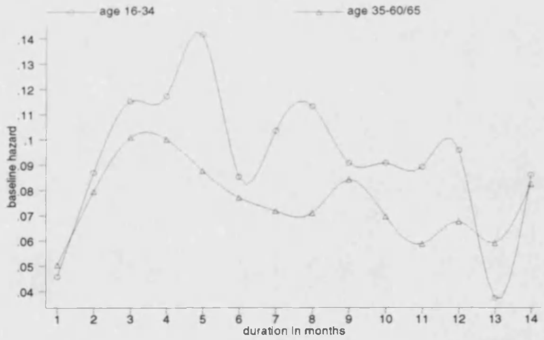


Figure C.5: Baseline hazard by age group

Table C.5: Maximum likelihood estimates of re-employment probabilities by sex and occupation group. Individual controls

	male			female		
Variables	all	high	low	all	high	low
Individual Characteristics						
Sex						
16-24 years of age	0.281***	0.371***	0.167	−0.113	−0.147	−0.054
25-34 years of age	0.583***	0.612***	0.517***	0.341***	0.198	0.461***
35-49 years of age	0.401***	0.426***	0.348***	0.256***	0.268**	0.192*
White	0.164*	0.322***	0.035	0.352***	0.410***	0.276
Married	0.320***	0.297***	0.364***	0.001	−0.118	0.154**
Migrant	−0.031	−0.011	−0.047	0.127	0.123	0.200
Head of Household	0.143***	0.211***	0.025	0.024	−0.039	0.093
Individual's Education						
Other Voc	0.202***	0.164	0.232***	0.065	0.191*	0.025
Other Acad	0.129*	−0.063	0.265**	−0.084	−0.059	−0.151
Low Voc	0.177***	0.151**	0.210**	0.139*	0.193	0.145
O Level	0.002	−0.036	0.060	0.099	0.291***	−0.002
Mid Voc	0.250***	0.346***	0.052	−0.183	0.394**	−0.569*
A Level	0.074	0.075	0.073	−0.060	0.096	−0.140
High Voc	0.421***	0.425***	0.322**	0.143	0.374**	−0.073
Degree	0.245***	0.268***	0.163	0.099	0.201	0.082
Last Job's Occupational Group						
Operator	0.727***		1.080***	1.037***		1.526***
Sales	0.710***		1.094***	1.039***		1.526***
Personal	0.744***		1.134***	1.095***		1.572***
Clerical	0.668**			0.756*		
Craft	0.733***	0.305		1.024***	0.437	
Technical	0.666**	0.067		0.805*	−0.117	
Professional	0.634	−0.251		0.449	−0.796*	
Manager	0.394	−0.534**		0.307	−0.874**	
Household Structure						

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Table C.5: *continued*

no dep child < 6	0.212***	0.230***	0.195***	−0.068*	−0.130**	−0.018
no dep child < 16	0.248***	0.252***	0.248***	0.409***	0.499***	0.351***
no working	1.025***	1.021***	1.046***	1.186***	1.246***	1.198***
one person house	1.657***	1.663***	1.637***	2.129***	2.248***	2.067***
two person house	0.959***	0.898***	1.043***	1.322***	1.404***	1.275***
Benefits						
Housing benefit	−0.404***	−0.287**	−0.529***	−0.164	−0.368	−0.023
Unemp benefit	0.355**	−0.157***	0.009	−0.258***	−0.223***	−0.257***
Family credit	−0.089*	0.076	0.561**	0.362**	0.179	0.386**
No of Cases	8963	4674	4289	7011	2785	4226

NOTES: a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Region, Time and Occupation dummies and Industry's share of employment.

c) The robust standard errors are clustered by region, occupation and time period. This allows for correlation of errors between individuals in the same cluster.

Table C.6: Maximum likelihood estimates of re-employment probabilities by age group and occupation group. Individual controls.

		16-34			35-59/64	
Variables	all	high	low	all	high	low
Individual Characteristics						
Sex	0.005	−0.012	0.008	0.027	−0.009	0.043
16-24 years of age						
25-34 years of age	0.223***	0.150**	0.278***			
35-49 years of age				0.258***	0.284***	0.211***
White	0.141	0.209*	0.059	0.505***	0.553***	0.440**
Married	0.246***	0.179**	0.340***	−0.127**	−0.121	−0.144
Migrant	0.038	0.019	0.086	0.105	0.187	−0.015
Head of Household	0.243***	0.372***	0.112*	−0.019	−0.002	−0.054
Individual's Education						

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Table C.6: *continued*

Other Voc	0.141**	0.145	0.182**	0.198***	0.264**	0.146*
Other Acad	−0.003	−0.077	0.046	0.137	0.171	0.162
Low Voc	0.126**	0.116	0.194**	0.164**	0.217**	0.078
O Level	0.051	0.162*	0.023	0.058	0.067	0.078
Mid Voc	0.069	0.343***	−0.136	0.192	0.396***	−0.423
A Level	−0.004	0.109	−0.084	0.153*	0.138	0.251
High Voc	0.274***	0.424***	0.044	0.327***	0.442***	0.215
Degree	0.232***	0.330***	0.173	0.144*	0.194*	−0.024
Last Job's Occupational Group						
Operator	1.048***		1.399***	0.578***		1.214***
Sales	1.030***		1.404***	0.593***		1.265***
Personal	1.047***		1.420***	0.677***		1.375***
Clerical	0.885***			0.516		
Craft	0.995***	0.357		0.652***	0.349	
Technical	0.944***	0.101		0.427	−0.250*	
Professional	0.754	−0.381		0.385	−0.638*	
Manager	0.672	−0.490*		0.067	−0.854**	
Household Structure						
no dep child < 6	0.113***	0.090	0.114***	−0.077	−0.032	−0.214**
no dep child < 16	0.230***	0.230***	0.235***	0.475***	0.500***	0.493***
no working	0.983***	0.990***	0.999***	1.306***	1.272***	1.428***
one person house	1.586***	1.543***	1.617***	2.001***	1.993***	2.092***
two person house	0.963***	0.913***	1.011***	1.302***	1.248***	1.428***
Benefits						
Housing benefit	−0.333***	−0.404***	−0.260*	−0.305**	−0.337*	−0.237
Unemp benefit	−0.230***	−0.253***	−0.206***	−0.001	−0.065	0.159*
Family credit	0.259*	−0.039	0.366**	0.294	0.363*	0.300
No of cases	9495	3865	5630	6479	3594	2885

NOTES: a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Region, Time and Occupation dummies and Industry's share of employment.

c) The robust standard errors are clustered by region, occupation and time period. This allows for correlation of errors between individuals in the same cluster.

Table C.7: Maximum likelihood estimates of re-employment probabilities by occupation group using all the durations in the sample, controlling for entrance to sample (10 occupations). Individual controls.

Variables	all occup		high occup		low occup	
	coef	s.e.	coef	s.e.	coef	s.e.
Individual Characteristics						
Sex	−0.032	(0.022)	−0.053	(0.034)	−0.029	(0.029)
16-24 years of age	0.774***	(0.040)	0.844**	(0.054)	0.681***	(0.059)
25-34 years of age	0.577***	(0.036)	0.638***	(0.048)	0.473***	(0.055)
35-49 years of age	0.487***	(0.032)	0.549***	(0.042)	0.380***	(0.051)
White	0.243***	(0.039)	0.225***	(0.060)	0.266***	(0.052)
Married	0.147***	(0.025)	0.063*	(0.034)	0.226***	(0.036)
Migrant	0.203***	(0.065)	0.190**	(0.088)	0.226**	(0.096)
Head of Household	0.058**	(0.025)	0.123***	(0.036)	−0.002	(0.035)
Individual's Education						
Other Voc	0.136***	(0.034)	0.152***	(0.053)	0.140***	(0.044)
Other Acad	0.049	(0.038)	0.098*	(0.060)	0.014	(0.050)
Low Voc	0.192***	(0.028)	0.294***	(0.040)	0.101**	(0.040)
O Level	0.202***	(0.029)	0.263***	(0.047)	0.178***	(0.036)
Mid Voc	0.331***	(0.054)	0.450***	(0.070)	0.216**	(0.089)
A Level	0.253***	(0.041)	0.381***	(0.055)	0.120*	(0.065)
High Voc	0.350***	(0.048)	0.447***	(0.060)	0.260***	(0.092)
Degree	0.429***	(0.040)	0.509***	(0.050)	0.322***	(0.078)
Last Job's Occupational Group						
Operator	1.277***	(0.046)			1.279***	(0.058)
Sales	1.255***	(0.060)			1.351***	(0.081)
Personal	1.211***	(0.055)			1.297***	(0.073)
Clerical	1.059***	(0.065)				
Craft	1.104***	(0.076)	−0.083	(0.072)		
Technical	0.745***	(0.204)	−0.741***	(0.242)		
Professional	0.655**	(0.295)	−0.870***	(0.335)		
Manager	0.758***	(0.130)	−0.586***	(0.161)		

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Table C.7: *continued*

Household Structure						
no dep child < 6	−0.067***	(0.019)	−0.122***	(0.029)	−0.017	(0.025)
no dep child < 16	0.042***	(0.012)	0.063***	(0.018)	0.023	(0.017)
no working	0.305***	(0.013)	0.285***	(0.019)	0.325***	(0.018)
one person house	0.107***	(0.040)	0.069	(0.056)	0.105*	(0.061)
two person house	0.126***	(0.029)	0.107***	(0.041)	0.149***	(0.044)
Benefits						
Housing benefit	−0.488***	(0.047)	−0.632***	(0.079)	−0.378***	(0.058)
Unemp benefit	−0.177***	(0.024)	−0.209***	(0.034)	−0.142***	(0.035)
Family credit	0.037	(0.092)	0.044	(0.151)	0.042	(0.116)
No cases	40041		18258		21783	

NOTES: a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Region, Time and Occupation dummies and Industry's share of employment.

c) The robust standard errors are clustered by region, occupation and time period. This allows for correlation of errors between individuals in the same cluster.

Table C.8: Maximum likelihood estimates of re-employment probabilities by occupation group dropping industrial share. Individual controls.

Variables	all occup		high occup		low occup	
	coef	s.e.	coef	s.e.	coef	s.e.
Individual Characteristics						
Sex	−0.038	(0.033)	−0.074	(0.050)	−0.035	(0.044)
16-24 years of age	0.112*	(0.058)	0.162**	(0.083)	0.085	(0.087)
25-34 years of age	0.460***	(0.053)	0.447***	(0.071)	0.486***	(0.078)
35-49 years of age	0.345***	(0.047)	0.389***	(0.061)	0.280***	(0.073)
White	0.229***	(0.086)	0.303***	(0.093)	0.131	(0.111)
Married	0.164***	(0.039)	0.110***	(0.055)	0.239***	(0.053)
Migrant	0.054	(0.069)	0.020	(0.101)	0.085	(0.106)
Head of Household	0.146*	(0.031)	0.191***	(0.045)	0.102**	(0.046)

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Table C.8: *continued*

Individual's Education						
Other Voc	0.147***	(0.047)	0.176**	(0.080)	0.136**	(0.060)
Other Acad	0.022	(0.057)	−0.060	(0.085)	0.050	(0.073)
Low Voc	0.143***	(0.043)	0.169***	(0.061)	0.149**	(0.065)
O Level	0.033	(0.042)	0.095	(0.069)	0.015	(0.055)
Mid Voc	0.064	(0.103)	0.318***	(0.100)	−0.251	(0.190)
A Level	0.019	(0.068)	0.084	(0.085)	−0.025	(0.104)
High Voc	0.287***	(0.071)	0.402***	(0.098)	0.120	(0.113)
Degree	0.178***	(0.060)	0.242***	(0.073)	0.116	(0.118)
Last Job's Occupational Group						
Operator	0.949***	(0.117)			1.332***	(0.200)
Sales	0.944***	(0.112)			1.347***	(0.198)
Personal	0.968***	(0.108)			1.381***	(0.190)
Clerical	0.886***	(0.232)				
Craft	0.938***	(0.124)	0.241	(0.179)		
Technical	0.929***	(0.253)	−0.035	(0.103)		
Professional	0.922**	(0.394)	−0.367	(0.245)		
Manager	0.679*	(0.390)	−0.570**	(0.223)		
Household Structure						
no dep child < 6	0.078***	(0.026)	0.335	(0.027)	0.083**	(0.034)
no dep child < 16	0.312***	(0.020)	0.052***	(0.041)	0.297***	(0.026)
no working	1.068***	(0.024)	1.066***	(0.032)	1.086***	(0.030)
one person house	1.760***	(0.073)	1.757***	(0.103)	1.747***	(0.094)
two person house	1.085***	(0.045)	1.052***	(0.064)	1.134***	(0.056)
Benefits						
Housing benefit	−0.303***	(0.082)	−0.325***	(0.124)	−0.265**	(0.111)
Unemp benefit	−0.124***	(0.034)	−0.144***	(0.043)	−0.079	(0.051)
Family credit	0.304***	(0.114)	0.116	(0.169)	0.385***	(0.146)
No of cases	15974		7459		8515	

NOTES: a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Region, Time and Occupation dummies and Industry's share of employment.

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Table C.8: *continued*

c) The robust standard errors are clustered by region, occupation and time period. This allows for correlation of errors between individuals in the same cluster.

Table C.9: Maximum likelihood estimates of re-employment probabilities by occupation group, more disaggregated. Individual controls.

Variables	all occup		high occup		low occup	
	coef	s.e.	coef	s.e.	coef	s.e.
Individual Characteristics						
Sex	−0.034	(0.034)	−0.070	(0.049)	−0.026	(0.045)
16-24 years of age	0.115*	(0.062)	0.171**	(0.085)	0.087	(0.089)
25-34 years of age	0.465***	(0.055)	0.456***	(0.073)	0.486***	(0.081)
35-49 years of age	0.347***	(0.048)	0.398***	(0.064)	0.278***	(0.074)
White	0.234***	(0.078)	0.320***	(0.095)	0.134	(0.103)
Married	0.168***	(0.039)	0.127**	(0.054)	0.244***	(0.057)
Migrant	0.054	(0.073)	0.017	(0.100)	0.088	(0.108)
Head of Household	0.145***	(0.033)	0.186***	(0.045)	0.099**	(0.048)
Individual's Education						
Other Voc	0.144***	(0.049)	0.168**	(0.080)	0.133**	(0.062)
Other Acad	0.018	(0.055)	−0.070	(0.084)	0.051	(0.072)
Low Voc	0.136***	(0.043)	0.153**	(0.062)	0.138**	(0.062)
O Level	0.039	(0.043)	0.103	(0.068)	0.012	(0.055)
Mid Voc	0.057	(0.111)	0.319***	(0.102)	−0.266	(0.196)
A Level	0.015	(0.063)	0.074	(0.084)	−0.042	(0.100)
High Voc	0.282***	(0.069)	0.389***	(0.093)	0.107	(0.114)
Degree	0.175***	(0.058)	0.238***	(0.074)	0.102	(0.110)
Last Job's Occupational Group						
Operator	0.992***	(0.093)			0.999***	(0.113)
Sales	0.911***	(0.104)			1.054***	(0.131)
Personal	0.952***	(0.095)			1.089***	(0.117)
Clerical	0.851***	(0.118)				
Craft	0.856***	(0.137)	−0.191*	(0.098)		

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Table C.9: *continued*

Technical	0.558*	(0.333)	−1.148***	(0.364)		
Professional	0.373	(0.464)	−1.630***	(0.525)		
Manager	0.738***	(0.248)	−0.597**	(0.248)		
Household Structure						
no dep child < 6	0.079***	(0.028)	0.336	(0.028)	0.088**	(0.038)
no dep child < 16	0.312***	(0.020)	0.049***	(0.041)	0.294***	(0.027)
no working	1.070***	(0.023)	1.073***	(0.032)	1.087***	(0.029)
one person house	1.766***	(0.069)	1.773***	(0.099)	1.751***	(0.095)
two person house	1.090***	(0.043)	1.057***	(0.063)	1.134***	(0.058)
Benefits						
Housing benefit	−0.304***	(0.078)	−0.320***	(0.114)	−0.264**	(0.106)
Unemp benefit	−0.128***	(0.033)	−0.143***	(0.043)	−0.084*	(0.047)
Family credit	0.311***	(0.115)	0.098	(0.171)	0.399***	(0.152)
No of cases	53722		24712		29010	

NOTES: a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Region, Time and Occupation dummies and Industry's share of employment.

c) The robust standard errors are clustered by region, occupation and time period. This allows for correlation of errors between individuals in the same cluster.

Table C.10: Maximum likelihood estimates of re-employment probabilities by occupation group controlling for Gamma distributed unobserved heterogeneity. Individual controls.

	Semiparametric			Weibull		
Variables	all	high	low	all	high	low
Individual Characteristics						
Sex	−0.026	−0.074	0.011	−0.029	−0.084	0.011
16-24 years of age	0.131*	0.188*	0.091	0.135*	0.195*	0.090
25-34 years of age	0.532***	0.507***	0.558***	0.552***	0.530***	0.568***
35-49 years of age	0.400***	0.436***	0.331***	0.417***	0.452***	0.343***
Notwhite	0.192***	0.310***	0.100	0.199***	0.322***	0.107

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Table C.10: *continued*

Married	0.179***	0.133**	0.255***	0.169***	0.121*	0.247***
Migrant	0.017	−0.002	0.050	0.006	−0.027	0.054
Head of Household	0.187***	0.228***	0.137**	0.194***	0.238***	0.143**
Individual's Education						
Other Voc	0.142***	0.192**	0.108	0.145**	0.195*	0.110
Other Acad	0.000	−0.095	0.032	−0.002	−0.096	0.029
Low Voc	0.176**	0.234***	0.131*	0.186***	0.252***	0.133*
O Level	0.054	0.147*	0.004	0.064	0.155*	0.016
Mid Voc	0.201***	0.369***	0.016	0.216**	0.385***	0.037
A Level	0.027	0.148	−0.075	0.040	0.170	−0.073
High Voc	0.309***	0.473***	0.066	0.325***	0.496***	0.073
Degree	0.176**	0.271***	0.100	0.183**	0.280***	0.109
Last Job's Occupational Group						
Operator	1.016***		1.442***	1.053***		1.499***
Sales	1.024***		1.486***	1.072***		1.555***
Personal	1.096***		1.560***	1.144***		1.628***
Clerical	0.937***			0.966***		
Craft	1.017***	0.220		1.057***	0.210	
Technical	0.969***	−0.094		1.000***	−0.109	
Professional	0.949**	−0.437		0.972**	−0.465	
Manager	0.743*	−0.586**		0.749*	−0.618**	
Household Structure						
no dep child < 6	0.082**	0.418	0.105**	0.083**	0.441	0.105**
no dep child < 16	0.380***	0.035***	0.349***	0.401***	0.034***	0.371***
no working	1.335***	1.319***	1.354***	1.409***	1.398***	1.427***
one person house	2.078***	2.064***	2.071***	2.151***	2.143***	2.140***
two person house	1.242***	1.190***	1.307***	1.291***	1.232***	1.368***
Benefits						
Housing benefit	−0.324***	−0.329**	−0.308**	−0.366***	−0.362**	−0.360***
Unemp benefit	−0.125***	−0.137***	−0.101**	−0.119***	−0.130***	−0.097*
Family credit	0.321**	0.038	0.473**	0.353**	0.064	0.502**
constant	−0.823***	−0.886***	−0.798***	−12.940***	−17.370***	−5.607
α	0.439***	0.412***	0.450***	0.660***	0.598***	0.732***

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Table C.10: *continued*

Constant	0.439***	0.412***	0.450***	−0.550***	0.598***	0.732***
Gamma Variance	224.898***	91.714***	108.968***	0.577***	−0.585***	−0.534***
Likelihood ratio statistic (1) vs (2)	225.92	109.355	157.170			
Prob test statis-tic¿chi2	0.00	0.00	0.00	0.00	0.00	0.00
No of cases	15974	7459	8515	15974	6521	9453

NOTES: a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Individual controls; Region, Time and Occupation dummies and Industry's share of employment.

c) The robust standard errors are clustered by region, occupation and time period. This allows for correlation of errors between individuals in the same cluster.

Table C.11: Maximum likelihood estimates of re-employment probabilities by occupation group dropping top & bottom region in education. Individual controls.

Variables	all occup		high occup		low occup	
	coef	s.e.	coef	s.e.	coef	s.e.
Individual Characteristics						
Sex	−0.068	(0.044)	−0.094	(0.073)	−0.086*	(0.052)
16-24 years of age	0.035	(0.085)	0.210*	(0.127)	−0.123	(0.113)
25-34 years of age	0.435***	(0.074)	0.471***	(0.100)	0.389***	(0.105)
35-49 years of age	0.402***	(0.065)	0.531***	(0.094)	0.236***	(0.092)
White	0.277**	(0.127)	0.517**	(0.219)	0.096	(0.127)
Married	0.109*	(0.057)	0.059	(0.081)	0.160**	(0.076)
Migrant	0.074	(0.093)	0.076	(0.142)	0.082	(0.138)
Head of Household	0.123***	(0.041)	0.178***	(0.064)	0.069	(0.055)
Individual's Education						
Other Voc	0.170**	(0.068)	0.295***	(0.113)	0.105	(0.087)
Other Acad	0.052	(0.077)	−0.054	(0.114)	0.115	(0.098)
Low Voc	0.141**	(0.059)	0.199**	(0.086)	0.133*	(0.080)

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Table C.11: *continued*

O Level	0.022	(0.058)	0.072	(0.097)	0.042	(0.075)
Mid Voc	0.053	(0.121)	0.297*	(0.153)	−0.199	(0.218)
A Level	−0.114	(0.102)	−0.037	(0.124)	−0.140	(0.163)
High Voc	0.196**	(0.100)	0.390***	(0.137)	−0.080	(0.158)
Degree	0.153*	(0.084)	0.272**	(0.111)	0.043	(0.142)
Last Job's Occupational Group						
Operator	0.708***	(0.185)			1.103***	(0.282)
Sales	0.646***	(0.179)			1.037***	(0.274)
Personal	0.712***	(0.171)			1.106***	(0.267)
Clerical	0.337	(0.389)				
Craft	0.589***	(0.194)	0.469	(0.306)		
Technical	0.278	(0.412)	−0.225*	(0.132)		
Professional	−0.211	(0.685)	−1.258***	(0.433)		
Manager	−0.455	(0.670)	−1.358***	(0.397)		
Household Structure						
no dep child < 6	0.091**	(0.036)	0.302*	(0.042)	0.060	(0.048)
no dep child < 16	0.290***	(0.029)	0.104***	(0.056)	0.289***	(0.037)
no working	1.047***	(0.032)	1.026***	(0.044)	1.093***	(0.039)
one person house	1.638***	(0.107)	1.569***	(0.146)	1.716***	(0.138)
two person house	1.047***	(0.065)	0.963***	(0.095)	1.152***	(0.076)
Benefits						
Housing benefit	−0.352***	(0.115)	−0.333**	(0.155)	−0.305*	(0.158)
Unemp benefit	−0.099**	(0.045)	−0.094	(0.058)	−0.083	(0.067)
Family credit	0.377***	(0.142)	0.181	(0.216)	0.490**	(0.192)
No of cases	8129		3574		4555	

NOTES: a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Individual controls; Region, Time and Occupation dummies and Industry's share of employment.

c) The robust standard errors are clustered by region, occupation and time period. This allows for correlation of errors between individuals in the same cluster.

Table C.12: Maximum likelihood estimates of transitions to inactivity. Individual controls

Variables	all occup		high occup		low occup	
	coef	s.e.	coef	s.e.	coef	s.e.
Individual Characteristics						
Sex	−0.455***	(0.047)	−0.602***	(0.085)	−0.382***	(0.059)
16-24 years of age	−0.286***	(0.073)	−0.362***	(0.128)	−0.252**	(0.102)
25-34 years of age	−0.503***	(0.073)	−0.476***	(0.111)	−0.474***	(0.101)
35-49 years of age	−0.367***	(0.067)	−0.495***	(0.104)	−0.243**	(0.097)
White	−0.070	(0.069)	0.019	(0.132)	−0.113	(0.093)
Married	0.180***	(0.054)	0.267***	(0.092)	0.118*	(0.070)
Migrant	−0.106	(0.141)	−0.211	(0.240)	−0.088	(0.181)
Head of Household	−0.050	(0.051)	0.038	(0.078)	−0.097	(0.067)
Individual's Education						
Other Voc	−0.009	(0.075)	0.158	(0.136)	−0.108	(0.093)
Other Acad	0.070	(0.081)	0.333**	(0.161)	−0.008	(0.094)
Low Voc	0.070	(0.075)	0.083	(0.123)	0.096	(0.098)
O Level	0.165***	(0.061)	0.251**	(0.123)	0.119*	(0.070)
Mid Voc	−0.002	(0.147)	0.190	(0.220)	−0.204	(0.213)
A Level	0.243***	(0.085)	0.034	(0.154)	0.399***	(0.106)
High Voc	0.167	(0.120)	0.157	(0.184)	0.246	(0.165)
Degree	−0.100	(0.103)	−0.003	(0.150)	−0.302*	(0.177)
Last Job's Occupational Group						
Operator	−0.335**	(0.141)			−0.192	(0.206)
Sales	−0.270*	(0.138)			−0.156	(0.208)
Personal	−0.233*	(0.133)			−0.094	(0.196)
Clerical	−0.162	(0.308)				
Craft	−0.235	(0.144)	−0.177	(0.316)		
Technical	0.217	(0.337)	0.465***	(0.176)		
Professional	0.475	(0.537)	0.833*	(0.434)		
Manager	0.676	(0.521)	0.985***	(0.382)		
Household Structure						
no dep child < 6	0.113***	(0.039)	−0.072	(0.050)	0.135***	(0.051)

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Table C.12: *continued*

no dep child < 16	−0.045*	(0.027)	0.087	(0.062)	−0.022	(0.034)
no working	−0.351***	(0.029)	−0.577***	(0.044)	−0.234	(0.035)
one person house	−0.322***	(0.085)	−0.615***	(0.141)	−0.132	(0.111)
two person house	−0.193***	(0.060)	−0.325***	(0.098)	−0.120	(0.079)
Benefits						
Housing benefit	−0.112	(0.107)	−0.247	(0.195)	−0.072	(0.131)
Unemp benefit	−0.656***	(0.051)	−0.513***	(0.081)	−0.761***	(0.065)
Family credit	0.307*	(0.178)	0.686**	(0.290)	0.133	(0.223)
No cases	15974		7459		8515	

NOTES: a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Individual controls; Region, Time and Occupation dummies and Industry's share of employment.

c) The robust standard errors are clustered by region, occupation and time period. This allows for correlation of errors between individuals in the same cluster.

Appendix D

Appendix for Chapter 4

D.1 Definition of the variables used in the estimation.

REGIONAL VARIABLES:

Regional Education Externalities: Share Other Voc - Share Degree: Share of working age population with highest educational attainment for all levels of education, as defined on section C.1, by region and year.
Unemp Unskilled: Unemployment rate across all active individuals with qualifications of O level or less by region and year.
Unemp Semiskill: Unemployment rate across all active individuals with middle vocational qualifications or A level by region and year.
Unemp Semiskill: Unemployment rate across all active individuals with higher vocational qualifications, degree or more by region and year.
Earnings Unskilled: Average level of present discounted value of permanent earnings across all active individuals with qualifications below middle vocational by region and year.
Earnings Skilled: Average level of present discounted value of permanent earnings across all active individuals with qualifications of A level or more by region and year.

The present discounted value (PDV) of permanent earnings is calculated like in Rice (1999). We use data on earnings by 5 age groups (20-29, 30-39, 40-49, 50-59, 60-64) and 2 skill groups (skilled and unskilled) [1] from the NES. Then, for each skill group we obtain the PDV of permanent earnings in the following way:

$$\text{PDV of permanent earnings group i} = \sum_{j=1}^{6} \frac{w_j * age_j}{\beta_j}$$

where w_j is the average weekly earnings for members of occupation i in age group j, age_j is the age range of the age group j in weeks and β_j is the discount factor applied based on an annual discount rate of 0.05% (e.g. $\beta_{20-29} = (1+0.05)^9$, where the power is calculated from the age of 16 to the middle year of the age group).

Pup/teach primary: number of pupils per teacher in primary education by region and year.
Pup/teach secondary: number of pupils per teacher in secondary education by region and year.

INDIVIDUAL CHARACTERISTICS:

Individual Ability: Other Voc to > High Voc: 1 level of highest educational attainment at the moment of the interview, **0** otherwise.
Migrant: 1 if migrated from another region since last year, **0** otherwise.
Sex: 1 male, **0** female.
Ethnic origin: 1 notwhite, **0** otherwise.
Head of Household's education: Other Voc - degree: 1 level of highest educational attainment of the head of household, **0** otherwise.
Head of Household's Socio-economic group: Manual Unskilled - Non-manual Skilled: 1 socio-economic group of the head of household, **0** otherwise.

[1] The skill groups are based on the SOC and KOS occupations classifications. In particular, we use the classification proposed by Elias (1995) and recently used in Bell, Nickell and Quintini (2000), but aggregated to have two skill groups: Level 2: Managers and administrators, Professional occupations, Office Managers and managers/proprietors in agriculture and services, Associate professional and technical occupations, Craft and relations occupations, Buyers, brokers, sales reps (SOC minor groups: 10, 11, 12, 15, 1920-27, 29 13, 14, 16, 1730-3950-59). Level 1: Clerical, secretarial occupations, Personal and protective service occupations, Sales occupations (except buyers, brokers, sales reps), Plant and machine operatives, Other occupations in agriculture forestry, fishing, Other elementary occupations (SOC minor groups: 40-46, 4960-67, 6972,73, 7980-8990, 91-95, 99)

Head of household's labour force status: unemployed: 1 head of household unemployed, **0** otherwise.
Head of household's labour force status: employed: 1 head of household employed, **0** otherwise.
single parent: 1 head of household single parent, **0** otherwise.
youngsibl: number of younger siblings living in the household.
oldsibl: number of older siblings living in the household.

D.2 Additional tables & figures of Chapter 4.

Table D.1: Education attainment of stayers and leavers by age

	school leavers			school stayers			everyone		
	16yrs	*17yrs*	*18yrs*	*16yrs*	*17yrs*	*18yrs*	*16yrs*	*17yrs*	*18yrs*
Share of UK's working age population									
No qual	30.6	13.5	3.5	9.5	3.5	3.5	19.2	16.2	3.5
Other voc	2.0	1.9	1.5	0.5	0.6	0.9	1.2	1.8	1.1
Other acad	20.8	8.7	3.0	6.7	2.9	1.7	13.2	11.3	2.2
Low voc	2.4	8.5	10.5	0.9	3.8	4.0	1.6	6.1	6.4
O level	42.2	51.3	24.2	78.8	77.3	25.6	61.9	55.9	25.1
Mid voc		4.4	9.0		1.6	5.1		2.2	6.5
A level			45.2			57.7			53.2
More	2.1	11.6	3.0	3.7	10.3	1.4	2.9	6.4	2.0
Total	46.0	23.3	36.3	54.0	76.7	63.7	100.0	100.0	100.0
Vocational	7.7	18.5	24.7	2.1	6.7	11.8	4.3	12.6	16.5
Academic	92.3	81.5	75.3	97.9	93.3	88.2	95.7	87.4	83.5
No qual	30.6	13.5	3.5	9.5	3.5	3.5	19.2	16.2	3.5
Any qual	69.4	86.5	96.5	90.5	96.5	96.5	80.8	83.8	96.5
$<$ O level	55.7	32.6	18.5	17.6	10.8	10.2	35.1	35.5	13.3
O level	42.2	51.3	24.2	78.8	77.3	25.6	61.9	55.9	25.1
$>$ O level	2.1	16.1	57.3	3.7	11.9	64.2	2.9	8.7	61.7

Table D.2: Region's ranking by education. Top 5 regions

	No qual		Other Voc		Other Acad		Low Voc		O Level	
region	83	99	83	99	83	99	83	99	83	99
GrLon	3	3	10	17	3	2	1	1	14	2
RSE	1	1	13	6	12	7	6	3	16	17
EAng	6	6	17	15	8	15	4	4	10	16
Scot	7	4	1	13	1	1	16	5	6	1
SW	2	2	9	4	7	12	8	10	17	14

	Mid Voc		A Level		High Voc		Degree		Average edu	
region	83	99	83	99	83	99	83	99	83	99
GrLon	1	1	16	15	7	3	17	17	16	16
RSE	15	6	15	16	15	13	16	16	17	17
EAng	5	2	13	4	5	6	12	15	12	11
Scot	16	4	17	17	14	17	14	13	15	15
SW	9	7	14	14	17	16	13	14	14	14

Table D.3: Region's ranking by education. Bottom 5 regions

	No qual		Other Voc		Other Acad		Low Voc		O Level	
region	83	99	83	99	83	99	83	99	83	99
SY	16	14	2	8	10	17	7	14	2	9
RN	13	12	8	3	15	14	13	16	8	8
WMid	17	16	6	16	11	10	2	2	3	4
Mersey	10	17	11	1	16	6	5	6	13	5
T&W	11	13	15	9	17	13	15	17	4	3

	Mid Voc		A Level		High Voc		Degree		Average edu	
region	83	99	83	99	83	99	83	99	83	99
SY	4	5	5	2	13	2	4	5	2	4
RN	13	17	2	1	8	7	3	4	5	5
WMid	7	11	4	5	1	1	1	3	1	1
Mersey	2	12	9	8	6	9	5	2	6	2
T&W	8	14	3	11	2	10	2	1	3	3

Table D.4: Probit estimation of the individual's probability of participating in education

Variables	16year olds		17year olds		18year olds	
	Coef	Mg V	Coef	Mg V	Coef	Mg V
Regional Education Externalities						
Share Other Voc	−0.205***	−0.093	−0.243***	−0.154	−0.065	−0.072
Share Other Acad	0.024	0.011	0.113**	0.071	−0.073	−0.081
Share Low Voc	0.041	0.019	0.113	0.072	−0.013	−0.014
Share O Level	0.065	0.030	0.335**	0.212	0.144	0.158
Share Mid Voc	0.051	0.023	0.019	0.012	−0.030	−0.033
Share A Level	−0.141	−0.064	−0.075	−0.048	0.199*	0.219
Share High Voc	−0.071	−0.032	0.227**	0.144	−0.043	−0.047
Share Degree	0.353***	0.160	0.111	0.070	0.417***	0.458
Regional Labour Markets						
Unemp Unskilled	0.156*	0.071	0.173**	0.110	0.144	0.158
Unemp Semiskill	0.078***	0.035	0.035	0.022	−0.045	−0.049
Unemp Skilled	−0.082***	−0.037	−0.025	−0.016	−0.036	−0.040
Earnings Unskilled	−2.011***	−0.911	0.051	0.033	−1.245**	−1.368
Earnings Skilled	0.347	0.157	0.584	0.370	1.652***	1.816
Region's Education Quality						
Pup/teach primary	−0.822**	−0.372	−0.171	−0.108	−0.893	−0.981
Pup/teach 2ndary	0.817*	0.270	−0.200	−0.077	0.111	0.040
Individual Ability						
Other Voc	−0.192***	−0.067	0.123	0.046	0.099	0.036
Other Acad	−0.022	−0.007	0.038	0.014	−0.140**	−0.049
Low Voc	0.007	0.002	0.543***	0.185	0.230***	0.087
O Level	0.872***	0.332	1.305***	0.456	0.751***	0.213
Mid Voc			0.783***	0.247	0.797***	0.309
A Level					1.633***	0.554
High Voc					0.838***	0.325
> O Level	0.956***	0.212				
> Mid Voc			1.769***	0.372		
> High Voc					1.517***	0.530
Individual Characteristics						
migrant	−0.083*	−0.028	−0.130**	0.065	0.133***	0.049

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Table D.4: *continued*

sex	0.212***	0.065	0.173***	−0.051	−0.023	−0.008
notwhite	0.739***	0.182	0.693***	0.225	0.821***	0.319
Head of Household's Education						
Other Voc	0.080***	0.026	0.102***	0.039	0.187***	0.070
Other Acad	−0.090	−0.031	−0.066	−0.026	−0.230**	−0.078
Low Voc	0.129***	0.041	0.091***	0.034	0.104***	0.038
O Level	0.305***	0.109	0.356***	0.141	0.199***	0.068
Mid Voc	0.311***	0.111	0.307***	0.121	0.227***	0.078
A Level	0.606***	0.159	0.544***	0.186	0.638***	0.248
High Voc	0.447***	0.125	0.442***	0.155	0.378***	0.145
Degree	0.937***	0.209	0.890***	0.270	0.509***	0.198
Head of Household's Socio-economic Group						
Man Unsk	−0.197***	−0.069	−0.189***	−0.074	−0.145**	−0.051
Man Semisk	−0.152***	−0.053	−0.234***	−0.092	−0.144***	−0.050
Man Skilled	−0.114***	−0.036	−0.221***	−0.082	−0.137***	−0.051
Non-man Unsk	0.039	0.013	−0.083	−0.032	0.075	0.027
Non-man Semisk	0.126***	0.040	0.048	0.018	0.000	0.000
Non-man Skilled	−0.122***	−0.042	−0.161**	−0.063	−0.014	−0.005
Head of Household's Labour Force Status						
unemployed	−0.163***	−0.056	−0.107***	−0.042	−0.109	−0.039
inactive	0.200	0.062	0.090	0.034	0.039***	0.014
Household Structure						
single parent	−0.039***	−0.013	0.036***	0.014	0.189	0.071
youngsibl	−0.002	−0.001	0.006	0.002	0.001	0.001
oldsibl	−0.105***	−0.035	−0.105***	−0.040	−0.109***	−0.039
Constant	17.686**		−5.238		−2.692	
Prob(staying)	0.73		0.61		0.33	
Log Likelihood	−19084		−16830		−11893	
χ^2	10499		16258		11120	
Pseudo R^2	0.218		0.2761		0.296	
No Observations	35359		34173		30537	

NOTES

a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Individual controls; Region and year dummies and Industry's share of employment.

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Table D.4: *continued*

b) Standard errors are clustered by region and year. This allows for correlation of errors between individuals in the same cluster.

Table D.5: Probit estimation of the individual's probability of staying on & participating in education not controlling for ability

Variables	16year olds	17year olds		18year olds	
	stay / part	stay	part	stay	part
Regional Education Externalities					
Share Other Voc	−0.233***	−0.142*	−0.220***	−0.156	−0.131
Share Other Acad	0.034	0.254***	0.119**	−0.021	−0.086
Share Low Voc	−0.018	0.367*	0.025	−0.078	−0.001
Share O Level	0.367**	0.643***	0.557***	0.498	0.305
Share Mid Voc	0.057	0.000	−0.053	−0.038	−0.027
Share A Level	−0.169*	−0.109	−0.056	−0.014	0.328***
Share High Voc	−0.057	0.273**	0.242**	0.031	−0.078
Share Degree	0.401***	−0.110	0.072	0.606***	0.378**
Regional Labour Markets					
Unemp Unskilled	0.191**	0.151	0.241***	0.056	0.143
Unemp Semiskill	0.070**	0.018	0.032	−0.008	−0.021
Unemp Skilled	−0.080***	−0.010	−0.024	0.024	−0.012
Earnings Unskilled	−1.895***	−0.269	0.002	−1.681***	−1.240***
Earnings Skilled	0.619	0.939*	0.384	2.047***	1.825***
Region's Education Quality					
Pup/teach primary	−0.804*	−0.264	−0.425	−0.223	−0.654
Pup/teach 2ndary	0.932**	0.682	0.394	0.008	−0.291
Individual Characteristics					
migrant	−0.174***	−0.318***	−0.251***	0.022	0.136***
sex	0.264***	0.066***	0.238***	−0.130***	0.064***
notwhite	0.697***	0.349***	0.661***	0.517***	0.747***
Head of Household's Education					
Other Voc	0.113***	0.133***	0.147***	0.152***	0.229***

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Table D.5: *continued*

Other Acad	−0.021	−0.209**	0.007	−0.220	−0.214**
Low Voc	0.214***	0.119***	0.193***	0.076*	0.184***
O Level	0.458***	0.304***	0.519***	0.166***	0.399***
Mid Voc	0.462***	0.174***	0.461***	0.247***	0.460***
A Level	0.768***	0.480**	0.799***	0.635***	1.037***
High Voc	0.601***	0.404***	0.623***	0.308***	0.621***
Degree	1.130***	0.740***	1.145***	0.432***	0.938***
Head of Household's Socio-economic Group					
Man Unsk	−0.206***	−0.099	−0.236***	−0.108	−0.240***
Man Semisk	−0.132***	−0.124**	−0.229***	−0.105	−0.213***
Man Skilled	−0.075**	−0.083*	−0.178***	−0.047	−0.157***
Non-man Unsk	0.087	−0.089	−0.057	0.000	0.013
Non-man Semisk	0.217***	0.119**	0.156***	0.005	0.063
Non-man Skilled	−0.185***	−0.161***	−0.230***	0.026	−0.071
Head of Household's Labour Force Status					
unemployed	−0.233***	−0.102**	−0.220***	−0.064	−0.161***
inactive	0.297***	0.138	0.216*	0.044***	0.129***
Household Structure					
single parent	−0.098***	−0.023***	−0.052***	0.133	0.151***
youngsibl	−0.023***	0.000	−0.017**	−0.004	−0.014
oldsibl	−0.133***	−0.094	−0.155***	−0.103***	−0.167
Constant	13.769*	−4.570	−2.745	−0.365	−3.374
Prob(staying)	0.731	0.799	0.555	0.734	0.444
Log Likelihood	−20594	−9241	−19249	−7470	−13857
χ^2	8898	3790	13304	2814	9284
Pseudo R^2	0.156	0.090	0.172	0.088	0.180
No Observations	35359	18688	34173	12187	30537

NOTES

a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Individual controls; Region and year dummies and Industry's share of employment.

b) Standard errors are clustered by region and year. This allows for correlation of errors between individuals in the same cluster.

Table D.6: Probit estimation of the individual's probability of staying on & participating in education dropping top & bottom regions

Variables	16year olds	17year olds		18year olds	
	stay / part	stay	part	stay	part
Regional Education Externalities					
Share Other Voc	−0.252***	−0.056	−0.175**	−0.185	−0.067
Share Other Acad	0.015	0.269***	0.100*	−0.077	−0.132**
Share Low Voc	0.017	0.494**	0.232	0.069	0.028
Share O Level	0.161	0.564**	0.162**	0.545*	0.202*
Share Mid Voc	0.001	0.071	0.346	−0.139	0.236*
Share A Level	0.029	−0.175	0.035	−0.006	−0.127
Share High Voc	−0.119	0.421**	−0.116	0.214	0.239
Share Degree	0.022**	−0.063	0.143	0.408**	0.018*
Regional Labour Markets					
Unemp Unskilled	0.351	0.138	0.015	0.144	0.267
Unemp Semiskill	0.147***	−0.020	0.091	0.022	−0.028
Unemp Skilled	0.089***	0.051	0.034	0.045	−0.036
Earnings Unskilled	−0.125***	−0.044	−0.030	−0.057***	−0.069***
Earnings Skilled	−3.201**	0.044**	−0.038**	0.061***	−2.559***
Region's Education Quality					
Pup/teach primary	1.671	1.111	1.301	1.094	2.157
Pup/teach 2ndary	−0.562	1.735	−0.223	3.457	−0.362
Log Likelihood	−13263	−5335	−10559	−4166	−7054
χ^2	5659	3248	11628	2247	10265
Pseudo R^2	0.148	0.134	0.275	0.116	0.312
No Observations	22467	11259	21683	7067	19034

NOTES

a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Individual controls; Region and year dummies and Industry's share of employment.

b) Standard errors are clustered by region and year. This allows for correlation of errors between individuals in the same cluster.

Table D.7: Probit estimation of the individual's probability of staying on in education, interacting ability with labour market variables.

Variables	16 year olds Coef	17 year olds Coef	18 year olds Coef
REGIONAL LABOUR MARKET VARIABLES:			
Individual with low ability (less than Olevel)			
Unemp Unskilled	0.090	0.178	0.029
Unemp Semiskill	0.082*	0.087	0.027
Unemp Skilled	−0.061	0.141	−0.098
Earnings Unskilled	−2.335***	−0.957	−3.817
Earnings Skilled	0.713	0.354	3.446**
Individual with high ability (more than Olevel)			
Unemp Unskilled	0.181**	0.090**	0.118
Unemp Semiskill	0.074**	0.004	−0.013
Unemp Skilled	−0.092***	−0.071*	0.018
Earnings Unskilled	−1.731**	1.808	−1.115***
Earnings Skilled	0.054	0.812*	1.515***

NOTES

a) *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

b) Other variables included in the estimation: Regional & Individual controls; Region and year dummies and Industry's share of employment.

b) Standard errors are clustered by region and year. This allows for correlation of errors between individuals in the same cluster.

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