Human Resources Practices in Portuguese IT firms

Evidence on compensation policies

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Thesis to obtain the Master of Science Degree in

Industrial Engineering and Management

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November 2017

Agradecimentos

Aos meus orientadores, Professor Francisco Lima e Professor António Sérgio Ribeiro, que foram fundamentais para a conceção e qualidade desta Dissertação. Um grande agradecimento pelo auxílio, paciência, disponibilidade e motivação para finalizar esta etapa académica.

Aos membros do Júri, Professor Rui Baptista e Professor António Miguel Amaral, pelas sugestões apresentadas aquando a correção do Projeto.

Um obrigada imprescindível à minha mãe, Paula Dias, que esteve sempre disponível nos momentos de maior ansiedade e incerteza. Sem o seu contínuo incentivo e estímulo não teria sido possível a realização deste trabalho. Um agradecimento ao resto da minha família, pai e irmão, pela confiança atribuída e por me proporcionarem a oportunidade de estudar em Lisboa.

À minha avó, Augusta, um agradecimento especial pela inabalável fé que sempre depositou em mim.

À Inês e à Joana por toda a ajuda prestada, pelas palavras e apoio emocional nas alturas mais críticas.

Abstract

The growing demand for Information Technology (IT) products and processes has led to the rapid expansion of the IT sector. The implications for employment patterns raises the interest to investigate the human resource practices followed by firms in this sector. Thus, the dissertation aims to analyze the IT sector in Portugal from 2008 to 2012, using information provided by *Quadros de Pessoal.* Namely, it intends to explore the compensation policies applied by IT firms by estimating wage equations as a function of industry, firms and worker characteristics. The results suggest a positive relation between wages and education, tenure and firm size. There is evidence of a wage premium for a higher education in IT fields, and for IT related occupations. A higher level in the hierarchy is positively related with a reward in compensation, linked to an internal promotional system. A managerial-oriented career entails a compensation premium against employees technically-oriented. The interaction of job level and education leads to conclude that a degree in a course in IT fields does not translated directly into an immediate advantage for the highest level of job pyramid. Tenure and its interaction with education and occupation are strong features related to higher compensations, what is an evidence of an internal labor market playing its role in the IT sector.

Key words: management of IT human resources, compensation policies, multiple regression, fixed-effects

Resumo

São cada vez mais os trabalhadores portugueses a apostar no setor das Tecnologias da Informação (TI) como saída profissional devido à crescente procura de produtos e serviços ligados ao setor, assim sendo cresce o interesse em estudar as práticas de recursos humanos nas empresas deste setor.

Esta dissertação tem como objetivo estudar o setor das TI em Portugal durante os anos de 2008 a 2012, utilizando para isso a informação presente na base de dados Quadros de Pessoal. Nomeadamente pretende averiguar quais as políticas de compensação que são aplicadas pelas empresas de TI. Para tal, utiliza modelos econométricos que procuraram estudar a remuneração mensal em função de caraterísticas do trabalhador (capital humano) e da empresa

Os resultados sugerem uma relação positiva entre uma remuneração mais elevada e um maior nível de escolaridade, antiguidade e dimensão da empresa. Existe também evidência de um prémio salarial quando estamos perante educação superior em cursos da área das TI, e para profissões especificamente ligadas a esta área. Um nível mais elevado na hierarquia da empresa parece ter um efeito positivo no salário, possivelmente ligado a um sistema interno de promoções. Os trabalhadores com uma carreira mais orientada para a gestão apresentam um prémio salarial relativamente a trabalhadores com uma carreira mais técnica.

Da interação entre a posição na hierarquia da empresa e a educação conclui-se que uma educação especializada em TI não é diretamente traduzida numa vantagem salarial imediata para os trabalhadores no topo da hierarquia. A antiguidade e a sua interação com a educação e com a profissão é fortemente relacionada com benefícios salariais, o que evidencia o papel de um mercado interno laboral sobre o setor das TI em Portugal.

Palavras chave: gestão de recursos humanos de TI, políticas de compensação, regressão múltipla, modelo dos efeitos fixos

Table of Contents

List of Abbreviations

CAE	*Classificação da Atividade Económica*
CIO	Chief Information Officer
CPP	*Código Português de Profissões*
ELM	External Labor Market
ICT	Information and Communications Technology
ILM	Internal Labor Market
IS	Information System
ISCED	International Standard Classification of Education
ISCO	International Standard Classification of Occupations
ISIC	International Standard Industry Classification of All Economic Activities
IT	Information Technology
HR	Human Resources
HRM	Human Resources Management
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
RBV	Resource-Based View
QP	*Quadros de Pessoal*

List of Figures

List of Tables

1. Introduction

Information Technology (IT) is changing the means of operation and the employment patterns of the various industries throughout the world. It impact cannot be ignored and in response to the growing demand for IT products and processes, employment in the IT industry increased rapidly, especially in the computer and data processing subsector. Consequently, having a pool of specialized workers in the development, installation and supply of IT is a critical factor and that can be decisive in the achievement of competitive advantage by a firm, an industry or even a country. In Europe, contrary to the rest of workforce, IT specialists has resisted the effects of the downturn and of uncertainty on global labor markets during the economic crisis. The IT employment showed an average growth rate of 3% since 2006, that was eight times higher than the average growth rate for total employment over the same period, according to Eurostat data. This behavior raises the interest of researchers namely in human resources management field.

There is agreement that the effective utilization of IT depends on the availability of IT professionals to plan for, develop, maintain, and integrate information systems applications. Since last century important shifts in labor demand have chosen individuals skilled and with higher levels of education (Autor, Katz and Krueger, 1998). Demand has migrated from occupations with low and middle salaries and no skills to rewarded jobs, requiring capabilities, training, superior knowledge or management skills. It eventually became a driver that led workers to acquire new skills and competencies to meet demand.

1.1. Context and problem definiton

Information technology is considered a new type of economic activity and there are still many doubts about its classification by economic organizations as OECD, which constantly adapts the IT activities spectrum. It is also a sector that is able to generate profit quickly and to present a positive balance in generation of employment against periods of economic depression. In Portugal, little is known about this sector and about its workforce. Literature on salary structure of IT companies is also scarce. Thus, this work arises from the lack of information on this topic, aiming to contribute to a better understanding of IT as an economic activity that presents characteristics in terms of wages different from those observed in other sectors in Portugal.

The dissertation uses *Quadros de Pessoal* data to examine human resources practices in Information Technology firms in Portugal. The goals are to investigate human capital factors influencing the definition of compensation policies, analyzing variables as tenure, education, job levels and occupations. It intends to explore how time of proficiency and schooling background are awarded, and inquire whether managerially-oriented employees earn a higher wage than technically-oriented employees. Explore the features of firms as dimension and industry, and the relation with pay. The study inspects the specific

IT abilities, looking into the workforce with academic degrees in information technologies careers and for who perform tasks directly related with IT field, and examine the wage premium.

The dissertation aims to review the existing literature in information systems, characteristics of its human resources and common practices applied to these professionals. Furthermore, the work intends to estimate wage regressions in Portuguese IT firms as a function of firms' personnel features provided by *Quadros de Pessoal*.

1.2. Organization of chapters

The dissertation contains six chapters. The Introduction contextualizes the topic that will be addressed and clarifies the motivation for the study, describes the problem and objectives. Chapter 2 provides a theoretical framework, discussing the main concepts and theories related with labor markets and personnel practices. Chapter 3 presents the dataset's structure and explains the research methodology developed in the dissertation. The descriptive analysis in chapter 4 discusses the evolution of firms' and employees' features aiming to provide a holistic view on sector under study. Chapter 5 characterize the salary structure of the sector, using wage regressions to inspect firms' compensation policies. The final chapter contains meaningful conclusions and recommendations for future research.

2. Theoretical Framework

This dissertation being conceived in the context of personnel practices, begins by introducing the concept of labor market, with special focus on internal labor market. Next, we define the industry that will be study, the IT sector, and discusses one theory in the field of strategic management, the Resource-Based View. This perspective is one of the most used in study the value of information technologies and bridges the management of human capital linked to the sector. The chapter is finalized with the human resources practices specific to IT employees.

2.1. Labor Markets

2.1.1. Internal and External Labor Markets

Labor markets establish the interaction between a worker and an employer through an exchange of skills from the first, for wages or other forms of compensation from the second. In a microeconomic perspective, as other markets, labor markets are a function of supply (workforce) and demand (employers) where the price of labor is negotiated. A point of equilibrium in the function assumes an agreement between the workers and the employer, resulting in an employment relationship, where its duration depends on the costs involved. A disequilibrium between supply and demand, for instance an excess supply and lack of demand leads to a situation of lower wages and less employment.

The existence of an organization assumes a delimitation between the inside or interior of the organization and the outside or external environment. As Doeringer and Piore (1971) explains, within the organization exists the Internal Labor Market (ILM) where a set of administrative rules and procedures govern the pricing and allocation of labor. Outside the organization there is a market which follows the actual economic trends, where wages payed and the allocation of jobs are controlled by economic variables. This is known as the External Labor Market (ELM).

Connecting the two markets, ILM and ELM, are ports of entry and exit. This concept refers to jobs that each organization uses to hire employees from ELM (entry-level) and the jobs which normally are related with career end of the worker (exit-level). Once within the organization, an employee can start her journey along the job ladder and she is no longer affected by variations in economy, neither from direct competitors in the ELM. The fluidity of labor markets is a necessary condition for competition to prevail. This ensures workers' mobility across firms who would otherwise be subject to exploitation by the firm that employs them (Lazear and Oyer, 2004).

Baker et al. (1994) collected twenty years of personnel data from one firm located in USA. They find evidence of an internal labor market, however not in the way predicted from the theory suggested by Doeringer and Piore (1971) in their pioneer work. The study of Baker and Gibbs allows them to infer the hierarchical structure of the firm, verify the tenure of an employee inside the firm and supports that firms learn about employees' abilities during their careers. The researchers do not find evidence of ports of entry or exit, occurring significant entry in all jobs and all levels in the firm. Also the study did not support the idea of Doeringer and Piore (1971) that wages were attached to jobs, but showed the importance of job levels as determinants of wage.

Analyzing data from Sweden, Lazear and Oyer (2004) find that labor markets are fluid in terms of entry and exit and wage determination. A significant fraction of positions are filled by workers from the outside even if, upper in the hierarchical level, the number of insider promotions increases; and the majority of factors that determine the wage are exogenous to the firm, being the salaries regulated by general market conditions. They concluded that external labor markets were prevalent and forceful in that country.

In their work, Doeringer and Piore (1971) established three major factors that generate an ILM: skill specificity, on-the-job training, and customary law.

Skill specificity is related to how skills can be utilized within different ILM – general skills – or, instead, the set of skills just applied in a single enterprise – specific skills. The specificity of a skill increases the cost for the employer when providing it to employees. In other way, how much specific skilled workers stay, lower are the probabilities to abandon the organization. Skill specificity is provided by a training process. The specificity of a job is defined by its skill content. Hence, a completely specific job utilizes specific skills and a more general job use general skills. The specificity also applies to technology in the same way it applies to jobs.

On-the-job training is the process of development and enhancement of workers' skills throughout their career within the firm. Depending on the complexity of the task, job training can consist in a job demonstration, in a role of assistant by the trainee or a promotion ladder, in which the work on lower-level jobs develops the skills required for the higher level. On-the-job training can be less costly than formal instruction because it is derived from the context of the job itself, where the trainee learns about the required skills. Nevertheless, the process frequently involves waste of material, machine damage, reduction in product quality, and sacrifices in productivity of both the trainee and the instructor. On-the-job training is closely related with skill specificity once specificity tends to promote this type of training by reducing the number of employees learning a particular skill at a given time. The worker cannot use the human capital acquired through specific training in other firm because it is firm-specific. So she is incentivized to stay on and to follow a career within the firm, pursuing job security and structured promotions.

Customary law can be defined as a set of unwritten rules based upon past or precedent practices, which govern any aspect of the work relationship from discipline to compensation. The custom influences the rules of wage determination and allocation of labor through a strict upholding of rules. Custom at workplace are responsible for the formation of social groups or communities within the internal labor market, and are determinant in the employment stability. In that way, internal markets may be especially effective in training because they become social institutions. Part of the skills and conducts that are needed to achieve a successful job performance are group customs, and they are achieved and developed by the social cohesion and group pressure which administers customary law.

Before considering the existence of an ILM in Information Technology firms it is important to emphasize that the utility of the ILM, as an analytical construction, does not depend on the existence of administrative rules. It depends rather upon on the rigidity of the rules which define the boundaries of internal markets and which govern pricing and allocation with them (Doeringer and Piore, 1971). If the rules are not rigidly applied, the economic independency of the internal market is minimal and the internal market is affected by changes in the external economic conditions. With rigid rules the internal market will respond to dynamic economic events in a manner not predicted from conventional economic theory.

2.1.2. Internal Labor Markets: industrial and craft

According to Doeringer and Piore (1971), there are two types of ILM: enterprise and craft. Based on the work of these scholars, Osterman (1982) proposes four models of internal labor markets as industrial, salaried, craft and secondary. Briefly:

- Industrial model assumes that work is organized into a series of defined jobs, clear work and responsibilities rules assigned to each classification, wages are attached to the jobs, seniority limits promotions, and no overall job security is guarantee (layoff can take place at any time);
- The salaried model accepts flexible personnel procedures in order to provide employment security through commitment of employees with employer (Osterman, 1987). It assumes flexible career lines and job descriptions, personal considerations in wage setting and employment security (lifetime employment with the firm);
- In craft model workers have more market power and greater mobility, and they are more loyal to the skill or profession than to the firm, skills acquired are not firm specific but occupation specific, and jobs do not suppose lengthy job ladders;
- The secondary model contains the jobs with no perspective of future career where usually the workers are low skilled and poorly paid (Osterman, 1987).

This theoretical framework only uses the distinction between industrial model and craft model given that they are the most representative models. The classification into industrial or craft ILM strategies depends on certain jobs attributes and on entry features (Ang and Slaughter, 2004). Jobs attributes falls in education requirements, length of time required for average proficiency skill specificity, importance of personality and merit in promotion, and extent of control (Osterman, 1984). The level of job attributes must be higher in industrial ILM than in craft model (Ang and Slaughter, 2004).
In terms of entry features:

- industrial ILM possess a limited number of ports of entry allocated to a job classification; career progression occurs along a marked job ladder; there are well-defined procedures and company norms administrate job security rules; it exists a set of skills and knowledge that are specific to the organization (and which are not initially available in the workforce); training is provided by the organization (firm specific knowledge); interorganizational mobility is difficult because the entry-level is constrained; there is a great mobility inside organization, once there are few jobs which constitutes entry barriers to internal employees; the hiring standards (controlled by the manager) vary with the tightness of the labor market, so the openness of enterprise markets vary with labor market conditions;
- in craft model, most job classifications constitute a port of entry from the ELM so the internal mobility in this type of market is infrequent, but the interorganizational mobility is easier than under industrial context; craft ILM prefers training workers with similar qualifications who can be hired from ELM or promoted internally; the goal is to form a homogeneous group in terms of qualities/skills; the hiring criteria does not vary with market conditions.

2.2. Information Technology: firms and management strategies

2.2.1. Information Technology sector

Information Technology (IT) is a category of Information and Communications Technology (ICT) (Zuppo, 2012) where the latter is defined by all the technologies used by people and organizations that allow access, processing and communication of information (Zhang et al., 2008). IT being a subset of ICT, comprises the systems that support information processing but where telecommunications technology is excluded.

Since 1998 the Organization for Economic Co-operation and Development (OECD) has been trying to define the ICT sector based on the existing industry. The Organization supporting itself on Revision applied – Rev. 3.1 in 1998 – of International Standard Industry Classification of All Economic Activities (ISIC). The latter should have combined manufacturing and services industries whose products capture, transmit or display data and information electronically. After a definition of ICT goods in 2003 and ICT services in 2006, a new revision process of ICT sector was made in 2006 based on ISIC Rev. 4. From the latter, the definition in use to identify ICT economic activities (industries) is:
"The production (goods and services) of a candidate industry must primarily be intended to fulfil or enable the function of information processing and communication by electronic means, including transmission and display" (OECD, 2007).

The principle above encompasses ICT manufacturing, trade and services industries based on ISIC Rev. 4, the one currently in force. The codes of each group can be consulted in table 3.2 of Chapter 3.
Even today, there is no consensus about the spectrum of ICT activities. The trouble lies on difficulty to classify a fast-changing sector that are evolving on an almost daily basis. The OECD recommend a

future revision of the actual definition when a new ISIC Revision takes place. In Portugal, the taxonomy in practice is *Classificação Portuguesa das Atividades Económicas (CAE).*

Concerning employment and skill specificity of ICT professional, defined by OECD in 2004, employment is distinguished between ICT sector employment – “defined as employment in industries traditionally defined as belonging to the ICT sector (all occupations, even those with no use of ICTs” (OECD, 2015) – and ICT skilled employment – “defined as employment in occupations that use ICT to various degrees across all industries” (OECD, 2015). Into ICT skilled employment we can find ICT basic users, advanced users and specialists. While the users enable propagations of innovational technologies across all economic sectors, ICT specialists are “workers who have the ability to develop, operate and maintain ICT systems, and for whom ICT constitute the main part of their job”.

The classification of ICT specialist by International Standard Classification of Occupations (ISCO), in force 2008 version, ISCO-08, until 2015 contain the codes *133 ICT service managers*, *25 information and communications technologies professionals*, *35 information and communications technicians* and other isolated codes that can be consulted in table 3.6 in Chapter 3. Some countries, Portugal included, do not report occupations with ISCO-08 codes which generates missing data. Between several proposals to mitigate the loss of information, the one used in this dissertation is based on the combination of occupations and educations taxonomies. Here we apply *Código Português de Profissões* (CPP), the Portuguese taxonomy equivalent to ISCO, and *Habilitações Literárias* codes defined in *Quadros de Pessoal (QP)* the survey where our data came, equivalent to International Standard Classification of Education (ISCED) levels.

The Portuguese taxonomies applied over this work are specified in Chapter 3: Data and Research Methodology.

From here it came a market associated with IT, established by industries including electronics, software, internet, computer hardware, semiconductors, engineering, healthcare, e-commerce and computer services (Chandler and Munday, 2012). As examples of IT firms there are Apple, Amazon, IBM and Accenture among many others.

The functions developed by IT workers involve technical activities as software development and installation and network administration, and managerial activities like planning and management of an organization’s technology resources and services.

2.2.2. Strategic Management of IT in firms

Most of the reviewed literature does not directly address companies with economic activity in information technology. It focuses mainly on the application of information technologies (as an artifact and as capabilities) to firms and relates the IT business value to company performance (Melville, 2004).

Nonetheless, firms classified as IT are rich in acquiring IT as an artifact and in providing services related to IT, so it is pertinent to approach in this theoretical framework the IT business value.

The purpose of strategic management is to understand the sources that provide sustained competitive advantage for firms (Porter, 1980; 1985). These sources must be valuable for the firms and difficult to acquire by competitors. IT was identified as one possible source in creating competitive and sustainable advantage (Clemons, 1986; Feeny and Ives, 1990; Barney, 1991).

The most used theory that establishes a link between IT and sustained competitive advantage is the Resource-Based View (RBV). The theory formulated an approach where the capacity to use IT to empower the fundamental resource advantages of firms enables IT to be a likely source of sustained competitive advantage (Mata et al., 1995).

2.2.3. Resource-Based View theory applied to IT

The RBV is a widely-used theory which states that to reach success, an organization needs to develop resources that provides a sustainable and competitive advantage. RBV allows to analyze the efficiency and competitive advantage implications of specific firm resources like entrepreneurship, culture, organizational routines and also IT. To provide a sustainable and competitive advantage the resources must be valuable, rare, difficult to imitate and irreplaceable (Barney, 1991). This is often mentioned as RBV of a firm.

Researches made by Makadok (2001) and Grant (1991) suggest that firms create competitive advantage by assembling the resources in order to create organizational capabilities. These firm-specific capabilities incorporated in organizational processes are responsible for increase economic returns, beating their rivals because the firm is more effective than other firms in implementing resources (Makadok, 2001). Following researches in Information Systems adopted this capability notion of resources establishing a connection between the value of IT resources and the value of IT capabilities.[1] Information System (IS) scholars argue that rivals can easily replicate investments in IT resources (purchase the same software for instance) so resources by themselves are not a source of sustained competitive advantage. Rather firms should use their IT resources to leverage IT investments and create unique IT capabilities that will impact positively the firm's performance.

Hence RBV theory of a firm, in the IT context, is capable to explain how IT may be associated with competitive advantage and some Information Systems researchers begun to employ the resource-based perspective to increase and deepen the understanding IT business value (Bharadwaj, 2000; Santhanam and Hartono, 2003).

[1] Information Systems (IS) are the software and hardware systems that supports data-intensive applications; they are the IT used by an organization, and it is through IS that people interact with technologies that supports the business processes.

The empirical study of Bharadwaj (2000) tested the relationship between the performance of a firm and their IT capability by comparing the financial performance of IT firms. Her study supports the argument that those firms that develop an effective IT capability are able to achieve a better financial performance, compared to those that do not develop an effective IT capability. Santhanam and Hartono (2003) replicated her results proving the robustness of previous RBV framework, and extend it by showing that IT indeed has a sustained impact on firm performance. Moreover, their results suggest that returns provided by IT capabilities should be maximized over several periods of time consistent with RBV.

The resources of the firm can be seen as capital, and distinguishable between physical, human or organizational capital (Barney, 1991). The first two contain components of IT resources: organizational capital is related with social structures of the firm and it will not be analyzed below; physical capital resources are related to plant, equipment facilities location, raw materials, physical technologies of which the technological IT resources are part.

Human capital resources comprise the training, experience, relationships and insight of firm's employees (Barney, 1991). They are named human IT resources for IT sector specifically and has two dimension (Capon and Glazer, 1987; Copeland and McKenney, 1988): technical IT skills – programming, systems analysis and design, competencies in emergent technologies – and managerial IT skills – abilities such as effective management of IT functions, coordination and interaction with user community, and project management and leadership skills.

Mata et al. (1995) study, through RBV lens, how information technologies in a firm provide sustained competitive advantage. The researchers concluded that only IT managerial skills may provide sustained competitive advantage. It is the ability of IT managers to manage the different employees of the firm and to work with managers of other firms that draw the difference between firms that create sustained competitive advantage and those that do not. Mata et al. (1995) states that technical skills are responsible for a firm to gain competitive parity in IT, but by themselves they just can provide temporary competitive advantage. Nonetheless managerial IT skills can only be used to leverage a firm's technical IT skills if the latter exists in firm.

Also considering RBV theory, Bharadwaj (2000) finds that IT capabilities are positively related to firm performance and relates these capabilities with human IT resources. According to the author, firms with solid human IT resources are able to:

- integrate the IT and business planning process more effectively,
- conceive and develop reliable and cost effective applications that support the business needs of the firm faster than competitors,
- communicate and work with business units more efficiently,
- anticipate future business needs of the firm and innovative valuable new products features before competitors.

The RBV of a firm suggests for IT sector the search for resources of sustainable competitive advantage must pay more attention on the process of organizing and managing IT within a firm and focus less on technical IT component (Mata et al., 1995).

Melvile et al. (2004) compiles much of the theoretical framework developed for IT resources-based view of firms. The author proposes an integrative model of IT business value that is based first on RBV theory and then on microeconomics assumptions. He finds that IT is valuable – the locus of IT business value generation is the organization that invests in and deploys IT resources – but the extension and dimension are limited by complementary organizational resources and by the competitive macro environment. When adopting a strategy, a firm must be conscious that there are many environmental factors that could affect that strategy. There are external environmental factors such as politic, economic, legal and social trends, as well internal environmental factors as technology, business model and workforce characteristics.

From the understanding conveyed by the RBV of a firm, it is possible to perceive the importance given to human IT resources in providing the firm with sustained competitive advantage. These capabilities, which are mostly organization-specific and difficult to duplicate once they are concerned with the individual knowledge and experience of an employee, suggest that a correct management of the workforce is a source of competitive advantage, allowing a firm to achieve its goals (Barney, 1991). The concept of Human Resources Management (HRM) enters here as the firm's strategic approach, responsible for managing the workforce while dealing with specific personnel practices and policies such as recruitment, promotion, remuneration, incentives, training and administration. The Strategic Human Resources Management is a proactive approach of HRM, where the planning of policies and practices of human resources come as the process of best aligning the needs of workers with the firm's strategic goals, maximizing the productivity by optimizing the effectiveness of its employees. These theme, specially applied to IT employees, is discussed later in this chapter.

2.3. Human IT Resources

Making a bridge from the firm's RBV perspective, the importance of human capital, and the internal labor market, an IT firm can adopt different ILM strategies to manage their different oriented type of workers (technical and managerial).

In the context of IT firms, Igbaria et al. (1991) states that IT professionals can follow a managerial-oriented career or a technical-oriented career. The data from Igbaria et al. (1991) suggest three cluster of positions within Management Information Systems professionals:

1. *technically oriented systems programmers, applications programmers and software engineers;*
2. *managerially oriented computer managers, systems analysts and project leaders;*
3. *technically or managerially oriented consultants.*

Ang and Slaughter (2004) replicate the results of Igbaria et al. (2011), and obtain two clusters solutions where one of the clusters contains managerial-oriented IT jobs and the other contains technically-oriented IT jobs. They extended their knowledge about IT human capital and established a link with the ILM models – industrial and craft – based on entry features and job attributes. The authors concluded that managerial-oriented IT jobs follow an industrial ILM strategy and technical-oriented IT jobs follow a craft ILM strategy. The authors also obtain two clusters related with exit features which indicate that turnover rate and expected tenure are significantly different between the two clusters. Managerial-oriented IT jobs have lower turnover and higher expected tenure while technical jobs behave in opposite way, higher turnover and lower expected tenure.

The IT professionals who are more management-oriented should take an industrial strategy. They possess a high level of organizational specific knowledge and are characterized by high requirement for education, length of time for proficiency, level of skill specificity, importance of personality, merit and extent of control. Usually this kind of workers are promoted from within the organization to occupy high responsibility positions (O'Bryen and Pick, 1995).

The IT professional that are more technical-oriented should follow a craft strategy, since they require less organization specific skills and have lower required levels of education, length of time for proficiency and extent of control. Usually, the firm prefers to hire this kind of professionals from ELM (Slaughter and Ang, 1996).

2.4. Human Resources practices at IT firms

Firms in general, but Information Technology firms in particular, aim to develop an internal environment which attracts and inspire IT professionals to deliver maximum performance and productivity. Literature suggests that successful firms at recruiting and retaining IT human capital look beyond specific human resources (HR) practices to craft an IT HR strategy (Agarwal and Ferrat, 1999).

Considering this, IT HR strategy could be interpreted as an organization's bundle of practices in several IT HR areas – recruitment and selection, appraisal, reward and development – in order to enhance productivity by eliciting productive work behavior and influence joining and staying behaviors. Agarwal and Ferrat (2001) underlay two factors that must be taken into consideration by managers when defining an IT HR strategy. These factors are length of employment relationship and relative concern for the individual and productivity. First, length of employment is related with the time that an employee remains in the firm. Usually this concept remits for two inverse HR practices, the transaction-based and commitment-based. The first one emphasizes individual short-term exchanges relationships, and the second focus on mutual, long-term exchange relationship (Arthur, 1992; Tsui et al., 1995). Secondly, relative concern for the individual and productivity shows the culture engaged by IT firms. One dimension reflects the interpersonal concerns and pays attention to individual needs through HR practices; the other is about productivity, paying attention to work and output (Agarwal and Ferrat, 2002).

An organization with results-oriented culture emphasizes the need for IT workers to achieve professional goals, being more productivity concerned (Couger and Zawacki, 1980). This kind of work arrangements are interesting and challenging for the employee, especially for the top performer, and are associated with performance measurements and feedback (McClelland and Koestner, 1992). A firm with concerns about the individual valorize IT professional's personal growth and this is why they contemplate practices as recruiting and retention (Agarwal and Ferrat, 2001).

Firms that obtain productive contribution from workers, by valorizing organization-specific knowledge and commitment, seek long-term relationships with IT employees. These firms choose to spend more resources in recruitment and training, investing in career development and security to extract the benefits of long-term employment. Conversely, firms needing a generic and diverse set of IT skills prefer short-term employment relationships, bet in a high volume of recruiting activity, which results in high turnover, and increasing costs in compensations and benefits, with which they attract workers.

Agarwal and Ferrat (2001) propose four strategic IT HR management archetypes based on variables "length of relationship" and "relative concern for the individual vs productivity". They are:

- Short-term professional, which is a strategy characterized by a high concern for productivity but a low concern for the individual. Little attention is given to practices which promote job security, instead recruitment and reward are popular practices that raise competition and reach a higher performance from workers. Contracts are intended to ensure a high turnover of employees;
- High-performance professional, where the concern for the individual is greater than in the previous case but still the concern for productivity is much greater. Most contracts are of short duration;
- Balanced professional, where concern for the individual increases but the concern to get the higher productivity is still present. Measures that promote professional security to the worker are taken, deteriorating the use of recruitment and compensation practices that encourage increase competition;
- Long-term investment is the strategy where concern for the individual is as high as concern for productivity. Procedures such as training, investment in career and restricting ports of entry are encouraged, ensuring job security to worker. The goal is to create an investment and loyalty relationship between employer-employee, thus long-term contracts are usually established.

Organizations try to seek balance between the poles long-short term relationship and individual-productivity achievements. They pursue a strategy of human resources management which fits with firm's objectives.

Depending on what an enterprise values more, it exists a set of IT HR practices that are categorized in recruiting and retention practices and which are at the basis of the four strategies above. From a study where were selected 32 organizations, exemplar in retaining successful IT workers, Agarwal and Ferrat

(2002) interviewed CIO's and HR officers to understand their innovative and effective practices. These practices were grouped by the authors in what they named as "strategic star", an approach of five strategic levels (Figure 2.1).

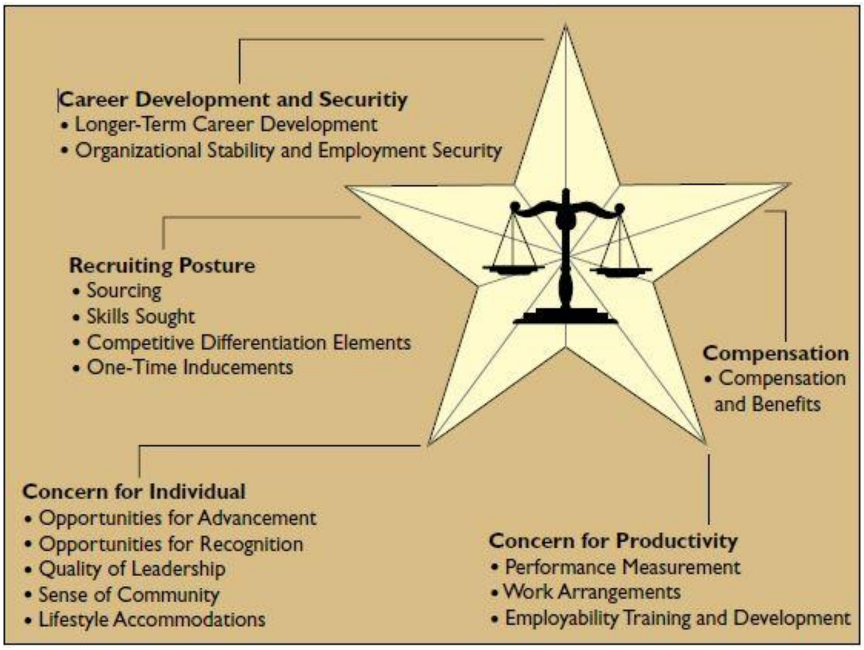

Figure 2. 1 - Five strategic levels star adapted from Agarwal and Ferrat (2002)

According with the Five strategic levels star, recruiting Postures focus on the essential HR practices to influence the joining behavior of IT professionals:

- Compensation reflects the practices adopted by firms to face the rivals in the labor market, competing for IT workers.
- Concern for productivity focus on work and highlights practices to IT workforce's productivity, work arrangements, performance measurements, and employability training and development.
- Concern for the individual highlights opportunities for worker career's development, recognition, quality of leadership, sense of community and lifestyle concern.
- Career Development and Security, arises from length of employment, pay attention to long-term career development, organizational stability and employment security.

3. Data and Research Methodology

3.1. Dataset: Quadros de Pessoal

In order to study the IT industry in Portugal for this dissertation, we use a Portuguese dataset – *Quadros de Pessoal* (QP) – which contains personnel records. A period of five years, between 2008 and 2012, was selected. QP is an annual mandatory survey conducted by the Portuguese Ministry of Labour and Social Security (*Gabinete de Estratégia e Planeamento do Ministério do Trabalho e da Segurança Social*). This national survey covers all firms in the private sector with at least one salaried worker and excludes military, public administration and self-employed employees. The data contained in QP are available since 1985 until the present. The information shown in QP is the actual situation in October of the reference year. Each year the survey collects data on around 350 000 firms and 2.5 million employees.

QP provides a matched employer-employee dataset with information about the firm, the establishment and the employee. As one unique number identifies firms and workers, it is possible to track and merge information about them throughout time. With more detail, it enables to identify a worker who apparently left the IT industry, and understand if she really abandoned the IT sector; follow up of how many companies have worked, progression within the job ladder, what type of occupation has been developed, and whether she has improved her education.

Concerning firms, we have information about location, number of employees, age, equity, legal framework, sales and industry. For workers, QP provides gender, age, nationality, education level, job level, wage, regular bonus, hours worked, admission date and occupation. The information about the wage includes base salary and regular benefits. Regular compensations could contain monthly allowance for meals, accommodation, transportation, tenure of the worker in a firm, productivity, attendance, dangerous jobs and night shifts. Data about irregular benefits were not taken into consideration due to uncertainty of its origins – as the information is collected in October, the irregular benefits just take into account that month.

It is important to point out that using a matched employer-employee dataset – entails advantages such as having information that maintains an updated view of the private sector in Portugal. It is also possible to build a customized database to study statistically a single industry, demographic characteristics of specific workers, among many other potentials. The disadvantages are that all the information is provided by employers themselves, which may lead to inaccurate information, lacks information on workers' family background and it is not possible to follow the worker when she leaves one of the firms covered by the dataset.

As it is provided detailed information on both the wages and the characteristics of each individual worker, and basic information about the firm and the establishment, through QP it is possible to increase the comprehensiveness at microeconomic level about the employer-sector in Portugal.

3.2. Methodology

3.2.1. The multiple regression model

We use the multiple regression to relate wage with some variables provided by QP (Wooldridge, 2009) as it allows us to hold all explanatory variables and control the variation of just one – what is named as *ceteris paribus* analysis. This is important both for testing economic theories and for evaluating policy effects when the researcher rely on nonexperimental data. We use the ordinary least squares (OLS) method to estimate parameters in the regression as it is a well-fitted method to predict the linear equation and minimize the square difference between the actual wage data and the estimated wage data. Thus, the general multiple regression models can be written as the following equation 1:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + u$$

Equation 1

where y is the dependent or explained variable – wages in logarithm – and x_k are the independent or explanatory variables – selected from QP; β_0 is the intercept and β_k are the coefficients or parameters associated with x_k; the term u refers to error term, responsible for unobserved part of equation, which contain all other factors than x_k that affect y.

Multiple regression model relies on five assumptions. The first defines equation 1 as the population model, and states that it is linear in the parameters β_k. Assumption number two calls for the need of a random sample of n observations. A third assumption allows explanatory variables to be correlated, apart from perfect collinearity. The key assumption for regression 1 is named zero conditional mean and states that all unobserved factors are uncorrelated with the explanatory variables (see equation 2). This condition breaks y into two components: $1)\ \beta_0 + \beta_k x_k$, the systematic part of y, i.e. the part of y explained by independent variables, and $2)$ u the unsystematic part of y, i.e. the part of y which cannot be explained by x_k. In case of dependent variables and error term factors are correlated, there is an endogeneity problem. The validity of equation 2 underlies that OLS estimation is unbiased.

$$E(u|x_1, x_2, \dots, x_k) = 0$$

Equation 2

The final assumption defines u as homoscedastic, meaning that the variance of factors in error term is the same given any values of the explanatory variables. All the five assumptions conclude that OLS is the best linear unbiased estimator.

As is typical in the literature, the wage equation is a log equation, where wages appear in the log form. The β_k coefficients can be interpreted as the percentage change that each variable causes on wages (for large values, the coefficients have to be transformed with the exponential). Thus, the change is in relative terms, which is less restrictive than if wages entered without the log transformation (implying an absolute variation). Applying OLS to a wage equation does not ensure that the error term is not correlated with any of the explanatory variables. However, it is the estimation model that provides the best initial approach to the study developed in this dissertation. It implies that the coefficients presented in the applied sections cannot be interpreted as expressing a causal relationship, as the relationship is subject to potential biases arising from the endogeneity of some variables, most notably education. However, in the results section, the fixed-effects is presented and applied in order to solve some of the issues of the OLS model.

3.2.2. Variables

The information contained in the QP allows to define a set of explanatory variables related with demographic and human capital variables to be include in the wage regressions. Some appear as continuous and other as categorical. Table 3.1 summarizes all the variables considered in the following chapters.

Table 3. 1 - Explanatory variables that are used in regression model.

Variable		Description
Gender	Categorical -Binary	Worker gender
Age (years)	Continuous	Worker Age
Age2 (years)	Continuous	Worker Age squared
Lisbon	Categorical – Binary	If the firm is in the district of Lisbon
Firm CAE	Categorical – 4 dummies	IT economic activity developed by the firm
Firm size	Categorical – 4 dummies	Dimension of the firm measured by the number of employees
Tenure	Categorical – 4 dummies	Length of the employment relationship in the same firm
Education	Categorical – 4 dummies	Level of education of a worker
Job level	Categorical – 5 dummies	Hierarchy level occupied by worker inside the firm
Occupation IT	Categorical – Binary	If worker has an occupation specialized in IT
Occupation IT	Categorical – 4 dummies	Detailed IT occupations

Firm CAE

Firm CAE stands for *Classificação da Atividade Económica (CAE)* and is the sector where a firm performs its economic activity. CAE is the Portuguese equivalent to International Standard of Industry Classification (ISIC).

Table 3.2 provides information about IT CAEs at five digits according to revision 3 starting in 2008. This one is the same provided ISIC, rev.4. To establish the dummies in regression we group CAEs at two digits where we get four dummy variables.

Table 3.2 - Classification of Economic Activities, revision 3, regarding to IT sector

CAE 3	Description	Dummies
58210	Publishing of computer games	58
58290	Other software publishing	58
62010	Computer programming activities	62
62020	Computer consultancy activities	62
62030	Computer facilities management activities	62
62090	Other information technology and computer service activities	62
63110	Data processing, hosting and related activities	63
63120	Web portals	63
63990	Other information service activities n.e.c.	63
95110	Repair of computers and peripheral equipment	95

Firm size

In Portugal firm size is defined by Eurostat criteria that follows "*Recomendação da Comissão Europeia 2003/361/CE de 6 de maio de 2003".* The criteria use number of employees jointly with turnover and assets to define the firm's dimension. Here we simplify and just take in consideration the number of employees, resulting in four groups:

- Micro-firms have up to 10 employees
- Small firms have up to 50 employees
- Medium-sized firms have up to 250 employees
- Large firm have 250 or more employees.

Tenure

Tenure could be defined as a continuous variable, but we opt for a discrete nature to observe the impact of first years of the worker's career. Four tenure dummies were crated, one for workers without experience in a firm – 0 years – other for an experience of 1 to 3 years, the next for 4 to 10 years and the last comprises workers with long experience in a firm – more than 10 years.

Education

The education system in Portugal comprises three major groups: basic, secondary and tertiary degree.[2] The first one has a duration of 9 years where the general areas of knowledge are taught; secondary education lasts for 3 years and is where the student chooses the specific area of education. Upon

[2] Information collected in http://dge.mec.pt/, official website of the *"Direção-Geral da Educação".*

entering higher education, students become part of tertiary education where up to 2005 a cycle of 5 years corresponds to the Bachelor degree. In 2006, a reformulation takes place due to the Bologna Process and bachelor is converted in a degree of 3 year, followed by a master degree with the duration of 2 years. Upon completion of these 5 years, the student can follow a PhD.

Table 3. 3 - Education variable and dummies

Education variable	Years of school	Dummy
Basic	9	Basic
Secondary	12	Secondary
Tertiary	>12	Tertiary no IT Tertiary IT

Looking for education codes used in QP – the same applied in *International Standard for Education, ISCED* – it is possible to identify the different field of study (table 3.4). We select Math and Statistics, Informatics and Engineering within tertiary education to create a dummy for workers with background in IT. We decided not restrict to the Informatics field once the other two are rich in providing IT specific knowledge.

Table 3. 4 - ISCED codes

Code	Course
546	Bachelor in math and statistics
548	Bachelor in computer science
552	Bachelor in engineering
646	Graduation in math and statistics
648	Graduation in computer science
652	Graduation in engineering
746	Master in math and statistics
748	Master in computer science
752	Master in engineering
846	PhD in math and statistics
848	PhD in computer science
852	PhD in engineering

Job level

Job levels are related with responsibility, education and skills required, and task complexity. They are defined by the Ministry of Employment, being the same for all firms, and consist in a hierarchy of eight levels (table 3.5).

Table 3. 5 - Job levels

Job Level	Description	Dummies
1	Top managers	Top manager
2	Intermediate managers	Intermediate manager and Supervisor
3	Supervisor, Team leader	
4	Highly-skilled professionals	Highly-skilled
5	Skilled professionals	Skilled
6	Semi-skilled professionals	
7	Non-skilled professionals	Semi- , Non- skilled and Trainee
8	Apprentices, Trainees	

Occupation IT

In a first step, the codes for IT occupation were aggregated in a single binary variable for workers belonging to one of the IT occupations. A posterior step leads to the decomposition of that variable into four dummy variables (table 3.6). We have chosen the Portuguese taxonomy *"Código das Profissões (CPP)"* that it is equivalent to the European, International Standard Classification of Occupations (ISCO). The IT occupations cover from Chief Information Officer (CIO) to programmers, data basis specialist, systems analysts and administrators.

Table 3. 6 – Occupation codes and dummies

CPP 2010	Dummies
13300 Directors of Information and Communication Technologies (ICT)	Director
25110 Systems Analysts	Systems and Programmers
25120 Software Developer	Systems and Programmers
25130 Web and multimedia programmer	Systems and Programmers
25140 Application Developer	Systems and Programmers
25190 Other analysts and programmers, of software and applications	Systems and Programmers
25210 Administrator and Database Design Specialist	Systems and Programmers
25220 Systems Administrator	Systems and Programmers
25230 Computer Network Specialist	Systems and Programmers
25290 Other database and network experts	Systems and Programmers
5110 Technical operator of information and communication technologies (ICT)	Technician
35120 Technical support for users of information and communication technologies (ICT)	Technician
35130 Technician in computer networks and systems	Technician
35140 Web Technician	Technician
24210 Analyst in management and organization	Consultant

The aim is to provide an understanding of the salary structure of Information Technology (IT) sector in Portugal by analyzing gender, age, demographic information, human capital variables in IT firms with different sizes.

We will look to the relationship of internal labor market dimensions discussed above, to workers' characteristics – as education, labor market experience and occupation – and to firms' features – such as industry and size. The dissertation develops econometric models in order to study more deepen some of the features above and their indicators. We believe that an econometric approach is the most suitable to identify personnel practices and policies adopted by firms. Thus, a linear regression model is applied through software STATA to study wage formation.

4. Descriptive Analysis

The first step to understand the Portuguese Information Technology sector is to perform an explanatory analysis with the data provided by *Quadros de Pessoal*. We will study the trend followed by IT firms and their workforce, during a period of five years, starting in 2008. Table 4.1 summarizes how the workers moves over the years.

Table 4. 1 – Moves of employees across firms from 2009 to 2012

	2009	2010	2011	2012
Missing	13	5	1	1
Workers reported in year t-1 who remains in the company in year t	23668	23976	26317	26385
Workers reported in year t-1 who moves to another IT company in year t	1862	1974	1151	2302
Workers who in year t worked for multiple firms	114	96	85	60
Workers who joined to data base in the year t because the firm where they are employed shifted to an IT CAE	1150	968	896	890
Workers who joined to database in the year t and reported in year t-1 as belonging to a CAE no IT	2198	1913	2469	1748
Workers who not reported in the year t-1 that joined our database in the year t	4516	4089	4453	3770
Total	33521	33021	35372	35156

The starting year is 2008 with 30503 professionals

In this analysis we will explore firms and workers features, and wages information. When dealing with wages, only workers with compensation above zero will be considered; otherwise, all observations are take into account, in order to do not exclude potential employees which do not declare their salaries. Variables as firm size, occupation, years of schooling, job level, tenure, among others are statistically described below.

4.1. Firms' features

We start by providing a broad overview of the number of firms composing the IT industry in Portugal, the size of this industry in term of employees, and the average number of workers employed in firms (table 4.2). The initial step in constructing the sample used in the dissertation was the selection of all firms belonging to the IT sector according to the industries considered in table 3.2 in the previous section.

Table 4. 2 - Overview of IT firms' evolution during 2008-2012

Year	Number of firms	Average number of employees	Number of employees	Percentage of firms by firm size			
				Micro	Small	Medium	Large
2008	2785	11.0	30503	0.82	0.14	0.03	0.00
2009	2962	11.3	33521	0.82	0.14	0.04	0.01
2010	2170	14.9	33021	0.76	0.18	0.05	0.01
2011	2059	16.7	35372	0.75	0.19	0.05	0.01
2012	1893	17.9	35156	0.74	0.19	0.06	0.01
Total	11869		167573	9294	1948	522	91

A total of 11869 companies belong to the IT sector between 2008 and 2012 (table 4.2). The majority are micro firms (78.3%), 16.4% are small, 4.4% are medium and only 0.8% are large firms. Since 2009 the number of firms decreased, a trend followed by those classified as micro, the more representative of Portuguese business fabric. The number of employees grows almost 16% between the five years and the average number of employee by firm also rises from 11 to 17.9, meaning that although the number of firms has decreased, the number of workers employed by each firm is, on average, higher. This coincides with the increase of medium and large firms, 13.9% and 79.4% respectively.

Figure 4.1 shows the number of employees across firm size categories during 2008-2012. The total number of employees covered is about 30107 for micro firms, 39250 for small, 54600 for medium-sized and 43547 for large firms. The sector has experienced a large increase in the number of workers employed by large firms and a decrease trend for micro and small firms. The medium and large firms are the largest employers even if there are much more micro and small firms. For the period under study, micro firms employ 4.4 workers on average, small firms employ 24.5, medium have 132.8 workers, and large firms employ 589.2.

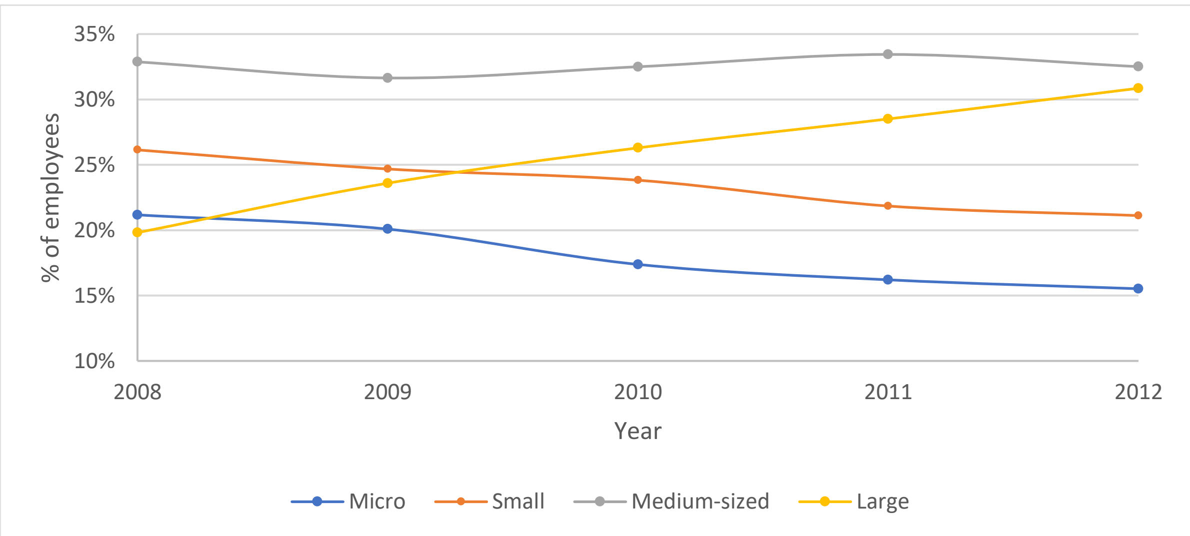

Figure 4. 1 - Percentage of employees in micro, small, medium and large firms (2008-2012)

About 5382 (45.4%) firms have the headquarters located in the district of Lisbon employing 112493 (67.1%) workers. In terms of dimension 71.6% of IT companies in Lisbon are micro firms and employs 11.6% of the Lisbon workforce; 20.1% are small firms with 19.9% workers; 6.8% are medium-sized which containing 34.5% of labor force; and a small percentage of 1.4% large firms is compound by a total of 34% of employees based in that district.

For economic activities performed in sector, the higher weight goes to C*omputer programming, consultancy and facilities management (CAE 62)* representing more than 80% of IT business web. *Computer games and software publishing (CAE 58)* and *Data processing, hosting and web portals (CAE 63)* are responsible for 8% and 7%; finally comes *Repair of IT products* (*CAE95)* industry with 4%. Table 4.3 displays the distribution of workers within industry and the evolution of over years.

Table 4. 3 - Distribution of employees across industry (2008-2012)

Year	Percentage of employees by industry			
	CAE 58	CAE 62	CAE 63	CAE 95
2008	0.09	0.81	0.01	0.03
2009	0.08	0.82	0.07	0.02
2010	0.05	0.84	0.09	0.02
2011	0.00	0.81	0.12	0.03
2012	0.00	0.86	0.08	0.03
Total	9801	138808	14846	4118

4.2. Workers' features

In order to analyze the wage data correctly all values were updated with inflation rate to the year 2012. Wages are the sum of base salary and regular benefits, where zero euros wages were excluded.

Next table 4.4 and figure 4.2 shows the average wage over years and the progression of each component across total dataset. The number of observations is 158972.

Table 4. 4 - Total, base and regular wage and respective standard deviation (2008-2012)

Year	Base (€)	SD (€)	Regular (€)	SD (€)	Total (€)	SD (€)
2008	1603.90	1201.62	225.31	360.97	1829.22	1316.80
2009	1596.66	1190.49	210.23	349.70	1806.90	1295.68
2010	1595.33	1168.61	222.44	375.49	1817.77	1297.22
2011	1520.42	1137.36	224.14	364.39	1757.84	1267.19
2012	1435.43	1079.32	203.13	305.28	1649.92	1174.53

Figure 4.2 displays little fluctuation for overall wage and base salary until 2010, and a decreasing after that year; regular benefits are stable for the period under analysis. On average, the base salary has a weight of 87.5% and the regular benefits represent 12.3% of total wage.

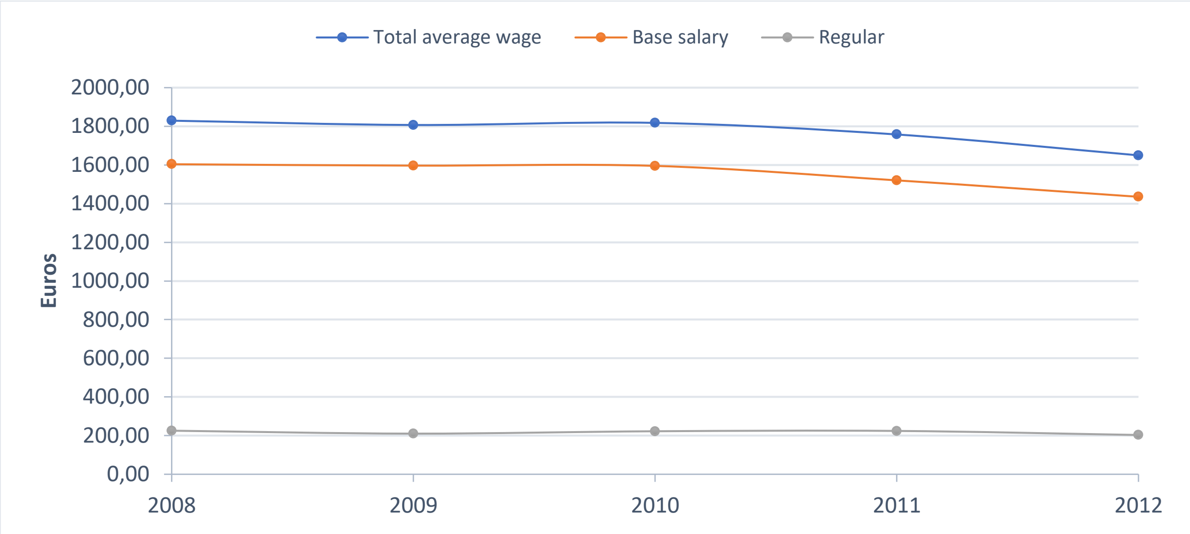

Figure 4. 2 - Total, base and regular wages of employees over years (2008-2012)

Concerning to the economic activity, figure 4.3 shows the evolution of total wage for each industry. Table 4.5 presents information about the base salary and the regular benefits. Industries of *Computer games and software publishing (CAE 58)* and *Data processing, hosting and web portals (CAE 63)* are those which further decreases their remunerations. Base wage and regular benefits follow the trend of total wage. A difference of almost 500€ on the average wage falls on the workers in a period of five years for CAE 58. Firms in C*omputer programming, consultancy and facilities management (CAE 62)* industry benefit of an increase in the average wage in 2010, but in 2012 it reaches its lowest value. Although this variation is less abrupt than the variations in CAE 58 and CAE 63. The industry of *Repair of IT products* (*CAE 95)* presents an inverse behavior for wages since they increase over years. It pattern is similar to the one displayed by CAE 62, but the difference between wages becomes lower over the years. The base salary is responsible, on average, for 91% of total wage in CAE 58, 87% in CAE 62, 88% in CAE 63 and 82% in CAE 95.

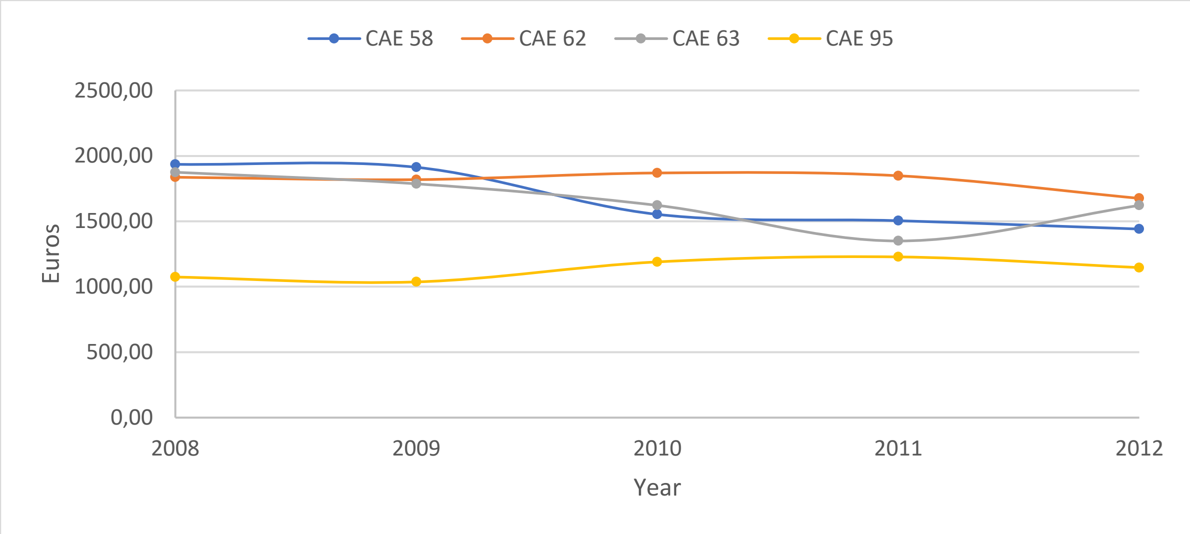

Figure 4. 3 - Evolution of wages across industries (2008-2012)

Table 4. 5 - Table with base and regular wage for each industry (2008-2012)[3]

Year	Base (€)				Regular (€)			
	CAE 58	CAE 62	CAE 63	CAE 95	CAE 58	CAE 62	CAE 63	CAE 95
2008	1767.52	1605.01	1649.77	852.09	167.80	231.68	225.14	221.18
2009	1755.13	1596.46	1629.85	881.09	157.67	221.99	156.55	155.82
2010	1372.55	1639.43	1621.84	975.77	180.58	229.90	178.39	215.16
2011	1344.14	1597.79	1168.44	1012.40	145.58	236.10	176.19	196.88
2012	1277.68	1458.88	1404.14	942.11	146.97	205.46	208.77	188.52

4.2.1. Age and gender

Table 4.6 shows data concerning workers' age and gender. The workers' age suffers a constant increase during period covered and shows an average of 34.5 years. Regarding gender, the sector is composed, overwhelmingly, by males, about 71%.

[3] See table 3.2 in Chapter 3.

Table 4. 6 - Age and gender for 2002-2012

Year	Average age of employees	Standard deviation age of employees	Percentage of male
2008	33.9	8.0	71.7
2009	34.2	8.0	71.8
2010	34.4	8.0	71.3
2011	34.7	8.0	70.6
2012	35.1	8.1	70.6

4.2.2. Education

To analyze workers' education, eight academic levels were considered and grouped into three categories (table 4.7). The first category is "Lower than 3rd cycle" with a total duration of 9 years – variable Basic in table 3.3 – and comprises the levels "Below the 1st cycle of basic education" (a small percentage of 0.14% of total workers who did not attend school) and 1st/2nd/3rd cycle of basic education; the second category is "High school + Technical education" – variable Secondary in table 3.3 – and it comprises High school and Post-secondary education not higher than level IV; then comes "Tertiary education (total)" – variable Tertiary in table in 3.3 – and it aggregates the Bachelor, Graduation, Master and Ph.D. degrees. "Tertiary education (total)" is divided in "Tertiary no IT" and "Tertiary IT", where the latter corresponds to a tertiary education in computer science, engineering or math and statistics; and the former, corresponds to a tertiary education in any course does not included in "Tertiary IT". Along the period, the demand for tertiary education has been rising, with a decreasing proportion of workers holding lower educational levels (figure 4.4).

Table 4. 7 - Education level in IT (2008-2012)

Education level	%
Lower than 3rd cycle	7.3
High school + Technical education	31.7
Tertiary education (total)	60.9
Tertiary No IT	21.0
Tertiary IT	39.9
Schooling ignored	0.1

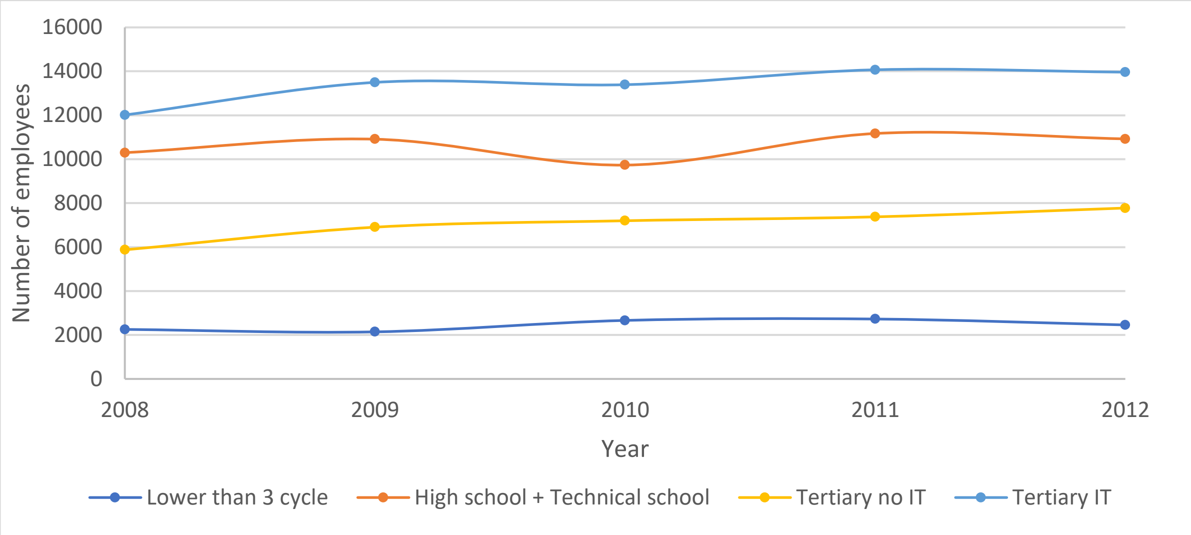

Figure 4. 4 - Evolution of employees' education (2008-2012)

The total number of workers with valid information for education levels is 158779 where employees with tertiary education are about 61.1% (97027) and 65.6% (63641) are specialized in IT careers.

Figure 4.5 shows the wage variation by education level over five years. The data displays that employees with knowledge in information technologies courses receive an average payment higher than other individuals, being the differences more accentuated when the number of years of school attendance decreases.

We verify a structure with three major layers for wage across education levels: at the bottom is the basic level with a payment below 1200€, followed by secondary (1300€ to 1500€), and a top layer for tertiary levels, paying, on average, more than 1800€. As reported by Walker and Zhu (2008), there is a large increase in employment of individuals with computer science, math and engineering degrees getting graduate jobs, which allows them to receive higher wages.

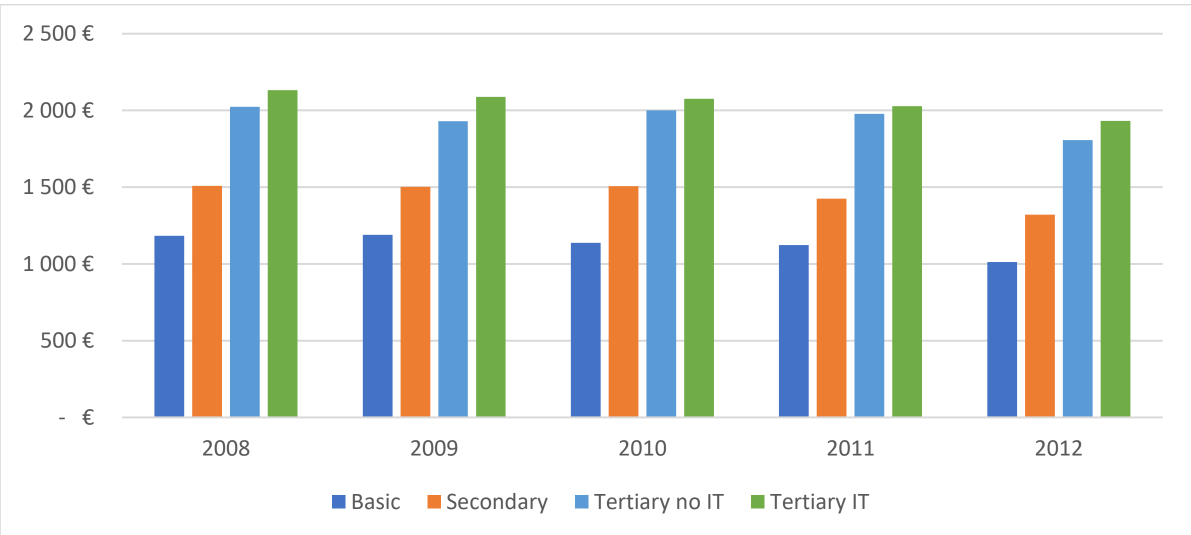

Figure 4. 5 - Evolution of wages across education levels (2008-2012)

4.2.3. Job level

The job hierarchy, concerning to the capabilities, responsibilities and autonomy that an employee needs to carry out the tasks associated with her occupation, is composed of eight levels as previously discussed. Levels 2 and 3, intermediate managers and supervisors, were grouped in one level due to the low number which constitutes supervisors; the same procedure was applied to levels 6, 7 and 8, semi, non-skilled and trainee professionals.

Statistical results in table 4.8 show that most of the workforce occupies the highest position in the hierarchy – 37.0% are classified as top manager – and almost 65% of all employees are placed on the three highest steps of the ladder. The bottom levels include a small percentage of the workforce – 5.5% are semi, non-skilled professionals or trainees. It can be concluded that in the IT sector, the bulk of workers perform management tasks where they are highly specialized and which involve high responsibility and autonomy. The prevalence of micro and small firms also contributes to the high percentage of workers assigned to the top job levels.

Table 4. 8 - Job levels in IT firms (2008-2012)

Job level (%)	
Top managers	37.0
Intermediate managers and Supervisors	27.0
Highly-skilled professionals	11.9
Skilled professionals	15.6
Semi-skilled, Non-skilled and Trainees	5.5
Job level ignored	3.0

From figure 4.6 we can observe that there is a positive evolution for managerial levels (top and intermediate managers), which shows the number of workers who occupy top hierarchical levels has been increasing. For 2010 and beyond the number of intermediate managers and supervisors increased in deterioration of the number of highly-skilled professionals. The rise in average firm size and the increasing importance of large firms in this sector, with deeper hierarchies, probably explain the increase in the number of intermediate managers and supervisors.

Figure 4.6 shows that the hierarchical structure of job levels inside IT firms remains stable over the period under analysis. Although over the years the growth rate of the number of IT professionals has grown 25%, with an annual growth of 4.5%, the relative size of levels remained virtually stable, exception for levels 2/3 and 4. The same behavior was registered for Baker et al. (1994).

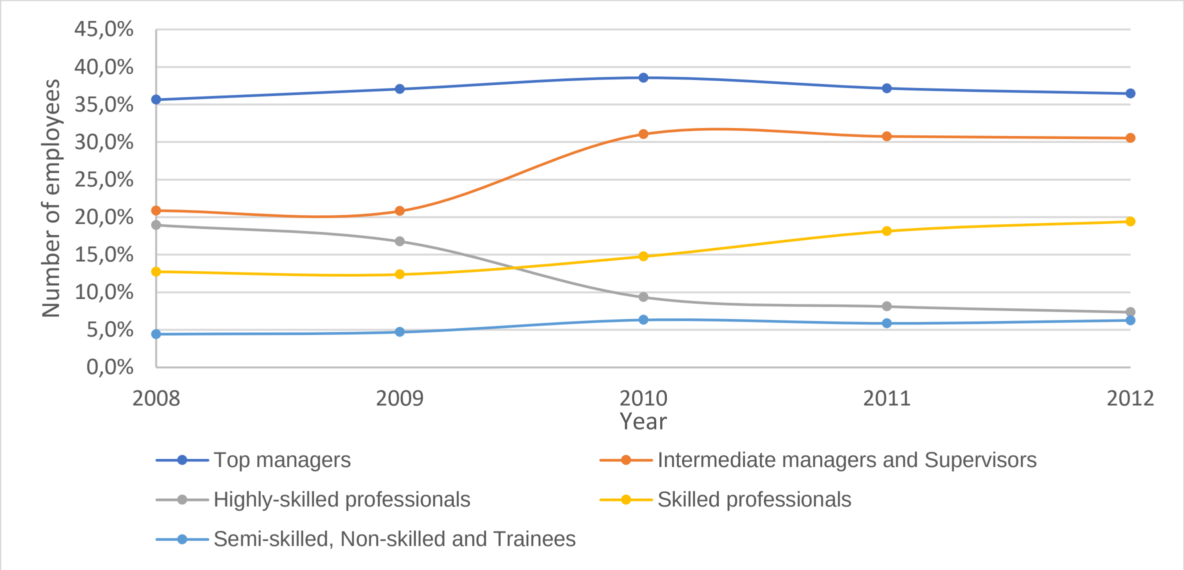

Figure 4. 6 - Evolution of employees' job levels (2002-2008)

Figures 4.7, 4.8, 4.9 and 4.10 show the evolution of workers job levels assignment at different firm sizes.

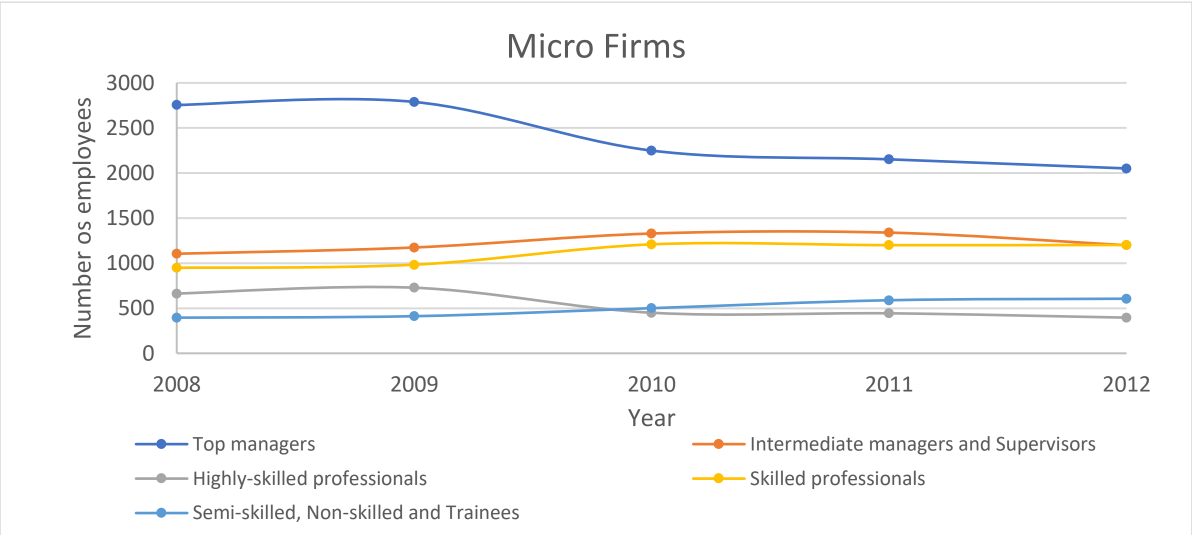

Figure 4. 7 - Job levels of employees in micro firms (2008-2012)

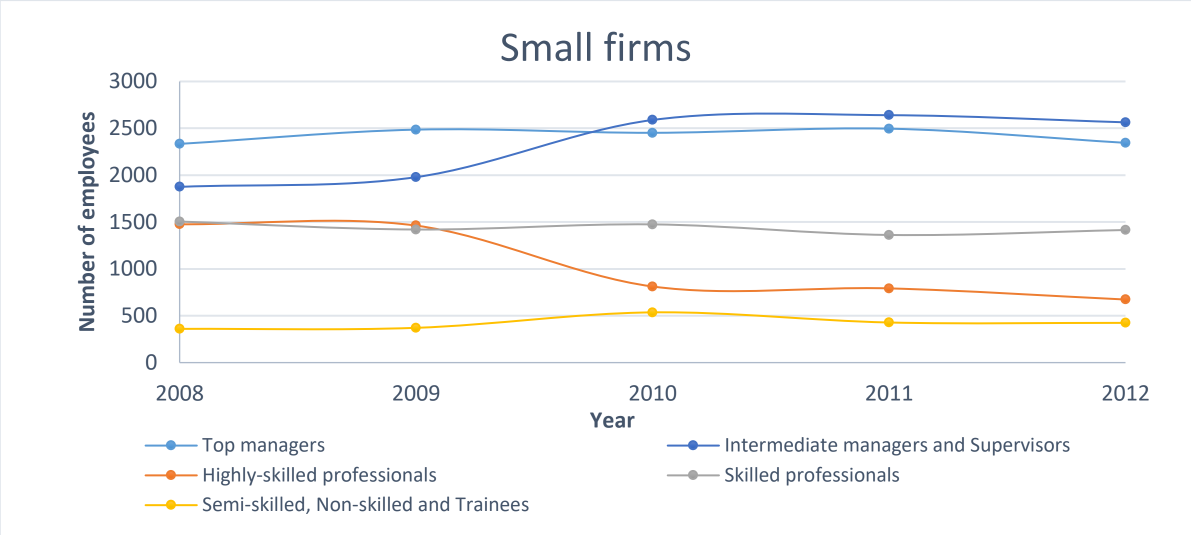

Figure 4. 8 - Job levels of employees in small firms (2008-2012)

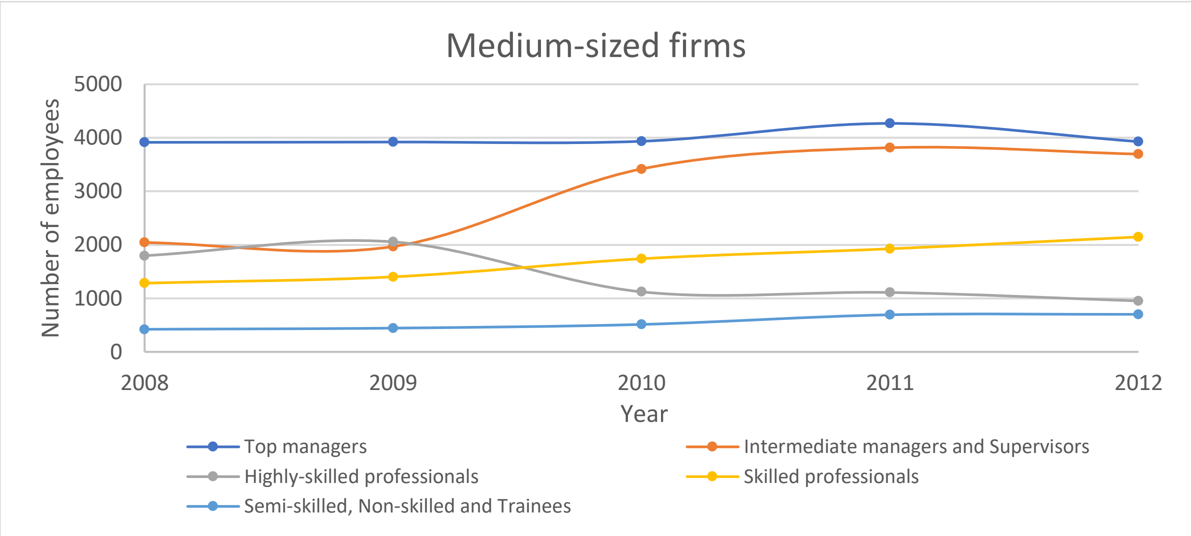

Figure 4. 9 - Job levels of employees in medium-sized firms (2008-2012)

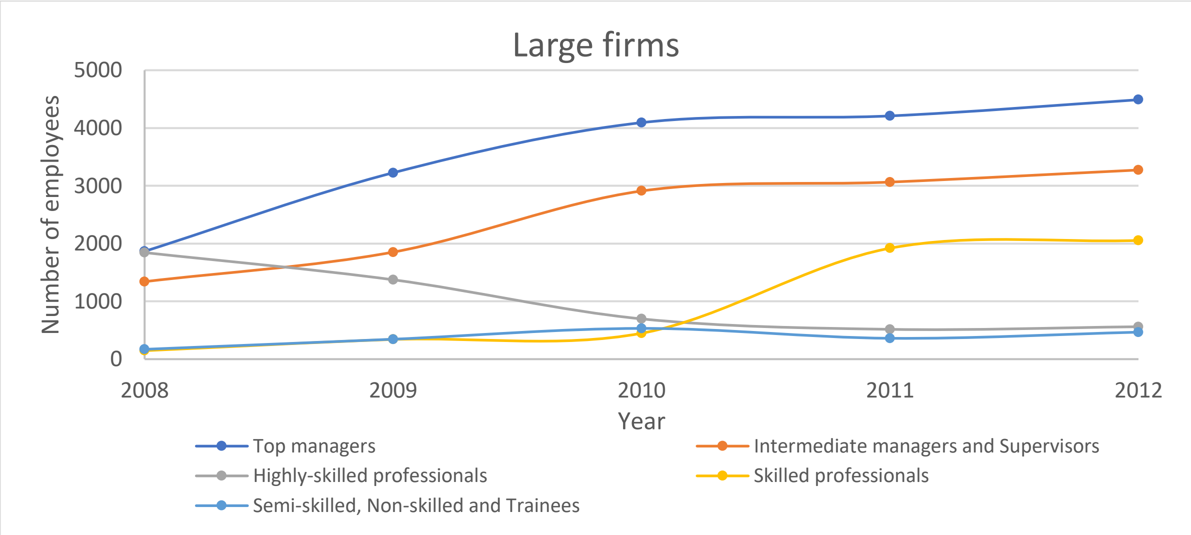

Figure 4. 10 - Job levels of employees in large firms (2008-2012)

The evolution of workers is different across form size, although all figures have in common an increase in the number of intermediate managers and supervisors and a decrease of highly skilled professionals. Again managerial-oriented workers appear in higher number than technical ones. Table 4.9 shows that when the dimension of the sector increases the more accentuate the difference between top levels (1, 2 and 3) other job levels becomes.

Table 4. 9 - Job levels in micro, small, medium-sized and large firms (2008-2012)

Job level (%)	Micro	Small	Medium	Large
Top managers	38.8	30.9	36.6	41.1
Intermediate managers and Supervisors	20.4	29.7	27.4	28.6
Highly-skilled professionals	8.9	13.3	12.9	11.5
Skilled professionals	18.4	18.3	15.6	11.3
Semi-skilled, Non-skilled and Trainees	8.3	5.4	5.1	4.3

Concerning top managers, the percentage in micro firms is due to a large number of firms that employs a maximum of three people (41.6%), thus these individuals, most likely being the owners of the firm, are responsible for all management; already a greater weight in medium-sized (36.6%) and large firms (41.1%) can be explained by the existence of several departments related to the specific area of operation within the firm, where for each there are management employees. Small firms, not having a size in terms of the number of employees for that division into departments, allocate a significant percentage of their workers at the level of technicians, namely as skilled professionals.

Job levels classified as managerial comprise about 64% of workforce. IT is a sector where specific knowledge and skills are needed, and for this reason a higher number of technical-oriented employees were expected. Notwithstanding theoretical frameworks and RBV theory refers the importance of managerial human resources to create sustainable advantage.

Figure 4.11 shows how education is distributed for each job level: 74.1% (79386) of the three higher top levels of the hierarchy are occupied by workers with tertiary education, belonging 70% (55650) of them to workers with tertiary IT. Technical-oriented workers comprise 33% (55347) of total data, having 62% (34301) of them basic or secondary education level. Thus, lower education levels manifest more in technical-oriented jobs while higher education levels are more frequent in managerial-oriented careers. These results are in line with what was expected according to literature (O'Bryen and Pick, 1985; Slaughter and Ang, 1996).

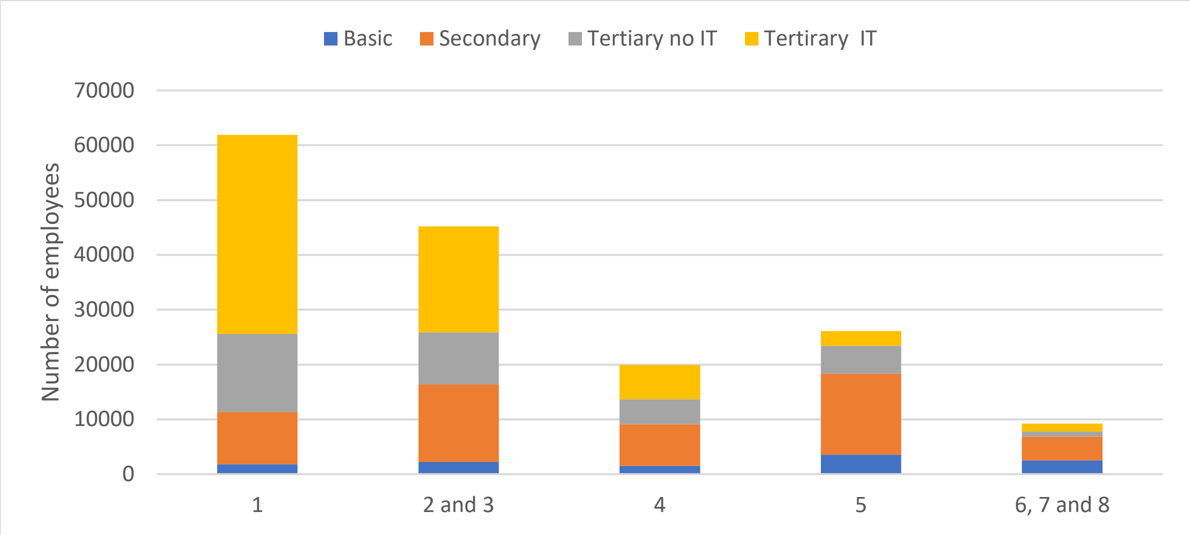

Figure 4. 11 - Distribution of education levels across job levels (2008-2012)

Figure 4.12 presents the evolution of workers' wages at each job level, where the total number of employees is 154671. Top managers are in level 1 and represent 35.8% of workers under study; levels 2 and 3, Intermediate Managers and Supervisors characterize 29.0% of employees; highly-skilled and skilled professionals, levels 4 and 5, are compound by 12.8% and 16.7%; levels 6 to 8 are the ones which contain professionals in low levels of job ladder representing 5.9% of their total.

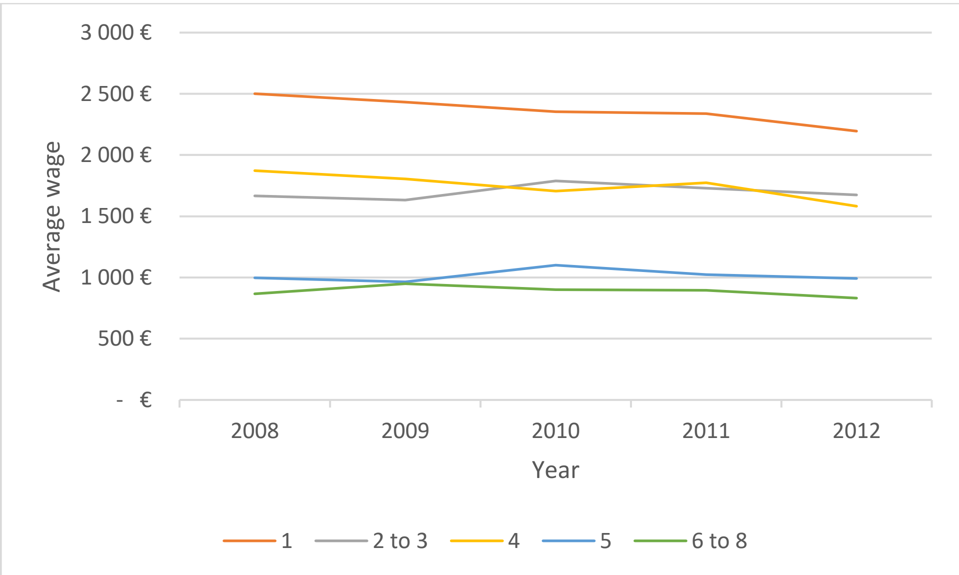

Figure 4. 12 - Evolution of wages across job levels (2008-2012)

The graphic exhibits a distinction in salaries between managerial-level group (1, 2 and 3) and those classified as technical-level (5 to 8). Level 4, highly-skilled, seems to address to managerial levels wages, even if it is classified as belonging to technically-oriented group. Level 1, top managers, shows a downward pattern over years, while levels 2,3 and 4 suffers alternate increases and decreases.

Three pay groups are visible: the one represented by levels 5 to 8 that has lower wages, followed by the group represented by levels 2 to 4 and, in the top of hierarchy is level 1 with higher compensations. This behavior represents the different compensations attributed over the job pyramid and the striking wage gap among technicians and managers. The structure is in accord with Igbaria et al. (1991) results. Although level 4 is associated with the technical-oriented level, the compensation policy for these workers follows the policy applied to managerial group, what can be seen as a measure to promote motivation and prepare the professionals of level 4 to a management position where responsibilities increase. Ang and Slaugther (2004) defend that managerial-oriented and technically-oriented IT group jobs follow separately strategies of management, being the compensation one of the dimensions.

Figure 4.13 characterizes each firm size with a different scenario of wage distribution. The higher rewards are provided by medium and large organizations. For medium firms, compensations vary between 906€ for levels 6 to 8 and 2553€ for top managers. In the case of large firms, the range is 1106€ until 2504€ where the low number is for level 5, skilled professionals, and the maximum for level 1.

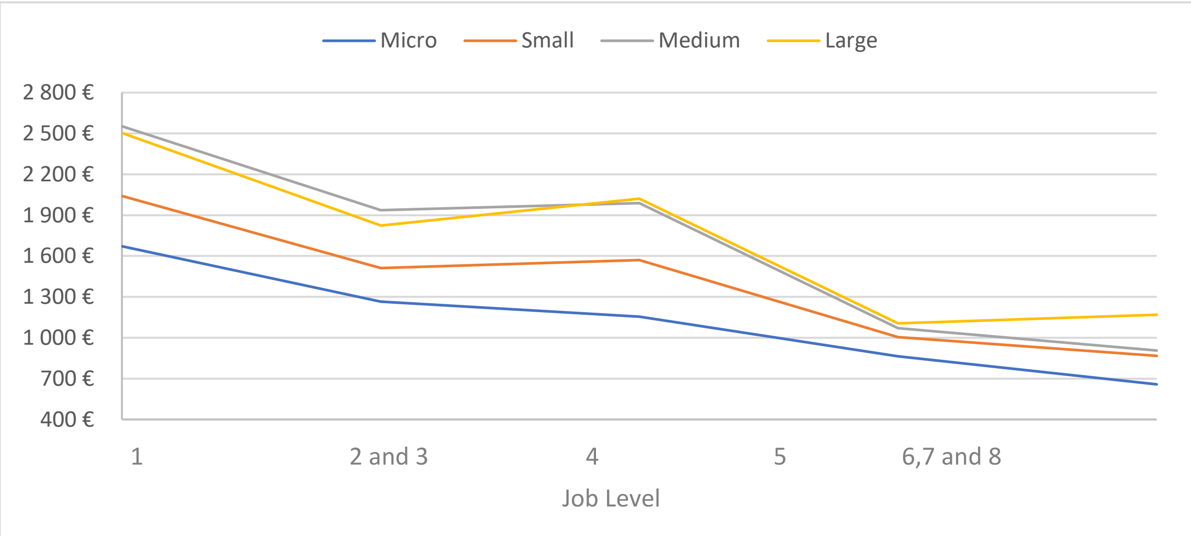

Figure 4. 13 - Job levels salary across firm sizes (2008-2012)

4.2.4. Occupation

The IT occupations are related with IT capabilities necessary to more specialized tasks in the sector under analysis. The occupation of IT director comprises function as to receive feedback from their team of programmers, technicians, consultants, among other, to evaluate their needs (physical resources) and to provide orientation; manage and provide training; create, manage and monitor IT projects, strategies and policies; evaluate the IT needs of the firm; manage the budget allocated to IT department.

The programmers and systems workers develop software for applications and operative systems, coordinate procedures to test and validate software programs; search and develop methods to implement technological solutions; design, develop, control, provide maintenance, performance support and security measures of IT and infrastructures (databases, equipment and software, networks operative systems). The technicians are responsible to provide support to IT users and for the daily operation of technological systems, computers and networks. IT Consultants formulate proposals, IT recommendations and follow their implementation through the development of instructions, procedures, manuals and other documents; accompany clients and develop IT solutions to organizational problems.

Table 4.10 provides information about occupations. Given that previous statistics pointed to a percentage higher than 60% for managerial employees, it would be expected to find more occupations related with management tasks and senior positions.

Table 4. 10 - Occupations with higher percentage of employees for IT sector (2008-2012)

Occupation IT	%
Occupation No IT	36.5
CIOs	1.5
Engineers and analysts of systems and Programmers	41.7
Technicians	15.7
Consultants	4.7

Note: “Occupation” no IT refers to occupations not classified as IT.

Figure 4.14 follows the evolution over time of employees with IT tasks and no IT tasks. The total is 106367 individuals, meaning that 63.5% of workers of IT sector as an information technology specific task.

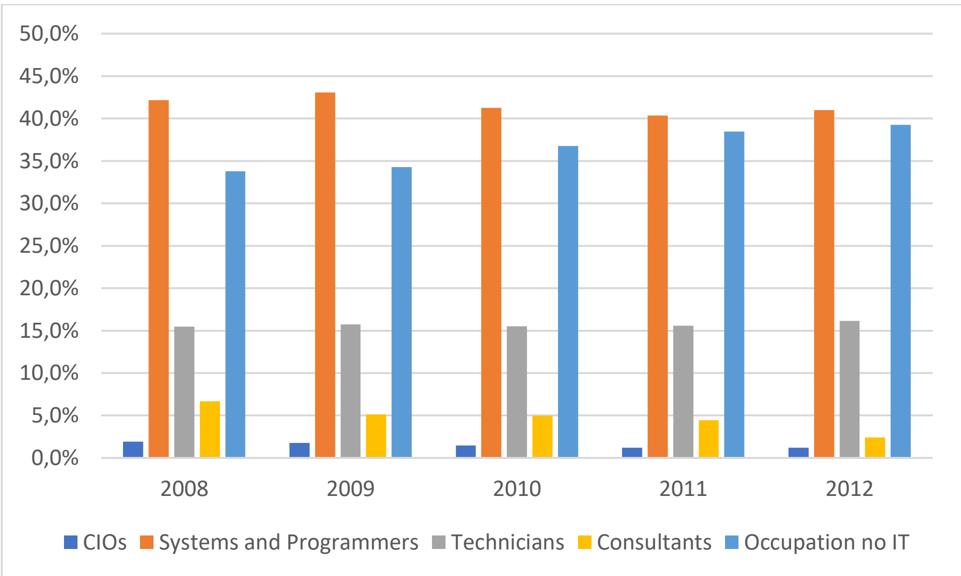

Figure 4. 14 - Evolution of employees’ occupation (2008-2012)

Through figure 4.14 we see an increase of 11% year in number of systems professionals and programmers, and a reduction in the number of consultants. Other activities are stable over time.

Wage evolution across the IT occupations over 2008 to 2012 are in figure 4.15. Directors, consultants, technicians, systems professionals and programmers present almost none fluctuation in wages. A large gap appears between director and other occupations reflecting the higher compensation of being assigned to a task with higher responsibilities. Technicians are the professionals with lower compensation follow by systems workers and programmers. The average wage payed to consultants change between 2300€ and 2700€.

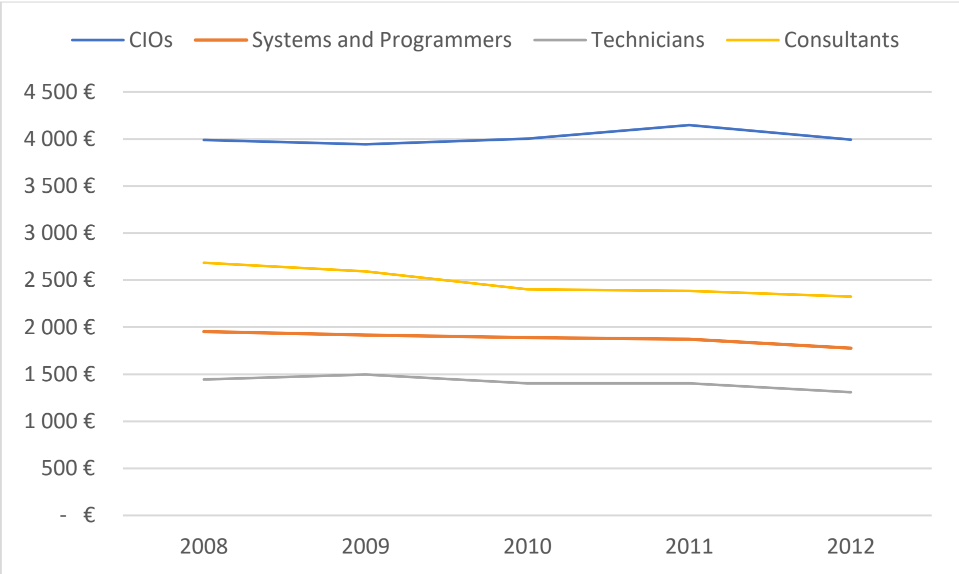

Figure 4. 15 - Evolution of wages across IT occupations (2008-2012)

Figure 4.16 shows how the salaries of each IT occupation are distributed by the four existing IT economic activities. *Repair of IT products (CAE 95)* is the industry that pays a lower wage among other; at the other extreme is *data processing and web portals (CAE 63)* that offers the higher compensation to its workers.

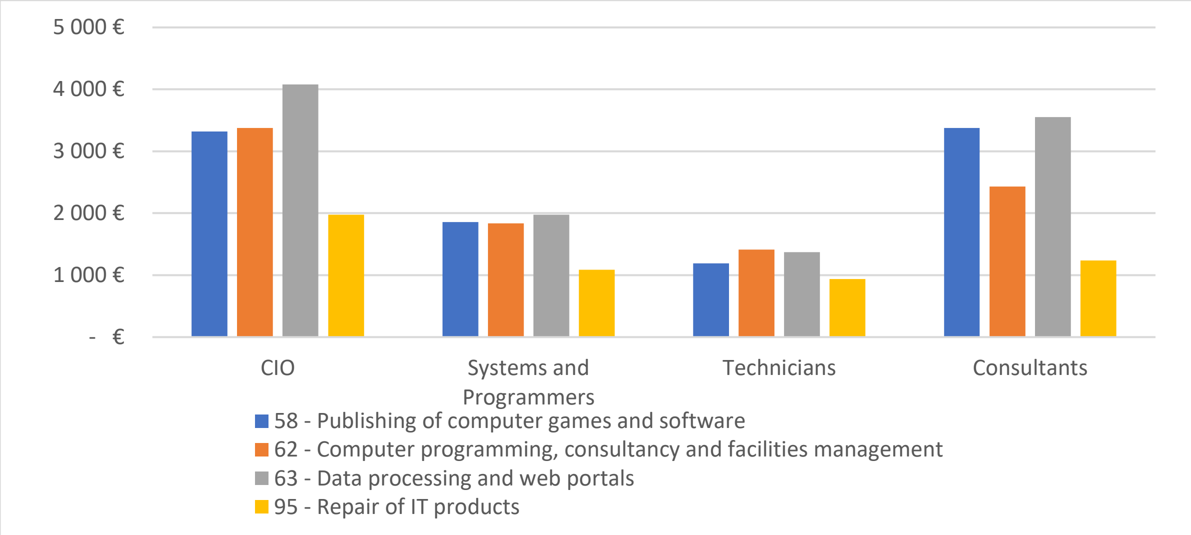

Figure 4. 16 - Wages distribution across industry for employees with IT occupation (2008-2012)

Once again, it is possible to find a structure where, regardless of the CAE, the salary grows according to the order of technicians, programmers and systems, consultants and directors, exception made for CIO and consultants in *publishing data and software (CAE 58)* industry.

Table 4.11 displays the IT occupation across job levels. It is difficult classify occupations as managerially-oriented or technically-oriented, although the table help us to identify one occupation as being more or less managerial or technical. Directors, systems workers and programmers as consultants have higher percentage of job levels 1, 2 and 3; technicians show a spread of percentages across job hierarchy and display the two kind of job level groups.

Table 4. 11 - Distribution of occupation IT across job levels (2008-2012)

	CIO (%)	Systems and Programmers (%)	Technicians (%)	Consultants (%)	Total
Level 1	84.0	51.1	12.7	40.3	37950
Levels 2 and 3	10.7	30.0	39.9	40.8	29866
Level 4	4.5	11.7	13.9	15.0	11247
Level 5	0.8	5.6	25.0	2.7	9233
Levels 6,7 and 8	0.1	1.5	8.5	1.2	2913
Total	2125	60356	22643	6085	

It is interesting verify that the occupation “more managerial” are the ones who obtain high pay as figure 4.15 shows. Following Mata et al. (1995) discussion on RBV theory, IT managerial skills provide sustained competitive advantage while technical skills provide competitive parity. Thus CIOs, systems workers and consultants are IT human resources that theoretically are positively correlated with firm performance. Even if skill specificity of technical employee is indispensable, it is the managerial component that has the knowledge to trace a strategy and to guide the workforce through it.

4.2.5. Tenure

Workers’ tenure shows if job relationships are more stable or not and serves as an indicator of specific human capital accumulation. We created four categories, one with workers who are employed less than one year of tenure, a second with one to three years, a third composed by employees with four to ten years; and the last category with employment length of more than ten years. The pooled information shows a predominance of employees with a tenure of 1-3 years, almost 38%, followed by a range of 20% to 30% for employee below one year of tenure and 4 to 10 years, and the lower group of 11% to employees that works at the same firm for more than ten years (table 4.12).

Table 4. 12 - Mean percentage of employees' tenure (2008-2012)

Tenure	Total
Less than 1 year	20.3
1-3 years	37.7
4-10 years	30.6
>10 years	11.4

Figure 4.17 shows a uniform distribution of professionals inside the categories. It displays a rise of professionals with longer tenures of 4-10 years and 10+ years, growth rates are respectively 37% and 108%; already the number of employees that works for less than one year drops 22%. There seems to exist a trade-off here between professionals of high turnover, who probably established contracts of short-duration with professionals who have a long-term relationship with their employers. Chapter 5, through an econometric model, looks at tenure to understand if it is possible draw some conclusion about the duration of the employment relationship.

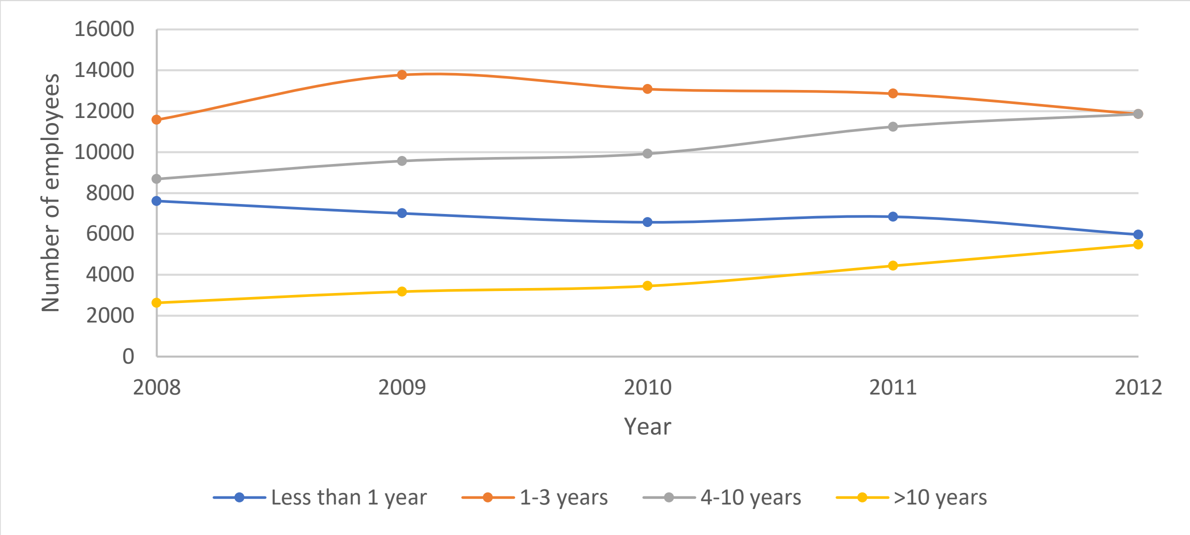

Figure 4. 17 - Evolution of length of employment (2008-2012)

Also for this variable, we analyze the worker's tenure for each category of firm size. Figures 4.18 until 4.21 display the trends.

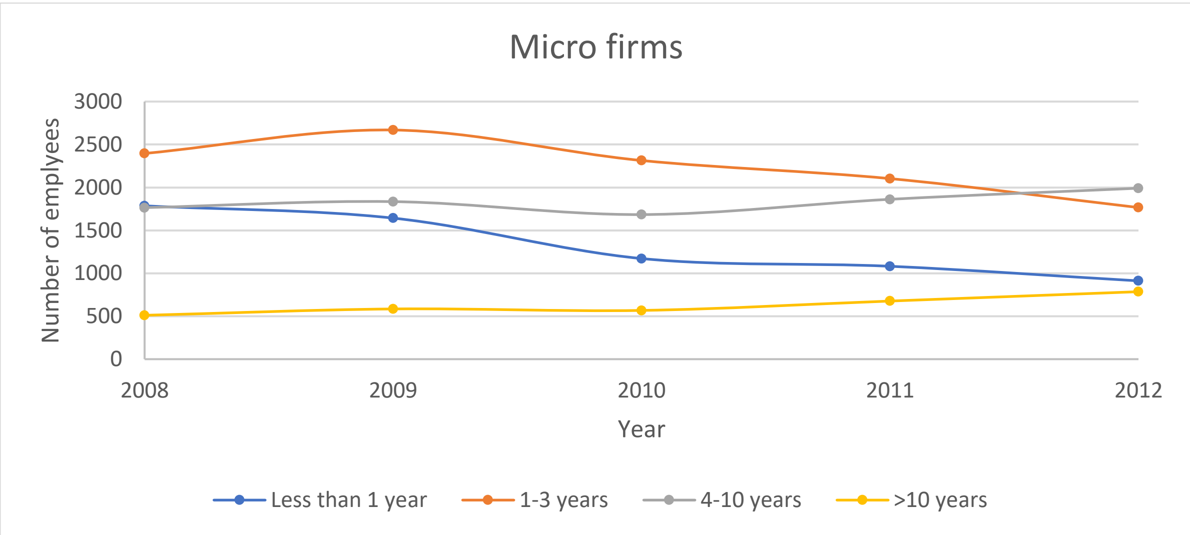

Figure 4. 18 - Length of employment in micro firms (2008-2012)

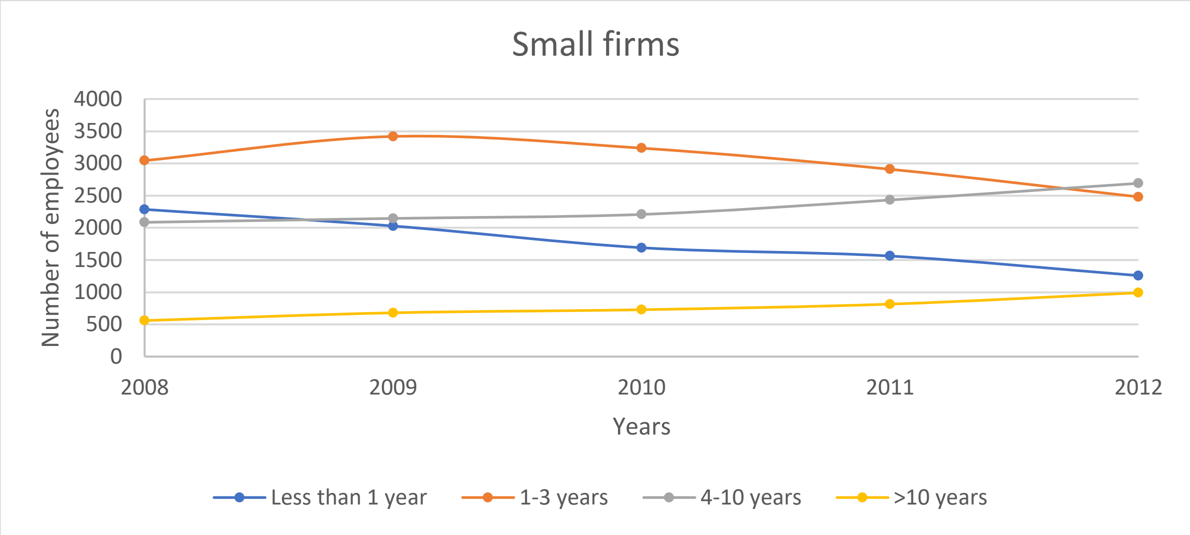

Figure 4. 19 - Length of employment in small firms (2008-2012)

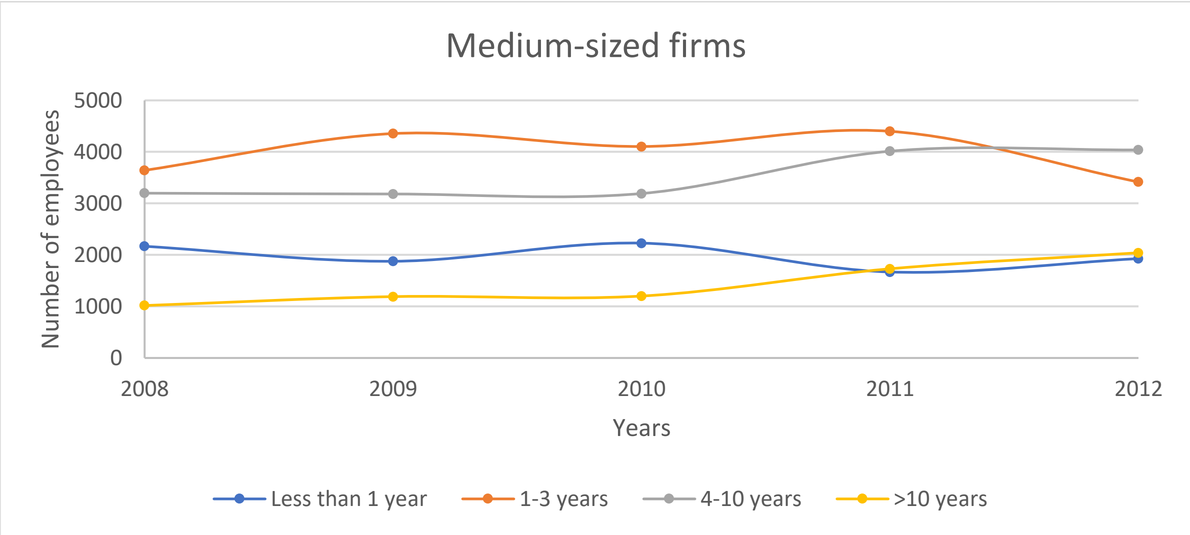

Figure 4. 20 - Length of employment in medium-sized firms (2008-2012)

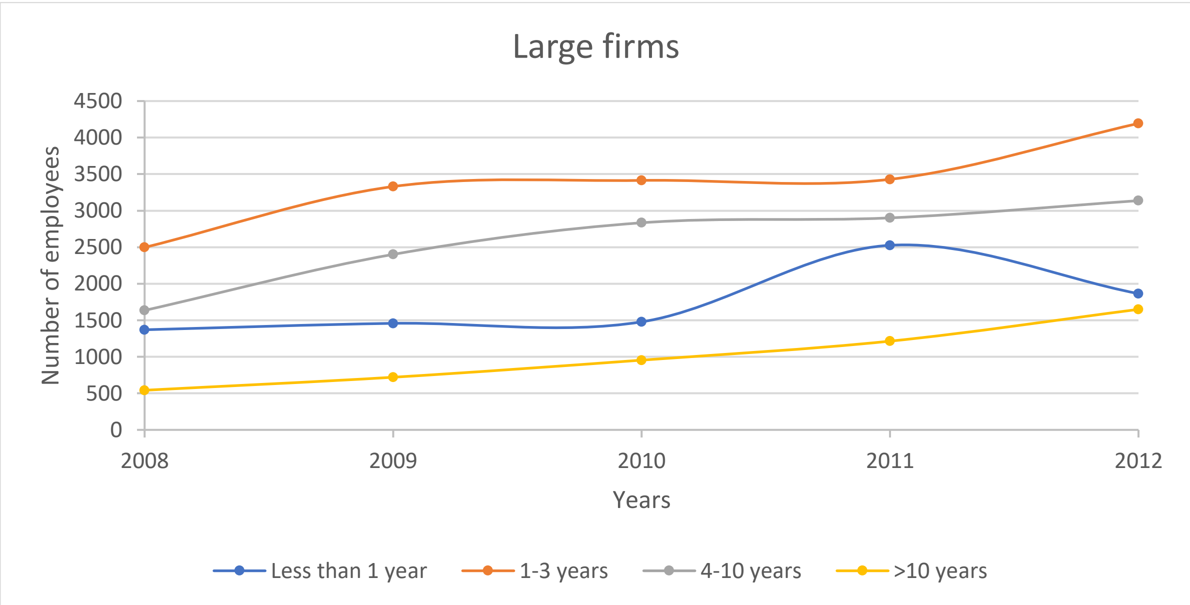

Figure 4. 21 - Length of employment in large firms (2008-2012)

For micro, small and medium-sized firms, the number of workers with contracts from <1year to 3 years decreases; in contrast, for large firms the number of employees grows for any employment duration.

Tenure seems to be independent of firm dimension, which are described in table 4.13. Majority of individuals have a length of employment between 1 to 3 years, followed by workers with a tenure of 4 to 10 years. The number of new workers – employed for less than a year – have been around 20%.

Table 4. 13 - Mean percentage of tenure in micro, small, medium-sized and large firms (2008-2012)

Tenure	Micro	Small	Medium	Large
Less than 1 year	21.9	22.5	18.1	20.0
1-3 years	37.4	38.5	36.5	38.7
4-10 years	30.4	29.5	32.3	29.6
>10 years	10.4	9.6	13.2	11.7

5. Wage regression results

Chapter 5 aims to study wage policies in the Portuguese IT sector, where the focus is a multiple wage regression applied to the QP data. In order to analyze the wage data correctly all values were updated with inflation rate to the year 2012. Wages are the sum of base salary and regular benefits, where zero euros wages were excluded. To run a regression model with variables presented in Chapter 3 and described in Chapter 4 we use the software STATA. Option “robust” was added to the end of regression to validate the model for heteroskedascity conditions.

Table 5.1 displays the wage regression results for a base specification. It includes the set of variables that remain in the regression for the subsequent specifications. The control group is a male, located in a district other than Lisbon, employed by a micro firm which operates in *data processing, hosting and web portals (CAE 63)*, basic level of education and experience in the firm between 1 and 3 years. To interpret the estimated coefficients as percentages of wage variation, the transformation $100(e^{\beta} - 1)$ is applied.

The regression in table 5.1 explain 41.9% of logarithmic wages variation, where all coefficients are significant. Those that mirror human capital attributes – education and tenure – are positive, a typical result for wage regressions. The research of Cardoso (2000) which investigates firms’ wage policies in Portugal, comprises similar results.

The results show that some form of gender wage gap is present: females receive lower wages (-18%) when compared to men. As described in Chapter 4 about 70% of individuals who comprise the workforce are male, thus this is a sector with a strong prevalence of men, receiving higher wages, even when controlling for workers and firms’ characteristics. Age has a curvilinear effect, and the negative coefficient on age squared indicates a higher return to experience for early years of employment. The IT sector develops activities related to new technologies that quickly become obsolete over time. A young, trend-following and easily adaptable workforce is then required.

Workers employed in a firm having headquarter located in the district of Lisbon are likely to receive higher wages (15%). Lisbon is the capital of Portugal, where the unemployment rate is lower than total unemployment rate in the country – 12.4% against 13.8% in 2011.[4] It is a very competitive city where are located higher number of firms, mainly belonging to tertiary sector, which use higher wages as strategy to attract qualified human resources.

The larger the size of the firm, the higher the worker wage, relative to a worker in a micro-firm (less than ten employees): more 25% in small firms, 47% in medium, and 49% in large firms. In their study about IT sector in Singapura, Ang et al. (2002) state that larger firms are able to pay better salaries once they

[4] https://www.pordata.pt/Municipios/Taxa+de+desemprego+segundo+os+Censos+total+e+por+sexo+(percentagem)-405 (accessed on October 12)

hold high power over the market, with higher rate of return on capital. Their human resources need to possess capabilities that allow firms to deal with a high degree of complexity, that is, the human capital of employees in large institutions is different than that of small ones. The authors alert that, being difficult to monitor the performance of a worker in a large firm, these firms provide a better payment as incentive. The comparison of coefficients for medium and large firms can be explained through their life cycles. Medium and large firms are generally in maturity stage where face lower risk when compared to small firms, so they likely will have their market position assured and are in a sustainable path.

Comparing compensations in *data processing and web portals (CAE 63)* industry, employees in *publishing data and software (CAE 58)* firms receive on average more 19.4%. *Publishing data and software (CAE 58)* is the industry paying higher wages in the IT sector. This industry performs highly specialized activities which require human capital with specific knowledge and understanding. Also, since less than 6% of market is formed by these firms, workers employed in this industry are rewarded for their specialization.

Workers employed in firms belonging to *computer programming, consultancy and facilities management activities (CAE 62)*, receive more 14.3% than the control industry (CAE 63). Similarly to CAE 58, CAE 62 comprises activities as conception and development of programs requiring specialized human capital. They develop consultancy activities too, an area with high growth rate during recent years in Portugal, and which more efforts are done when recruiting IT experts.

CAE 95, *Repair of IT products* consist of activities as maintenance and repair of computer, pen drives, hard drives, and other hardware, meaning that workers in this industry do not need the same type of skills than professionals in the other IT industries. This industry employs predominantly workers who develop technician IT occupations and occupy lower job levels. Therefore, it is expected that their wages are lower when comparing to other activities. The results confirm this and show that employees in firms that belong to the *IT repair industry (CAE 95*) earns on average less 7.3% relatively to firms in CAE 63.

The positive coefficients for education show that general human capital is highly valuated in the IT sector. Workers with the secondary level of education receive more 31% when compared with basic education, while tertiary level receive more 83% since presents higher human capital endowment as reported in personnel studies. IT firms belongs to tertiary sector, providing mainly services that require more qualified workforce.

Tenure is also rewarded. On average new workers in the company receive less 11.7% than a worker with a seniority between 1 and 3 years. Older workers earn on average more 13.3% if they have 4 to 10 years of experience, and 28.7% if they have been employed at the firm for more than 10 years. A higher compensation for tenure can be a measure applied by firms to reduce turnover rates over time. In their study about turnover and labor market strategies to IT, Ang and Slaughter (2004) indicates that firms apply different strategies for distinct IT jobs, which is related to different turnover rates. They argue that more managerially-oriented workers have lower turnover rates and higher expected tenure leading to an industrial strategy; contrary to technically-oriented workers who experience present higher turnover rates and lower expected tenure conducting to a craft strategy. Chapter 4 indicates that most of the professionals under analysis follow a managerially-oriented career, as job levels show, what defines long length of employment thus higher tenure. Also, in a highly specialized sector as IT, firm-specific knowledge is desirable, and it is beneficial to select practices resulting on longer organizational tenure. The rising of wages over tenure are indicative of a strong internal labor market.

Table 5. 1 - Wage regression results for the Portuguese IT sector (2008-2012)

VARIABLES	Base regression
Female	-0.203***
	(0.003)
Age	0.075***
	(0.001)
Age2	-0.001***
	(0.000)
Lisbon	0.138***
	(0.003)
Firm size:	
Small	0.222***
	(0.005)
Medium	0.390***
	(0.004)
Large	0.402***
	(0.005)
Industry:	
58 - Publishing of computer games and software	0.177***
	(0.007)
62 - Computer programming, consultancy and facilities management	0.134***
	(0.005)
95 - Repair of IT products	-0.076***
	(0.009)
Education level:	
Secondary	0.267***
	(0.006)
Tertiary	0.607***
	(0.006)
Tenure:	
0 years	-0.124***
	(0.003)
4 to 10 years	0.125***
	(0.003)
>10 years	0.252***
	(0.005)
Dummies for years	Yes
Constant	4.669***
	(0.027)
Observations	154905
R^2 adjusted	0.419
F-Statistic	5633.25

The dependent variable is the worker real wage (2012 prices) in logarithm. Data for 2008-2012. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

The next regressions investigate variables that provide firm advantage and are responsible for specific IT knowledge and ability. Therefore, job level, education in IT courses and IT occupations regressors are added to the model in table 5.1. The results are displayed in table 5.2.

Education is important and referred as a factor that allows an individual to progress in career (Osterman, 1984). Although, looking at education from another perspective, we can associate it with a measure of skill specificity when considering that workers coming from IT courses will have more knowledge in this area than others. Is this vantage reflected in the wage regression? In model 1, the variable Education is unfolded into four dummies, being the control group workers with basic education. All the parameters are statistically significant. Results show a premium for workers with tertiary background in information technology education. Against employees with basic school level it was expected that a worker with tertiary schooling would receive a higher wage (table 5.1 displays a positive coefficient of 0.633). However, what is interesting is the comparison of positive variations for tertiary education specialized in IT and not specialized: the first group presented a wage premium of 88%, against the 75% belonging to professionals without IT studies, holding all other independent variables fixed. This can be explained by the fact that human resources with academic knowledge in the core activity of the organization provide competitive advantage, since higher levels of IT education are positively related with the firm performance (Bharadwaj, 2000). These results are corroborated by the research of Walker and Zhu (2005), which verifies that math and engineering courses (tertiary IT) are those with the highest wage returns. Also Ang et al. (2002) when investigating salary data for IT professionals in Singapore, conclude that compensation is directly determined by human capital endowments of education and experience. Additionally, they find that compensations are superior for workers with IT bachelor and/or IT major, when compared to workers with other tertiary degree, as seen in our estimations in table 5.2.

As seen in the theoretical framework, IT Human Resources are classified as managerial or technical. These statuses are connected with the job levels, where the three first levels – top managers, intermediate managers and supervisors – represent managerially-oriented employees, and the remaining five represent the technically-oriented. Thus, is it possible to find this division when evaluating wages? Or do these clusters arise only when we evaluate the job level? Are there wage differences among these levels? Model 2 presents the results for the wage equation when job level dummies are included in the regression. Once again, all the coefficients are significant. Before analyzing these, we run a regression for a binary variable associated to have a managerial job level or not (not shown in the table). The statistically significant coefficient associated to this variable is 0.22, meaning that an employee in the three top levels of job hierarchy earns on average more 24% than an employee allocated to technical levels, holding other all factor constant. Managerial IT employees are responsible for providing a sustained and competitive vantage to the firms, which is translated into higher remunerations. The different job levels measure distinct but related aspects of a firm’s stock of human capital, therefore higher job levels translate into more stock of human capital, what is rewarded through a better compensation.

When investigating the wages differences over the hierarchy through model 2 we use skilled professionals as the comparison group. Estimated parameters show a wage detriment of 5% for employees with low skill level abilities and a wage premium of 53% for workers in the top of hierarchy. We find that workers in high-skilled layer (0.306 log points) receive, on average, a higher compensation than supervisors and intermediate managers (0.286 log points). These highly-skilled workers possess strong specific sector knowledge. As seen in descriptive analysis, these professionals represent less than 12% of the total observations, meaning that they are a scarce human resource. Employers need to provide higher payment in order to retain them in their firms.
The results answer affirmatively to the question about wages differentiation between managerial and technical professionals.

Adding other measure to skill specificity, namely the occupation, does not means that all professionals in the sector develop tasks where specific computer knowledge is needed. How does salary reflect a premium for workers with IT occupation? Models 3 and 4 in table 5.2 study the premium associated to tasks where knowledge and skills in IT are needed. First, model 3 verifies how much an IT occupation influences wages. The binary regressor – Occupation IT – shows that employees with IT specific occupations receive a compensation on average 8.5% superior to employees with occupations not directly related to IT.

Dividing IT occupation into dummies for specific tasks help us to understand which are the occupations with better payments, comparing again with individuals assigned to occupation not specific in IT. Model 4 shows that the initial wage premium of 8.5% for IT occupations is an average that conceals the heterogeneity in the compensations of the different IT professionals according to the tasks performed. CIOs get the higher monetary compensation, about 64% of premium, as this occupation is associated with a managerial task. The CIO position requires large responsibilities and strategic vision for the firm, while leading the specialized workforce.

The remaining estimated parameters in model 4 display increases in payment for consultants (26%) and for programmers and systems professionals (12%). Technicians receive a wage penalization of 4% when compared with no IT occupation. Consultancy analyzes the needs and problems of clients, search for better solutions, plans and builds computers systems while integrating all the hardware and software. Since they provide directly assistance to clients beyond technical knowledge, they need interpersonal skills. All these features are translated into a superior compensation to these professionals. Programmers and systems workers are the highly specialized workforce who develops activities related to the core business of the firm. They are the source of firm competitive advantage as they are more technical oriented or more managerial oriented. Finally, technicians are the workforce less specialized and, regarding to job level, with more technical orientation instead of a managerial orientation. This is reflected in a negative relationship between the dummy in question and wages.

Model 5 in table 5.2 presents a final regression that includes the whole set of variables used in the previous models. In particular, it adds the job level variables to the specification of model 4. R^2 adjusted increases and now the set of regressors explain 48.1% of the logarithmic variation. The objective is to observe the change in the estimated parameters when two variables conveying partially the same information are included in the wage equation. As expected, the parameters for job levels and occupations dummies decrease, especially for occupations. The dummy for programmers and systems workers becomes statistically non-significant. Occupations underlie a hierarchy; in turn this multi-level structure is mirrored by job levels. Therefore, it suggests that job level dummies capture some of the effect of occupation dummies in the explanation of compensations.

Table 5. 2 - Estimation results of wage equation with specific IT workforce features

VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5
Education level:					
Secondary	0.270***	0.212***	0.260***	0.247***	0.206***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Tertiary no IT	0.564***	0.423***	0.561***	0.527***	0.407***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Tertiary IT	0.633***	0.450***	0.612***	0.555***	0.429***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Job level:					
Top manager		0.427***			0.409***
		(0.004)			(0.004)
Intermediate manager and supervisor		0.286***			0.280***
		(0.004)			(0.004)
Highly-skilled		0.306***			0.301***
		(0.004)			(0.004)
Semi-, Non-skilled and trainee		-0.051***			-0.055***
		(0.006)			(0.006)
Occupation IT			0.082***		
			(0.003)		
Occupation IT:					
CIO				0.495***	0.383***
				(0.014)	(0.014)
Systems and Programmers				0.112***	0.000
				(0.003)	(0.003)
Techician				-0.040***	-0.060***
				(0.004)	(0.004)
Consultant				0.231***	0.1665***
				(0.006)	(0.005)
Dummies for years	Yes	Yes	Yes	Yes	Yes
Constant	4.654***	4.875***	4.644***	4.492***	4.923***
	(0.027)	(0.026)	(0.027)	(0.027)	(0.026)
Observations	154905	150617	154905	154905	150617
R^2 adjusted	0.421	0.473	0.424	0.437	0.481
F-Statistic	5450.10	5303.50	5276.45	5041.53	4888.77

The dependent variable is the worker real wage (2012 prices) in logarithm. Data for 2008-2012. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Each regression has the following additional variables: gender, age, age^2, district of Lisbon, firm size, industry and tenure.

5.1. Interactions

After analyzing factors that determine the compensation practices in IT firms, we now explore some possible interactions between those determinants.

Table 5.3 presents the interaction between education and the job ladder. The control group are professionals with basic level of education classified as skilled. The results show that the advantage of secondary schooling compared with basic education is associated to higher wages only at the bottom of the hierarchy. Tertiary (no IT) provides a wage premium along the hierarchy, especially for the intermediate managers and supervisors. Tertiary IT only entails a wage advantage for the lower levels, being not significant to the intermediate managers and negative the top managers. Clearly, the educational specialization in IT fields does not translated directly into an immediate advantage at the top of the hierarchy. It can also be the case that firm size variables do not fully capture the relationship with wages, and the regression is capturing top managers with IT education in small firms compared with top managers occupied by professional without that educational specialization.

Table 5. 3 - Interaction between job level and education

Job Level	Education		
	Secondary	Tertiary no IT	Tertiary IT
Top manager	-0.035	0.125***	-0.099***
	(0.022)	(0.022)	(0.022)
Intermediate manager and Supervisor	0.012	0.220***	0.017
	(0.015)	(0.016)	(0.016)
Highly-skilled	0.059***	0.141***	0.089***
	(0.016)	(0.017)	(0.017)
Semi-, Non-skilled and trainee	0.232***	0.176***	0.388***
	(0.016)	(0.024)	(0.019)
	Observations	R^2 adjusted	F-Statistic
	150617	0.478	3574.18

The dependent variable is the worker real wage (2012 prices) in logarithm. Data for 2008-2012. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The regression has the following additional variables: gender, age, age^2, district of Lisbon, firm size, industry, tenure, education, job level and dummies for years.

Tables 5.4 and 5.5 show the interaction between tenure and occupation and between tenure and education. Workers with experience of 1 to 3 years and who does not develop an IT task are the base group in table 5.4. The positive coefficients associated to the new employees entail a wage premium for those with tenure less than one year. This wage premium can be interpreted as a motivational measure to promote effort and good performance from these IT workers. The table shows significant and negative values to higher tenure, translated as wage penalizations. The negative behavior can be due to unobservable differences in workers characteristics. The IT sector is a recent and highly changing industry, subject to substantial technological innovations. It is therefore expected that the abilities and knowledge of senior professionals become quickly obsolete. However, professionals with more experience in the firm continue to receive higher compensations than workers with less experience, since the result of balance is always positive. For instance, a consultant with tenure higher than ten year earns more 49% (0.244 + 0.230 – 0.075 = 0.399 log points – not displayed in table 5.4) than a worker in the control group.

In table 5.5, the comparison group are also workers with experience of 1 to 3 years, with basic level of education. For the dummy education tertiary IT, all the coefficients are significant, reflecting that specialized knowledge in IT courses is rewarded over the employment relationship. From the two tables, we conclude that tenure and its interactions with education and occupations are strong features that allows the workforce to receive higher wages in IT sector. The workers' wage is set by employers who administrates the rules that govern the price of labor, is an evidence of an internal labor market playing its role in the IT sector.

Table 5. 4 - Interaction between tenure and occupation IT

Tenure	Occupation IT			
	CIO	Systems and Programmers	Technicians	Consultants
0 years	0.037	0.062***	0.053***	0.051***
	(0.063)	(0.008)	(0.010)	(0.015)
4 to 10 years	-0.117***	-0.006	-0.037***	0.007
	(0.035)	(0.007)	(0.009)	(0.012)
>10 years	-0.134***	0.004	0.003	-0.075***
	(0.036)	(0.010)	(0.013)	(0.015)
	Observations	R^2 adjusted	F-Statistic	
	154905	0.437	3440.71	

The dependent variable is the worker real wage (2012 prices) in logarithm. Data for 2008-2012. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The regression has the following additional variables: gender, age, age^2, district of Lisbon, firm size, industry, tenure, education, occupation and dummies for years.

Table 5. 5 - Interaction between tenure and education

Tenure	Education		
	Secondary	Tertiary no IT	Tertiary IT
0 years	0.022	0.011	0.057***
	(0.017)	(0.018)	(0.016)
4 to 10 years	0.037**	0.015	0.042**
	(0.014)	(0.015)	(0.014)
>10 years	0.103***	0.075***	0.103***
	(0.017)	(0.019)	(0.17)
	Observations	R^2 adjusted	F-Statistic
	154905	0.421	3827.29

The dependent variable is the worker real wage (2012 prices) in logarithm. Data for 2008-2012. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The regression has the following additional variables: gender, age, age^2, district of Lisbon, firm size, industry, tenure, education and dummies for years.

5.2. Fixed-effects estimation

All the results obtained until now through the multiple regression model relies on five assumptions highlighted in Chapter 3. The most difficult and strong states that the unobserved error term is uncorrelated with explanatory variables. The failure of this condition leads to a biased estimation. In order to soften this condition and address some kinds of omitted variable bias, will use the panel data information to better detect and measure effects that cannot be observed in cross-sectional data and affect the dependent variable. The general panel data models are:

$$y_{it} = \beta_0 + \beta_1 x_{it1} + \cdots + \beta_k x_{itk} + u_{it}$$

Equation 3

Coefficients i, t and k refers to cross-sectional observation number, time period and variable label. The term u_{it} is divided in a_i, the part of error term which captures all unobserved time-constant or fixed factors that affect y_{it}, and v_{it}, the part that contains the unobserved effects that change over time and affect y_{it}. The term a_i is translated as a dummy for each observation when the model assumes the fixed-effects form and can be correlated with the explanatory variables. That is not the case of the random-effects model, where the term a_i is considered a random variable sharing some of the proprieties assumed for the error term v_{it}. In both cases, the estimation raises several issues to obtain the estimated coefficients calling for procedures that avoid the direct estimation of the term a_i. We follow the fixed-effects model and need to transform the model in order to remove the time-constant effect of equation 3. Consider the average over time of equation 3,

$$\overline{y_i} = \beta_0 + \beta_1 \overline{x_1} + \cdots + \beta_k \overline{x_k} + \overline{u_i}$$

Equation 4

Where $\overline{y_i}$=$T^{-1}\sum_{t=1}^{T} y_{it}$. Once a_i is constant over time, their average value is a_i. Subtracting 4 to 3 we get

$$\ddot{y_{it}} = \beta_1 \ddot{x_{it1}} + \cdots + \beta_k \ddot{x_{itk}} + \ddot{u_{it}}$$

Equation 5

Resulting in an equation where the unobserved effect a_i disappears, meaning that we should estimate equation 5 applying OLS. This estimation model takes the name of fixed effect or within estimation. The within estimation interpretation comes from the transformation above. Contrary to the simple OLS, where the coefficients are basically identified by comparing the different values of the explanatory variables across levels, the within estimation identifies the coefficients from the change of the variable within each observation across time. The fixed effect of each observation, say a worker, captures the part of her ability that is constant across time, but unobserved to the researcher.

The fixed effects model relies on conditions of linearity in parameters, random sample, no perfect collinearity between independent variables and, the key assumption, strict exogeneity once u_{it} is uncorrelated with x_{itk} across all time periods. The four assumptions allow the within estimator to be unbiased. The fixed effects estimator allows arbitrary correlation between time-constant a_i and explanatory variables in all periods of time. The drawback of this model is that if an independent variable is constant over time for an observation i, the fixed-effect transformation $\ddot{x_{itk}}$ makes this variable to disappear. In a real application, if an explanatory variable for an individual is the same for all time periods, it disappears when performing a fixed effect transformation and it is not possible to estimate the associated coefficients. Gender is an example of a time constant variable. In addition, for those variables where there is little change within individuals, as is the case of workers' education in Portugal, even if the coefficient is estimated it will likely be not significant given that it hinges on a small subset of within changes.

5.2.1. Results of fixed-effects model

Table 5.6 presents a regression similar to Model 5 in table 5.2. As more extensive interpretation was previously made, a brief discussion of the results is provided given that part of the interpretation of results from the previous section translate to this one. Moreover, we take an exploratory approach, given that the full development of the fixe-effects model would imply extending the applied part of this dissertation (descriptive statistics included) beyond the limits of this dissertation. The R^2 within is the amount of time variation in the dependent variable that is explained by the time variation in the explanatory variables (Wooldridge, 2009). Given that the model explains the within variation, the R^2 within is small as is expected and frequent in this kind of models.

Relatively to the firm size, a change to a large firm is rewarded with a wage increase of 11.5%, on average. Large firms offer wage premiums as an effort to retain the more competent individuals. For the industry, a move to *Publishing of computer games and software (CAE 58)* activities entails a lower wage of 2.6%. Considering the previous discussion about this variable, this calls for further investigation. The coefficients for the remaining CAEs are statistically non-significant.

The age coefficients show the same quadratic form as before. Education levels are non-significant, what was expected whereas there are few observations of individuals changing their educational level. The coefficients for tenure show two significant and negative values for a tenure less than one year and tenure higher than ten years. The first, for new workers, is not surprising given the stepper wage tenure profile at the beginning of the employment relationship, when the workers are still in the first steps of the specific human capital accumulation. For longer careers, the lower human capital accumulation, the quick technological change observed in the IT sector and the difficulty for a worker to adapt to it can provide part of the explanation.

Occupation displays negative values linked to programmers and systems professionals. We believe that the key for this behavior lies on two reasons. First, a worker who moves to a specific IT occupation, comes from an occupation (maybe in a different sector) other than IT where she is better payed; or she is allocated to a specialized IT tasks, where she has no skill and lack of know-how, what leads to a penalty in compensation. We would need to analyze the specific occupational transitions and the associated career progression to further inform the interpretation of the results.

Concerning job levels, a worker who moves to a highly-skilled position is compensated with 5.5% of wage premium on average. A similar premium is associated with the intermediate manager level. The results can be read as promotions as the coefficients capture the transition of workers to a specific job level and assuming that most transitions are moves upward in the job hierarchy. The rise to the highest level of the hierarchy – *top manager* – is translated into a 6.9% wage premium. A job level linked to specialized or management positions brings awards since they need knowledge, abilities and/or ask for greater responsibility. The transition to the lowest job level – *semi-, non-skilled and trainee* – entails a negative wage premium and is probably associated with a demotion.

Table 5. 6 - Wage regression results using fixed effect estimators

Variables	Fixed effects model	Variables	Fixed effects model
Age	0.050***	Tenure:	
	(0.003)	0 years	-0.022***
Age2	-0.001***		(0.003)
	(0.000)	4 to 10 years	0.001
Lisbon	-0.022**		(0.002)
	(0.008)	>10 years	-0.015**
Firm size:			(0.005)
Small	0.038***	Occupation IT:	
	(0.010)	CIO	0.018
Medium	0.097***		(0.026)
	(0.009)	Systems and Programmers	-0.017**
Large	0.109***		(0.005)
	(0.010)	Technicians	-0.027***
CAE:			(0.005)
58 - Publishing of computer games and software	-0.026**	Consultants	0.034***
	(0.010)		(0.007)
62 - Computer programming, consultancy and facilities management	0.009	Job level:	
	(0.008)	Top manager	0.067***
95 - Repair of IT products	-0.012		(0.006)
	(0.031)	Intermediate manager and supervisor	0.045***
Education level:			(0.005)
Secondary	-0.013	Highly-skilled	0.054***
	(0.010)		(0.005)
Tertiary no IT	-0.021	Semi-, Non-skilled and trainee	-0.013*
	(0.013)		(0.007)
Tertiary IT	-0.003		
	(0.013)	Dummies for years	Yes
		Constant	6.497***
			(0.076)
Observations	150345		
i (individuas)	52348		
R^2 within	0.031		

The dependent variable is the worker real wage (2012 prices) in logarithm. Data for 2008-2012. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

6. Conclusions and Future Research

The dissertation studies the compensation policies in the IT sector in Portugal between 2008 to 2012 using the QP data set. QP is a matched employer-employee data set containing information about the industry, firms and workers, as well as wages. QP is a very useful tool to analyze the worker's professional progression since it allows tracking individuals and firms over the years. Through *QP* is possible to increase the comprehensiveness at microeconomic level about the employer-sector in Portugal. The descriptive analysis shows how the number of IT firms decreased accompanied by an increase of firm size. The sector is strongly dominated by males, with tertiary level of education, where 40% of the workers possess a degree in IT field related degree. The workforce is highly qualified since about 75% of it occupies management and highly skilled positions. Concerning occupations, the statistics show that more than 60% of the employees in the sector perform specific IT tasks, where more than 40% are programmers and systems analysts.

The results from the wage regressions shows that a managerial-oriented job is related with, on average, 24% higher pay when compared to technical-oriented positions; against a skilled professional, a top manager earns more 53%, intermediate manager and supervisor more 33%, followed by highly-skilled worker with a wage premium of 35%; workers in the lowest levels – semi-, non- skilled and trainee - receive less 5%. The highest levels in job pyramid underlie, beyond skilled and knowledge about the sector, higher responsibilities and abilities to control and monitor. Therefore, they are rewarded with higher wages. Education specialized in IT presents a positive relationship with wages: on average, and against an employee with basic level of education, a worker with IT tertiary schooling background earns more 88%, while a worker with tertiary education not IT earns more 75%. Workers in IT occupations receive an 8.5% wage premium. When separating into different IT occupations, and relatively to workers with no IT tasks, CIOs earn more 64%, IT consultants get more 26%, programmers and systems analyst are reward with 12%, and technicians receive a wage penalty of 4%.

The regression also shows that large firms entails higher compensations, on average 49%, probably due to the complexity of these firms and as an incentive to capture qualified workforce. Industries also provide distinct wage premiums, which are higher or lower depending on the degree of specialization required. From the interaction between variables, the dissertation concluded that the educational specialization in IT fields does not translates directly into an immediate advantage at the top of the hierarchy; tenure and its interaction with education and occupations are strong features that allows the workforce to receive higher wages in IT sector. Moreover, workers' wage is set by employers who administrates the rules that govern the price of labor, what is an evidence of an internal labor market playing its role in the IT sector. The results from the regression with interactions shows that future developments should consider the detailed information on the workers progression within and across firms. That would allow to investigate the strength of the internal labor markets and the role of the different forms of human capital accumulation

After the analysis of the wage level regressions, a fixed-effects model was applied to explore a within estimator that solves part of the estimation biases present in the pooled cross section models. The more interesting outcomes are that a change to a large firm is compensated in 11%; concerning job levels, a worker promoted to highly-skilled is compensated with, on average, 5.5% of wage premium; a promotion to top manager has associated a premium of 6.9%. The use of the longitudinal fixed effects model is also an avenue to future research, requiring a closer look at the workers' transitions across the different dimensions analyzed in the dissertation. Furthermore, an extension of the model to consider multiple fixed effect, namely firm fixed effects, can also be considered.

The work developed can be extended to study IT professional in industries other than IT. It would be interesting to contrast with the results obtained in the IT industry, where there is a natural match between the industry and workers' skills. The introduction of a previous step in the estimation, with a probabilistic model for the employment in the IT would be interesting by itself and would also provide a way to control for the selection into the IT industry that we imposed to pursue our study, improving the identification of the parameters of the model. Furthermore, the value of the IT skills can be studied by observing the displacement of workers when firms exit the market, assuming that this event can be considered exogenous to the worker's skills and performance.

A highly specialized sector as the IT industry, with its rapid expansion and being at the front of the technological change, provides a promising ground for future research. The research results discussed in this dissertation suggest that the IT sector strongly rewards IT skills and their development. The increase in the demand of IT professionals across the economy and the male dominance of the sector and the profession calls for specific policies aiming to foster the increase in the supply of IT skills.

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