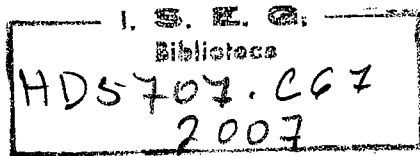


UNIVERSIDADE TÉCNICA DE LISBOA

INSTITUTO SUPERIOR DE ECONOMIA E GESTÃO



ESSAYS ON JOB-MATCHING THEORY

DOUTORAMENTO EM ECONOMIA

Márcio Veras Corrêa

Orientador: Professor Doutor Mário José Gomes de Freitas Centeno

Júri:

Presidente: Reitor da Universidade Técnica de Lisboa
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À minha esposa, Ana Perpétua,
e minha filha, Maria Carolina, por tudo...

Agradecimentos

Relacionar todas as pessoas decisivas, direta e indiretamente, para o sucesso na realização de meu doutorado não é uma tarefa fácil, já que muitos apoios me foram dados ao longo deste percurso.

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Finalmente, gostaria de agradecer a Titia que foi, certamente, uma de minhas melhores professoras!

Resumo

O objectivo principal da *Job Matching Theory* é o de explicar os efeitos dos custos de mobilidade sobre o equilíbrio no mercado de trabalho. A ideia chave por trás deste tipo de modelo é a de que antes do início da actividade produtiva, tanto as firmas como os trabalhadores têm que despende tempo e recursos de forma a encontrar seu parceiro de produção.

Nesta dissertação, nosso objectivo é o desenvolver três artigos, todos desenvolvidos no mesmo ambiente, com o intuito de responder três questões distintas.

No primeiro capítulo – *Job Matching, Technological Progress, and Worker-Provided On-the-job Training* – nosso objectivo é o de estudar os efeitos do investimento em treinamento pagos pelo trabalhador empregado sobre o mercado de trabalho caracterizado por dois tipos distintos de progresso tecnológico: destruição criativa e renovação.

No segundo capítulo – *Technological Progress and Average Job Matching Quality* – nosso objectivo é o de estudar, também em um cenário caracterizado por *search frictions*, os efeitos da taxa de progresso tecnológico sobre a qualidade média das parcerias produtivas.

No terceiro e último capítulo – *Job Matching, Unexpected Obligations and Retirement Decisions* – nosso objectivo é o de investigar os efeitos de variações não antecipadas no nível das obrigações dos trabalhadores sobre a sua regra óptima de entrada na reforma.

Palavras-chave: Parceiras Produtivas, Criação de Empregos, Destruição de Empregos, Desemprego, Capital Humano, Destruição Criativa, Renovação, Reforma.

Abstract

The main objective of the *Job Matching Theory* is to explain the effects of mobility costs over the labor market equilibrium. The basic idea behind these models is that before the production begins, firms and workers have to spend resources in order to find their production partner.

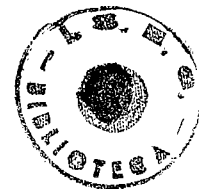
In this dissertation, our main objective is to develop three essays, all carried out in the same environment – that of the *Job Matching Theory* – with the aim of answering three distinct questions.

In the first chapter – *Job Matching, Technological Progress, and Worker-Provided On-the-job Training* – the objective is to study the effects of the worker-provided on-the-job training investments on a labor market characterized by technological progress of the creative destruction type and the renovative type.

In the second chapter of the dissertation – *Technological Progress and Average Job Matching Quality* – our objective is to study, also in a labor market characterized by search frictions, the effects of technological progress on the average quality of the job matches.

In the third and final chapter of the thesis – *Job Matching, Unexpected Obligations and Retirement Decisions* – our objective is to investigate the effects of unexpected changes in the worker's obligations on the decision to retire.

Keywords: Job Matching Theory, Job Creation, Job Destruction, Unemployment, Human Capital, Creative Destruction, Renovation, Retirement.



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Capítulo 1

General Introduction

The main objective of the *Job Matching Theory* is to explain the effects of mobility costs over the labor market equilibrium. The basic idea behind these models is that before the production begins, firms and workers have to spend resources in order to find their production partner. In other words, this theory shows that, given both the presence of imperfect information in the location of the agents as well as individual heterogeneities, there is a need that workers and firms invest resources both in the location as well as in the choice of the partner for the production.

The basic model, which had its beginnings with the work of Mortensen (1982), Diamond (1982) and Pissarides (1985), has three fundamental pillars. The first considers the flow of workers between employment and unemployment in order to determine the equilibrium rate of unemployment. The second uses the value functions of the worker, in both employment and unemployment states, and of the firm, with a free and occupied job, together with the *Generalized Nash Bargaining Solution*, in order to obtain the equilibrium wage rate. Finally, the last pillar uses the *matching function* – a function that resembles a production function and depends upon the rates of both unemployment and vacancy – in order to determine the number of job matches created in each period.

One of the most interesting results obtained with this modeling choice is that because both rates (vacancy filling and vacant-job location) depend on the relative number of agents, there is a congestion effect acting on the workers and firms. In this way, the greater the number of firms with vacancies, the easier it will be for an unemployed worker to find a job. In turn, if the number of unemployed workers increases we will

have the reverse effect, that is, it will be more difficult for the unemployed worker to leave this status.

Another interesting result that this model generates is that as we model the matching and production processes separately, it is possible to separate the specific effects of each activity over the labor market equilibrium.

Extensions to this model are many, as for example, the introduction of different mechanisms to determine the equilibrium wage rate; the evaluation of the labor market effects of different public policies and the determination of the impacts of different optimal agents' decisions over the labor market equilibrium.

In this dissertation, our main objective is to develop three essays, all carried out in the same environment – that of the *Job Matching Theory* – with the aim of answering three distinct questions.

In the second chapter – *Job Matching, Technological Progress, and Worker-Provided On-the-job Training* – the objective is to study the effects of the worker-provided on-the-job training investments on a labor market characterized by technological progress of the creative destruction type and the renovative type.

We found in the creative destruction model that the greater the technological progress rate, the less was the probability of the worker investing in specific human capital, while the effects of the general human capital investments were zero. In its turn, we found in the renovation model that the greater the technological progress rate, the higher was the probability of the worker investing in specific human capital, while the effects of the general human capital investments were again non-existent.

We will also see, in the creative destruction model, that if the worker invests in specific human capital the result will be an increase in the job creation and the job destruction dynamics, while if the investment is totally directed at the market we will

have the opposite effect. In its turn, in the renovation model, we have that if the worker invests in human capital totally directed at the market the result will be a reduction in the job creation and the job destruction dynamics, while if the investment is match specific we will have an increase in the job creation and a complete renovation of the job matching technology.

In the third chapter of the dissertation – *Technological Progress and Average Job Matching Quality* – our objective was to study, also in a labor market characterized by search frictions, the effects of technological progress on the average quality of the job matches.

We verified at the end of this chapter that the effects of technological progress on the labor market depend upon the initial conditions of the economy. If the economy is totally characterized by the presence of low-quality job matches, an increase in the technological progress is accompanied by an increase in the average quality of jobs. In turn, if the economy is totally characterized by the presence of high-quality job matches, an increase in the technological progress rate implies the reverse effect.

Finally, if the economy is totally characterized by the presence of very high-quality jobs, an increase in the technological progress rate implies an increase in the average quality of the job matches.

In the fourth and final chapter of the thesis – *Job Matching, Unexpected Obligations and Retirement Decisions* – our objective was to investigate the effects of unexpected changes in the worker's obligations on the decision to retire.

We considered, throughout this chapter, that the firm does not know the level of the worker's obligations, and is unable to determine the right moment for the worker to retire.

We found that the wage rate decreases when the worker obtains the right to retire and that it is necessary that the retirement benefits be greater than the unemployment insurance in order to have flows of workers from unemployment to retirement, while it is not necessary that this be greater than the wage rate to realize flows of workers from employment to retirement.

We also verified that the more difficult it is to obtain the right to retire, the higher will be the job creation flow.

The main objective of this chapter is to approach these apparently contradictory predictions, attempting to answer questions such as: given higher technological progress rates, what will be the best investment for the worker? What will be the impact of this decision on labor market outcomes, namely the unemployment rate?

However, one aspect of great importance to the labor market, and which should necessarily be considered in attempting to answer these questions, is the understanding of the relationship between changes based on technological progress and the dynamics of creation and destruction of jobs in frictional labor markets⁴.

In a seminal paper on the relationship between economic growth and the process of creation and destruction of jobs, in a frictional labor market, Mortensen and Pissarides (1998) defended that if technological progress is of the creative destruction type⁵, the effect of a positive variation in the technological progress rate would be an increase in the unemployment rate.

The idea defended by the authors was that once a match has been formed, the firm would take on the costs of physical and human capital investments, in order to use the highest available technology in its production. However, having initiated production, the firm would not be able to change its human and physical capital stocks in order to accompany the technological frontier.

The consequences of this rigidity would be a progressive reduction in the productivity of the match, *vis-à-vis* new formed matches, at a rate proportional to the technological progress, and an increase in the unemployment rate, due to the combination of the low incentives to create new vacancies with a higher obsolescence rate of the existing matches.

⁴ See Pissarides (2000) for a complete justification of this argument.

⁵ See Pissarides (2000) and Aghion and Howitt (1992) for a characterization of the creative destruction technological progress.

If the technological progress has the possibility of renovation⁶, the authors showed that since the firm has the possibility to jump onto the technological frontier, undertaking the costs related to the physical and human capital renovation, the result is a fall in unemployment, due to a combination of renovation and increase in the creation of new vacancies.

In this manner, and considering both previous scenarios, Mortensen and Pissarides concluded that the impact of changes on the technological progress rate in the labor market depends on the firm's decision on the type of technological progress: either to renew, or not, its production technology. However, Mortensen and Pissarides considered that all decisions were taken by the firm, not considering any decision made by the worker⁷.

Therefore, the aim of this chapter is to add to the literature the impact of the workers' decision to invest in training on the technological progress in the labor market.

The basic model is based on Mortensen and Pissarides, with the introduction of on-the-job training.

We will consider – as in Mortensen and Pissarides – that the production technology is fixed at the highest existing level at the moment the match is formed. However, we will also assume that the worker may decide in a unilateral manner whether or not to invest in human capital, generating an increase in the match productivity. The workers must also decide if the training is match oriented (specific human capital), market and match oriented (general human capital that is useful both inside the firm and in other firms) or market oriented (general human capital that is only useful at other firms).

We will see that, if growth is of the creative destruction form, the greater the technological progress rate, the less will be the incentive for the worker to invest in

⁶ When renovation is possible the match is maintained while making a complete update in the production technology. See Mortensen and Pissarides (1998) for details.

⁷ According to OCDE (2003) about one third of the total on-the-job training is worker-provided.

specific human capital. However, if we consider the possibility of renovation, we will have the opposite effect, as defended by Murnane, Willett e Levy (1995).

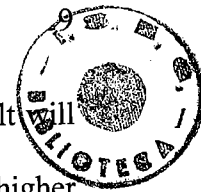
We obtain this previous result in the creative destruction technological progress model because the greater the growth rate the higher will be the worker's costs – relative to the received benefits – from the investment in specific human capital. In turn, in the renovation one, we have that the greater the growth rate the higher will be the worker's benefits received – relative to the costs – from the investment in specific human capital.

We will see that the effect of technological progress on human capital investment totally targeted at the market is inexistent in both models, as the investment benefits and costs will be equally affected⁸.

We will also see, in a particular specification of the creative destruction model, that if the worker invests in specific human capital the result will be an increase in the job creation and the job destruction dynamics, while if the investment is totally directed at the market we will have the opposite effect. In its turn, in the renovation model, we have that if the worker invests in human capital totally directed at the market the result will be a reduction in the job creation and the job destruction dynamics, while if the investment is match specific we will have an increase in the job creation and a complete renovation of the job matching technology.

Note that we have two simultaneous effects acting over the job destruction dynamics in the creative destruction model. In one side, when the worker invests in specific human capital, we observe a reduction in the destruction dynamics, since we have an increase in the job matching productivity. However, on the other side, the investment in specific human capital also increases the market tightness, which also increases

⁸ Bartel and Sicherman (1998) also verified the ambiguity created by technological rate variations over training investment decisions.



worker's wage rate and the destruction process. We will see that the final result will be an increase in the job destruction flow, since the increase in the wage rate is higher than the increase in job matching productivity⁹.

This chapter is organized in the following manner. In the next section we will briefly review the literature on job matching and worker-provided on-the-job training. Section 3 presents the creative destruction and renovation models. In Section 4 we will carry out two empirical exercises, while in the last section we present the main conclusions.

2.2. Job Matching and Worker-Provided On-the-job Training

Several authors have already investigated the impact of human capital investment on the labor market. However, little research has been carried out on the optimum level of worker-provided human capital investments in a frictional labor market¹⁰. Exceptions to this are Acemoglu (1997), Moen (1999) and Laing, Palivos and Wang (2003).

Especially interested in the theme of inefficiency, Acemoglu approached the question of the optimum level of physical and human investments in both a perfect and imperfect labor market.

The author verified that if the labor market is imperfect and human capital investment is totally targeted at the market, the investment level will be inefficient due to the positive externality created by the worker's decision over the remaining firms in the market. Acemoglu defended that as the worker is unfamiliar with his future employer, at the moment he invests in human capital, we will have, as a result, low levels of

⁹ These two effects are also in the renovation model. However, they have different signs.

¹⁰ See Leuven (2005) for an on-the-job training survey and Bishop (1997) for a survey on employed-provided training.

investment, since the worker would not obtain all the benefits generated by his decision. Acemoglu also argued that the greater the process of innovation, the larger would be the human capital investments, although this increase would not be enough to solve the problem of inefficiency.

Moen was also interested in the question of inefficiency. He developed a model for studying the impact of human capital investments on the probability of finding a new job. According to Moen, when a worker invests in general human capital it creates a positive externality over the remaining firms in the market, as well as a negative externality over the remaining workers, and the efficiency problem depends on the magnitude of both effects.

Moen shows that as the number of new job offers depends on the worker education and the volume of unemployed workers searching for a job, the greater the competition for jobs, the greater will be the probability of a worker investing in human capital.

In turn, Laing, Palivos and Wang developed a model that considers human capital investments as the basic source of economic growth. According to these authors, the worker invests in human capital in order to follow the knowledge boundary, showing that given the presence of generations, there will always be groups with obsolete human capital co-living with groups with the highest level of human capital.

We consider in the model formulation both the presence of the externality defended in the papers of Acemoglu and Moen, as well as the interaction between human and physical capital investments. However, there are some differences between the proposed model and the previous ones.

First, we will consider a more generic formulation for human capital, where the worker can invest in three types of human capital: human capital totally targeted at the

market, without any value for the firm, human capital totally targeted at the firm, without any value for the remaining firms in the market, and human capital with value for the market and for the firm, as in Kuhn and Sweetman (1999)¹¹.

A particular specification of the last type of investment that we will consider throughout this chapter is the perfect general human capital investment – an investment that is targeted equally at the market and at the firm – proposed by Becker (1993).

Second, we will consider two types of technological progress: creative destruction and renovation.

Third, we will set aside the effects of human capital investments on the probability of getting a new job while unemployed, concentrating basically on the income incentives generated by the investment for the employed worker.

Finally, we will focus on the question of the optimal rule of investment instead of the question of efficiency, already widely approached in the literature.

2.3. Theoretical Models

In this section we will develop two theoretical models, whose basic difference lies in the form of technological progress: creative destruction or renovation.

2.3.1. Creative Destruction

The economy is formed by a constant population of workers, who live infinitely, and a great number of firms, which once matched, one by one, give way to a production

¹¹ Stevens (1994) also suggested the need for distinct formats to those traditionally adopted to human capital.

activity. The firms and the workers are risk neutral and discount the future at an exogenous and constant rate r .

Before production, firms and workers are involved in a search process to find a partner, where $P(t)c$ measures the search cost for the firm and $P(t) = e^{gt}$ represents a common growth factor.

After finding a production partner the firms fix their production technology, which cannot be updated in the future.

The amount of job matches formed per period of time t is given by a non-negative, concave, homogeneous of degree one and increasing in both arguments function $m(v, u)$, where v represents the vacancy rate and u the fraction of unemployed workers in the economy.

The unemployed workers move to an employed situation according to a Poisson Process with an arrival rate $\theta q(\theta)$, while a job vacancy moves towards a filled position also according to a Poisson Process with an arrival rate $q(\theta)$, where θ represents the ratio of v and u . An occupied job may be destroyed due to an idiosyncratic shock that follows a Poisson Process with arrival rate λ .

We also need to assume that $r + \lambda > g$, so that the effective discount rate is positive.

Let $P(\tau)x$ represent the production generated, in each time t , by a job matching formed at moment τ and that, once production has begun, the workers may later decide whether to invest or not in human capital, at the cost $P(t)z$, and the final destination of investment: firms, market or both.

Suppose that, if the investment is totally targeted at the firm, there is an increase of $\varphi P(\tau)x$ in the productivity of the ongoing job matching, where $\varphi \in (0, 1)$, while if the investment is totally targeted at the market, there is an increase of $\delta P(t)x$ in the

productivity of the future job matching of that worker who invests in training and an increase of $\delta\varepsilon P(t)x$ in the opportunity cost of the job for this same worker, where $\delta \in (0,1)$.

Note that we are considering that if the investment in human capital is totally targeted at the firm, the production of the job matching is less than the production obtained at the highest technological level.

Let $V(t)$ and $J(\tau, t)$ represent the values of a vacancy and a job occupied at moment τ , to the firm, while $U(t)$ and $W(\tau, t)$ represent the values of unemployment and employment in a job created at moment τ , to the worker. Thus, the value functions for the firm and the worker are given by:

$$(1) \quad rV(t) = -P(t)c + q(\theta)[J(t, t) - V(t)] + \dot{V}(t);$$

$$(2) \quad rU(t) = \varepsilon P(t)x + \theta q(\theta)[W(t, t) - U(t)] + \dot{U}(t);$$

$$(3) \quad rJ(\tau, t) = \text{Max}\{P(\tau)x[1 + \delta(1-\psi)_{v,s} + \alpha_{\tau,t}\phi\psi_{\tau,t}] - w(\tau, t) - \lambda[J(\tau, t) - V(t)] + J(\tau, t); rV(t)\};$$

$$(4) \quad rW(\tau, t) = \text{Max}\{w(\tau, t) - \alpha_{\tau,t}P(t)z - \lambda[W(\tau, t) - U(t)] + W(\tau, t); rU(t) + \delta\varepsilon(1-\psi)_{v,s}P(t)x + \alpha_{\tau,t}\delta\varepsilon(1-\psi)_{\tau,t}P(t)x\};$$

where $\alpha_{\tau,t}$ is a variable that represents the decision to invest in human capital, at moment t , in a job created at τ ; $w(\tau, t)$ is the wage rate at moment t , in a job

created at τ ; $\varepsilon P(t)x$ is the opportunity cost of the job and ψ measures the impact of the human capital investment over the ongoing matching¹².

The first and the second expressions are the standard asset equations for the firm, with a job vacancy, and for the worker, in the unemployment position.

The expression (3) is the asset equation for the firm with an occupied job. It tells us that an occupied job: produces $P(\tau)x[1 + \delta(1-\psi)_{\nu,s} + \varphi\psi_{\tau,t}]$, if the worker has invested $(1-\psi)$ in training, at the time s of his previous job, and ψ in training, at the time t of his actual job; pays $w(\tau,t)$ as a wage rate; and with probability λ it is destroyed due to an idiosyncratic shock.

Note that if the worker has invested $(1-\psi)_{\nu,s}$ in human capital, at time s of his previous job created at ν , his current job matching will be $\delta(1-\psi)_{\nu,s}P(\tau)x$ more productive than another job with that firm and the worker which has not invested in human capital targeted at the market. In turn, if the worker decides, at the moment t of his current job matching, to invest $\psi_{\tau,t}$ in human capital directed at his current job, his current matching will be $\varphi\psi_{\tau,t}P(\tau)x$ more productive than another job made by a similar firm and a worker that does not make such an investment.

Expression (4) tells us that once employed a worker receives $w(\tau,t)$ as a wage rate; spend $P(t)z$ in training investments; and with probability λ goes to retirement, due to an idiosyncratic shock.

We can also observe from (4) that, once in unemployment, the worker receives the common value of that position, $rU(t)$, plus the term related with his past training

¹² We suppose that $\psi \in [0,1]$ and α is a variable that equals one, if the worker invests in training, and zero if he does not invest.

investments, $\delta\varepsilon(1-\psi)_{v,s}P(t)x$, and the term related with his present training investment, $\delta\varepsilon(1-\psi)_{\tau,t}P(t)x$, if he decided to invest.

Now, considering that $\varepsilon \in [0,1)$, we can observe from (2) and (4) that the worker always receives a fixed proportion of a new job matching productivity, as the opportunity cost of the employment.

We can observe from the previous equations that if the worker invests in human capital and chooses $\psi = 0$, his investment is totally directed at the market, not affecting the productivity of his actual job matching. On the other hand, if he chooses $\psi = 1$, his investment is totally directed at the current job, affecting exclusively the productivity of his current job matching. If he chooses $\psi \in (0,1)$, his investment affects both the productivity of his future job matching and the productivity of his current job, at rates ψ and $(1-\psi)$, respectively.

Considering the usual hypothesis of free entry, we have from (1), that

$$(5) \quad \frac{J(t,t)}{P(t)} = \frac{c}{q(\theta)}.$$

This expression tells us that there is job creation up to the point where the value of a new job matching equals the search cost, expressed in terms of the rate that at which vacancy becomes filled.

Supposing that the surplus generated by the matching is divided according to the Generalized Nash Bargaining Solution¹³, where β represents the worker's bargaining strength, then $w(\tau,t)$ satisfies:

¹³ See Binmore, Rubinstein and Wolinsky (1986) concerning the use of Nash Bargaining in job search models.

$$(6) \quad \beta[J(\tau, t) - V(t)] = (1 - \beta)[W(\tau, t) - U(t)].$$

Using (1) – (6), we have that

$$(7) \quad w(\tau, t) = \beta \left\{ P(\tau) x [1 + \delta(1 - \psi)_{v,s} + \alpha_{\tau,t} \psi_{\tau,t} \phi] \right\} + \\ (1 - \beta) P(t) \left\{ \omega(\theta) + \alpha_{\tau,t} [z + \delta(1 - \psi)_{\tau,t} \varepsilon x] \right\},$$

where

$$(8) \quad \omega(\theta) = \varepsilon x [1 + \delta(1 - \psi)_{v,s}] + \frac{\beta c \theta}{(1 - \beta)}.$$

Note from the previous expression that the wage rate is composed of two terms. The first one is related to the worker's productivity in the current job, while the second one is related to his outside option.

We can also observe from (7) and (8) that if the worker decides to invest in training, $\alpha = 1$, the greater will be the worker's wage, for a given technological progress rate.

Also note from these two expressions that the greater the technological progress rate, the higher will be the worker's wage rate and that the firm pays part of the costs of human capital investment¹⁴.

The following Lemma shows the conditions under which the worker invests in human capital accumulation.

¹⁴ The firm pays part of the investment costs in human capital, due to the increase in the worker's outside option arising from his investment.

Lemma 2.1 Given the share of firm-specific human capital, ψ , if:

a) $\beta\psi\varphi P(\tau)x + (1-\beta)P(t)\delta(1-\psi)\varepsilon x \geq \beta P(t)z$, the worker invests in human capital;

b) $\beta\psi\varphi P(\tau)x + (1-\beta)P(t)\delta(1-\psi)\varepsilon x < \beta P(t)z$, the worker does not invest in human capital.

We assume, in a stationary setting, that if the costs of human capital investments are equal to the benefits, the worker decides to invest in human capital¹⁵.

The previous lemma tells us that the worker will make an investment in human capital whenever the benefits are greater than the costs of the investment.

We can also see that if we consider that the advantages of investing in human capital totally targeted at the firm are greater than the advantages of investing in human capital totally targeted at the market ($\psi = 1$), then we will have the worker investing in human capital whenever $\varphi P(\tau)x \geq P(t)z$. In this way, the greater the technological progress rate, the lower will be the probability that the worker invests in human capital towards the firm.

In turn, if we consider that the advantages of investing in human capital totally targeted at the firm are less than the advantages of investing in human capital totally targeted at the market ($\psi = 0$), then the condition for investment is $(1-\beta)P(t)\delta\varepsilon x \geq \beta P(t)z$. Note, in this last case, that technological progress does not affect the probability of investment in human capital totally targeted towards the market.

¹⁵ To show the previous lemma we need only to substitute (7) in (4) and differentiate it with respect to α .

The following Lemma assumes that it is optimal to invest in human capital ($\alpha = 1$) and derives the destination of this investment.

Lemma 2.2 Given the worker invests in human capital, $\alpha = 1$, if:

- a) $\beta\phi P(\tau)x > \beta\delta P(\tau)x + 2(1-\beta)\delta P(t)\varepsilon x$, the worker invests in human capital totally targeted at the firm;
- b) $\beta\phi P(\tau)x < \beta\delta P(\tau)x + 2(1-\beta)\delta P(t)\varepsilon x$, the worker invests in human capital totally targeted at the market;
- c) $\beta\phi P(\tau)x = \beta\delta P(\tau)x + 2(1-\beta)\delta P(t)\varepsilon x$, the worker invests in perfect general human capital.

We assume, in a stationary setting, that the worker invests in perfect general human capital, that is $\psi = (1-\psi)$, if indifferent between investing totally to the firm or totally to the market¹⁶.

The previous lemma tell us that once a worker has decided to invest, if the advantages of investing in human capital totally targeted at the market are greater than the advantages of investing in human capital totally targeted at the firm, the worker will always decide to invest towards the market.

Also note that the worker compares the benefits he receives with the investment in human capital totally targeted at the firm with those he receives with the investment in human capital totally targeted at the market and the one he would have received, had he invested in his previous job in human capital directed to the market. In other words, for a worker to invest in human capital totally targeted at the firm, it is

¹⁶ As before, we need only to substitute (7) in (4) and differentiate it in function of ψ .

necessary that the benefits he receives at moment t be greater than the sum of the benefits he receives with the investment in human capital totally targeted at the market, at the same moment t , and those related to the investment in human capital targeted at the market at moment s .

Proposition 2.1 Let $\beta = (1 - \beta)$ and $\frac{\varphi P(\tau)x}{P(t)} \geq z = \delta \varepsilon x$. Then, if:

a) $\frac{\varphi P(\tau)x}{P(t)} > \frac{\delta P(\tau)x}{P(t)} + 2z$, the worker invests in human capital totally targeted at the

firm;

b) $\frac{\varphi P(\tau)x}{P(t)} < \frac{\delta P(\tau)x}{P(t)} + 2z$, the worker invests in human capital totally targeted at the

market;

c) $\frac{\varphi P(\tau)x}{P(t)} = \frac{\delta P(\tau)x}{P(t)} + 2z$, the worker invests in perfect general human capital.

Proof. We need only to consider $\beta = (1 - \beta)$ and $z = \delta \varepsilon x$ in Lemma 2.1 and 2.2 and

observe that, given $\frac{\varphi P(\tau)x}{P(t)} \geq z$, the worker will always invest in human capital

accumulation. ■

For a better understanding of the previous proposition, that is, the determination of the optimal investment rule as well as the effects of the technological progress rate over it, let us consider a particular situation where the cost of human capital investments is low and $\varphi > \delta$. That is, we will consider the situation where z is low and that the increase in the productivity of the ongoing job matching, given the investment totally

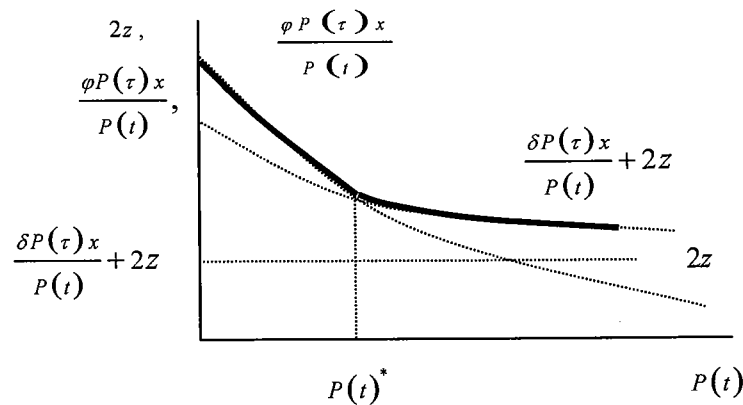
targeted at the firm, is higher than the increase in productivity of the future job matching of that worker who invests in training totally targeted at the market.

In this particular case, the optimum investment rule, for different values of $P(t)$, is given by the darker line in the figure below.

Note from this figure that for values less than $P(t)^*$, the human capital investment is totally targeted at the firm. At $P(t)^*$ the investment is in perfect general human capital, while to the right of $P(t)^*$ the investment is totally targeted at the market.

In this way, the optimum investment rule will depend on the relative behavior of the last expressions represented in the figure. The greater z is, the less is the probability that the worker will invest in human capital. In turn, the greater are the net benefits of the investment totally targeted at the firm *vis-à-vis* the investment totally directed at the market, the greater is the probability that the worker invests totally to the firm.

FIGURE 2.1
Optimal
Investment Rule



Having presented the human capital investment rule, we will now see how to determine the optimal job creation and job destruction dynamics.

From (3) and (5) we have that¹⁷

(9)

$$J = (1 - \beta) \int_0^T \left\{ x [1 + \delta(1 - \psi) + \alpha\psi\phi] - e^{gt} [\omega(\theta) + \alpha z + \alpha\delta(1 - \psi)\varepsilon x] \right\} e^{-(r+\lambda)t} dt;$$

$$(10) \quad J = \frac{c}{q(\theta)};$$

$$(11) \quad x[1 + \delta(1 - \psi) + \alpha\psi\phi] = e^{gt} [\omega(\theta) + \alpha z + \alpha\delta(1 - \psi)\varepsilon x];$$

characterize the optimal life of a job, T , in terms of market tightness and human capital investment decisions, and the optimum job creation rule in a stationary setting¹⁸.

Proposition 2.2 Assume that $\varepsilon = 0$, the human capital investment costs (z) are low, so that the worker always invests in training, and that the benefits received are such that the investment is in perfect general human capital. In this way, if there is a change in the relative benefits received by the investment, in a manner that ψ varies to:

- a) $\psi = 1$, then the effects of human capital investment are an increase in the job destruction and job creation dynamics;
- b) $\psi = 0$, then the effects of human capital investment are a reduction in the job destruction and job creation dynamics.

¹⁷ Solving the differential equation (3) and considering $J(t, t) = P(t)J$, we obtain the expression (9) at $t = 0$. Using this previous condition in (5), we obtain (10). Finally, solving (9), in respect to T , we obtain (11).

¹⁸ Given the optimal human capital investment decisions, expressions (9) – (11) uniquely determine the equilibrium in $T - \theta$ space.

Proof. We need only to differentiate (9) and (11) in terms of ψ , consider (10) and Lemma 2.2 to demonstrate that the job creation increases while the job destruction decreases with $\psi = 1$. Substituting (11) in (9), considering the Implicit Function Theorem and Leibniz Rule, we can demonstrate that as ψ increases, T also increases, due to the increase in θ . ■

The idea behind the previous proposition is that when there is human capital investment the worker's wage rate will be greater, which induces a greater obsolescence rate, without necessarily bringing about an increase in the job matching productivity. In this way, if investment starts to be totally directed at the firm, the worker's investment decision leads to an increase in the job destruction and job creation flows, as the effect of the increase in the wage rate is greater than the effect of a higher job matching productivity generated by the investment. In turn, if the investment starts to be totally directed at the market, we will have the opposite effect. Note also that if the investment continues to be in perfect general human capital ($\psi = 1 - \psi$), the gains and losses created by the worker's decision do not change, and as a result, his decision will not affect the initial dynamics of creation and destruction of jobs.

Now, because in the steady state the job creation equals the job destruction flow, we have that

$$(12) \quad JC = \theta q(\theta)u = \lambda(1-u) + e^{-\lambda T} JC = JD,$$

where JD represents job destruction and JC job creation.

In this way, we have that

$$(13) \quad u = \frac{\lambda}{\lambda + \theta q(\theta)(1 - e^{-\lambda T})},$$

represents the equilibrium unemployment rate.

Note from this expression that the entire effect of human capital investments over the unemployment rate occurs via θ and T . Therefore, the less is θ or T , the higher will be the unemployment rate.

2.3.2. Renovation

Now, consider the scenario where renovation is possible¹⁹.

The basic idea behind this model is that if the worker decides to invest in human capital totally targeted at the firm, his actual job matching jumps to the technological boundary. Suppose that:

$$(14) \quad rV(t) = -P(t)c + q(\theta)[J(t,t) - V(t)] + \dot{V}(t);$$

$$(15) \quad rU(t) = P(t)\varepsilon x + \theta q(\theta)[W(t,t) - U(t)] + \dot{U}(t);$$

$$(16) \quad rJ(\tau, t) = \text{Max}\{P(\tau)x[1 + \delta(1 - \psi)_{v,s}] + \alpha_{\tau,t}\psi_{\tau,t}P(t - \tau)x - w(\tau, t) - \lambda[J(\tau, t) - V(t)] + J(\tau, t); rV(t)\};$$

$$(17) \quad rW(\tau, t) = \text{Max}\{w(\tau, t) - \alpha_{\tau,t}P(t)z - \lambda[W(\tau, t) - U(t)] + \dot{W}(\tau, t); rU(t) + \delta\varepsilon(1 - \psi)_{v,s}P(t)x + \alpha_{\tau,t}\delta\varepsilon(1 - \psi)_{\tau,t}P(t)x\};$$

are the worker and firm value functions.

¹⁹ The model in this section is similar to the previous one in all aspects, except in the technological progress definition.

Note from the previous expressions that if the worker invests in human capital and chooses $\psi = 1$, his actual matching will jump to the highest level of technology existing at the moment²⁰.

Given the hypothesis that the surplus generated by the matching is divided according to the Generalized Nash Bargaining, we have that:

$$(18) \quad w(\tau, t) = \beta \left\{ P(\tau) x [1 + \delta(1 - \psi)_{v,s}] + \alpha_{\tau,t} \psi_{\tau,t} P(t - \tau) x \right\} + \\ (1 - \beta) P(t) \left\{ \omega(\theta) + \alpha_{\tau,t} \left[z + \delta(1 - \psi)_{\tau,t} \varepsilon x \right] \right\},$$

represents the wage rate received in a job matching created at τ , where $\omega(\theta)$ is also given by (8). Note, as before, that the worker's wage is given by two terms, one representing his outside options and the other his productivity.

We can also observe that the worker's wage grows with technological progress, due to the increase in the second term of the right hand side of the previous expressions. However, and contrary to before, the first term of the right hand side may also increase at the technological progress rate, if the worker does not invest in human capital totally directed at the market.

Using the same argument as before, we have that whenever the benefits with human capital investment totally targeted at the firm exceed those obtained with the investment totally directed at the market, the worker will carry out this investment, as the next proposition clarifies.

²⁰ Cavalcanti (2004) used a closer idea to study the effects of layoff costs, which increase with tenure, over the labor market.

Proposition 2.3 Let $\beta = (1 - \beta)$ and $\frac{P(t-\tau)x}{P(t)} \geq z = \delta \varepsilon x$. Then, if:

a) $\frac{P(t-\tau)x}{P(t)} > \frac{\delta P(\tau)x}{P(t)} + 2z$, the worker invests in human capital totally targeted at the

firm;

b) $\frac{P(t-\tau)x}{P(t)} < \frac{\delta P(\tau)x}{P(t)} + 2z$, the worker invests in human capital totally targeted at the

market;

c) $\frac{P(t-\tau)x}{P(t)} = \frac{\delta P(\tau)x}{P(t)} + 2z$, the worker invests in perfect general human capital.

Proof. Substituting (18) in the value function (17), differentiating in terms of α and ψ , and considering $\beta = (1 - \beta)$, we have that if:

$$\psi P(t-\tau)x + P(t)\delta(1-\psi)\varepsilon x \geq P(t)z \quad \text{and} \quad P(t-\tau)x > \delta P(\tau)x + 2\delta P(t)\varepsilon x, \quad \text{the}$$

worker invests in human capital totally directed at the firm;

$$\psi P(t-\tau)x + P(t)\delta(1-\psi)\varepsilon x \geq P(t)z \quad \text{and} \quad P(t-\tau)x < \delta P(\tau)x + 2\delta P(t)\varepsilon x, \quad \text{the}$$

worker invests in human capital totally directed at the market;

$$\psi P(t-\tau)x + P(t)\delta(1-\psi)\varepsilon x \geq P(t)z \quad \text{and} \quad P(t-\tau)x = \delta P(\tau)x + 2\delta P(t)\varepsilon x, \quad \text{the}$$

worker invests in perfect general human capital.

Finally, considering $\frac{P(t-\tau)x}{P(t)} \geq z = \delta \varepsilon x$, we demonstrate the proposition. ■

We can observe from this previous proposition that the greater the technological progress rate, the greater will be the probability of the worker investing in human capital totally targeted at the firm, while its effects will be zero if the investment is totally directed at the market.

Also note that the results are similar to those previously obtained. The only difference is that the investment in human capital totally targeted at the firm that occurs now is more likely to occur at higher technological progress rates, contrary to the creative destruction scenario, where it was more likely to occur at lower rates.

Using (14) - (18) we have that T and θ are determined by²¹:

(19)

$$J = (1 - \beta) \int_0^T \{ x[1 + \delta(1 - \psi)] - e^{gt} [\omega(\theta) + \alpha z + \alpha \delta(1 - \psi) \varepsilon x - \alpha \psi x] \} e^{-(r+\lambda)t} .dt ;$$

(20) $J = \frac{c}{q(\theta)} ;$

(21) $x[1 + \delta(1 - \psi)] = e^{gT} [\omega(\theta) + \alpha z + \alpha \delta(1 - \psi) \varepsilon x - \alpha \psi x].$

Proposition 2.4 Assume that $\varepsilon = 0$, the human capital investment costs are low, so that the worker always invests in training, and that the benefits received are such that the investment is in perfect general human capital. In this way, if there is a change in the relative benefits received by the investment, in a manner that ψ varies to:

- a) $\psi = 1$, then the effects of human capital investment are an increase in the job creation and a complete renovation of the job matching;
- b) $\psi = 0$, then the effects of human capital investment are a reduction in the job creation and in job destruction dynamics²².

²¹ Note that as (19) does not depend on T by the Envelop Theorem, whilst (21) is decreasing in θ , the equilibrium also exists and is unique in $T - \theta$ space.

²² The proof here is similar to the one in proposition 2.2.

Note that the results found here are also similar to those obtained above²³. The main differences between the two models are the following:

- considering renovation, if the investment is in human capital totally targeted at the firm, the production technology will jump to the technological boundary, implying a complete renovation of the job matching, while if the technological progress is of the creative destruction type, this adjustment is only partial;
- the higher the technological progress rate, the lower is the probability of the worker investing in human capital totally directed at the firm, if the technology is of creative destruction type, and the greater is the probability of the worker investing in human capital totally targeted at the firm, if technology admits renovation.

2.4. Empirical Exercises

We will develop in this section two empirical exercises intending to empirically testing the model predictions. Initially we will estimate the impact of the technological progress rate on the probability of a worker investing in human capital totally targeted at the firm. The idea here is to test whether a greater growth rate implies an increase or a fall in the probability of a worker investing in human capital totally directed at the firm, supporting the model with renovation or the model with creative destruction technological progress²⁴.

In the following section we will use the model supported by our data to develop a numerical exercise in order to explore the impact of changes on workers' optimal investment decisions on the labor market.

²³ Note that as the expression that determines the unemployment rate in the case of renovation continues to be given by (14), the results are identical in both models.

²⁴ We will only estimate the effect of technological progress over the probability of the worker investing in human capital totally targeted at the firm, because its effects over the probability of the worker investing in human capital totally targeted at the market is zero, in the previous theoretical models.

2.4.1. Econometric Estimation

The model in the previous section showed that, if the benefits of human capital investments totally directed at the firm were greater than those benefits obtained from the investment completely targeted at the market, we should expect a greater technological progress rate to be associated with a lower probability of worker investment in match-specific human capital, if the technological progress were of the creative destruction type. On the contrary, if renovation is possible, a greater technological progress rate should lead to a greater probability of worker investment in match-specific human capital.

In this subsection, we use the European Community Household Panel (ECHP)²⁵ data base for Portugal, for the period 1994 - 1999, to empirically investigate what is the prevailing effect. In other words, our intention here is to estimate the effect of a higher technological progress rate over human capital investment decisions, giving support to the creative or to the renovation model.

One of the advantages of using the European Community Household Panel is that it gives us the ability to follow, over time, the workers' human capital investment decisions, allowing us to isolate all training decisions paid by the government and the firm, from those completely paid by the worker.

A – Data

Our empirical strategy to estimate the effect of the technological progress over the probability of the worker investing in human capital totally targeted at the firm was the following.

²⁵ See Eurostat (2003) for a complete characterization of the ECHP.

First, in order to obtain the information on the human capital investment decision totally financed by the worker, a crucial variable for our proposes, we considered the question of the ECHP concerning training participations which occurred in the previous year and which were not financed by the government or the firm.

More specifically, we initially considered the question: “Have you been at any time since the last year in vocational education or training, including any part-time or short course?” Then, we restricted the data to training participations which were totally financed by the worker, in order to have only worker-provided training.

Second, we restricted the data to employed workers, leaving training decisions by unemployed workers out of our empirical analysis, since we are only interested in on-the-job training investments.

Finally, in order to obtain the information about the final destination of investment, as ECHP does not have this information explicitly, we considered as a human capital investment totally directed at the market, the investment in training that occurred at the same time as the decision to search for a new job matching. Thus, we consider in this empirical exercise as investment in human capital totally targeted at the firm the investment in training that does not come with a search for another job.

Now, given the existence of variables that could confound the true effect of the technological progress over human capital investment decisions, we introduced some controls related to the basic job match characteristics²⁶. For example, we introduced wage, work conditions, work place, working time and main activity satisfaction intending to control the investment decisions that could be related to worker satisfaction with his job, a factor that could confound the true effect of the technological progress.

²⁶ See Annex 1 for the description of the variables used in the econometric model.

We initially expected that the higher the wage and the work satisfaction the lower will be the probability to invest in training, if the worker is satisfied with his employment status and not motivated to improve his actual situation. However, we could also expect a positive relationship with the training decision if the worker is satisfied with his conditions but also motivated to improve his situation.

In the Annex 1 we present the summary statistics for the sample of Portuguese workers. Most workers are satisfied with their job condition status and are highly satisfied with their work place but not with the wage received.

We also considered some controls related to the basic demographic characteristics such as tenure, sex, marital status, education and workers' age dummies intending to control individual factors that could also confound the true results.

We initially expected that the higher the workers' tenure, the lower is the workers' probability to invest in training. However, we could also obtain a positive sign, if the worker is motivated to improve his job position. We also expected that the higher the worker's age and the lower the education levels, the lower is the worker's probability to invest in training.

We can observe from the summary statistics that, in our sample, 37% of Portuguese workers have more than 15 years of tenure, while only 5% of them have more than 20 years.

The variable that we used to represent the technological progress rate was obtained from the European Commission Directorate for Economic and Financial Affairs, related to total factor productivity index for Portugal, for the years 1995 -1999²⁷.

We can also observe from the summary statistics that the average technological progress rate of Portugal, between the years 1994 and 1999, was around 2%.

²⁷ We obtain this information from the Ameco Database.

Finally, we also considered some controls related to firms, as job sector and job dimension dummies, intending to control for firm factors that could also confound the true effect of technological progress over human capital investment decisions.

B – Econometric Model

We estimated the latent variable model:

$$(1) \quad y_{i,t}^* = x_{i,t}\beta + c_i + e_{i,t},$$

where $y_{i,t}^*$ is a binary non-observable variable, taking the value of one if the worker invests in human capital totally directed at the firm and zero if he does not invest; $x_{i,t}$ is a vector of individual characteristics, c_i represents fixed individual non-observable characteristics, while $e_{i,t}$ is an error term.

Note from the last expression that as we do not observe $y_{i,t}^*$, but only the signal of $y_{i,t}$, it is considered that $y_{i,t} = 1$, if $y_{i,t}^* > 0$, and $y_{i,t} = 0$, if $y_{i,t}^* \leq 0$.

We estimate two different models, the unconditional probit and the random effect probit model. The basic differences between them lies in the distribution of the error term and in the hypothesis about the way that $x_{i,t}$ and c_i are correlated. The non-observable and fixed individual characteristics are unconsidered in the probit model, while it is considered that they follow a conditional normal distribution with linear expectations and constant variance in the random effect probit model²⁸.

²⁸ See Wooldridge (2002) for more details on both models.

C – Results

We estimate three different models: two probit models and a random probit one. In the first probit model we consider only the technological progress as the independent variable, while in the second we consider others covariates. The final estimated model is just a random probit version of the previous model. We also estimate these three models separately for males and females (see the Annex 1).

The estimated coefficients, together with their standard errors, are given in the table below.

TABLE 2.1
Estimation Results

<i>Countries</i>	<i>Probit</i>	<i>Probit</i>	<i>Random Probit</i>
<i>Variables</i>			
<i>Constant</i>	-7.47(0.652)*	-5.63(0.774)*	-5.42(1.015)*
<i>Technological progress</i>	0.06(0.006)*	0.05(0.007)*	0.05(0.010)*
<i>Wage satisfaction</i>	-	0.07(0.032)**	0.10(0.046)**
<i>Main activity satisfaction</i>	-	0.08(0.041)***	0.10(0.057)***
<i>Education (less than secondary)</i>	-	-0.74(0.050)*	-1.00(0.082)*
<i>Education (secondary)</i>	-	-0.18(0.053)*	-0.26(0.085)*
<i>Work place satisfaction</i>	-	-0.10(0.038)*	-0.15(0.054)*
<i>Working time satisfaction</i>	-	0.13(0.048)*	0.15(0.068)**
<i>Work conditions satisfaction</i>	-	-0.08(0.042)***	-0.08(0.059)
<i>Work security satisfaction</i>	-	-0.15(0.036)*	-0.23(0.051)*
<i>Aggregate work satisfaction</i>	-	0.19(0.030)*	0.23(0.044)*
<i>Tenure (at least 20)</i>	-	-0.23(0.112)**	-0.15(0.145)
<i>Tenure (at least 15)</i>	-	-0.15(0.046)*	-0.22(0.072)*

<i>Public sector</i>	-	0.25(0.042)*	0.31(0.067)*
<i>Large company</i>	-	0.23(0.059)*	0.31(0.092)*
<i>Full-time</i>	-	-0.23(0.067)*	-0.24(0.101)**
<i>Married</i>	-	-0.33(0.033)*	-0.50(0.054)*
<i>Male</i>	-	-0.07(0.030)**	-0.10(0.051)**
<i>Age (25 - 35)</i>	-	-0.53(0.107)*	-0.78(0.169)*
<i>Age (35 - 45)</i>	-	-0.70(0.070)*	-0.99(0.112)*
<i>Age (45 - 55)</i>	-	-0.69(0.057)*	-0.94(0.090)*
<i>Age (55 - 65)</i>	-	-0.64(0.046)*	-0.89(0.074)*
<i>Age (higher 65)</i>	-	-0.46(0.037)*	-0.62(0.058)*
<i>Number of Observations</i>	28523	28523	28523
<i>Likelihood Ratio Test Statistic</i>	127.81	1982.48	878.59

Note: *, ** and *** represent significance at levels 1, 5 and 10%, respectively. The estimates contain year dummies. For the Random Probit Model the presented statistic is not the Likelihood Ratio Test Statistic but the Wald Test Statistic. Standard errors in parenthesis.

We can observe from these models that technological progress affects, in a positive and highly significant way, the probability of the worker investing in human capital totally directed at the firm, as predicted by the renovation model.

We can also observe from Table 2.1 that wage, main activity, working time and the aggregate work satisfaction also affects, in a significantly positive way, the probability of the worker investing in training totally targeted at the firm. In its turn, work place, work conditions and work security satisfaction all affect in a negative, and significant way, the probability of the worker investing in training totally targeted at the firm.

Looking at the variables related to the basic worker characteristics, we can observe that the higher the level of worker education, the less is his probability of investing in

training, and that the familiar commitment affects negatively, and in a significant way, the probability of on-the-job training investments. We can also observe from Table 2.1 that the higher the worker tenure, the lower will be his investment in training and that male Portuguese worker also invest less in training totally directed at the firm.

Looking at the variables related to the basic firm characteristics, we can see that the workers in large companies and the workers in the public sector invest more in training totally directed at the firm, while the workers in full time invest less.

We can observe from Tables 2.5 and 2.6 in the annex that the male and female estimations give us very similar results. The only difference is found in the levels of statistical significance of some variables.

2.4.2. Numerical Simulation

In the previous subsection we saw that the greater the technological progress rate, the higher was the probability of Portuguese workers to invest in human capital totally directed at the firm, giving empirical support to the renovation technological progress model.

Here we develop a numerical exercise with the supported model, using sensitivity analysis. That is, to explore the impact of variations in costs and benefits of human capital investments on the labor market, evaluating if it was more advantageous for the worker to invest in human capital totally directed at the market or if it was more advantageous to invest in human capital totally targeted at the firm.

To develop this numerical example we considered the following parameters: 0.03 as an average GDP growth rate and 0.015 as the interest rate. We also used 0.03 as the idiosyncratic shock, 0.3 as the worker bargaining power, 1.3 as the employment opportunity cost and 2 as the productivity parameter. The reason for using these

parameter values is that they are a good representation of the Portuguese economy during the period of analysis, 1994 – 1999²⁹.

The function that we used in determining the number of matches formed in each period was the usual Cobb Douglas, while the rest of the parameters used in the simulation, as well as its definition and values, are all in Annex 2.

The strategy that we used in this section was the following. First, we considered an initial scenario where there was no human capital investment, due to high cost of training investment. Then, we changed the investment costs, as well as the incentives to invest in human capital totally aimed at the firm and at the market, so as to test their effects over the wage rate, the unemployment rate, the job creation and job destruction dynamics. In other words, the exercise that we developed in this section considered three different scenarios. In the first, we supposed that the investment costs were so high that the worker did not invest in human capital accumulation. Following this first scenario, we reduced the costs in order to have human capital investment. Given this cost reduction, we considered the aggregate effects if the investment was in human capital totally target at the firm (second scenario) or if the investment was in human capital totally target at the market (third scenario)³⁰.

The table below shows the basic effect of these changes over job destruction (T), job creation (θ), unemployment rate (u) and wage rate (w) in the three scenarios discussed above.

We can see from this table that if there is a sudden reduction in the human capital investment costs and if the benefits of the investment totally directed at the firm are greater than the benefits of the investment totally targeted at the market (scenario 2),

²⁹ In this subsection we undertake an analysis similar to the one developed by Albrecht and Vroman (2005).

³⁰ The basic difference between the second and the third scenarios is in the relative benefits of training investments. In the second it is more advantageous to invest in training totally directed at the firm, while in the third it is more advantageous to invest in training totally directed at the market.

we will have an increase in the job creation dynamics and wage rate, and a reduction in unemployment rate and job destruction flows³¹.

In turn, if the benefits of the investment in human capital totally aimed at the market exceed the benefits of the investment totally targeted at the firm (scenario 3), we will have a reduction in job creation dynamics and an increase in job destruction, unemployment rate and wage rate.

TABLE 2.2

Simulation Results

<i>Variables</i>	<i>Scenario 1</i>	<i>Scenario 2</i>	<i>Scenario 3</i>
<i>T</i>	4.87	7.53	2.49
<i>θ</i>	5.12	25.70	0.55
<i>u</i>	0.08	0.03	0.36
<i>w</i>	1.89	3.86	2.32

Note: Scenario 1 – there are no investments. Scenario 2 – the worker invests in human capital totally targeted at the firm.

Scenario 3 – the worker invests in human capital totally targeted at the market.

We can observe from the table above that if the investment suddenly starts to be totally targeted at the firm, the result will be a great increase in the wage rate and in the job creation dynamics. In turn, if the investment starts to be totally targeted at the market, the result will be a strong increase in the unemployment rate, jumping from 8% to 36%.

³¹ The results differ from those obtained in proposition 4 because we are considering now that $\varepsilon \neq 0$.

2.5. Conclusion

The main goal of this chapter was to study the effect of technological progress on optimum worker-provided on-the-job training.

We showed, in a creative destruction scenario, that the greater the technological progress rate, the lower would be the incentives of the worker to invest in human capital totally target at the firm, while in a renovation scenario the result was the opposite.

In both scenarios the impact of the technological progress rate on the investment in human capital totally targeted at the market was nonexistent, as it affects equally the costs and benefits obtained with the investment.

We also saw that the aggregate labor market effect of the investment in human capital depends on the investment type. If the progress is of the creative destruction form and there are no unemployment benefits the more the investment is directed at the firm, the greater is the job destruction flow and the dynamic of new job creation.

The empirical test developed for Portugal points in favor of the renovation model of technological progress, since the greater the technological progress rates, the higher is the probability of a worker investing in human capital totally directed at the firm.

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2.7 Annex

2.7.1 Annex 1

TABLE 2.3

Description of Variables

<i>Training</i>	<i>Dummy variable that equals 1 if the worker participated in a worker-provided training in the last year and looking for a job and 0 otherwise;</i>
<i>Technological progress</i>	<i>Total factor productivity (TFP);</i>
<i>Wage satisfaction, work conditions satisfaction, work place satisfaction, working time satisfaction, work security satisfaction, main activity satisfaction and aggregate work satisfaction</i>	<i>Dummy variable that equals 1 if satisfaction and 0 otherwise;</i>
<i>Education (secondary)</i>	<i>Dummy variable that equals 1 if the worker has finished the second stage of the secondary level of education and 0 otherwise;</i>
<i>Education (less than secondary)</i>	<i>Dummy variable that equals 1 if the worker has finished less than the second stage of the secondary level of education and 0 otherwise;</i>
<i>Age (25 - 35)</i>	<i>Dummy variable that equals 1 if the worker has age between 25 and 35 years old and 0 otherwise;</i>
<i>Age (35 - 45)</i>	<i>Dummy variable that equals 1 if the worker has age between 35 and 45 years old and 0 otherwise;</i>
<i>Age (45 - 55)</i>	<i>Dummy variable that equals 1 if the worker has age between 45 and 55 years old and 0 otherwise;</i>
<i>Age (55 - 65)</i>	<i>Dummy variable that equals 1 if the worker has age between 55 and 65 years old and 0 otherwise;</i>
<i>Age (greater than 65)</i>	<i>Dummy variable that equals 1 if the worker has age greater than 65 years old and 0 otherwise;</i>
<i>Male</i>	<i>Dummy variable that equals 1 if the worker is male and 0 otherwise;</i>
<i>Married</i>	<i>Dummy variable that equals 1 if the worker is married and 0 otherwise;</i>



<i>Full-time</i>	<i>Dummy variable that equals 1 if the worker is working in a full-time job and 0 otherwise;</i>
<i>Large company</i>	<i>Dummy variable that equals 1 if the worker is working in a large company (with 500 or more workers in his local unit) and 0 otherwise;</i>
<i>Public sector</i>	<i>Dummy variable that equals 1 if the worker is working in a public sector job and 0 otherwise;</i>
<i>Tenure (at least 15)</i>	<i>Dummy variable that equals 1 if the worker has at least 15 years of tenure and 0 otherwise;</i>
<i>Tenure (at least 20)</i>	<i>Dummy variable that equals 1 if the worker has at least 20 years of tenure and 0 otherwise.</i>

TABLE 2.4

Summary Statistics

<i>Variable</i>	<i>Mean</i>	<i>Standard Error</i>
<i>Training</i>	0.05	0.21
<i>Technological progress</i>	102.04	2.90
<i>Wage satisfaction</i>	0.36	0.48
<i>work conditions satisfaction</i>	0.75	0.43
<i>work place satisfaction</i>	0.82	0.38
<i>working time satisfaction</i>	0.81	0.39
<i>work security satisfaction</i>	0.74	0.44
<i>main activity satisfaction</i>	0.75	0.43
<i>aggregate work satisfaction</i>	0.41	0.49
<i>Education (secondary)</i>	0.10	0.31
<i>Education (less than secondary)</i>	0.84	0.37
<i>Age</i>	40.03	13.83
<i>Male</i>	0.61	0.49

<i>Married</i>	0.69	0.46
<i>Full-time</i>	0.95	0.21
<i>Large company</i>	0.05	0.20
<i>Public sector</i>	0.11	0.31
<i>Tenure (at least 15)</i>	0.37	0.48
<i>Tenure (at least 20)</i>	0.05	0.21

TABLE 2.5

Estimation Results – Male

<i>Countries</i> <i>Variables</i>	<i>Probit</i>	<i>Probit</i>	<i>Random Probit</i>
<i>Constant</i>	-7.48(0.905)*	-6.36(1.066)*	-5.97(1.402)*
<i>Technological progress</i>	0.05(0.009)*	0.06(0.010)*	0.05(0.013)*
<i>Wage satisfaction</i>	-	0.02(0.044)	0.07 (0.062)
<i>Main activity satisfaction</i>	-	0.09(0.056)***	0.09(0.078)
<i>Education (less than secondary)</i>	-	-0.81(0.072)*	-1.08(0.120)*
<i>Education (secondary)</i>	-	-0.13(0.078)	-0.24(0.126)***
<i>Work place satisfaction</i>	-	-0.07(0.050)	-0.13(0.072)***
<i>Working time satisfaction</i>	-	0.10(0.064)	0.14(0.090)
<i>Work conditions satisfaction</i>	-	-0.06(0.057)	-0.07(0.080)
<i>Work security satisfaction</i>	-	-0.19(0.048)*	-0.27(0.068)*
<i>Aggregate work satisfaction</i>	-	0.22(0.040)*	0.26(0.058)*
<i>Tenure (at least 20)</i>	-	-0.30(0.166)***	-0.22(0.212)
<i>Tenure (at least 15)</i>	-	-0.02(0.060)	-0.06 (0.094)
<i>Public sector</i>	-	0.16(0.062)*	0.21(0.097)**
<i>Large company</i>	-	0.25(0.084)*	0.43(0.127)*
<i>Full-time</i>	-	-0.20(0.136)	-0.31(0.199)

<i>Married</i>	-	-0.31(0.048)*	-0.43(0.077)*
<i>Age (25 - 35)</i>	-	-0.49(0.051)*	-0.68(0.080)*
<i>Age (35 - 45)</i>	-	-0.65(0.066)*	-0.95(0.106)*
<i>Age (45 - 55)</i>	-	-0.72(0.079)*	-0.99(0.124)*
<i>Age (55 - 65)</i>	-	-0.76(0.096)*	-1.12(0.153)*
<i>Age (greater than 65)</i>	-	-0.87(0.161)*	-1.28(0.248)*
<i>Number of Observations</i>	17359	17359	17359
<i>Likelihood Ratio Test Statistic</i>	81.18	1079.48	484.57

Note: *,** and *** represent significance at levels 1, 5 and 10% , respectively. The estimates contain year dummies. For the Random Probit Model the presented statistic is not the Likelihood Ratio Test Statistic but the Wald Test Statistic. Standard errors in parenthesis.

TABLE 2.6

Estimation Results – Female

<i>Countries</i>	<i>Probit</i>	<i>Probit</i>	<i>Random Probit</i>
<i>Variables</i>			
<i>Constant</i>	-7.40(0.948)*	-4.75(1.143)*	-4.60(1.492)*
<i>Technological progress</i>	0.06(0.009)*	0.04(0.011)*	0.04(0.014)*
<i>Wage satisfaction</i>	-	0.15(0.049)*	0.17(0.070)**
<i>Main activity satisfaction</i>	-	0.06(0.062)	0.11(0.087)
<i>Education (less than secondary)</i>	-	-0.66(0.071)*	-0.91(0.116)*
<i>Education (secondary)</i>	-	-0.24(0.074)*	-0.31(0.116)*
<i>Work place satisfaction</i>	-	-0.12(0.056)**	-0.16(0.082)**
<i>Working time satisfaction</i>	-	0.15(0.075)**	0.16(0.103)
<i>Work conditions satisfaction</i>	-	-0.11(0.064)***	-0.10(0.090)
<i>Work security satisfaction</i>	-	-0.12(0.054)**	-0.19(0.076)**

<i>Aggregate work satisfaction</i>	-	0.15(0.046)*	0.20(0.067)*
<i>Tenure (at least 20)</i>	-	-0.14(0.156)	-0.07(0.205)
<i>Tenure (at least 15)</i>	-	-0.34(0.074)*	-0.46(0.116)*
<i>Public sector</i>	-	0.36(0.060)*	0.43(0.094)*
<i>Large company</i>	-	0.19(0.086)**	0.17(0.136)*
<i>Full-time</i>	-	-0.25(0.080)*	-0.23(0.119)***
<i>Married</i>	-	-0.37(0.047)*	-0.57(0.078)*
<i>Age (25 - 35)</i>	-	-0.45(0.055)*	-0.57(0.084)*
<i>Age (35 - 45)</i>	-	-0.66(0.067)*	-0.85(0.106)*
<i>Age (45 - 55)</i>	-	-0.72(0.086)*	-0.97(0.136)*
<i>Age (55 - 65)</i>	-	-0.65(0.109)*	-0.85(0.169)*
<i>Age (greater than 65)</i>	-	-0.74(0.160)*	-0.15(0.252)*
<i>Number of Observations</i>	11164	11164	11164
<i>Likelihood Ratio Test Statistic</i>	50.07	922.14	397.16

Note: **, * and *** represent significance at levels 1, 5 and 10% , respectively. The estimates contain year dummies. For the Random Probit Model the presented statistic is not the Likelihood Ratio Test Statistic but the Wald Test Statistic. Standard errors in parenthesis.

2.7.2 Annex 2

TABLE 2.7

Parameters Definitions and Values

<i>Parameters</i>	<i>Symbol</i>	<i>Value</i>
<i>Growth rate</i>	g	0.03
<i>Matching Function Parameter</i>	h	0.5
<i>Interest Rate</i>	r	0.015

<i>Productivity Gain</i>	δ	variable
<i>Productivity Parameter</i>	x	2
<i>Investment Cost</i>	z	variable
<i>Search cost</i>	c	0.2
<i>Bargaining Parameter</i>	β	0.3
<i>Employment Opportunity Cost</i>	ϵx	1.3
<i>Productivity Parameter</i>	φ	0.4
<i>Idiosyncratic Shock</i>	λ	0.03
<i>Investment Decision</i>	α	variable
<i>Current Investment Decision</i>	ψ_a	variable
<i>Past Investment Decision</i>	ψ_p	0.5

Capítulo 3

Technological Progress and Average Job Matching Quality

3.1. Introduction

A model for the labor market has to be able to explain several aspects related to job creation and job destruction dynamics. Davis, Haltiwanger and Schuh (1996), for example, found that job creation and destructions flows are typically high, heterogeneous, and asymmetric and that the job destruction process is the one which normally dictates job changes³². In other words, according to these authors, a labor market model should explain that, independently of the current economic state, job creation and job destruction flows are normally high, distinct for different sectors and periods, and that the destruction process should be the main responsible for the changes in the job match characteristics.

Apart from these facts, the authors also argued that a labor market model should be able to explain that the best job matches present lower creation and destruction rates and that the break ups are, in a great majority, driven by worker decisions, if the matches are of high quality, and by firms if they are of low quality.

Based on these empirical evidences³³, several studies were conducted in an attempt to explain some of these facts, determining their consequences over particular aspects of the labor market as, for example, the evolution of the average job quality.

Caballero and Hammour (1994), for example, formalized the idea that recessions are periods of high job destruction and low job creation flows, and that if considered together, the result should be an increase in the average match quality. According to

³² Shimer (2005) argues that the job creation process is the one that drives the job changes.

³³ Davis, Haltiwanger and Schuh (1996) approached the facts for the U.S. economy. See Mortensen and Pissarides (1999b) for OECD countries.

these authors during a recession there is a process of elimination of the less productive jobs from the market. The idea was that these periods are characterized by a *cleansing effect* whereby the least efficient jobs would be the first ones to be eliminated, only the most productive jobs remaining in the market³⁴. However, although Caballero and Hammour showed the consequences of a recession over the average quality of jobs, their results do not have empirical support, as Bowlus (1995) demonstrated.

Bowlus found, with an empirical analysis of the evolution of job quality in the US, that what is happening is precisely the opposite of what Caballero and Hammour suggested. In other words, Bowlus observed that recessions are periods not only of no improvement, but actual deterioration in the average quality of matches³⁵.

Based on these findings, Barlevy (2002) considered, in addition to the effect of a recession over job destruction, the effects of recessions over the job creation dynamics. This author argued that considering on-the-job search, we would have the creation of an additional effect, empirically stronger than the one proposed by Caballero and Hammour, which he denominated *sullyng effect*.

The idea defended by Barlevy was that recessions were periods characterized by low quality job creation. In this way, if these effects overcome those generated by the destruction dynamics, we would have a reduction, and not an improvement, in the average quality of job matches.

However, although Barlevy demonstrated the reduction in the average quality of jobs during recessions, the proposed dynamics goes against the stylized fact proposed by Davis, Haltiwanger and Schuh that the job destruction process must be the main responsible for the characteristics of the existing jobs in the market.

³⁴ The papers by Hall (1991) and (2000), Mortensen and Pissarides (1994) and Gomes, Greenwood and Rebelo (1999) support this argument.

³⁵ Davis, Haltiwanger and Schuh (1996) also found these empirical facts in the US, while Fernandez (2004) verified it for Spain.

In order to address this issue, this chapter has as its principal goal the study of average job quality, bearing in mind the greater importance of the destruction dynamics in the determination of the quality of matches, and that the job destruction process is determined by workers, if the matches are of high quality, and by the firms, if they are of low quality.

The proposed model is more closely related to the creative destruction technological progress model of Mortensen and Pissarides (1998), with the introduction of heterogeneity both in job matching quality and in the information set of the worker and the firm.

The idea behind this last aspect is to consider that the information sets of the worker and the firm, which are responsible for the individuals' evaluation of the job quality, do not coincide.

We will see that these simple changes are enough to create heterogeneity in the job destruction process and a greater relative importance of the destruction dynamics in basic job aspects, as argued by Davis, Haltiwanger and Schuh. We will also see that for specific parameters and initial conditions, it is possible to create either the *sullying* or the *cleansing* effect proposed by Caballero and Hammour (1994) and Barlevy (2002).

The intuition of the model is that, for the group of low quality matches, an increase in the technological progress rate implies both an increase in the job destruction flow as well as a reduction in the job creation dynamics. Taking these two flows into consideration, we will have a reduction in the average job quality. In turn, for the high-quality matches, both effects will imply not a reduction, but an increase, in the average quality. Thus, and considering both previous scenarios, the effect of higher

growth rates over the average job quality will depend on the relative dimension of high versus low job quality intervals.

However, although the present model is compatible with the results of Caballero and Hammour (1994) and Barlevy (2002), two aspects will differentiate it from those models. First, in the Barlevy model the *sullyng effect* is the result of a high-low quality job creation, while in our model this effect is obtained via job destruction dynamics. Second, in these models the idea of quality is closely related with the notion of job match productivity, while in our model the concept of quality is associated with the idea of non-monetary job attributes. In other words, according to Caballero and Hammour (1994) and Barlevy (2002), an improvement in the average quality of job matches is equivalent to an improvement in the average match productivity, while in our model an improvement in the average quality implies a qualitative average improvement, not necessarily implying any change in the average productivity. In this way, the heterogeneity proposed by the model is equivalent to differences in match attributes, which create value, both for the worker as well as for the firm, without implying any change in the match productivity.

This chapter is organized in the following way. In the next section we will characterize the *cleansing* and *sullyng effects*. In the following section we will develop a theoretical model, and in the fourth section we will see the main results obtained concerning the effect of changes in technological progress rate over the average job matching quality. In the final section we will see the main conclusions.

3.2. Cleansing and Sullyng Effects

The technological progress dynamics of creative destruction type implies the existence of a constant process of creation and destruction of job matches due to the

hypothesis that only the most-recently jobs have the highest level of technology. In other words, the idea behind the *Schumpeterian* growth models is that new job matches are located on the technological frontier. However, the only way of updating an already existing job match is via the destruction of this relationship and formation of a new one.

With this idea in mind, Caballero and Hammour (1994) studied the effects of lower technological progress rates over the average quality of job matches. They found that there are two flows acting simultaneously over the labor market during periods of low growth. On one side, there is an increase in the job destruction dynamics, as the matches with older technology suffer a rise in the probability of becoming unproductive and being destroyed. However, on the other side, there is a reduction in the job creation process, as it is less advantageous for the firms to create new job matches during periods of lower growth.

The main goal of Caballero and Hammour was to determine which of these effects prevailed during less favorable periods of economic growth. The basic result obtained was that during periods of low growth there is a *cleansing effect* acting over the labor market which created an average improvement in the quality of job matches. In other words, the authors noted that during low-growth periods the job destruction flow exceeds the job creation, creating an average rise in the quality of the ongoing job matches.

The authors also found that it was to be expected that an efficient economy would concentrate all its creation and destruction processes in these periods, since the opportunity cost of job match restructuring would be more beneficial in less-favorable periods. Similar results were also obtained by Mortensen and Pissarides (1994), Gomes, Greenwood and Rebelo (2001), Hall (1991) and Hall (2000).

In another scenario, Mortensen and Pissarides (1994) considered both the effects of aggregate and specific shocks over the dynamics of creation and destruction of jobs. The authors detected a negative correlation between job creation and job destruction processes during periods of recession, and that the destruction flow appeared to have a more volatile dynamic than the job creation flow, a result closely related to those obtained by Caballero and Hammour.

In still another model, Gomes, Greenwood and Rebelo (2001) found that when explicitly introducing a rule of acceptance and rejection of a job match, together with the existence of incomplete markets, in a model that considers aggregate and specific shocks, the result would be an improvement in the average quality of matches, similar to the findings of Caballero and Hammour.

In turn, Hall (1991, 2000) also approached the effect of low growth rates in a creative destruction scenario on job matches, obtaining an increase in the unemployment rate followed by an improvement in the average quality of job matches.

However, although all these authors have modeled that the consequences of a recession over the average quality of job matches would be negative, these results were not empirically supported, as Bowlus (1995), Davis, Haltiwanger and Schuh (1996) and Fernandez (2004) demonstrated. According to these authors, the average quality of matches is not negatively, but rather positively related with economic growth rates. Thus, we can expect deterioration in the average quality of jobs during periods of recession and an improvement in their quality during good periods.

Based on these empirical results, Barlevy (2002) showed that the simple introduction of on-the-job search in a job matching model would be enough to obtain results different from those defended by Caballero and Hammour, although more compatible with the empirical evidence.

Barlevy argued that during a recession there were two processes acting simultaneously in the labor market. On one hand, there was an increase in the destruction of less-efficient jobs, which gave way to the *cleansing effect* proposed by Caballero and Hammour. On the other hand, there was a process of low-quality job creation that gave way to an additional effect over the labor market that Barlevy denominated *sullyng effect*.

In other words, the idea defended by Barlevy was that during a recession there were two effects acting in opposing directions in the labor market. On one side of the market, via destruction dynamics, there was an elimination of the less-efficient job matches, while on the other side, there was a process of creation of less-efficient job matches and more workers were stuck in mediocre matches. In this way, the final result would depend on the magnitude of these two fluxes. If the low-quality job creation dynamics exceed the destruction process we will have a reduction in the average quality of job matches.

The model of Gomes, Greenwood and Rebelo's model argues for a *cleansing effect* during periods of recessions, they maintain that the model is also compatible with the *sullyng effect* proposed by Barlevy. According to them, this effect occurs because during recessions the worker obtains reduction in his rent, which in turn implies an increase in the probability that the worker accepts job offers with lower wages, creating job matches with lower quality.

3.3. Theoretical Model

In this section we will present the characteristics of our theoretical model. The modeled scenario is founded on Mortensen and Pissarides (1998) technological progress model with the inclusion of heterogeneity, both in match quality and the

information set of the worker and firm in the evaluation of the expected quality of jobs.

Agents and Preferences. The economy is formed by a constant population of workers, who live infinitely, and a great number of firms that together give rise to the production activity. Firms and workers are heterogeneous, neutral to risk and maximize the discounted expected present value of rents, subject to the available information.

Suppose transferable utility, the existence of a perfect capital market and that the worker and firm discount the future at an exogenous and constant rate r ³⁶.

Each firm has only one job position, which can be occupied or not, and employs only one worker at each moment. In turn, each worker can be employed in only one job per period or unemployed.

Search and Production. Before the beginning of production, firms and workers undertake an individual, independent and expensive process of search. Let $P(t)c$ be the search cost for the firms, where $P(t) = e^{gt}$ represents a common factor of growth.

Assume that there is no on-the-job search and that the quantity of job matches formed per period is given by function $m(v, u)$ non-negative, concave, homogeneous of degree one and increasing in its two arguments, where v represents the vacancy rate and u the quantity of unemployed workers in the economy, per period.

³⁶ See Rogerson, Shimer and Wright (2004) on the non-transferable utility theme.

The unemployed workers move to an employment situation according to a rate $\theta q(\theta)$, where θ is the ratio of v and u , while a job vacancy becomes occupied at a rate $q(\theta)$.

Before production begins, firms fix their technology at the cost $P(t)K$. Assume that it is irreversible and is in the technological frontier at the moment that the match is formed³⁷.

Note that with this technological progress format, since a job match, once created, cannot be updated, its production will remain constant at its initial level, τ .

Suppose that the occupied jobs can be destroyed due to an idiosyncratic shock that follows a Poisson Process with arrival rate λ , which aims to capture, for example, any negative exogenous events that affect the productivity of a particular job matching.

Observe from the two previous conditions that a particular job match can be destroyed due to an aggregate shock, represented by larger growth rates that affect the obsolescence rate of all existing job matches, or due to a specific shock, which acts individually over a particular job match.

Every occupied match has two components that affect its value for the firm. The first one is given by $P(\tau)x$, and represents the production generated by a job match formed in τ . The second one is represented by the term α and aims to capture differences in quality of the job matches created at the same moment τ ³⁸.

Assume that α is time invariant and uniquely determined at the moment that the match is formed, in an exogenous and independent way, from a particular distribution

³⁷ See Mortensen and Pissarides (1998) and Pissarides (2000) for a different formulation of the technological progress.

³⁸ We will consider that, although a higher matching quality does not affect the job productivity, it affects the effective discount rate. In other words, we will consider that the higher the job quality, the less the value of the match will be discounted, as workers and firms prefer a good job in relation to a lower quality one.

function. Suppose also that it is an experience good, that is, it can only be known after the beginning of production³⁹, and that the firm and the worker have different information sets⁴⁰ in the evaluation of the expected value of α .

If, apart from the previous conditions, we consider that at any time both firms and workers can terminate the ongoing job match, that is, they can break up the partnership and return to the search process in order to find a new partner, we have that jobs created at each moment will have distinct obsolescence periods, according to their quality and the technological progress rate.

Note that the idea behind the previous condition on α is that before the formation of a job match two workers (firms) are seen in an identical way by the firms (workers) and only after the production starts does the quality of the job match start to be revealed.

Suppose, in order to facilitate the presentation of the main results of the model, that α is defined in the interval:

$$(1) \quad \left(0, \frac{r}{1-\lambda}\right).$$

Wages. If a productive match is destroyed by the worker, by the firm or even in an exogenous way, both the worker and the firm have to pay the costs related to the return to the search process. In this way, a productive match generates a surplus that has to be distributed among the two parties. Let us suppose that this division is

³⁹ Note that the condition that α is an experience good implies that all meetings will give rise to job matches, since there is no rejection before production starts.

⁴⁰ The idea of this condition is to consider that workers and firms do not calculate the expected value of α in the same way.

determined from the *Generalized Nash Bargain Process* between the firm and the worker, where β represents the workers' bargaining power⁴¹.

Equilibrium. Let $V(t)$ represent the present discounted value for a firm of the expected gains from a job vacancy created at t , $J(\tau, t)$ the present discounted value for a firm of the expected gains associated with a job created at τ , with quality α and occupied in period t , $U(t)$ the present discounted value for the worker of the expected gains associated with the unemployment, and $W(\tau, t)$ the present discounted value for the worker of the expected gains associated with a job created at τ , with quality α , in period t . Thus we have:

$$(2) \quad rV(t) = -P(t)c + q(\theta) \left[(1 + \alpha_F^e) J(t, t) - V(t) - P(t)K \right] + \dot{V}(t);$$

$$(3) \quad rJ(\tau, t) = P(\tau)x - w(\tau, t) + \alpha J(\tau, t) - \lambda \left[(1 + \alpha) J(\tau, t) - V(t) \right] + \dot{J}(\tau, t);$$

$$(4) \quad rU(t) = P(t)b + \theta q(\theta) \left[(1 + \alpha_w^e) W(t, t) - U(t) \right] + \dot{U}(t);$$

$$(5) \quad rW(\tau, t) = w(\tau, t) + \alpha W(\tau, t) - \lambda \left[(1 + \alpha) W(\tau, t) - U(t) \right] + \dot{W}(\tau, t);$$

where α_F^e represents the expected quality of the job match for the firm⁴²; $w(\tau, t)$ the worker's wage rate, at moment t , in a match formed at τ ; $P(t)b$ is the job opportunity cost for the worker, while the last terms represent, respectively, time variations in $V(t)$, $J(\tau, t)$, $U(t)$ and $W(\tau, t)$.

⁴¹ See Mortensen and Pissarides (1999b) for alternative formulations of the wage determination.

⁴² Suppose that $\alpha_F^e = \alpha^e$ and $\alpha_w^e = \alpha^e - \xi$, where ξ is a small term that represents the deviations in the worker's expectations in relation to the firm's expectations.

Note that with these value function specifications the job quality component enters in a proportional manner in $W(\tau, t)$ and $J(\tau, t)$. Thus, the term associated with the job quality depends on α and on the present discounted value of the expected gains associated with an occupied job for the worker and for the firm, $W(\tau, t)$ and $J(\tau, t)$.

The main reason behind this formulation is to consider that the effects created by the quality of a match directly affect the workers' and firms' valuations of the job matching. In other words, we are considering that the higher the job matching quality, the less it will be discounted, since it is preferred to a lower quality match.

Also note, from expression (2), that when a vacancy is occupied it will generate a gain given by the difference between the value of a vacancy and the value of an occupied job, plus the gains associated with the expected quality of the match to be formed.

In turn, we can verify from expression (4) that once the worker is employed, he will have a gain given by the difference between the value of employment and the value of unemployment, plus the gains associated with the expected quality of the match to be formed.

Continuing the equilibrium characterization, we will assume that $r + \lambda - \alpha(1 - \lambda) > g$ and $b < x$, in a way that the effective discount rate is positive and there are strictly positive advantages in the formation of a job match, as results from job search theory.

Considering the usual hypothesis of free entry, we have from (2), that

$$(6) \quad (1 + \alpha_F^e) J(t, t) = \left[\frac{P(t)c}{q(\theta)} + P(t)K \right],$$

where we can see that the expected value of a new job match is equal to the sum of the cost of occupying a vacancy, expressed in terms of the rate at which this vacancy is occupied, and the cost to create this new vacancy.

Now, as the surplus generated by the matching is divided according to the Generalized Nash Bargaining Solution, $w(\tau, t)$ satisfies:

$$(7) \quad \beta [J(\tau, t) - V(t)] = (1 - \beta) [W(\tau, t) - U(t)].$$

Using expressions (3) - (7), and assuming $\alpha_F^e = \alpha_W^e = \alpha^e$, the wage rate at moment t , in a match formed at τ , is given by:

$$(8) \quad w(\tau, t) = \beta P(\tau)x + (1 - \beta)P(t)\delta(\theta(t))\omega(\theta(t)),$$

where $\delta(\theta(t))$ and $\omega(\theta(t))$ are given by⁴³:

$$(9) \quad \delta(\theta(t)) = \frac{r - \alpha(1 - \lambda)}{r - \theta q(\theta)\alpha^e},$$

$$(10) \quad \omega(\theta(t)) = b + \left(\frac{\beta}{1 - \beta} \right) [c\theta + K\theta q(\theta)].$$

We can observe from the previous expressions that the wage rate is formed by two terms. The first is associated with the worker's productivity, and the second is related to his outside options.

⁴³ Suppose, to simplify the presentation of the basic results of the model, that the terms defined in expression (9) are always positive.

We can also observe from the previous expression that the greater the technological progress rate, the greater will be the worker's wage rate, due to the growth verified in the term related to his outside option, and that the greater α is, the less will be the wage growth, for a given technological progress rate.

Note also that the greater α^e and θ , the greater will be the wage growth, for a given technological progress rate. The reason for the first effect is that as α^e increases, the greater will be the expected quality obtained in a new job match, giving way to an increase in the worker's wage rate in his current job. In turn, the greater θ is, the greater will be the ratio of vacant jobs to unemployed workers, which implies greater wage rates, due to the *congestion effect*⁴⁴.

Another interesting aspect that we observe is that the worker's outside option increases at the technological progress rate, while the wage rate increases at a lower rate. As a consequence, there will be a moment T^W at which the worker will terminate his current match, as his outside option becomes greater than his wage.

In turn, as the worker's wage grows at a rate proportional to the technological progress rate, while the productivity of the job remains constant, there will be a moment T^F where the worker's productivity is lower than his wage, implying the destruction of the job match by the firm.

Thus, T^W and T^F represent the moments at which the worker and the firm destroy the job match, respectively.

Using expressions (3) to (5), together with equation (8) and conditions $\alpha_F^e = \alpha^e$ and

$\alpha_W^e = \alpha^e - \xi$, we have that T^F and T^W are determined by⁴⁵:

⁴⁴ The idea behind the *congestion effect* is that as θ grows, the probability of a firm occupying a vacancy decreases, while the probability on an unemployed worker finding a vacancy increases.

⁴⁵ The term δ_o is identical to δ , except that the denominator is $r - \theta q(\theta)(\alpha^e - \xi)$.

(11)

$$J(\tau, t) = \text{Max}_{T^F} \left\{ \int_t^{\tau+T^F} [(1-\beta)P(\tau)x - (1-\beta)P(s)\delta(\theta(s))\omega(\theta(s))] e^{-[r+\lambda-\alpha(1-\lambda)](s-t)} ds \right\}$$

(12)

$$W(\tau, t) = \text{Max}_{T^W} \left\{ \int_t^{\tau+T^W} [\beta P(\tau)x + (1-\beta)P(s)\delta(\theta(s))\omega(\theta(s)) - P(s)\varphi(\theta(s))\delta_o(\theta(s))\omega(\theta(s))] e^{-[r+\lambda-\alpha(1-\lambda)](s-t)} ds \right\}$$

where

$$(13) \quad \varphi(\theta(t)) = \frac{1-\lambda}{r-\alpha(1-\lambda)}.$$

We can observe from the previous expressions that T^F and T^W coincide, respectively, with the moment where the value of an occupied job is zero for the firm, and the moment where the value of the employment equals the value of unemployment for the worker.

Considering $\tau = t$ in the previous expressions, the first order conditions of the previous optimization problems are, respectively⁴⁶:

$$(14) \quad (1-\beta)x - (1-\beta)\delta\omega e^{gT^F} = 0,$$

$$(15) \quad \beta x - \omega e^{gT^W} [\varphi\delta_o - (1-\beta)\delta] = 0,$$

⁴⁶ Note that, in order to have strictly positive T^F and T^W , $x > \delta_o\omega > 0$ and $\beta x > [\varphi - (1-\beta)]\delta\omega > 0$.

where δ , ω and φ are given by expressions (9), (10) and (13) respectively.

Note, from the two previous expressions, that the optimal moments T^W and T^F diminish with higher values of θ . The reason for this behavior is that the larger θ is, the higher will be the worker's wage, implying a reduction in T^F . In turn, the greater θ is, the higher will be the worker's outside option, which implies a lower T^W .

We can also observe that T^W and T^F decrease with higher technological progress rates and T^W increases with higher positive values of ξ .

Finally, we can observe from these expressions that T^W diminishes with greater α , while T^F increases. The reason for this behavior is that the higher α is, the lower will be wage rate growth, if compared with the increase seen in the worker's outside option, which will make the obsolescence of the job match faster for the worker. On the contrary, greater α makes the obsolescence of the job match slower for the firm, as we can see in the figures below.

FIGURE 3.1
Job Destruction
Worker View

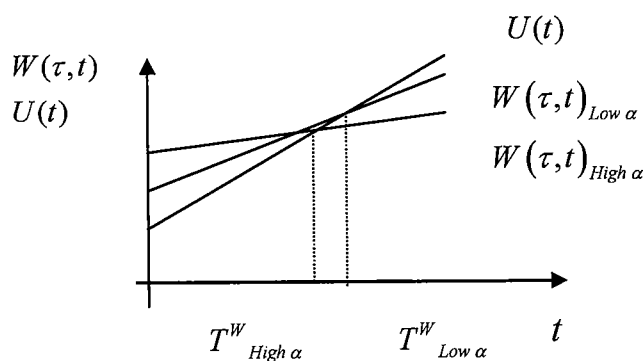
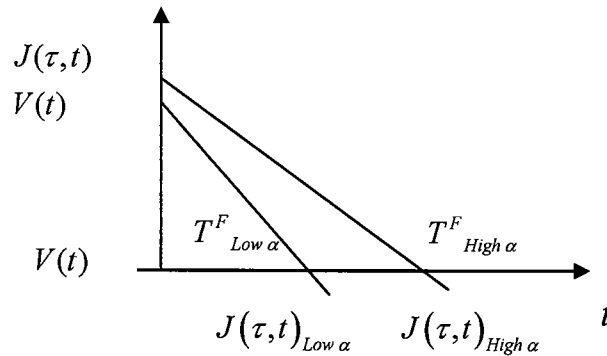


FIGURE 3.2
Job Destruction
Firm View



Note from the above figures that the greater α is, the higher will be the present discounted value of the expected gain given by the job match to the worker and to the firm. However, as time goes on, the higher quality job will more quickly lose its value for the worker, and more slowly lose its value for the firm, if compared with a job of low quality.

Proposition 3.1 Let α_I be the value of α that makes $T^F = T^W$. Thus, when:

- (a) $\alpha \leq \alpha_I$, the job match will exist, at most, until T^F ;
- (b) $\alpha \geq \alpha_I$, the job match will exist, at most, until T^W .

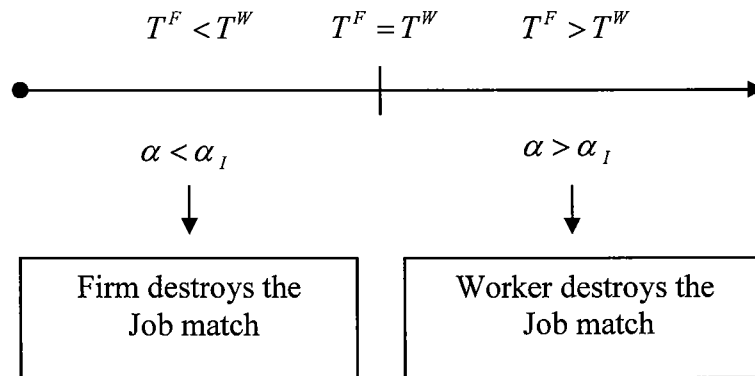
Proof. We need only to equal T^F and T^W to obtain an expression for α_I . ■

The idea behind proposition 3.1 is the following. If α is given by α_I we will have $T^F = T^W$. However, as α is lower than α_I we will have $T^F < T^W$ and, in this case, the firm will be the agent to destroy the job match. In turn, if α is greater than α_I we

will have the opposite scenario, that is, we will have $T^F > T^W$ and, in this case, the worker will be the agent to destroy the job match.

In other words, for different values of α we will have different agents initiating the destruction dynamics. If α is lower than α_I , the expression that determines T^W loses its importance in the equilibrium characterization, since the destruction of the job match will be T^F , a moment that happens earlier than T^W . In turn, if α is above α_I , the expression that determines T^F loses its importance in the equilibrium characterization, since the moment of destruction will be T^W , a moment that happens earlier than T^F , as we can see in the figure below.

FIGURE 3.3
Job Destruction



Continuing with the equilibrium characterization, when considering $\tau = t$,

$J(t, t) = P(t)J$ and the optimum T^F in (11), we have that

$$(16) \quad J = (1 - \beta) \int_0^{T^F} [x - \delta \omega e^{gt}] \cdot e^{-[r + \lambda - \alpha(1 - \lambda)]t} dt$$

represents the value of a job created at moment t and which will survive, if there is no exogenous destruction, up to moment T^F .

Using $J(t, t) = P(t)J$ in (6), we have that (16) and

$$(17) \quad J = \frac{1}{(1 + \alpha^e)} \left[\frac{c}{q(\theta)} + K \right].$$

determine the job creation dynamics.

These expressions tell us that the expected gains to the firm from a new job match must equal the expected costs associated with the creation of a new vacancy.

Note that, for given α , the expressions (14) – (17) determine the equilibrium in the $T - \theta$ space⁴⁷.

Having characterized the job creation and destruction dynamics, we must now obtain the expression that determines the equilibrium unemployment rate.

The job creation flow, at moment t , is given by:

$$(18) \quad JC = \theta q(\theta) u(t),$$

where $u(t)$ represents the unemployment rate, while the job destruction flow, at moment t , is given by:

$$(19) \quad JD = \lambda [1 - u(t)] + e^{-\lambda T} JC; \quad T = T^F, T^W,$$

⁴⁷ See Pissarides (2000) for details.

where the term $\lambda[1-u(t)]$ represents the job destruction flow which comes from the exogenous process and $e^{-\lambda T}$ measures the fraction of the job creation flow that survives up to the destruction moments T^F or T^W , in accordance with the quality of the job match. Therefore, from the two last expressions, the equilibrium unemployment rate is given by:

$$(20) \quad u = \frac{\lambda}{\lambda + \theta q(\theta)[1 - e^{-\lambda T}]}, \quad T = T^F, T^W.$$

Observe from this expression that the further α distances itself from α_l , above or below, the quicker will be the job match destruction as T^F or T^W diminishes, in accordance with the direction that α moves, leading to an increase in the equilibrium unemployment rate⁴⁸. Thus, as the quality of the match distances itself from the quality α_l , even in the direction of better qualities, the result will be an increase in the unemployment rate.

The basic reason for a higher job destruction rate in better qualities job matches is due to the fact that these types of jobs are less sensitive to what happens in the market. In this way, although a good quality job matching is preferable to a lower quality one, these jobs will be quickly destroyed, since the workers wage rate in these jobs do not follow the average increases in the wage rate.

Extension. Now we will see that it is possible to enrich the previous model in order to obtain more interesting results, according to the job match characteristics.

⁴⁸ Auer, Efendioglu and Leschke (2004) also found this empirical relationship.

As the model developed up to now does not consider the reaction of an agent when the other part decides to destroy the job match, we will introduce the idea that the results of such an action can be adverse enough that the agent affected by the destruction interferes in the process, avoiding the destruction of the job match⁴⁹.

Now, observe that in order to analyze the best response of an agent to the destruction decision of the other, we need to compare the value that this agent receives if such a decision were not taken by the other one.

Let us consider in this section that ε is positive. Now, as ε is the term that makes $\alpha_W^e \neq \alpha_F^e$ and, when considered in the job destruction dynamics, makes $T^F \neq T^W$, considering it to be positive implies that the only case to analyze is $T^F < T^W$. In this way, following this condition, at the moment T^F (at which the firm decides to destroy the job match) the value of the employment is given by:

$$(22) \quad J(\tau, T^F) = V(T^F) = 0.$$

Proposition 3.2 Suppose that $T^F < T^W$. Thus, whenever the job match quality is given by α_M , that satisfies

$$\alpha_M < \frac{r}{1-\lambda} - \frac{P(T^F)\delta_o\omega}{(1-\lambda)W(T^F, T^F)},$$

then it is more advantageous for the worker to maintain the current job match.

⁴⁹ Note that we are assuming with this scenario that there is no rigidity in downward wage movements.

Proof. The value of the unemployment option for the worker at moment T^F is

$U(T^F) = \frac{P(T^F)\delta_o\omega}{r - \alpha(1 - \lambda)}$. Thus, whenever $W(\tau, T^F) > U(T^F)$ it is advantageous for the

worker to maintain the present job match.

Manipulating these last two expressions, we arrive at the expression that α_M must satisfy.

Now, if we consider that it is possible to isolate the best jobs within the group of poor-quality job matches, and that $rW(\tau, T^F) > P(T^F)\delta_o\omega > 0$, we have that α_M is defined in interval (1). ■

The intuition of the preceding proposition is the following. If, at the moment that the firm decides to destroy the job match, the value of the job for the worker is higher than his outside option, then the worker will react to the job destruction, by accepting lower wages. Now, as the value of the job at moment T^F is higher than his outside option, we can expect that the worker will accept a wage rate reduction in order to maintain his current job match. Thus, whenever the job match is defined in the previous interval, the job will not be destroyed at T^F .

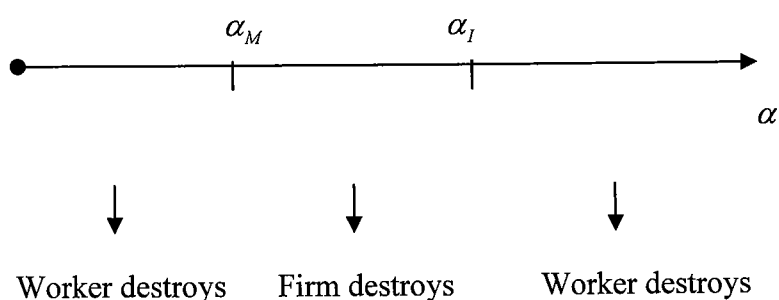
Note also that the higher ε is, the more probable it is that the worker will react to the job destruction.

Also note that the worker will preserve the matches with lower α because they are, at this moment, better than a high quality one – although they do not have good quality, they pay high wages.

Therefore, if the job match belongs to the lowest quality subgroup among those of lower quality, it will not be destroyed at T^F , but will last until the moment T^W . In

turn, if the job has quality between α_M and α_I , the job will be destroyed at T^F , as we can see in the figure below.

FIGURE 4
Job Destruction
Extension



3.4. Technological Progress and Average Job Matching Quality

In this section we will examine the effects of technological progress rate changes over the average quality of the job matches.

Assume initially that the economy is completely characterized by job matches defined in the interval of quality $\alpha_M \leq \alpha < \alpha_I$. In this case, we have that T is determined by expression (14) and we can observe that as g grows T^F falls, or in other words, as the technological progress rate grows, the quicker it is that firms will destroy the existing job matches. The reason for this behavior is that the greater g is, the higher will be the wage growth, and as the job has low quality, the quicker it will become obsolete, leading to its destruction.

In turn, regarding the job creation dynamics, as g grows, the less pronounced will be this process, because higher wages will be paid in those new jobs.

In this way, we will have as a final result an increase in the job destruction and a reduction in the job creation dynamics. Now, as the destruction occurs from the worst to the best job matches, the worst quality jobs will be the first to be destroyed, leading to an increase in the average quality of the existing matches in the interval $\alpha_M \leq \alpha < \alpha_I$.

Note also that if instead of an increase, there is a decrease in the technological progress rate, the result will be, as before, an increase in the average job match quality.

The idea now is that we have a reduction in the job destruction process and an increase in the job creation dynamics. However, the job creation flow would lead to the creation, in an independent manner, of job matches in the previous interval. In this way, we can expect no changes in the job quality coming from the job creation side. Furthermore, as the destruction dynamics follow the same process, that is, the jobs with less quality are the first to be destroyed, we will again have an increase in the average quality of job matches.

Now, consider the job matches defined in the interval $\alpha < \alpha_M$. In this case we will have T determined by the expression (15) and as g grows, T^W falls, that is, the quicker it is that the worker wishes to destroy the job match.

The reason now is that the wage rate does not respond to every increase in the worker's outside option, which leads him to destroy his current job match sooner.

In turn, on the job creation side, the results are identical to those previously obtained.

Thus, an increase in g implies an increase in the job destruction flow and a reduction in the job creation dynamics. However, there will be a difference in relation to the earlier results. As the workers destroy the jobs with greater α followed by the jobs with smaller α , the destruction process will generate opposite results, that is, we will

have the job matches being destroyed from the best to the worst ones, leading to a reduction in the average quality of the job matches. Therefore, whenever we consider the jobs defined in the interval $\alpha < \alpha_M$, the increase in the job destruction will be accompanied by a worsening in the average quality of the matches.

Now observe that if instead of an increase, there were a reduction in the technological progress rate, the result would be a reduction in the average quality of the job matches, according to the previous argument. Thus, as before, we would have the job destruction process determining the average quality of the matches, although to a lesser degree.

Finally, for the jobs with quality defined in the interval $\alpha \geq \alpha_I$, the destruction moment is again given by the expression (15) and the effect of changes in the technological progress over the average match quality are identical to those obtained previously for the jobs defined in the interval $\alpha < \alpha_M$.

Joining all the previous results, we can see that it is possible to obtain both an improvement and a worsening in the aggregate quality of the job matches. The final result will depend on both the distribution of the job matches and the parameters related with the determination of α_M and α_I .

3.5. Conclusions

The goal of this chapter was to analyze the behavior of the average quality of job matches, bearing in mind the empirical facts proposed by the literature.

Earlier studies defended distinct arguments as to the effect of periods of low growth over the average quality. On one hand, it was argued that these periods were characterized by a *cleansing effect*, which implied an increase in the average quality of the matches. On the other hand, it was argued that these periods were not

characterized by a *cleansing effect*, but rather by a *sullyng effect*. That is, these periods were moments of reduction in the quality of the matches.

We saw that it is possible to obtain both the *cleansing* as well the *sullyng effect*, depending on the distribution of the job matches and on the parameters related with α_M and α_I . The idea advanced was that variations in the technological progress rate create distinct dynamics in the job destruction process, depending on the quality of the job match.

We demonstrated that two simple modifications in the technological progress model of creative destruction type of Mortensen and Pissarides (in order to allow for the existence of stochastic job matches and differences in perceptions about the average quality of a new job match by the involved agents) was enough to explain the behavior of the average quality of jobs, taking into account the facts that the destruction process must be the main one responsible for this process and that, depending on the job quality, we will have different agents driving the destruction dynamics.

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Capítulo 4

Job Matching, Unexpected Obligations and Retirement Decisions

4.1. Introduction

The argument that, if nothing is done, retirement programs will go through serious financial problems in a not so distant future, has been a common one. The idea traditionally advanced is that the combinations of low fertility rates and increased life expectancy have led to the ageing of the population, risking the maintenance of social security programs. However, there are also other reasons proposed in the literature, not merely the demographic ones, which are important in the determination of the optimal rule of entry of workers into retirement and which also affect the continuity of this kind of program. One of these additional reasons, and probably the one most often heard in recent years, is the quality of the retirement systems⁵⁰.

The usual argument is that the facility to obtain the right to retirement, together with the attractiveness of the received benefits, increases the relative cost of the worker's permanence in the market, making it easier for him to retire.

Other processes advanced in the literature are that reductions in the employability rates, human capital obsolescence, discrimination, health problems, greater leisure preferences and long periods of unemployment or inactivity make it more difficult for the worker to remain in the labor force, due to the high cost that these factors impose on the worker having the right to retire, and yet not retired, in postponing his retirement decision⁵¹.

⁵⁰ See Gruber and Wise (2005) and references therein about the effects of social security programs in the optimal retirement rule.

⁵¹ See Bound, Schoenbaum and Waidman (1995), Fields and Mitchell (1984a), Flippen and Tienda (2000) and Johnson and Neumark (1997) about these points.

If we add to these previous problems the facts that, instead of being in a capital accumulation process, a factor that is determinant in relieving the reductions in the saving process common in retirement periods, we are seeing an increase in the individual debts, and that we are increasingly living in periods of higher economic turbulence⁵², which implies a greater probability in the occurrence of unexpected events, we can understand the reason for such great importance of this issue nowadays⁵³.

According to the Financial Stability Report of *Banco de Portugal* (2004) the difference between individual debts and assets has increased, not only at a historic level, but also internationally⁵⁴. The argument made is that the reductions in debt costs and increases in family income over the last years have been the major causes of this process. The consequences of this individual behavior are another threat to the social security programs, due to the high level of dependence that people have on benefits received from the government.

In this chapter, our goal is to approach the effects of changes in the individual's obligation over his optimal decision to retire.

We will evaluate not only the impacts of continuous and expected changes on the level of an individual's decision to retire, but also, the effects of unexpected changes in individual's obligations over their best rule of exiting the labor force. In other words, we will consider that there are events that alter the level of a worker's obligations – an unexpected debt, for example – changing his level of dependence on

⁵² Ljungqvist and Sargent (1998) argued that the increase in the European unemployment rate is a result of higher economic turbulence over the last 80 years.

⁵³ Mitchell and Fields (1984c) approached the effects of higher wealth on retirement incentives. See Browning and Lusardi (1996), Diamond and Hausman (1984) and Engen, Gale and Uccello (1999) about the effects of savings on the retirement decisions.

⁵⁴ See *Banco de Portugal* (2004) – chapter 5 – for an international comparison of individual debts.

the employed and unemployed conditions, in detriment to retirement, and causing changes in the optimal moment to exit the labor force.

We will see that a simple approach of this type generates interesting results, as for example, that the worker's wage rate diminishes when he earns the right to retire; that it is necessary that the retirement pension be greater than the unemployment benefit in order to take flows of workers from unemployment to retirement, while it is not necessary that the retirement pension be greater than the wage rate to take flows of workers from employment to retirement⁵⁵; and that the higher the probability of retirement decision, the lower will be the worker's wage rate and the dynamics of new job creations. We will also see that the easier it is to earn the right to retire, the less will be the job creation flow.

Some authors have already investigated the effects of unexpected events over the incentives of entering into retirement⁵⁶. However, none have approached the question of unexpected changes in the worker's obligations over the optimal retirement decisions rule in an imperfect labor market.

Also related with the same theme of the present chapter are Bhattacharya, Mulligan and Reed III (2004), who also approach the optimal retirement policy in a search frictions environment. However, although the present model has some similarities with this one, these authors consider only the flow of workers from employment to retirement, while we consider the flows from both employment and unemployment to retirement. Another difference between the models is that our goal is to investigate the effect of workers' obligations on their decision of going to retirement, while Bhattacharya, Mulligan and Reed III focus on the effects of the characteristics of the retirement programs over the best rule of exiting the labor force.

⁵⁵ This result goes against the one obtained by Bhattacharya, Mulligan and Reed III (2004).

⁵⁶ Some examples are Anderson, Burkhauser and Quinn (1986), Burtless (1986) and Williamson and McNamara (2002).

Another investigation close to the one developed here is that of Gordon and Blinder (1980) who estimate the relative importance of diverse factors – health, wage rates, preferences and incentives of the public and private retirement systems – over the decision of going into retirement. The greatest similarity lies in the determination of the reservation wage. However, one of the differences is that we also seek to determine the reservation unemployment benefit, that is, the unemployment benefit of indifference between the options of retirement and unemployment.

This chapter is developed in the following sequence. In the next section we carry out an empirical exercise intending to validate the basic hypothesis used in the model: that the greater the worker's obligation, the less will be the probability of him to retire. In Section 3 we develop the theoretical model, and in the last section we see the main conclusions.

4.2. Obligations and Retirement Decisions

The principal intuition behind the proposed mechanism to explain the workers' exit from the labor force is that the greater the workers' obligations the less will be the probability of them to retire.

In this section, we use data from the European Community Household Panel⁵⁷ (ECHP), to prove empirically this intuition. That is, our goal in this section is to determine the effects of greater obligations over the probability of the worker to exit the labor force.

We use this data base due to the ability that it permits us to follow both the level of the individual obligations over time and the moment that they decide to exit the labor force.

⁵⁷ See Eurostat (2003) for a complete characterization of the ECHP.

A – Data

The countries that we used in this empirical exercise were Portugal, Spain, France and Italy for the years 1994 – 1999. Our strategy was the following: initially, we eliminated from the data all those individuals who were not at the legal age to ask for their right to retire, in order to have only a set of workers who were close to their effective retirement moment.

The reason for the elimination of these observations was simple. As we were interested in studying the effect of obligations over the workers' entrance into retirement, we could not estimate this effect if our set of workers did not have the right to retire⁵⁸.

Now, as during the analyzed period the Portuguese legislation defined 55 as a minimum retirement age and 70 as a maximum, we restricted the data at the age interval [51,74], in order to have the effective retirement moment totally defined in the interval 1994 – 1999⁵⁹.

The same was repeated for the remaining countries, defining the age interval of [56,74] for Spain, [52,69] for France and [53,74] for Italy⁶⁰.

We then eliminated from the data those workers who experienced unemployment periods between the years 1994 and 1999, leaving this empirical analysis for a future work, as well as those who retired before and after the previously defined moments. The basic reason behind this last elimination was to exclude all workers who retired for reasons other than the normal ones.

⁵⁸ In this way, we can see the present empirical exercise as an analysis of a particular segment of the labor market to a situation where every worker has the right to retire.

⁵⁹ Note that, with this strategy, we can identify all individual characteristics near the worker's entry into retirement decisions.

⁶⁰ As Spanish and Italian legislation did not define, between 1994 and 1999, any maximum age of retirement, we considered the same age as Portugal, 70 years.

In this way, we considered in our empirical analysis only the transition between stable periods of employment and retirement.

The variable that we used to identify the entry into retirement was constructed using the longitudinal characteristic of the database. The retirement indicator was set equal to one if the worker decides to go to retirement in the next period, and 0 otherwise.

The variable that we used to capture the level of worker's obligations was constructed from the variable related to the household payment of debts.

Note that the last variable, which we used as a proxy for the worker's obligations, tells us that the greater the household debts, the higher will be the workers' obligations. Now, as this variable takes value 1 if any member of the household is currently paying any debt and 0 otherwise, we expect it to have a negative sign in the estimation, so that it agrees with the assumption of the model to be developed in the next chapter⁶¹.

A closer look at the summary statistics in the annex show us that, on average, 12% of the workers from Portugal and Italy have to repay debts, while this value grows to 21% if we consider only the Spanish workers. We can also see that Italy is the country that presents the lowest level of obligations, while France is the one that presents the highest.

To obtain the information related to the effect of worker's health over his retirement decisions, we consider the question in the ECHP related to the number of nights spent in hospitals during the last 12 months. The reason to include this last variable is that the model needs to capture the effects of the worker's health over his retirement decision. We can expect that the greater the number of nights spent in hospital, the more probable it is that the worker decided to retire due to poor health. Another look at the summary statistics shows us that the Italian workers spent the greatest number

⁶¹ See the annex for a complete description of the variables used.

of nights in hospitals, while the Portuguese workers were those who spent the lowest number of nights in the 12 months prior to retirement.

Regarding the workers' education, marital status and age, which are all important to control for the basic workers' characteristics, we consider: a dummy variable that equals one if the worker has finished the third level education and zero otherwise; a dummy variable that equals one if the worker has finished less than the second stage of the secondary education and zero otherwise; a dummy variable that equals one if the worker is married and zero otherwise; and a dummy variable that equals one if the worker was more than 60 years old and zero otherwise.

The summary statistics show us that Portugal is the country that has the lowest number of workers who finished third level education, only 6%, while Spain is the country that has the greatest, 19 % of workers. We can also see that Portugal is the country that has the highest number of workers with less than the second stage of the secondary education, 90%, while France is the country that has the lowest, 47%. In all countries the number of married workers is around 82%, while the number of workers older than 60 years is between 7 % for France and 33% for Portugal.

Finally, we also considered the worker's tenure and the satisfaction with his present job. Both variables were included in order to capture the effects of the quality of the job over the worker's retirement decision. Now, the greater the job satisfaction, the more will be the worker's commitment to the job, we expect the relationship between the worker's satisfaction with his present job and his retirement decision to be negative.

B – Econometric Model

In order to analyze the relationship between obligations and the worker's exit from the labor force we estimated the latent variable model:

$$(1) \quad y_{i,t}^* = x_{i,t}\beta + c_i + e_{i,t},$$

where $y_{i,t}^*$ is a binary non-observable variable, which takes value one if the worker decides to retire and zero otherwise, $x_{i,t}$ is a vector of individual characteristics, c_i represents non-observable and fixed individual characteristics, and $e_{i,t}$ represents an error term.

Note from the last expression that as we do not observe $y_{i,t}^*$, but only the signal of $y_{i,t}$, it is considered that $y_{i,t} = 1$, if $y_{i,t}^* > 0$, and $y_{i,t} = 0$, if $y_{i,t}^* \leq 0$.

We estimate two different models, the unconditional probit and the random effect probit model. The basic differences between both models reside in the distribution of the error term and in the way that $x_{i,t}$ and c_i are correlated. The non-observable and fixed individual characteristics are ignored, in the probit model, while a conditional normal distribution with linear expectations and constant variance are considered in the random effect probit model⁶².

C – Results

We initially estimate three different models for each country. Two probit models differing only in the vector of covariates, and a random probit model. In the first probit model we consider only the worker's obligations as independent variable, while

⁶² See Wooldridge (2002) for more details on both models.

in the second we consider other covariates. The third and final estimated model is simply a random probit version of the more complete probit model. In table 4.1 we show these three models for the whole sample and table 4.2 and 4.3 present the results for the male and female sub-samples.

The estimated coefficients, together with their standard errors, are given in the tables below.

TABLE 4.1
Estimation Results – General

<i>Countries</i>	<i>Probit</i>	<i>Probit</i>	<i>Random Probit</i>
<i>Variables</i>			
France			
<i>Constant</i>	-0.84(0.062)*	-0.89(0.144)*	-1.03(0.190)*
<i>Obligations</i>	-0.24(0.108)**	-0.20(0.113)***	-0.23(0.138)***
<i>Married</i>	-	-0.22(0.120)***	-0.26(0.151)***
<i>Lower than high school</i>	-	0.23(0.108)**	0.27(0.136)***
<i>Age more than 60</i>	-	1.25(0.184)*	1.38(0.226)*
<i>Health</i>	-	0.01(0.013)	0.01(0.015)
<i>Tenure more than 15 years</i>	-	-0.05(0.107)	-0.03(0.133)
<i>Job Satisfaction</i>	-	-0.06(0.109)	-0.10(0.137)
<i>Number of Observations</i>	832	832	832
<i>Likelihood Ratio Test Statistic</i>	5.04	67.54	49.54
Italy			
<i>Constant</i>	-0.72(0.031)*	-0.97(0.121)*	-1.02(0.134)*
<i>Obligations</i>	-0.14(0.100)	-0.10(0.106)	-0.10(0.113)
<i>Married</i>	-	-0.10(0.089)	-0.12(0.098)
<i>Lower than high school</i>	-	0.10(0.068)	0.10(0.074)

<i>Age more than 60</i>	-	<i>1.46(0.085)*</i>	<i>1.52(0.097)*</i>
<i>Health</i>	-	<i>0.01(0.004)</i>	<i>0.01(0.004)</i>
<i>Tenure more than 15 years</i>	-	<i>0.08(0.081)</i>	<i>0.74(0.088)</i>
<i>Job Satisfaction</i>	-	<i>-0.13(0.068)***</i>	<i>-0.14(0.074)***</i>
<i>Number of Observations</i>	<i>2111</i>	<i>2111</i>	<i>2111</i>
<i>Likelihood Ratio Test Statistic</i>	<i>2.11</i>	<i>334.02</i>	<i>256.64</i>
<i>Spain</i>			
<i>Constant</i>	<i>-0.62(0.032)*</i>	<i>-0.55(0.085)*</i>	<i>-0.71(0.118)*</i>
<i>Obligations</i>	<i>-0.14(0.072)***</i>	<i>-0.13(0.072)***</i>	<i>-0.12(0.089)</i>
<i>Married</i>	-	<i>-0.17(0.077)**</i>	<i>-0.20(0.107)**</i>
<i>University</i>	-	<i>-0.15(0.075)**</i>	<i>-0.17(0.103)***</i>
<i>Tenure more than 10 years</i>	-	<i>0.15(0.064)**</i>	<i>0.19(0.086)**</i>
<i>Number of Observations</i>	<i>2239</i>	<i>2239</i>	<i>2239</i>
<i>Likelihood Ratio Test Statistic</i>	<i>3.64</i>	<i>16.80</i>	<i>12.01</i>
<i>Portugal</i>			
<i>Constant</i>	<i>-0.34(0.028)*</i>	<i>-0.38(0.113)*</i>	<i>-0.62(0.182)*</i>
<i>Obligations</i>	<i>-0.23(0.084)*</i>	<i>-0.22(0.085)*</i>	<i>-0.24(0.120)**</i>
<i>Married</i>	-	<i>-0.25(0.066)*</i>	<i>-0.38(0.110)*</i>
<i>Lower than high school</i>	-	<i>0.25(0.093)*</i>	<i>0.44(0.148)*</i>
<i>Tenure more than 15 years</i>	-	<i>0.14(0.055)*</i>	<i>0.21(0.090)**</i>
<i>Job Satisfaction</i>	-	<i>-0.21(0.058)*</i>	<i>-0.26(0.081)*</i>
<i>Number of Observations</i>	<i>2416</i>	<i>2416</i>	<i>2416</i>
<i>Likelihood Ratio Test Statistic</i>	<i>7.78</i>	<i>52.78</i>	<i>42.18</i>

Note: *,** and *** represent significance at levels 1, 5 and 10% , respectively. We also tested other variables, such as household size, job status, number of employees in the current job and job sector, but all were strongly non-significant. For the Random Probit Model the presented statistic is not the Likelihood Ratio Test Statistic but the Wald Test Statistic. Standard errors in parenthesis.

TABLE 4.2

Estimation Results – Males

<i>Countries</i>	<i>Probit</i>	<i>Probit</i>	<i>Random Probit</i>
<i>Variables</i>			
France			
<i>Constant</i>	-0.90(0.080)*	-0.78(0.210)*	-0.89(0.263)*
<i>Obligations</i>	-0.20(0.134)	-0.13(0.140)	-0.17(0.165)
<i>Married</i>	-	-0.31(0.170)***	-0.34(0.206)***
<i>Lower than high school</i>	-	0.18(0.137)	0.19(0.165)
<i>Age more than 60</i>	-	1.25(0.264)*	1.30(0.301)*
<i>Health</i>	-	0.02(0.016)	0.02(0.018)
<i>Tenure more than 15 years</i>	-	-0.01(0.138)	-0.01(0.166)
<i>Job Satisfaction</i>	-	-0.15(0.139)	-0.18(0.168)
<i>Number of Observations</i>	543	543	543
<i>Likelihood Ratio Test Statistic</i>	2.15	34.01	26.30
Italy			
<i>Constant</i>	-0.65(0.037)*	-0.94(0.157)*	-0.97(0.172)*
<i>Obligations</i>	-0.24(0.120)**	-0.20(0.129)	-0.20(0.136)
<i>Married</i>	-	-0.10(0.127)	-0.10(0.140)
<i>Lower than high school</i>	-	0.12(0.079)	0.12(0.086)
<i>Age more than 60</i>	-	1.39(0.095)*	1.45(0.110)*
<i>Health</i>	-	0.01(0.004)	0.01(0.005)
<i>Tenure more than 15 years</i>	-	0.09(0.094)	0.08(0.103)
<i>Job Satisfaction</i>	-	-0.15(0.079)***	-0.16(0.086)***
<i>Number of Observations</i>	1515	1515	1515
<i>Likelihood Ratio Test Statistic</i>	4.25	251.41	189.60

Spain			
<i>Constant</i>	-0.62(0.036)*	-0.65(0.121)*	-0.89(0.180)*
<i>Obligations</i>	-0.19(0.084)**	-0.18(0.084)**	-0.20(0.105)**
<i>Married</i>	-	-0.11(0.112)	-0.08(0.166)
<i>University</i>	-	-0.08(0.087)	-0.06(0.123)
<i>Tenure more than 10 years</i>	-	0.18(0.076)**	0.23(0.105)**
<i>Number of Observations</i>	1718	1718	1718
<i>Likelihood Ratio Test Statistic</i>	5.14	12.26	8.82
Portugal			
<i>Constant</i>	-0.30(0.034)*	-0.31(0.161)**	-0.45(0.245)***
<i>Obligations</i>	-0.28(0.106)*	-0.24(0.107)**	-0.24(0.143)***
<i>Married</i>	-	-0.27(0.099)*	-0.37(0.154)**
<i>Lower than high school</i>	-	0.27(0.128)**	0.37(0.191)***
<i>Tenure more than 15 years</i>	-	0.12(0.068)***	0.17(0.107)
<i>Job Satisfaction</i>	-	-0.27(0.070)*	-0.30(0.096)*
<i>Number of Observations</i>	1585	1585	1585
<i>Likelihood Ratio Test Statistic</i>	6.94	40.17	26.48

Note: *,** and *** represent significance at levels 1, 5 and 10% , respectively. We also tested other variables, such as household size, job status, number of employees in the current job and job sector, but all were strongly non-significant. For the Random Probit Model the presented statistic is not the Likelihood Ratio Test Statistic but the Wald Test Statistic. Standard errors in parenthesis.

TABLE 4.3

Estimation Results – Females

Countries	Probit	Probit	Random Probit
<i>Variables</i>			
France			
<i>Constant</i>	-0.75(0.101)*	-0.96(0.208)*	-1.14(0.301)*

<i>Obligations</i>	-0.31(0.186)***	-0.29(0.200)	-0.34(0.252)
<i>Married</i>	-	-0.15(0.193)	-0.20(0.252)
<i>Lower than high school</i>	-	0.27(0.192)	0.33(0.251)
<i>Age more than 60</i>	-	1.33(0.280)*	1.54(0.389)*
<i>Health</i>	-	-0.05(0.054)	-0.06(0.063)
<i>Tenure more than 15 years</i>	-	-0.16(0.187)	-0.15(0.239)
<i>Job Satisfaction</i>	-	0.09(0.184)	0.04(0.239)
<i>Number of Observations</i>	289	289	289
<i>Likelihood Ratio Test Statistic</i>	2.89	37.00	21.43
Italy			
<i>Constant</i>	-0.93(0.064)*	-0.96(0.218)*	-0.96(0.218)*
<i>Obligations</i>	-0.12(0.179)	0.16(0.191)	0.16(0.191)
<i>Married</i>	-	-0.23(0.140)***	-0.23(0.140)***
<i>Lower than high school</i>	-	0.01(0.132)	0.01(0.132)
<i>Age more than 60</i>	-	1.62(0.199)*	1.62(0.199)*
<i>Health</i>	-	-0.01(0.024)	-0.01(0.024)
<i>Tenure more than 15 years</i>	-	0.04(0.161)	0.04(0.161)
<i>Job Satisfaction</i>	-	-0.12(0.141)	-0.12(0.141)
<i>Number of Observations</i>	596	596	596
<i>Likelihood Ratio Test Statistic</i>	0.47	80.94	72.94
Spain			
<i>Constant</i>	-0.59(0.066)*	-0.47(0.131)*	-0.59(0.178)*
<i>Obligations</i>	0.02(0.145)	0.04(0.146)	0.07(0.177)
<i>Married</i>	-	-0.20(0.121)***	-0.26(0.163)
<i>University</i>	-	-0.35(0.155)**	-0.42(0.205)**
<i>Tenure more than 10 years</i>	-	0.11(0.128)	0.19(0.170)
<i>Number of Observations</i>	521	521	521
<i>Likelihood Ratio Test Statistic</i>	0.01	8.83	7.39

<i>Portugal</i>			
<i>Constant</i>	-0.40(0.048)*	-0.44(0.167)*	-0.75(0.298)*
<i>Obligations</i>	-0.15(0.141)	-0.15(0.143)	-0.24(0.216)
<i>Married</i>	-	-0.33(0.096)*	-0.57(0.179)*
<i>Lower than high school</i>	-	0.19(0.137)	0.44(0.245)**
<i>Tenure more than 15 years</i>	-	0.19(0.096)**	0.31(0.174)**
<i>Job Satisfaction</i>	-	-0.09(0.102)	-0.30(0.157)**
<i>Number of Observations</i>	831	831	831
<i>Likelihood Ratio Test Statistic</i>	1.20	20.19	19.73

Note: **, * and *** represent significance at levels 1, 5 and 10% , respectively. We also tested other variables, such as household size, job status, number of employees in the current job and job sector, but all were strongly non-significant. For the Random Probit Model the presented statistic is not the Likelihood Ratio Test Statistic but the Wald Test Statistic. Standard errors in parenthesis.

We can observe from the three models in Table 4.1 that the worker's obligations affect negatively, and in a significant way, the probability of workers from France, Spain and Portugal going to retirement. We obtain a similar result for Italy, although it is statistically non-significant in all three models.

We can also observe from the French and Italian models that the younger the worker is, the less is his probability of retiring and that the family commitment affects negatively, and in a significant way, the probability of workers from France, Spain, Italy and Portugal going to retirement.

From the university and lower than high school variables we can observe that the higher the education level, the lower is the probability of going to retirement. A possible justification for this could be that the lower the worker's education, the more probable it is that we will find him working in a more physically demanding job, a factor that could positively affect his entry into retirement.

The worker's satisfaction with his present job also affects in a negative and significant way the probability of the Portuguese and Italian workers exiting the labor force.

An opposite result gives us the worker's tenure in Italy, Spain and Portugal, demonstrating that the higher the worker tenure, the higher will be his probability of exiting the labor force⁶³.

We can observe from Table 4.2 that the male estimations give us very similar results. The only difference is found in the statistical significance of some variables. On one hand, we can observe an increase in the significance level of some variables, as is the case of the Italian male. On the other hand, we can also see a reduction in the significance level of some variables, as is the case of France and Portugal.

Table 4.3 gives us a different picture. First, we can observe from the estimated models for Italy and Spain that there is an opposite sign for the effect of the workers' obligations over their retirement decisions. However, we can also note from these estimations that all these results are not statistically significant.

Another difference among the female and the other two estimated models is found in the significance levels of some variables. However, and contrary to the previous analysis, we can now see a generalized decrease in the significance levels of some variables of the models.

4.3. Theoretical Model

We saw in the previous section that the greater the worker obligations, the lower will be his probability of going to retirement. In this section we will develop a theoretical model intending to evaluate the aggregate effects of this workers' strategy.

⁶³ We obtain a different signal for France, although it is statistically non-significant.

Suppose that our economy is composed of a constant population of workers who live infinitely and a great number of firms that once together, one by one, give rise to a productive activity. Every worker has the right to go to retirement⁶⁴. Firms and the workers are risk neutral and discount the future at the exogenous and constant rate r . Before the beginning of production, firms and workers are involved in a search process to find a partner, where c represents the cost of the search for the firm. The occupied jobs produce x at each instant of time and can be destroyed due to an idiosyncratic shock that follows a Poisson Process with arrival rate λ . The number of job matches formed per period is given by a non-negative, concave, homogeneous of degree one and increasing in both arguments function $m(v, u)$, where v represents the vacancy rate and u the fraction of unemployed workers in the economy.

The unemployed workers move to an employed situation at a rate $\theta q(\theta)$, while a job vacancy moves towards a filled position according to a rate $q(\theta)$, where θ represents the ratio of v and u .

Each firm has only one job position, which can be empty or occupied, while each worker can be retired (having he decided to go to retirement), unemployed or employed in only one job position per period. Workers can go immediately to retirement or postpone, at no cost, their exit from the labor force. Suppose that this decision depends only on the exogenous level of workers' obligations, o . However, once the worker has decided to retire he cannot return to the labor force.

At each moment there is a change in the worker's obligation, determined from a general distribution $G(o)$, defined in the unit interval. Suppose that o affects positively the value of employment and unemployment and that each firm knows

⁶⁴ Note again that as we are only interested in explaining the flow of workers to retirement, we can see the present model as an analysis of a particular segment of the labor market, where every worker has just earned his right to retire.

neither the level of workers' obligations, considering that they move to retirement at rate φ , nor the effects of obligations over their decision of entry into retirement⁶⁵.

We are therefore considering that there are events that change the level of a worker's dependence on the employed and unemployed conditions, postponing his exit from the labor force, and that the firm does not take this movement into account, considering that workers enter into retirement at a rate φ .

Let S and T represent, respectively, the reservation obligations of the employed and unemployed worker⁶⁶. Suppose that V and J represent both the values of a vacancy and an occupied job to the firm, while U , W and R represent the values of unemployment, employment and retirement to the worker. Accordingly, the value functions for the firm and the worker are given by:

$$(2) \quad rV = -c + q(\theta)[J - V];$$

$$(3) \quad rU = \text{Max}\{z + \theta q(\theta)[W - U]; rR - o\};$$

$$(4) \quad rR = y - dR;$$

$$(5) \quad rW = \text{Max}\{w - \lambda[W - \text{Max}(U, R)]; rR - o\}$$

$$(6) \quad rJ = x - w - \lambda[J - V] - \varphi[J - V];$$

where z represents the unemployment insurance benefits, y the retirement benefits, d the rate that the retired worker leaves this condition and w the worker's wage rate⁶⁷.

⁶⁵ Observe that the right to retire affects positively the employment and unemployment options due to the increase in the worker's outside option that it creates.

⁶⁶ Note that S (T) represents the indifference obligations' level between employment (unemployment) and retirement.

⁶⁷ Note that once in retirement, the only way to abandon this situation is at rate d .

We can see from these expressions and the above assumptions about S and T that the worker evaluates the employment and unemployment options according to his obligations. Thus, whenever $o > S$ ($o > T$) the employed (unemployed) worker postpones his entrance into retirement. In turn, whenever $o \leq S$ ($o \leq T$) the employed (unemployed) worker decides to go to retirement⁶⁸. Note also that once the decision to go to retirement is postponed, the worker remains in the labor force until his obligation is reduced to a value below S or T .

We can also observe from expressions (2), (4) and (6) that they are not affected by the worker's obligation, as the only reason for their presence in the model is to create pressure on the worker's decision to retire, and from (5) that once an idiosyncratic shock occurs, the worker decides whether to go to unemployment or retirement.

Also note from the previous expressions that we are modeling a situation where the worker values differently from the firms, and without knowledge of them, their options. If we eliminate this previous condition, we would have the firm knowing the right rate that the workers leave the labor force, that is, we would have $G(S) = \varphi$.

Accepting the usual hypothesis of free entrance, we have from (2) that

$$(7) \quad J = \frac{c}{q(\theta)}.$$

Thus, there is job creation up to the point where the value of a new job matching equalizes the cost of occupying a vacancy, expressed in terms of the rate that this position becomes occupied.

⁶⁸ See Mortensen and Pissarides (1994) for details.

If the surplus generated by the matching is divided according to the *Generalized Nash Bargaining Solution*, then the wage rate satisfies⁶⁹:

$$(8) \quad \beta[J - V] = (1 - \beta)[W - \text{Max}[U, R]].$$

Using expressions (2) – (8), the wage rate is given by⁷⁰:

$$(9) \quad w = \beta \left[x - \frac{\varphi c}{q(\theta)} \right] + (1 - \beta) \frac{y}{(r + d)}, \text{ if } R \geq U$$

$$w = \beta \left[x + c\theta - \frac{\varphi c}{q(\theta)} \right] + (1 - \beta)z, \text{ if } R < U.$$

Note that they are both composed of two terms. From the first expression, the first term is related to the worker's productivity in his current job and to the expected search cost, given the worker's decision to go to retirement; while the second term is related to the retirement benefits. From the second expression, the first term is related to the worker's productivity in his current job, the average search cost and the expected search cost, given the worker's decision to go to retirement; while the last is related to the unemployment insurance benefits.

Note from both expressions that they do not depend on the worker's obligations, since the firm does not know its effects over the worker's entrance into retirement; that the worker's wage rate diminishes with the right to retire, and that the higher the

⁶⁹ See Binmore, Rubinstein and Wolinsky (1986) concerning the use of Nash Bargaining in job search models. The term β represents the worker's bargaining power.

⁷⁰ Note from (8) that $W = U + \frac{\beta}{(1 - \beta)} J$. Using this expression in the left-hand side of (5), together with (3) and (6), we obtain (9).

probability of the worker's entrance into retirement, in the firms' perspective, the lower will be his wage rate⁷¹.

Note from the first expression that the greater the production generated by the job matching, the retirement benefits, the worker's bargaining power and the lower the market tightness, the higher will be the worker's wage rate.

The wage rate increases with reductions in the market tightness because the firm deducts from the worker's wage rate the effect that his entry into retirement generates to the firm – search costs to find another unemployed worker. The higher the market tightness, the more easily a firm with a vacancy can find an unemployed worker; the lower will be the wage penalization, and the higher will be the worker's wage rate.

Continuing the equilibrium characterization, suppose that:

$$(10) \quad z(o) = z + o \text{ and}$$

$$(11) \quad w(o) = w + o,$$

represent, respectively, the wage and the unemployment benefits compatible with the employed and unemployed worker's obligations.

Using this definition, suppose that (3) and (5) are given by

$$(12) \quad rU(o) = \text{Max}\{z(o) + \theta q(\theta)[W(o) - U(o)]; rR\};$$

$$(13) \quad rW(o) = \text{Max}\{w(o) - \lambda[W(o) - \text{Max}[U(o), R]]; rR\}.$$

Now, as in the indifference levels S and T , we have that:

⁷¹ It is enough to compare the present model with one excluding the right to retire to see this result.

$$(14) \quad W(S) = R,$$

$$(15) \quad U(T) = R,$$

then, evaluating (12) and (13) at T and S , together with the expression (4), we have that:

$$(16) \quad w(S) = \frac{ry}{(d+r)} + \frac{\beta\lambda c}{(1-\beta)q(\theta)},$$

$$(17) \quad z(T) = \frac{ry}{(d+r)} - \frac{\beta c\theta}{(1-\beta)},$$

represent the wage rate and unemployment insurance benefits compatible with the indifference obligation.

Note that expression (16) ((17)) tells us that there is an $w(S)$ ($z(T)$) that makes the worker indifferent between employment and retirement (unemployment and retirement) options.

Note from (16) that the greater are y , r , β , λ and θ , or the less is d , the higher is the wage that the worker wishes to receive, given his obligations, in order to be indifferent between going or not to retirement. In this manner, we can expect that economies with larger retirement benefits, or higher θ , will have a higher flow of workers from employment to retirement⁷². In turn, we have from (17) that the larger are y and r , or the lower are d , θ and β , the greater must be the unemployment insurance benefits to be compatible with the indifference between the unemployment and retirement options.

⁷² Saas (2003) and Eschtruth and Gemus (2002) confirm this result for U.S.

The entry into retirement increases with reductions in the market tightness basically because firms deducts from the worker's wage rate the effect that his entry into retirement generates to the firm – search costs to find another unemployed worker. In this way, the higher is θ , the lower is the incentive to postpone retirement.

Now, as we consider that in indifference the worker decides to go to retirement, then whenever the wage rate and the unemployment benefits compatible with his obligations are given by (16) and (17), the employed and unemployed worker will leave the labor force. In turn, if the wage rate (unemployment insurance benefits) compatible with his obligations is higher than $w(S)$ ($z(T)$), we will have the worker postponing his entry into retirement.

Proposition 1 It is necessary that $y > z(o)$, in order to have flows of workers from unemployment to retirement. In turn, it is not necessary that $y > w(o)$ to have flows of workers from employment to retirement.

Proof. We need only to use (16) and (17) and consider a general level of obligations to demonstrate proposition 1. ■

The previous proposition tells us that it is necessary to compensate the unemployed worker, apart from the term related to the unemployment insurance benefits, with an amount related to the gains that the unemployed worker obtains when finding a new vacancy and moving into an employed status, for there to be a flow of workers from unemployment to retirement. Thus, if the unemployed worker is not correctly compensated, he will not be motivated to exercise his right to retire.

The same cannot be said about the employed worker because even when reducing his retirement pension to an amount below $w(o)$, it still may not be enough to eliminate the flow of workers from employment to retirement.

Having determined the entry into retirement dynamics, given worker's obligations, we will now see the optimal job creation rule. From expression (6), we have that:

$$(18) \quad [r + \lambda + \varphi] \frac{c}{q(\theta)} = x - w.$$

In this we have that the higher is the rate that the worker goes to retirement (in the firm's perspective), the lower will be the rate of job creation; and that the older is the labor force (closer to obtain the right to retirement), the lower will be the job creation dynamics⁷³. Note also that the higher are r , λ , c and x , or the lower is w , the lower will be the job creation rate.

Another thing that we can observe is that if φ is higher than the rate at which the worker effectively requests his right to retire, the right to retire drives a reduction in the job creation flow when compared to the model where $G(S) = \varphi$. Thus, the ignorance of the exact rate whereby the worker goes to retirement could severely penalize the job creation dynamics.

Now, supposing that b measures the rate at which workers enter into the labor force⁷⁴, the unemployment rate dynamic is given by:

⁷³ As before, it is enough to compare the model with one excluding the right to retire to see this result.

⁷⁴ As the present model considers only workers with the right to retire, we could see b as the rate at which an unemployed worker receives his right to retire, accounting for the unemployment rate in our model.

$$(19) \quad \dot{u} = \lambda[1-G(T)](1-u-a) + b - \theta q(\theta)u - G(T)u,$$

where the first term on the right-hand side represents the flow of workers who move to unemployment due to the idiosyncratic shock, the second term represents the number of workers who enter the labor market via unemployment, the third term represents the number of unemployed workers who move to the employment condition, and the last gives us the number of unemployed workers who move to retirement.

Now, as in the steady rate $\dot{u} = 0$, then:

$$(20) \quad u = \frac{\lambda[1-G(T)](1-a) + b}{\lambda[1-G(T)] + \theta q(\theta) + G(T)},$$

represents the equilibrium unemployment rate.

Note that if the number of new unemployed workers rises or if the probability of the unemployed workers going into retirement falls, the result will be an increase in the equilibrium unemployment rate.

The idea behind this latter effect is that the lower is T , the greater is the probability of an unemployed worker not to request his right to retire, increasing the unemployment rate. In turn, the higher is the market tightness or the retirement rate, the lower will be the unemployment equilibrium rate.

Continuing the equilibrium characterization, we have that:

$$(21) \quad \dot{a} = G(T)u + G(S)(1-u-a) - da + \lambda G(T)(1-u-a),$$

is the expression that determines the equilibrium rate of retirement. The first term on the right-hand side gives us the number of unemployed workers going to retirement, the second gives us the number of employed workers who decide to go to retirement, the third represents the number of retired workers who leave this status and the last represents the number of workers who move to retirement due to the idiosyncratic shock.

Considering also the steady state condition, we have that:

$$(22) \quad a = \frac{[G(S) + \lambda G(T)] + u[(1 - \lambda)G(T) - G(S)]}{G(S) + d + \lambda G(T)},$$

gives us the equilibrium retirement rate.

We can observe from this expression that whenever $G(S) > (1 - \lambda)G(T)$ the increase in the equilibrium unemployment rate comes with a decrease in the retirement rate. In turn, if $G(S) < (1 - \lambda)G(T)$, we will have the opposite effect.

Increases in $G(S)$ will be followed by an increase in the retirement rate if $(1 - u)d > uG(T)$, while if $(1 - u)d < uG(T)$, we will have the opposite effect. In turn, increases in d and decreases in $G(T)$ will be accompanied by reductions in a .

Proposition 2 The job creation condition (18) and the job destruction condition (16) uniquely determine the equilibrium values of θ and $w(S)$.

Proof. As the job destruction condition is increasing in $\theta - w(S)$ space, while the job creation condition does not depend on $w(S)$, the equilibrium exists and is unique.

Knowing the equilibrium values of θ and $w(S)$, expressions (9), (17), (20) and (22) determine the equilibrium values of w , $z(T)$, u and a . ■

Now, note that the main characteristics of the model are obtained from the expressions that determine the job creation and job destruction dynamics, the unemployment and the retirement rate. An increase in the retirement benefit, for example, will be followed by increases in $w(S)$, $z(T)$ and no changes in the job creation dynamics. Now, as $G(S)$ and $G(T)$ increase, the overall effect over unemployment and retirement rates will depend on the magnitude of these two movements.

Note also that increases in φ come with reductions in θ . Now, as θ decreases we will again have two effects acting over the unemployment and retirement rates. On one hand, the reduction in $w(S)$ comes with a reduction in a , due to the lower employed entrance rate into retirement, and an increase in u . But on the other hand, the increases in $z(T)$ come with an increase in a , due to the higher unemployed entrance rate into retirement, and a reduction in u . The overall effect will depend on these two opposite effects.

4.4. Conclusions

The goal of this chapter was to study the effects of higher obligations level over the optimal entrance of workers into retirement.

We saw, in a search frictions environment, that the worker's wage rate diminishes with the right to retire. We also saw that the retirement pension should be higher than the unemployment benefits in order to have workers going from unemployment to retirement, while it is not necessary that this be higher than the wage rate to have

flows of workers from employment to retirement. We also showed that that the easier it is to obtain the right to retire (and exit from the labor force), the lower will be the wage rate and the job creation flow dynamics. Finally, we also estimated the effects of a worker's obligations over his probability of continuing in the labor force, confirming the basic hypothesis proposed by the model.

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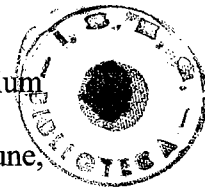
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4.6. Annex

TABLE 4.4

Description of Variables

<i>Retirement</i>	<i>Variable that takes value 1 if the worker decides to retire in the next period and 0 otherwise;</i>
<i>Obligations</i>	<i>Variable that takes value 1 if any member of the household is currently paying any debt and 0 otherwise;</i>
<i>Age more than 60</i>	<i>Variable that takes value 1 if the worker is more than 60 years old and 0 otherwise;</i>
<i>Married</i>	<i>Variable that takes value 1 if the worker is married and 0 otherwise;</i>
<i>University</i>	<i>Variable that equals 1 if the worker has finished a third level education and 0 otherwise;</i>
<i>Lower than high school</i>	<i>Variable that equals 1 if the worker has finished less than the second stage of secondary education and 0 otherwise;</i>
<i>Job Satisfaction</i>	<i>Variable that equals 1 if the worker is satisfied with his job and 0 if not satisfied;</i>
<i>Tenure more than 10 years</i>	<i>Variable that equals 1 if the worker has tenure of more than 10 years and 0 if not;</i>
<i>Tenure more than 15 years</i>	<i>Variable that equals 1 if the worker has tenure of more than 15 years and 0 if not;</i>
<i>Male</i>	<i>Variable that equals 1 if the worker is male and 0 otherwise;</i>
<i>Health</i>	<i>Number of nights spent in hospital in 12 months prior to retirement.</i>

TABLE 4.5
Summary Statistics

<i>Variable</i>	<i>Mean</i>	<i>Standard Error</i>
Portugal		
<i>Retirement</i>	0.36	0.47
<i>Obligations</i>	0.12	0.32
<i>Age more than 60</i>	0.33	0.47
<i>Married</i>	0.81	0.39
<i>University</i>	0.06	0.25
<i>Lower than high school</i>	0.90	0.30
<i>Job Satisfaction</i>	0.33	0.47
<i>Tenure more than 10 years</i>	0.72	0.45
<i>Tenure more than 15 years</i>	0.64	0.48
<i>Male</i>	0.65	0.47
<i>Health</i>	0.52	5.22
Spain		
<i>Retirement</i>	0.26	0.44
<i>Obligations</i>	0.21	0.40
<i>Age more than 60</i>	0.21	0.41
<i>Married</i>	0.84	0.36
<i>University</i>	0.19	0.39
<i>Lower than high school</i>	0.72	0.45
<i>Job Satisfaction</i>	0.37	0.48
<i>Tenure more than 10 years</i>	0.70	0.46
<i>Tenure more than 15 years</i>	0.64	0.48
<i>Male</i>	0.77	0.42
<i>Health</i>	0.84	4.98
France		
<i>Retirement</i>	0.18	0.38

<i>Obligations</i>	0.37	0.48
<i>Age more than 60</i>	0.07	0.25
<i>Married</i>	0.75	0.43
<i>University</i>	0.16	0.37
<i>Lower than high school</i>	0.47	0.50
<i>Job Satisfaction</i>	0.45	0.50
<i>Tenure more than 10 years</i>	0.65	0.48
<i>Tenure more than 15 years</i>	0.56	0.50
<i>Male</i>	0.65	0.48
<i>Health</i>	0.76	4.26
Italy		
<i>Retirement</i>	0.23	0.42
<i>Obligations</i>	0.11	0.31
<i>Age more than 60</i>	0.14	0.34
<i>Married</i>	0.85	0.35
<i>University</i>	0.12	0.32
<i>Lower than high school</i>	0.59	0.49
<i>Job Satisfaction</i>	0.37	0.48
<i>Tenure more than 10 years</i>	0.83	0.37
<i>Tenure more than 15 years</i>	0.79	0.41
<i>Male</i>	0.72	0.45
<i>Health</i>	1.27	7.29