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THE DESIRABILITY OF WORKPLACES AND WAGE DETERMINATION: AN ALGORITHM-BASED APPROACH

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"*Happiness is only real when shared.*"

(Christopher McCandless, Into the Wild)

Abstract: What makes a firm desirable? How does desirability impact the determination of wages? This dissertation aims to analyse the impact of desirability on wages, while also attempting to further understand the determinants of firm desirability. The analysis draws on employer-employee matching data for workers and firms in Portugal, from 2013 to 2022, as well as an algorithm-based approach, more specifically an adaptation of Google's PageRank, to measure desirability. This study contributes to existing literature of labour market dynamics by measuring and controlling for a majorly unobservable and unquantified attribute, desirability, through an algorithm-based approach. The measure of desirability is included in various specifications of existing wage-setting frameworks to quantify the true effects of firm desirability on wages. The evidence suggests that the main driver for firm desirability is not wages, but rather firm-specific characteristics, such as dimension. Regarding the effects of desirability on wages, the results show a predominantly positive and significant relation between wages and desirability, which is crescent with qualifications. A Gelbach-style decomposition (Gelbach, 2016) complements the analysis by indicating that more desirable firms often offer better firm-wide compensation policies, influencing the preferences of workers. Especially for lower-skilled workers, these policies compensate the less favourable valuation of worker characteristics as well as the drop in wage category. Overall, the study finds that more desirable firms not only tend to offer higher wages but also better non-pecuniary attributes. Despite benefiting workers in general, the relation between wages and desirability is more pronounced at the top levels of qualifications, suggesting that the preferences of workers potentially contribute to an increase of wage inequality.

JEL codes: C36; J24; J31; J33; J42; J81

Keywords: Amenities; Compensation Differentials; Firm Desirability; Monopsony; Outside Options; PageRank; Wage Determination; Worker Mobility

Resumo: O que torna uma empresa desejável? De que forma a desejabilidade das empresas afeta a determinação dos salários? Esta dissertação tem como objetivo analisar o impacto da desejabilidade nos salários, procurando, simultaneamente, uma melhor compreensão dos determinantes da desejabilidade. A análise é baseada em dados de correspondência entre trabalhador e empregador, para trabalhadores e empresas em Portugal, entre 2013 e 2022, assim como numa abordagem algorítmica, mais especificamente, numa adaptação do algoritmo PageRank, da Google. Este estudo contribui para a literatura existente das dinâmicas do mercado laboral, através da quantificação e controlo de um atributo predominantemente não observável e não quantificável, com recurso a uma abordagem algorítmica. A medida de desejabilidade é incluída em múltiplas especificações de modelos de determinação salarial de forma a analisar a relação entre desejabilidade e salários. Os resultados sugerem que o principal impulsionador de desejabilidade não são os salários, mas sim características específicas da empresa, como a sua dimensão. No que concerne aos impactos da desejabilidade nos salários, os resultados mostram uma relação positiva e significativa entre a desejabilidade das empresas e os salários dos trabalhadores, mais pronunciada para trabalhadores mais qualificados. As decomposições ao estilo de Gelbach (Gelbach, 2016) complementam a análise ao indicarem que empresas mais desejáveis frequentemente oferecem melhores estruturas de compensação transversais à empresa, influenciando as preferências dos trabalhadores. Especialmente para trabalhadores menos qualificados, este tipo de políticas não só compensa a valorização menos favorável das suas características, mas também a descida de categoria salarial. Em suma, o estudo indica que empresas mais desejáveis tendem a pagar melhores salários assim como melhores atributos não-pecuniários. Apesar de beneficiar a generalidade dos trabalhadores, a relação entre desejabilidade e salários tende a favorecer os trabalhadores mais qualificados, sugerindo que as preferências dos trabalhadores potencialmente contribuem para um crescimento da desigualdade salarial.

Códigos JEL: C36; J24; J31; J33; J42; J81

Palavras-chave: Amenidades; Diferenciais de Compensação; Desejabililade Empresarial; Monopsónio; Opções Externas; PageRank; Determinação Salarial; Mobilidade de Trabalhadores

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1. Introduction

What makes a firm desirable? How does desirability impact the determination of wages? When a worker is faced with the decision to move to a new job or firm, there are many factors that influence the outcome of such decisions. These factors can either be pecuniary, such as income or expected income or non-pecuniary, such as amenities, whose role on wage outcomes has been studied for centuries, with Adam Smith pioneering the understanding of its importance. In the Wealth of Nations, Adam Smith states that inequalities can arise from the nature of the employments, defending that non-pecuniary attributes such as cleanliness or dirtiness, honourableness or dishonourableness are responsible for wage variations, all other things equal (Smith, 2008). This view laid the foundation for the development of the compensation differential theory. In this setting, favourable job characteristics, such as amenities, are seen as a compensation for lower wages (Rosen, 1974), contributing to a more complete understanding of wage dynamics. Whereas traditional approaches to wage determination emphasize individual characteristics, such as education and experience (Mincer, 1974), and productivity (Hicks, 1932), as the primary explanatory factors of wage determination, modern developments of wage theories have demonstrated the importance of job and firm-specific attributes in wage outcomes, setting the base for this work.

In this dissertation, the aim is to understand and quantify the effects of firm desirability on wages. As such, the first step in the empirical analysis of the study is to measure desirability and understand what its determinants are. As desirability is a very broad concept and a majorly non-observable characteristic, measuring it poses difficulties. To address such challenges, an adaptation of Google's PageRank algorithm is employed. The original conception of the algorithm, designed to rank webpages, is built upon a very general premise. According to PageRank, the quality of a web page is determined by the quality and quantity of other webpages that point to it. Naturally, given the generality of the premise of the algorithm, and by consequence, the generality of the mathematics of the algorithm, adaptations are not only possible, but frequent. In the context of labour market, to follow the premise of the algorithm, it is necessary to consider firms as webpages and workers as links. In this framework, the desirability of a firm is determined by the flow of workers between firms, so, if a large set of workers move from Firm A to Firm B, then, Firm B is more desirable. Using employer-employee matching data for workers and firms in Portugal

from 2013-2022, it is possible to create the base for the algorithm by attributing each combination of firms (origin-destiny) an identifier, which is the key for the computation of the algorithm. However, the analysis of the desirability component goes beyond its quantification. Given the nature of the concept of firm desirability, it is needed to account for several factors when attempting to understand the determinants of desirability. As such, various specifications of a model that controls for the wage component are considered, while additionally controlling for the average worker characteristics, the average contract and for firm-specific characteristics.

The main component of the dissertation, the analysis of the effects of firm desirability on wages is divided into three parts. Firstly, the empirical framework is set, by utilizing wage-setting empirical frameworks established in literature (see Blanchflower 1996; Manning 2011). Here, various specification of models of wage determination account for rent-sharing, control for outside options and take into consideration a vector of worker characteristics, as well as controlling for worker and firm fixed effects, basing the analysis on a strong and empirical and theoretical background. The second part of the analysis not only produces the main results but also states the contribution of this study to the existing literature on wage determination. Here, the abovementioned wage-setting models are extended for desirability, incorporating the output of the PageRank algorithm in a percentile format.

The evidence suggests that there is more to desirability than wages, with worker, contract and firm components registering greater importance than the wage component in the explanation of the PageRank scores of firms. Nevertheless, the effects of desirability on wages are not only observable but also economically significant. The evidence points to a majorly positive response to wages to increases in desirability, especially in the full specifications of the model. Furthermore, for all specifications there is evidence that higher-skilled workers, the ones who occupy managerial positions, tend to register higher wage gains in response to increases in desirability than the lower-skilled workers. In the case of lower-skilled workers, the response of wages to increases in desirability is, in some specifications, negative, indicating that in the base of the workforce, the desirability of firms can be used as a compensation differential, meaning that firms can set their workers' wages at a lower level and compensate them through favourable non-pecuniary attributes, in this case, desirability. The Gelbach-style decompositions indicate that higher paying firms often offer better

compensation policies. Such policies, which are transversal to the firm, compensate not only for a lower remuneration of workers' characteristics, especially for lower-skilled workers, but also for a drop in wage category. This means that workers prefer to work in more desirable firms, despite being less compensated for their specific characteristics and despite dropping in wage category, due to firm-wide compensation policies, reflected in the firm component of the decompositions, which leads to higher wages.

The dissertation is structured as follows: Section 2. contains a literature review on the different focuses of this study. Section 3. defines the primary data sources, describes the treatment applied to the data and sets the empirical framework of all components of the dissertation. Section 4. presents the results of all the models estimated and analysis completed as well as discussing the produced results. Section 5. concludes by resuming the entire dissertation, stating the implications of the main results obtained and proposes further developments to the study as well as presenting limitations to the study.

2. Literature Review & Conceptual Framework

This section reflects on the existing literature on the various topics of interest for this dissertation. Therefore, this chapter is divided into five sub-sections, each of which presents the main literature in the respective field.

2.1 Desirability

When studying and understanding the effects of the desirability of firms on wage determination and negotiation, the first step in the analysis must be the comprehension of the concept of desirability and the characteristics that influence it. Naturally, the question that poses is: What makes a firm, or a job more desirable? What influences the decision of workers to apply for a certain job in a certain firm?

The Anticipatory Psychological Contracts (hereafter APC) theory, according to Moser et al. (2017) suggests that job seekers base their job decisions in three types of employer attributes, which are of transactional (monetary and other tangible compensations), relational (employer-employee relation) and ideological nature (commitment to valued causes, etc). As expected, one of the main contributing factors to the decision to apply for a job at a certain firm is income, or, in other words, compensation, with higher compensation leading to more favourable evaluations of jobs (Barber & Roehling, 1993). However, due to the scope of this dissertation, the focus is going to be on the attributes that are not perceived as transactional but can affect the employer's attractiveness, a concept first introduced in Turban and Greening (1997). The importance of employer branding, a concept first defined by Ambler and Barrow (1996) reflects the reputation of a firm, which is none other than the perceived quality of characteristics of different natures that a firm possesses. According to Cable and Turban (2003), the reputation of firms impacts job seekers in two distinct manners: first, it serves as a signal for job attributes and secondly, it can be seen as an attribute, capable of adding value to a job beyond its characteristics.

Considering the APC theory, there are firm-specific characteristics from a relational and ideological nature that allow firms to differentiate themselves from others, affecting their branding as employers. As for relational attributes, there is evidence that leadership style influences the organizational image of a firm (see Kashyap & Rangnekar, 2016; Sahu et al., 2018), which directly affects a firm's desirability. Tanwar and Prasad (2017) argue that work-life balance is hugely relevant to employer branding, indicating that employees prefer workplaces where flexible working hours and remote work facilities are provided, with

Maurya and Agarwal, (2018) arguing that work-life balance does not only improve firm's attractiveness but also allows to retain talent. There is also evidence that ideological characteristics such as Corporate Social Responsibility have considerable influence on employer attractiveness (see Dogl & Holtbrugge, 2014; Klimkiewicz & Oltra, 2017; Tanwar & Prasad, 2017) as well as social media presence, where its importance to firm reputation has been evidenced by Dabirian et al. (2017) and Robertson et al. (2019).

Nevertheless, there are many other factors that influence the decision to apply for a job, from job qualifications (see Belt & Paolillo, 1982) to social influences (see Kilduff, 1990) which corroborates the theory that organization's attractiveness also depends on workers' individual characteristics (Kristof-Brown et al., 2005). Therefore, the desirability of firms is a very complex object of study, as it depends on observable characteristics but also on non-observable characteristics, such as reputation. However, when discussing firm reputation, non-pecuniary characteristics such as amenities should be considered, as evidenced by Lazear and Shaw, (2007), suggesting that money is not everything for workers as they value other benefits and characteristics of the workplace, enhancing the importance of amenities in job and workplace choices.

2.2 Amenities: Compensation Differentials?

The importance of non-pecuniary characteristics and their direct impact on desirability not only affects the attraction of the workforce (Turban & Greening, 1997) but also has implications on wage determination. The impact of non-pecuniary characteristics on wages has been studied for more than two hundred years, marking the original conceptualization of the compensation differential theory which suggested that unfavourable characteristics such as dishonourableness or a lack of cleanliness commanded higher wages, all other things equal (Smith, 2008).

This insight has been formalized in modern labour economics in Rosen (1974) by introducing a hedonic pricing framework in which jobs are understood as bundles of attributes, both pecuniary and non-pecuniary. Workers, assumed to have heterogeneous preferences, choose among such bundles based on their utility, resulting in an equilibrium where wage differentials reflect the value of non-wage job characteristics. Rosen (1986) later expanded the original model into a theory of equalizing differences, reinforcing that, in competitive labour markets, differences in job characteristics must be compensated through wages to equalize utility across occupations.

Empirical studies have attempted to quantify these compensating differentials, particularly focusing on undesirable job characteristics such as physical risk or irregular hours. Brown (1980), in one of the earliest empirical applications, found that jobs involving greater occupational risk tended to offer higher wages, consistent with compensating differential theory. However, estimating these wage differentials is challenging due to issues of unobserved heterogeneity. Workers may differ in unobservable traits such as risk tolerance or productivity, potentially biasing estimates. Hwang, et al. (1992) address this concern by demonstrating that unobserved productivity can lead to underestimation of the true value of compensating differentials, highlighting the need for careful econometric design in such studies.

Recent research has moved beyond observational data by employing experimental and quasi-experimental methods. Mas and Pallais (2017), through a large-scale field experiment, found that workers were willing to accept wage reductions of up to 8% in exchange for desirable job amenities such as flexible scheduling and remote work options. This provided causal evidence that workers place substantial monetary value on non-wage attributes, reaffirming the centrality of amenities in job choice decisions. ´

Sockin (2021), using detailed matched employee-employer U.S. data and natural language processing techniques, demonstrated that firms offering higher wages also tend to provide better non-wage amenities. Despite contrasting the abovementioned theory of compensating differentials, this correlation means that well-paying firms are often the ones that offer the best non-pecuniary characteristics, amplifying differences in total compensation across the labour market, meaning that, amenities can not only serve as compensation differential but also as a premium to work at a better-paying firm.

In sum, the theory of amenities as compensating differentials has developed from classical observations to a sophisticated body of empirical and theoretical research. Job amenities are now widely recognized as integral to labour supply decisions, job matching, and wage formation. Whether measured through observational wage premiums or elicited through stated preferences and experiments, the evidence consistently shows that non-pecuniary job attributes carry real economic value with the capability to be seen as a characteristic that serves as a compensation differential or as a premium, enhancing its importance in wage structure and inequality.

2.3 PageRank & Applications

Understanding how preferences are formed and revealed in complex systems is a central concern in many fields, including economics. In environments characterized by large-scale interactions, such as the internet, labour markets or networks of firms, traditional metrics often fall short in capturing underlying structures of importance or desirability. One of the most influential tools developed to address this challenge is the PageRank algorithm, originally designed to rank webpages on the World Wide Web.

PageRank, introduced by Sergey Brin and Larry Page in 1998 (Brin & Page, 1998), represented a breakthrough in how information could be filtered and prioritized. Rather than relying solely on content or keyword frequency, PageRank assigned each webpage a score that reflected its importance within the entire web network. This importance was determined not only by the number of links pointing to a page but also by the quality of those links, meaning that links from pages that were themselves highly ranked carried more weight. In this way, PageRank embodied the notion that significance can be measured through association: a page is important if it is pointed to by other important pages.

Technically, PageRank models the internet as a directed graph, where each node is a webpage and each edge is a hyperlink from one page to another. The algorithm operates iteratively, updating each node's score based on the scores of the nodes linking to it, adjusted by the number of outbound links those referring pages have. This recursive logic creates a steady-state distribution of importance across the network, capturing a form of collective judgment that is more robust than simple frequency counts.

What makes PageRank especially powerful is its generality. The algorithm's core logic, the idea that connections can reveal value, applies broadly to any networked system where entities reference, endorse, or flow toward one another. In this sense, PageRank is more than just a tool for search engines; it is a foundational method for uncovering structure and hierarchy in complex relational data. The generality of the PageRank is what has allowed the algorithm to have many applications, despite some adaptations to the field of study, beyond its initial purpose of ranking webpages. The versatility of the algorithm can be seen through its different applications. For instance, in the field of Chemistry, Mooney et al. (2012) use PageRank for the study of molecules. Other fields of studies that have previously used some specification or adaptation of PageRank include Biology and Bioinformatics (see Jiang et al. 2009; Morrison et al., 2005); Neuroscience (see Zuo et al., 2012); Sports (see Radicchi, 2011);

Bibliometrics, where an specification of the algorithm was used to develop the Eigenfactor system (West, et al. 2010), and much more.

Despite its widespread adoption in fields such as computer science, information retrieval and network theory, the use of PageRank in economics has been relatively limited. This underutilization is striking given the algorithm's natural applicability to many economic contexts characterized by flows, rankings, and strategic interactions across networks. A notable exception is Sorkin (2018), who adapts the PageRank algorithm to study labour market dynamics by inferring firm rankings based on worker transitions. In this setting, the movement of workers between firms serves as a signal of relative desirability, allowing the algorithm to recover a structure of firm preferences without relying on direct measures. Sorkin's innovative use of PageRank illustrates the algorithm's power to uncover latent value hierarchies in economic networks and offers a compelling blueprint for its broader application within the discipline, which sets the technical framework for this dissertation.

2.4 Wage Determination & Labour Market Imperfections

To further analyse the impact of desirability on wage determination, it is not only important, but also necessary to understand which factors have an influence on the determination of wages. Existing literature highlights the importance of person-effects and firm-effects on the explanation of wage differentials (see Abowd et al., 1999; Goux & Marin, 1999). These findings imply that the distribution of wages is shaped by a range of determinants, including individual characteristics of workers such as skills and experience (Mincer, 1974) and by the accumulation of human capital over time (see Bagger et al., 2014; Becker, 1964). Moreover, the importance of job and firm characteristics should not be overlooked, as evidenced by the study on firm-specific wage premiums and its contribution to the rise of wage inequality in Germany (Card et al., 2013b).

The neoclassical approach to the determination of wages lays its foundation in the relation between marginal productivity of labour and wages (see Hicks, 1932). It assumes that labour markets are perfectly competitive, meaning that, in the presence of full access to information and the absence of transaction costs or labour market frictions, wages adjust freely to restore an equilibrium between supply and demand. However, this approach tends to neglect the effect that labour market imperfections can have on wages. Therefore, a complementary approach was needed. Robinson (1933) provided an alternative model for

the setting of wages with a focus on firm-specific setting of wages in a static labour market, introducing the term monopsony.

Despite some loss in popularity in the second half of the last century, the monopsony model evolved and regained its importance (Card, 2022), mainly due to the contribution of Alan Manning. Manning (2003) argued that even in a labour market characterized by multiple employers, monopsony power could arise due to friction in the market that restricts the options of workers, giving firms a bigger power to become price-makers. These frictions reflect the conditions that turn the labour market into a market of imperfect competition, such as imperfect information, geographic constraints of workers and employer differentiation due to specific characteristics of each firm, such as amenities. Manning (2003) also argues that the elasticity of labour supply to firms is often not perfectly elastic. The non-perfect labour supply elasticity is, therefore, a key aspect in the exercise of monopsony power.

Related lines of work tend to focus on other sets of frictions that can occur in the labour market. As workers and firms both take time in finding one another, search and matching frictions can arise. Mortensen and Pissarides (1994) incorporate these frictions into a dynamic framework where wages are determined through Nash bargaining between workers and firms. This model helps to explain wage dispersion and the coexistence between unemployment and job vacancies, something that traditional models were not capable of doing. Card et al. (2013a) find that workers that are employed at more profitable firms tend to earn higher wages, suggesting that firms tend to share their economic rents with their workers, a phenomenon known as rent-sharing.

Wage rigidity further complicates the adjustment processes in labour markets from adjusting downwards in response to excess supply of labour. One explanation for such rigidity is provided by Shapiro and Stiglitz (1984), through their efficiency wage model. In such framework, firms deliberately pay wages above the market-clearing level as a mechanism to discourage worker shirking in the presence of imperfect monitoring. Since effort is costly and cannot always be observed, higher wages increase the cost of job loss for workers, thereby providing a stronger incentive to remain productive. However, this wage-setting behaviour has important macroeconomic implications. Paying above-market wages leads to a situation where not all workers who are willing to work at the prevailing wage can find jobs, resulting in involuntary unemployment.

Oaxaca (1973) and Blinder (1973) introduced decomposition techniques in their studies to examine and control for differences in observable characteristics and potential discrimination related to gender and race, respectively. Policy measures, such as the introduction of minimum wages, also have effects on the determination of wages. Dube et al. (2010) argue that the imposition of minimum wages causes upward pressure at lower end of the wage distribution. Neumark et al. (2004) and Bossler and Schank (2023), despite arguing that there is upwards pressure in the low end of the distribution, suggeest that minimum wages often lead to reductions in working hours, leading to a potential decline in overall earnings.

Taken together, these findings challenge the assumptions of frictionless labour markets and underscore the importance of accounting for monopsony power, matching dynamics, bargaining power, rent distribution wage rigidity and compensation differentials when analysing wage setting, as evidenced by Postel-Vinay and Robin (2002), who measure the importance of market imperfections in the dispersion of wages in France, which they found to be 50%. These mechanisms are particularly relevant in understanding how job desirability and firm reputation affect wage determination and negotiation, as they introduce persistent heterogeneity in wages across similar workers and jobs.

2.5 Wage Bargaining & Outside Options

The relation between firms' financial condition and negotiated wage settlements is established in Abowd and Lemieux, (1993) using Canadian collective bargaining agreements. The abovementioned study does not only highlight the importance of controlling for and clustering for financial components such as revenues but also highlights the importance of collective bargaining or, in other words, the unionization of the labour market. By clustering for financial components, it allows for a segregation by dimension, which can prove to be very useful for the analysis of non-poaching agreements and its impacts on wage determination but also negotiation. No-poach agreements are covenants that prevent workers from moving to another firm in the same sector, which limits the outside options of workers, with impacts on the negotiation of their wages (see Krueger & Ashenfelter, 2018)

There is also evidence of the impact of regulation in the setting and negotiation of wages. For instance, evidence from multiple countries shows that more generous social security systems have a positive impact on wages, especially when it comes to privileged workers (Botero et al., 2004). As for the negotiation of wages, Hall & Krueger (2012) found

that a third of the responders of the survey they conducted in their study bargained their wages before accepting the job, not considering the offer as a "take it or leave it" nature. The importance of wage bargaining as a determinant of wages is documented in literature, as evidenced by Cahuc et al. (2006). Evidence on the importance of unions in the dispersion of wages shows that unions can play a pivotal role in the determination of wages, with different effects in different types of workers. Card (1996) finds evidence that unions not only have the power to raise the wages of workers, with bigger impacts on low-skilled workers but also have impacts on the selection of workers.

The use of Nash bargaining to determine wages highlights the importance of outside options. In this framework, widely used in the study of labour market dynamics (see Diamond, 1982; McDonald & Solow, 1981; Mortensen & Pissarides, 1994; Pissarides, 1985) wages are determined by a bargaining process that considers not only the bargaining power of firms but also the bargaining power of workers, measured by their outside options, meaning that workers with more options have more power to negotiate their wages, meaning that they can demand higher wages.

As for the impact of outside options on wage determination and bargaining, Caldwell and Danieli, (2024), using employer-employee data for Germany, show the importance of the outside options of workers to the determination of their wages, estimating that around 20% of the gender wage gap in Germany regards differences in outside options. Lachowska (2017) also argues that wages respond to outside options, with the survey results indicating that wages increase with better outside opportunities for workers. Caldwell and Harmon (2019) defend, by using employer-employee data from Denmark, that the expansion of former coworkers' firms increases the probability of a job-to-job transition which also increases the probability of increase in earnings, even if the worker does not move, indicating that the knowledge of outside options can result in higher bargaining power and consequently, in higher wages.

3. Data & Methodology

This chapter presents the primary data sources, the treatment applied to the data, as well as the theoretical and empirical framework on which this study is set. As such, it is divided into two main sub-sections, one that focuses on the data component, and other that details the empirical framework of this dissertation.

3.1 Primary Data Sources & Data Treatment

The investigative process required for this dissertation relies on two distinct data sources: the *Quadros de Pessoal* (Personnel Tables) and SCIE (*Sistema de Contas Integradas das Empresas*). The Personnel Tables, maintained by the Portuguese Ministry of Employment and Social Security, represent an annual mandatory survey conducted across all establishments employing at least one wage earner, providing a yearly longitudinally matched employee-employer-contract-job-title database.

The survey reports on all workers employed in October of each year, excluding civil servants and domestic service workers. Consequently, the dataset encompasses the entire workforce of private-sector firms operating in the manufacturing and services industries. A notable feature of this dataset is its high response rate, which mitigates issues commonly associated with panel data. The dataset includes detailed information on firm characteristics, such as location, industry, employment levels, sales, ownership structure, and legal framework as well as worker attributes, including gender, age, skill level, occupation, educational attainment, tenure at the firm, earnings, and working hours.

The secondary data source, SCIE, aims to characterise the economic and financial behaviour of firms through a range of key variables and financial ratios as well as to characterize the corporate dynamics of Portugal based on demographic indicators of firms. The datasets, published yearly, are composed of all firms (*sociedades, empresários em nome individual e trabalhadores independentes)* engaged in the production of goods and services during that period across the entire country. Excluded from the scope are financial and insurance companies, as well as entities not oriented towards the market, namely central and local government bodies and various associative activities.

For the pretended analysis, the chosen temporal horizon ranges from 2013 to 2022, with the ten-year interval allowing not only for more consistent data, as both the *Quadros de Pessoal* and SCIE databases suffered structural changes in 2011, but also allowing for a complete

analysis of worker's job and firm flows, which allows the computation of the firms' PageRank, which will be further discussed later in this work.

The investigation does not concern neither all workers nor all firms in Portugal, as that would raise some issues regarding the consistency of the analysis made. Instead, filters regarding age, remuneration control and work regime are used. The treatment applied to the original datasets follows procedures used in previous investigations (see Portugal et al., 2024) as well as further restrictions needed due to the nature of the study.

The worker database used for the analysis regards all employees between the ages of 18 and 65, who are working full time who do not report missing values in key variables such as wage, age or tenure. As for the firm panel, all firms that are registered as "*sociedades*" on SCIE and employ more than 10 people are considered. The resulting worker-firm panel is constructed by merging the abovementioned datasets using a fictional firm identifier (*Número de Pessoa Coletiva Fictício*). As such, it adheres to the restrictions previously outlined. However, some eligible workers and firms are not included in the final dataset due to mismatches during the merging processes.

3.2 Methodology

This section presents the empirical strategy employed to examine the role of job desirability in labour market dynamics. The analysis is divided into two main parts. The first focuses on measuring and explaining desirability, which is proxied using an algorithm based on the PageRank algorithm, adapted to apply to observed job transitions between firms. This network-based approach captures the relative attractiveness of positions as revealed by worker mobility patterns. The constructed measure is then analysed to identify the firm and job-level factors that shape desirability. The second part investigates the impact of desirability on wage determination, by employing models based on the existing framework for wage determination, that estimate the relationship between firm desirability and wages while accounting for worker and firm heterogeneity. Together, these components aim to provide a rigorous understanding of both the determinants and labour market implications of workplace desirability.

3.2.1 Desirability

Desirability is an inherently relational concept, often defined by how much others seek to engage with, select, or respond to a given individual or entity, playing a central role in contexts ranging from social networks to the labour market. However, measuring desirability poses a very complex methodological challenge as it is not directly observable, being

determined not only by observable interactions but also by underlying structures. To address such challenge, an algorithmic approach based on Google's PageRank algorithm is used. While originally developed to rank web pages, the mathematical structure of PageRank is highly generalisable, allowing it to be applied to a wide range of contexts. As previously discussed, the algorithm and its variants have been successfully employed in diverse fields of research to capture relative importance within complex networks.

PageRank is a network-based algorithm originally developed by Google to rank websites in search results. In essence, it evaluates the relative importance of nodes, such as webpages or, in labour economics, firms or jobs, within a directed network by considering both the quantity and quality of links pointing to them. The original conceptualization of PageRank is derived from Brin and Page (1998), being represented by:

$$PR(A) = (1-d) + d\left(\frac{PR(T1)}{C(T1)} + \cdots + \frac{PR(Tn)}{C(Tn)}\right) \tag{3.1}$$

Here, $PR(A)$ represents the PageRank score of page A, whereas d represents a damping factor between 0 and 1 which is usually assumed to be equal to 0.85. T1…Tn represents the different pages that point to page A. As for $C(A)$, it is defined as the number of links going out of page A. The core premise behind the structure of the algorithm is that a node is important if it is linked to by other important nodes. Instead of computing a simple count of incoming links, PageRank assigns more importance to links from other nodes that have high PageRank scores. The architecture of the algorithm creates a recursive system of influence, where each node's importance depends on the importance of those linking to it. The intuitive justification behind PageRank is that there is random web surfer who is given a web page at random and keeps clicking on links until he stops and starts from another random page. The probability of this "random surfer" visiting a page is its PageRank score (Brin & Page, 1998).

For the framework of this dissertation, instead of ranking webpages, the algorithm is used to rank firms, serving as a proxy for desirability. To compute this ranking, an adaptation of the PageRank algorithm is used, with the relations between firms being established through the mobility of workers. In the original framework, pages were ranked based on the number of links, giving more importance to the links that originated from firms with higher PageRank scores. In this setting, the ranking is determined by the mobility of workers, with higher importance given to workers that move from firms with higher PageRank scores. The

premise behind the use of this approach is the same used in Sorkin (2018), where a large flow of workers from Firm A to Firm B indicates an overall preference for the latter. These preferences are reflected in the calculation of the PageRank as its scores are determined by the mobility of workers. The output of the algorithm used in the scope of this dissertation can be easily observable as a matter of desirability. As the ranking given by the algorithm is determined by the flow of workers between firms, which reflects the preferences of workers, it can be said that a higher PageRank score reflects a higher desirability of a workplace. By reformulating the premise behind the use of the algorithm, a large flow of workers from Firm A to Firm B indicates that Firm B is more desirable, which is reflected on the output of the algorithm, the PageRank score of the firm.

In order to compute the algorithm, given that the data used comprises of yearly datasets for workers and firms merged through a common identifier, it is necessary to create a movement identifier that allows the count of worker flows between firms. In other words, it is necessary to create an identifier of the combinations of firms where a worker was working in a determined year and where the same worker was working on the year before, for all the years of the temporal horizon of the analysis. The creation of this identifier is the key to the computation of the adaptation of the PageRank algorithm, once it is the metric that allows to count the number of workers that move from Firm A to Firm B. Nevertheless, movements between the same firms in opposite directions have different identifiers, meaning that if a worker moves from Firm A to Firm B and another worker moves from Firm B to Firm A, these two workers will have different movement identifiers associated with them.

The measurement of desirability plays a pivotal role in the development of this study. Not only a part of the study is dedicated to understanding what factors influence the desirability of firms, but also the main component of this dissertation relies on understanding the effects of desirability in wage determination. In other words, the output of the PageRank algorithm is also used to understand the influence of desirability on wages. Both parts of the study will be further developed in this section.

With the purpose of understanding and better explaining the desirability of firms, the output of PageRank will be considered as the dependent variable, whereas worker, contract and firm characteristics will be considered as the controls used in the regressions of this section. The methods used follow an incremental approach, starting from a baseline Ordinary Least Squares (hereafter OLS) regression and adding, one by one, the type of controls (worker-level; contract-level; firm-level), as well as the introduction of year fixed

effects in all specifications. This approach allows for a clearer understanding of the magnitude of importance of the diverse set of characteristics in study. In order to further comprehend the magnitude of the controls (worker; contract; firm), decompositions of not only variance but also decompositions by average are conducted. The use of decompositions corroborates the critical reasoning behind the approach used, contributing to the clarity of results.

The first specification of the regression, is as said, a baseline OLS model with one term and year fixed effects, written as:

$$ln\,(PR_{f,t}) = \alpha + \beta ln\,(\overline{w_{f,t}}) + \varepsilon_{f,t} \tag{3.2}$$

This specification estimates the elasticity of firm desirability with respect to wages, that is, the percentage change in a firm's PageRank score ($PR_{f,t}$), a proxy for desirability, associated with a 1% change in the mean wage paid by the firm ($\overline{w_{f,t}}$). The wage variable reflects the total wage paid by including both base remuneration and regular additional payments. A high elasticity would indicate that firm desirability is highly responsive to changes in wages, suggesting that wage policies play a significant role in shaping the perceived attractiveness of a firm among workers.

The second specification extends equation (3.2) by incorporating average worker characteristics, yielding the following model:

$$ln\,(PR_{f,t}) = \alpha + \beta ln\,(\overline{w_{f,t}}) + \gamma\overline{X_{f,t}} + \varepsilon_{f,t} \tag{3.3}$$

Here, $\overline{X_{f,t}}$ is a vector of the average worker characteristics at firm *f* in year *t*, including education, age and tenure, their quadratic terms, the cubic term of tenure, and the firm's gender composition. Including squared and cubic terms allows for the modelling of potential non-linear relationships. By capturing these non-linearities, the model provides a more flexible and accurate representation of how observable worker attributes influence firm desirability.

The next extension takes into consideration the contractual aspects of the relation between worker and firm, resulting in:

$$ln\,(PR_{f,t}) = \alpha + \beta ln\,(\overline{w_{f,t}}) + \gamma\overline{X_{f,t}} + \lambda\overline{Z_{f,t}} + \varepsilon_{f,t} \tag{3.4}$$

In this specification, the vector $\overline{Z_{f,t}}$ is introduced, which captures average contract characteristics at the firm level, including regular hours worked, extra hours worked, and the logarithm of benefits paid by the firm. Controlling for $\overline{Z_{f,t}}$ is crucial, as these elements directly influence both compensation and working conditions, factors that are likely to affect how attractive a firm appears to workers. By accounting for these contractual features, the model better isolates the effect of wages from other non-wage components that may also shape firm desirability.

The final extension of the model, its most complete specification, incorporates controls for worker characteristics, contractual features, and firm-level attributes, while also including sector (η_s) and year (δ_t) fixed effects. It is defined as follows:

$$ln\,(PR_{f,t}) = \alpha + \beta ln\,(\overline{w_{f,t}}) + \gamma\overline{X_{f,t}} + \lambda\overline{Z_{f,t}} + \eta J_{f,t} + \eta_s + \delta_t + \varepsilon_{f,t} \tag{3.5}$$

The full model, as presented in equation (3.5), controls for the average total wage paid by each firm ($\overline{w_{f,t}}$), the characteristics of the average worker ($\overline{X_{f,t}}$), the characteristics of the average contract at each firm ($\overline{Z_{f,t}}$) and a vector of firm-specific controls ($J_{f,t}$). The latter includes the logarithm of the number of employees, the logarithm of value added per worker, and the logarithm of turnover per worker. This comprehensive specification allows for a more precise estimation of the relationship between wages and firm desirability, by accounting for both individual and firm-level heterogeneity, as well as differences across time and sectors.

Finally, to complete the methodological approach to the desirability of firms and deepen the understanding of the relative importance of the worker, contractual, and firm-level components, both variance and mean decompositions are conducted. The variance decomposition identifies the extent to which each group of variables contributes to the overall variation in firm desirability, helping to pinpoint the key drivers of heterogeneity across firms. The mean decomposition, in turn, will quantify how differences in average characteristics between groups account for disparities in firm PageRank scores. Together, these decompositions provide a more comprehensive view of the explanatory power of each component, complementing the regression analysis and offering insight into both the structure and sources of variation in firm attractiveness.

3.2.2 Wage Determination Models & Effects of Firm Desirability

This section presents the empirical strategy used to examine how firm desirability influences wage determination, drawing on theoretical foundations from imperfectly competitive labour markets. In contrast to standard competitive models, wage-setting in such environments is shaped not only by worker productivity, but also by labour market frictions, firm-specific wage-setting power, and the structure of outside options. Recent research in monopsony, rent-sharing and search-and-matching frameworks highlight the importance of heterogeneity in both firms and workers, as well as the role of frictions that prevent wages from fully adjusting to marginal productivity of workers. Within this context, firm desirability is hypothesised to play a significant role in shaping wage outcomes through mechanisms such as sorting and bargaining.

The empirical analysis proceeds in three stages. First, a series of wage regressions are estimated based on wage-setting models, where wages are regressed on firm performance measures while progressively introducing controls for observed worker characteristics, sector and year fixed effects, and unobserved heterogeneity at worker and firm level. The specifications are grounded in the Abowd, Kramarz and Morgolis (hereafter AKM) framework (Abowd et al., 1999), which enables the separation of worker and firm fixed effects, thereby isolating the contribution of each to wage variation. To address potential endogeneity in the firm performance measure, value added per worker, an instrumental variable strategy is implemented using firm-level sales per worker as an instrument.

Furthermore, the wage-setting models are extended to incorporate a direct measure of firm desirability, proxied by PageRank scores, derived from the structure of worker mobility across firms. Interaction terms between PageRank and worker education are included to explore whether the wage premium associated with firm desirability varies across skill groups, thus capturing potential complementarities between firm attractiveness and worker qualifications.

In addition, Gelbach-style decompositions (Gelbach, 2016) are applied to quantify the relative contribution of different covariate groups, such as worker sorting, firm compensation policies and compensation differentials to wage variation induced by desirability, thereby clarifying the underlying mechanisms through which firm desirability affects wage outcomes.

This layered empirical approach provides a robust and comprehensive framework for identifying the influence of firm desirability on wage determination, while accounting for key sources of bias and heterogeneity that arise in labour market data.

3.2.2.1 Wage-setting Models

This section sets out the empirical framework used to analyse the determination of wages. The analysis stems from previously used frameworks in labour market literature with a particular focus on rent-sharing and monopsony frameworks.

The hypothesis of rent-sharing states that workers may receive a portion of the rents generated by their employer, leading to a positive relation between firm performance and wages. This departs from the conception of the labour market as a perfect competition market, where wages are assumed equal to the marginal productivity of labour and are unaffected by firm characteristics. Instead, rent-sharing is a natural outcome in a labour market characterized by imperfect competition, wage bargaining, and frictions in job mobility, a framework introduced in Blanchflower et al. (1996), where the evidence shows that, when controlling for worker characteristics, industry fixed effects and for unionism, a rise in a sectors' profitability leads to an increase in the level of wages in that sector.

The empirical framework for the wage-related components of this dissertation stems from the bargaining and posting models of wage determination developed in Manning (2011). In Manning's wage-posting framework, firms set wages before hiring workers, with workers accepting the offer if the wage is higher than the value of leisure, which occurs with a certain probability G(w). In such scenario, the expected profits, $\pi(w)$, are given by the difference between productivity (p) and wages (w), multiplied by the probability of the worker accepting the offer. As such:

$$\pi(w) = (p - w) * G(w) \tag{3.6}$$

This leads to a first-order condition for wages where wages are determined by the elasticity of the probability function with respect to wages.

$$w(p) = \frac{\varepsilon(w(p))}{1 + \varepsilon(w(p))} p \tag{3.7}$$

Manning further develops the model by considering the previously described probability function as the labour supply curve facing the firm, with the result being a standard model of monopsony. This leads to a model where wages are determined by the elasticity of labour supply curve to the firm, by productivity (p) and by the general level of reservation wages (b_0), formulated as:

(3.8) $$w = \frac{\varepsilon}{1+\varepsilon} p + \frac{\varepsilon}{1+\varepsilon} b_0$$

In the context of this dissertation, the fundamentals of the abovementioned and described model are followed, with productivity being represented by the value added per worker and the general level of reservation wages being treated as the mode of wages of all workers within the same job-title, reflecting outside options, as well as controlling for worker characteristics and worker and firm-fixed effects.

Empirically, the analysis begins with a baseline OLS specification, stemming from rent-sharing frameworks such as Manning (2011), Card et al. (2018) and Card et al. (2013a), with the logarithm of the wages of workers being regressed on a measure of firm performance, the value added per worker, alongside a set of individual characteristics.

(3.9) $$ln(w_{i,f,j,t}) = \beta_q(ln(VA_{f,t}) * D_{i,q}) + \lambda_q(ln(BW_{j,t}) * D_{i,q}) + \boldsymbol{X'}_{i,t}\gamma_q + \varepsilon_{i,f,j,t}$$

In this specification, $ln(w_{i,f,j,t})$ represents the wage of worker *i*, employed in firm *f*, with a job *j* in a year *t*, in the logarithmic form. It is dependent on the interaction between the logarithmic form of the value added per worker, represented by $ln(VA_{f,t})$ and qualifications, represented by the binary variable $D_{i,q}$ that indicates if the worker *i* belongs to qualification group *q*. To control for outside options, the interaction between the qualification group dummy variable and the logarithm of the bargained wage, $ln(BW_{j,t})$, is considered. The term $\boldsymbol{X'}_{i,t}\gamma_q$ is included to control for a vector of observable worker characteristics that include tenure, age, and education and all the quadratic forms of all stated attributes as well as controlling for gender. The coefficients associated with the logarithm of the value added per worker (β_q) and with the logarithm of the bargained wage (λ_q) represent the elasticities of wages in response to the value added per worker and the bargained wage, respectively.

In the following specification, fixed effects at industry and time level are introduced, as follows:

(3.10) $$ln(w_{i,f,j,t}) = \beta_q(ln(VA_{f,t}) * D_{i,q}) + \lambda_q(ln(BW_{j,t}) * D_{i,q}) + \boldsymbol{X'}_{i,t}\gamma_q + \eta_s + \delta_t + \varepsilon_{i,f,j,t}$$

This specification addresses possible heterogeneity concerns across industries and over time, which was not accounted for in the previous specification of the model. The

addition of fixed effects at sector-level (η_s) and year fixed effects (δ_t) allows the model to control for systematic wage differences across industries as well as year-specific shocks that influence wages, reducing omitted variable bias.

The full model stems from the baseline OLS model portrayed in equation (3.10), with the addition of fixed effects at worker-level, firm-level and year fixed effects, being defined by:

$$ln(w_{i,f,j,t}) = \beta_q(ln(VA_{f,t}) * D_{i,q}) + \lambda_q(ln(BW_{j,t}) * D_{i,q}) + \boldsymbol{X'}_{i,t}\gamma_q + \mu_i + \varsigma_f + \delta_t + \varepsilon_{i,f,j,t} \quad (3.11)$$

In this framework, the implementation of fixed effects at worker-level and firm-level as well as the already implemented year fixed effects allow for a more complete and robust understanding of wage dynamics. Including worker fixed effects (μ_i) controls for the invariant unobserved worker characteristics such as innate ability, personality, etc. Firm fixed effects (ς_f) control for firm specific wage premiums that are constant over time, capturing the firm-specific component, as in the AKM model (Abowd et al., 1999). The full version adds to the previous frameworks by controlling not only for selection bias and unobserved ability but also for firm-specific wage setting factors, with the already included year fixed effects that control for exogenous shocks affecting wages.

Given the potential for reverse causality between productivity and wages, meaning that higher wages can lead to worker sorting which leads to higher productivity in the same way that higher productivity can lead to higher output, which can lead to higher wages, it is essential that such endogeneity concerns are addressed in the empirical strategy of the study. Therefore, it is needed to instrumentalize the variable that serves as a proxy for productivity (value added per worker) through a variable that is highly correlated with it but is not correlated with wages, such as sales per worker. This specification aims to remove the simultaneity bias and isolate the casual effect of productivity in wages. The choice of instrument follows Card et al. (2018), who argue that sales per worker is a strong predictor of value added while being plausibly exogenous to wages.

As such, to conduct this analysis, it is necessary to employ a two-stage model. Firstly, to define the instrumented variable in terms of the instrumental variable, or, in other words, to estimate value added per worker as sales per worker, as follows:

(3.12) $$ln\,(VA_{f,t}) = \pi_0 + \pi_1 ln(Sales_{f,t}) + \boldsymbol{Z}'\pi\ + \upsilon_{f,t}$$

For the instrument $ln(Sales_{f,t})$ to be valid, it must be strongly correlated with the endogenous regressor $ln\,(VA_{f,t})$, meaning that the covariance between the instrument and the regressor must be different from zero. The second condition that needs to be verified for the instrument to become valid is that it can only affect the outcome variable $ln(w_{i,f,j,t})$ through the regressor, meaning that it must not be related directly or through omitted variables, meaning that the covariance between the instrument and the error term in the main model regression must be equal to zero.

The second stage of the instrumental variable model consists of replacing the instrumented variable, in this case, the logarithm of value added per worker for the estimation obtained in the first stage model.

Following that, the baseline OLS model, equation (3.9), can now be rewritten as:

(3.13) $$ln(w_{i,f,j,t}) = \beta_q\left(ln(\widehat{VA_{f,t}}) * D_{i,q}\right) + \lambda_q\left(ln(BW_{j,t}) * D_{i,q}\right) + \boldsymbol{X}'_{i,t}\gamma_q + \varepsilon_{i,f,j,t}$$

The importance and interpretation of the results of this model remain equal to those of the previous framework where the instrumental variable was not considered. Following the same exercise for the model that encompasses fixed effects at sector level, equation (3.10) can be developed as:

(3.14) $$ln(w_{i,f,j,t}) = \beta_q\left(ln(\widehat{VA_{f,t}}) * D_{i,q}\right) + \lambda_q\left(ln(BW_{j,t}) * D_{i,q}\right) + \boldsymbol{X}'_{i,t}\gamma_q + \eta_s + \delta_t + \varepsilon_{i,f,j,t}$$

Here, once more, the interpretation of coefficients remains the same as when considering the baseline model with sector and year fixed effects. The full regression, in this framework, does not only address concerns regarding selection bias, omitted variable bias, firm-specific wage setting factors and exogenous shocks through the incorporation of fixed effects at worker and firm-level and year fixed effects, but also addresses endogeneity concerns, with the full model being defined by:

(3.15) $$ln(w_{i,f,j,t}) = \beta_q\left(ln(\widehat{VA_{f,t}}) * D_{i,q}\right) + \lambda_q\left(ln(BW_{j,t}) * D_{i,q}\right) + \boldsymbol{X}'_{i,t}\gamma_q + \mu_i + \varsigma_f + \delta_t + \varepsilon_{i,f,j,t}$$

The three specifications of the second-stage model allow for a more robust estimation of the factors that influence the dynamics of wages, focusing on the importance of rent-sharing, given in all models by the elasticity of wages with respect to productivity, measured by β_q. The relative importance of outside options is given by the elasticity of wages with respect to the bargained wage, and its magnitude is measured by λ_q. Observable worker characteristics, given by the vector ($\boldsymbol{X'}_{i,t}$), also affect the variation of wages, with the magnitude of the impact given by the semi-elasticity of wages with respect to each characteristic, measured by γ_q. All controls are interacted with a qualification variable as it allows for a more sensitive model, allowing for heterogenous effects of these variables across skill groups. The reasoning behind such option is evidenced by Card et al. (2016) and Manning (2003), where heterogeneity in wage premiums and in labour supply was evidenced, respectively.

3.2.2.2 Model Extension for Desirability

In the previous section the empirical framework for the analysis of wage dynamics was set, providing the foundation for the core objective of this study, to understand and analyse the relation between firm desirability and wages. In this section, the extension of the model to account for desirability is not only discussed but also formalized.

As presented in previous sections of this work, desirability is a broad concept, with many unobservable components, which makes it a very complex attribute to quantify appropriately. To address the challenges posed by the nature of the study, the strategy employed consisted of using an adaptation of the PageRank algorithm as a proxy for a firm's desirability. The algorithm based its scores on the movement of workers between firms for all the years of the temporal horizon that was considered in the research. As such, the reasoning behind the algorithm states that if there is a large flow of workers from Firm A to Firm B, then Firm B is more desirable.

Given the different objectives in this research, the output of the algorithm is going to be treated differently compared to the treatment employed in the models that aim to understand and explain desirability, namely section 3.2.1, where, given the PageRank scores for each firms, various specifications were developed in order to understand the importance of average wages paid in the perception of desirability as well as other contributing factors.

However, in this section, instead of using the logarithm of the PageRank score for each firm, the percentile on which each firm is included with respect to its PageRank will be considered. This approach was necessary as the absolute values of PageRank are comprised

of very small numbers, which are frequently very close to zero. As this would pose various challenges when aiming to understand the impact of desirability on wages, it was decided that an approach like the one used would allow for a much cleaner understanding of the model, while maintaining the conclusions given by the algorithm.

As the framework and baseline models for wage setting have been developed and discussed in the previous section, all that is needed now is to extend the previously described models to control for desirability. As such, the model defined by equation (3.9) can now be rewritten for its extended version by:

$$ln(w_{i,f,j,t}) = \theta_q(PR_{f,t} * D_{i,q}) + \beta_q(ln(VA_{f,t}) * D_{i,q}) + \lambda_q(ln(BW_{j,t}) * D_{i,q}) + \boldsymbol{X'}_{i,t}\gamma_q + \varepsilon_{i,f,j,t} \quad (3.16)$$

This extended baseline OLS model sets the framework for the empirical analysis that follows, as it did in previous sections of the work. Here, θ_q measures the average variation in wages of a worker *i*, of qualification level *q* associated with an increase in one percentile of the PageRank score, given by $PR_{f,t}$. The remaining model and interpretation are equal to that developed and analysed in the previous section, with β_q measuring the elasticity of wages with respect to a measure of firm productivity, value added per worker, λ_q measuring the elasticity of wages with respect to outside options of workers, given by the bargained wage and γ_q measures the importance of observable worker attributes in the determination of wages via a semi-elasticity.

The following specification of the model addresses concerns about heterogeneity across sectors and over time, with the inclusion of sector and time fixed effects, as such:

$$ln(w_{i,f,j,t}) = \theta_q(PR_{f,t} * D_{i,q}) + \beta_q(ln(VA_{f,t}) * D_{i,q}) + \lambda_q(ln(BW_{j,t}) * D_{i,q}) + \boldsymbol{X'}_{i,t}\gamma_q + \eta_s + \delta_t + \varepsilon_{i,f,j,t} \quad (3.17)$$

In this specification, the model controls for exogenous shocks through time fixed effects (δ_t) and for systematic wage differences between sectors, through the implementation of fixed effects at the sector level (η_s). In light of the AKM model (Abowd et al., 1999), the next development of the model considers not only year fixed effects but also worker, job and firm-level fixed effects, being defined as:

$$(3.18)\quad ln(w_{i,f,j,t}) = \theta_q(PR_{f,t} * D_{i,q}) + \beta_q(ln(VA_{f,t}) * D_{i,q}) + \lambda_q(ln(BW_{j,t}) * D_{i,q}) + \boldsymbol{X'}_{i,t}\gamma_q + \mu_i + \tau_j + \varsigma_f + \delta_t + \varepsilon_{i,f,j,t}$$

Controlling for worker, firm and year fixed effects enables to control for the indirect impacts of desirability on wages, leaving the estimation of the true casual relation between desirability and wage determination. In this setting, worker fixed effects (μ_i) control for possible worker sorting, job fixed effects (τ_j) control for compensation differentials and firm fixed effects (ς_f) control for firm specific wage premiums and policies. The bargained wage ($BW_{j,t}$) controls for the outside option of workers. As for the rent-sharing component of the model, given by the relation between wages and a proxy of productivity, value added per worker, can be seen as the monetary share of desirability, or in other words, an investment to keep the workforce. As indirect effects of desirability on wages are controlled for in this specification, this model will produce the main results of the study.

Moreover, all terms are interacting with qualifications as effects may be heterogeneous between workers, allowing for a more sensitive and realistic model. The interpretation of the results is similar to the interpretations made in the previous specifications of this model. The worker characteristics are included in the model through vector ($\boldsymbol{X'}$), which controls for age, tenure, education (and their quadratic forms) and for gender, in the base specifications of the model. In the full specification, due to the introduction of fixed effects at worker, firm and time-level, the vector ($\boldsymbol{X'}$) only controls for tenure and its quadratic form, as well as the quadratic form of the age variable.

Nevertheless, the concerns regarding endogeneity in the model are also present in this setting. As the proxy utilized for productivity, value added per worker may present problems of reverse causality with the dependent variable, it is necessary to account for such possibility and create an instrumental variable. As such, the model now transforms into a two-stage model. The first stage is defined entirely as in the previous section, given by equation (3.12). The second stage for the baseline model extended for desirability can now be written as:

$$(3.19)\quad ln(w_{i,f,j,t}) = \theta_q(PR_{f,t} * D_{i,q}) + \beta_q(ln(\widehat{VA_{f,t}}) * D_{i,q}) + \lambda_q(ln(BW_{j,t}) * D_{i,q}) + \boldsymbol{X'}_{i,t}\gamma_q + \varepsilon_{i,f,j,t}$$

Here, by estimating the value added per worker we address the challenges posed by endogeneity concerns, setting the framework for the further specifications of the model. Therefore, the next specification of the model, that controls for year and industry fixed effects can now be defined as:

$$ln(w_{i,f,j,t}) = \theta_q(PR_{f,t} * D_{i,q}) + \beta_q(ln(\widehat{VA_{f,t}}) * D_{i,q}) + \lambda_q(ln(BW_{j,t}) * D_{i,q}) + \boldsymbol{X'}_{i,t}\gamma_q + \eta_s + \delta_t + \varepsilon_{i,f,j,t} \quad (3.20)$$

The full model, formerly defined through equation (3.18), is now defined by the following equation:

$$ln(w_{i,f,j,t}) = \theta_q(PR_{f,t} * D_{i,q}) + \beta_q(ln(\widehat{VA_{f,t}}) * D_{i,q}) + \lambda_q(ln(BW_{j,t}) * D_{i,q}) + \boldsymbol{X'}_{i,t}\gamma_q + \mu_i + \tau_j + \varsigma_f + \delta_t + \varepsilon_{i,f,j,t} \quad (3.21)$$

The full empirical model extends the baseline wage-setting specification by addressing endogeneity concerns related to productivity, while allowing for heterogeneity in wage setting mechanisms across worker qualifications. In the model, the dependent variable is the logarithm of the total wage received by worker *i*, in firm *f*, with job *j*, in year *t*. It includes four key determinants of wages: desirability, given by PageRank score, in percentiles ($PR_{f,t}$), productivity, given by the logarithm of the instrumented added value per worker ($ln(\widehat{VA_{f,t}})$), outside options, proxied by the logarithm of the bargained wage at job level which is comprised of the mode of the wage of all workers with the same job ($ln(BW_{j,t})$) and worker observable characteristics, which are reflected in vector ($\boldsymbol{X'}$). The fixed effects included are at worker (μ_i), job (τ_j), firm (ς_f) level, as well as year fixed effects (δ_t). Controlling for these effects isolates the true effect of desirability on wages, measured by θ_q, as the worker fixed effects control for possible worker sorting and firm fixed effects control for firm specific pay premiums and policies. As for the rent-sharing factor, it controls the monetary share of desirability whereas the bargained wage helps to control for compensation differentials, through outside options.

3.2.2.3 Gelbach-style Decompositions

To deepen the understanding of the channels through which firm desirability influences wages, this study incorporates a decomposition framework based on the methodology introduced by Gelbach (2016). This framework enables the partitioning of the estimated effect of firm desirability, proxied by the PageRank percentile of the firm into

distinct channels associated with worker, firm, and job-level components. These decompositions provide insights into how each set of characteristics absorbs part of the total explanatory power of firm desirability on wages. In Gelbach's framework, the baseline model is defined as:

$$Y = X'\beta^B + \varepsilon \tag{3.22}$$

Here, X' represents the vector of used controls, with β^B representing the coefficients of the baseline model. The full specification of the model is defined by the same vector of controls of the baseline model, however, in this case, interacted with the coefficients of the full model ($X'\beta^F$), as well as the employed fixed effects (worker, job, firm). As such, the full model is derived from:

$$Y = X'\beta^F + D_w\theta_w + D_j\theta_j + D_f\theta_f + \mu \tag{3.23}$$

The development of the equation that defines the baseline model (3.22) leads to the condition that defines the coefficient for the base model (β^B), as follows:

$$\beta^B = (X'X)^{-1}X'Y \tag{3.24}$$

By replacing Y for its full model definition, detailed on equation 3.23,

$$\beta^B = (X'X)^{-1}X'[X'\beta^F + D_w\theta_w + D_j\theta_j + D_f\theta_f + \mu] \tag{3.25}$$

Further developing equation (3.25) results in:

$$\beta^B = \beta^F + (X'X)^{-1}X'D_w\theta_w + (X'X)^{-1}X'D_j\theta_j + (X'X)^{-1}X'D_f\theta_f \tag{3.26}$$

From here, it is possible to reach the final step in the theoretical foundation of the Gelbach-style decomposition. As such:

$$\beta^B = \beta^F + \widehat{\beta_w} + \widehat{\beta_j} + \widehat{\beta_f} \tag{3.27}$$

Here, the baseline coefficient (β^B) is equal to the full model coefficient (β^F) plus the estimated coefficient for each fixed effect, worker, job and firm, whose estimates are given by $\widehat{\beta_w}$, $\widehat{\beta_j}$ and $\widehat{\beta_f}$, respectively.

In the framework of this dissertation, the analytical strategy proceeds by first estimating the conditional association between firm desirability and each of the wage setting

fixed effects, worker, firm and job fixed effects. Each regression includes interactions between PageRank scores and qualification levels as well as observable individual characteristics such as age and tenure and their quadratic forms. Formally, for a fixed effect component (FE_k), the estimated model is defined by:

$$\widehat{FE_k} = \theta_{q,k}(PR_f * D_{i,q}) + \beta_{q,k}\left(ln(\widehat{VA_{f,t}}) * D_{i,q}\right) + \lambda_{q,k}\left(ln(BW_{j,t}) * D_{i,q}\right) + \boldsymbol{X}'_{i,t}\gamma_{q,k} + \eta_s + \delta_t + \varepsilon_{i,f,j,t} \quad (3.28)$$

Here, FE_k represents the fixed effect in analysis with $k \in \{w, j, f\}$ representing the type of fixed effect (worker, job or firm, respectively). The effects of each component of desirability are measured by $\theta_{q,k}$. As such, $\theta_{q,w}$ represents the effects related to worker sorting, reflecting the importance of the characteristics of workers. $\theta_{q,j}$, by being defined by job-title, represents the change in category of contract, which reflects compensation differentials. As for $\theta_{q,f}$, it reflects the across board compensation policies of firms, which can be seen as retention strategies. Together, these effects reflect the perennial effects of desirability, whereas β^F reflects time-varying workplace characteristics.

Therefore, this analysis allows the understanding of the channels on which increases in desirability relate to wages, providing a complementary approach for the study. The results of the decomposition are analysed in the next section, as well as their economic meaning and their implications.

4. Results & Discussion

This chapter proceeds with the presentation and interpretation of the empirical findings derived from the models described in the previous section. The empirical analysis begins by examining the determinants of firm desirability, providing the foundation for the understanding of the impact of this concept on wage determination. This analysis is followed by an exploration of wage-setting models which provide the theoretical basis and empirical framework for the inclusion of firm desirability in wage regressions. Building upon this, the core specification of this study, the analysis of wage determination models extended for desirability provides the main empirical results of this dissertation. The section then extends to a Gelbach-style decomposition setting, offering deeper insights into the underlying mechanisms driving the observed wage patterns.

The table below shows the estimations of all specifications of the desirability model, defined by equations (3.2) to (3.5). In this setting, the determinants of firm desirability are analysed. Starting from a single term regression where the relationship between the logarithm of PageRank and the logarithm of wages is analysed, in each specification, a control is added. The second specification controls for the average worker characteristics, the following model adds the average contract control, and the last specification also considers firm characteristics.

The results in Table 1 allow for a very reasonable understanding of the characteristics that have an impact on the desirability of firms. When considering the baseline specification of the model, we can observe that the elasticity of firm desirability with respect to wages is found to be low. According to the estimations in column (1), a 1% increase in the mean wage results in, all other variables constant, an approximate 0.082% increase in PageRank, the utilized proxy for desirability. This indicates, despite what could be thought, that firm desirability is not heavily correlated with wages. When contemplating the complete specification of this model, whose estimations are presented in column (4), some relations can be observed. The elasticity of PageRank with respect to wages is approximately 0.007%, meaning that the complete model reinforces that there is more to desirability than wages. For instance, the size of the firm, proxied by the number of employees, presents a coefficient of approximately 0.12, meaning that, on average, a variation of 1% in the number of employees is linked with a desirability increase, measured by PageRank, of approximately 0.12%.

Table 1. Estimation of Desirability models

	Base Specification	Base + Average worker	Base+ Average Worker + Average Contract	Base + Average Worker + Average Contract + Firm
Ln (PageRank)	(1)	(2)	(3)	(4)
Ln(wage)	0,08185***	0,10721***	-0,00492***	0,00650***
	(0,001)	(0,001)	(0,001)	(0,001)
Education		0,00837***	-0,00252***	-0,00227***
		(0,001)	(0,001)	(0,001)
Education2		-0,00059***	0,00006*	0,00013***
		(0,000)	(0,000)	(0,000)
Age		0,02091***	0,01468***	0,00799***
		(0,001)	(0,000)	(0,000)
Age2		-0,00029***	-0,0002***	-0,0001***
		(0,000)	(0,000)	(0,000)
Tenure		0,01032***	0,00588***	0,00699***
		(0,000)	(0,000)	(0,000)
Tenure2		-0,00128***	-0,00105***	-0,00123***
		(0,000)	(0,000)	(0,000)
Tenure3		0,00003***	0,00003***	0,00003***
		(0,000)	(0,000)	(0,000)
Female			0,05324***	-0,00019
			(0,001)	(0,001)
Ordinary Hours			-0,0011***	0,00114***
			(0,000)	(0,000)
Extra Hours			0,00051***	-0,00043***
			(0,000)	(0,000)
Ln (Benefits)			0,05124***	0,00087***
			(0,000)	(0,000)
Ln (Employees)				0,11585***
				(0,000)
Ln (VA p/ worker)				0,01022***
				(0,000)
Ln (Revenue p/ worker)				0,00318***
				(0,000)
Observations	401 612	401 612	394 403	386 530
R2	0,12	0,15	0,29	0,44
F-Statistic	11204,56	2779,28	8975,9	14433,07
Year fixed effects	Yes	Yes	Yes	Yes
Sector fixed effects	No	No	No	Yes

Note: VA stands for Value added. All worker and contract controls are defined by average. The level of significance is given by "*", with *** indicating significance for all values and zero "*" indicating that the estimation is not statistically relevant.

The coefficients of the full model regarding education show that, in low levels of average education, an increase in education reduces the desirability of firms, a trend that is inverted as the average level of education grows, evidenced by the negative and positive coefficients of education and its quadratic form, respectively. The effect of average age of workers in a firm's desirability records the opposite trend. When the average age is at lower levels, an increase leads to an increase in the PageRank score of the firm, an effect which is nullified or even reversed for higher level of average age. For lower levels of average tenure at the firm, an additional year in average tenure leads to an increase in desirability, a trend that is reversed for higher levels of average tenure, however, by observing the coefficient of the cubic form of tenure, it is possible to see that for even higher values of average tenure the effect on desirability becomes positive once more.

Considering the remaining controls, all have a positive impact on desirability apart from the percentage of women, which is not statistically significant and extra hours, indicating that overworked employees do not regard their employers as desirable. Firm performance, measured through the logarithm of value added per worker and the logarithm of the revenue per worker evidences a positive correlation with desirability, as the elasticity of the desirability measure with respect to the abovementioned controls is positive, approximately 0.010%, and 0.003%, respectively.

Tables 2 and 3 present the results for the variance and mean decompositions, respectively. In both, the results show the relative contributions of each component to the overall variance or mean, according to each decomposition.

Table 2. Variance Decomposition

Component	Covariance	Weight
Ln (PageRank)	0,32753	n.a.
Worker	0,000548	0,167%
Contract	0,000034	0,010%
Firm	0,10653	32,53%
Wages	0,000037	0,011%
Non-Explained	n.a.	67,286%

Note Table 2.: The covariance estimates concern the covariance of each component with the desirability measure, with exception of Ln (PageRank) where the estimate regards the variance of the component. The weight is calculated by dividing the covariance of each component by the variance of Ln (PageRank).

Table 3. Mean Decomposition

Component	Mean	Weight
Ln (PageRank)	0,89421	n.a.
Worker	0,142161	15,90%
Contract	0,203931	22,81%
Firm	0,5035	56,31%
Wages	0,044617	4,99%
Year	3,98E-15	0,00%

Note Table 3.: The mean of Ln (PageRank) comprehends the true mean of Ln (PageRank) subtracted by the value of the constant of the full model. The weights were obtained by dividing each component mean by the estimated, and presented mean for Ln (PageRank)

In the variance decomposition presented in Table 2, the total variation is captured by the variance of the logarithm of PageRank. The relative contribution of each component is computed by dividing its covariance with PageRank by the total variance. While the model accounts for only about 34,4% of the total variance, leaving approximately 65,6% unexplained, the firm component clearly emerges as the primary source of variation in firm desirability, explaining around 32,5% of the total. In contrast, the wage component contributes just 0,11%, reinforcing that firm desirability is driven by factors beyond compensation alone.

Table 3 presents the mean-based decomposition of firm PageRank. To compute the contribution of each component, the constant term from the full model is subtracted from the mean of the PageRank variable. The resulting decomposition highlights the relative importance of each factor in explaining the variation in mean PageRank scores. The firm component emerges as the primary driver, accounting for approximately 56.31% of the total. This is followed by the contract component (22.81%), the worker component (15.90%), and finally, the wage component, which contributes approximately 5%.

Both methods of decomposition lead to similar results. Despite the magnitude of importance varying between methods, both identify firm-specific characteristics as the main driver for desirability, and both highlight the relative low importance on wages on explaining desirability, a conclusion that had been reached in the least robust specification of the model, reinforcing the validity of the models employed to explain the desirability component.

Table 4. presents the results for the multiple specifications of the wage-setting model, defined by equations (3.9) to (3.14), producing the empirical framework for the remainer of the study. All terms are interacted with qualifications to allow heterogenous effects across different skill groups.

The baseline model, presented in column (1) lays the foundation for all the following developments of the model. It shows that the wage elasticity with respect to value added per worker generally increases with occupational skill level, though the pattern is not perfectly consistent as the effects may flatten or even slightly decline at the top, as evidenced by the coefficients of the three highest skill groups. Higher-skilled and supervisory roles tend to capture a larger share of productivity gains, suggesting greater rent-sharing at the top of the occupational hierarchy. The positive relationship between occupational skill level and wage elasticity with respect to value added per worker is robust across all model specifications. Regardless of the inclusion of alternative fixed effects, or estimation strategies, the trend

persists: higher-skilled and supervisory workers consistently exhibit greater wage responsiveness to firm-level productivity, indicating that higher-skilled workers tend to benefit more from productivity gains.

Table 4. Wage Determination Models

	Baseline OLS model	Baseline model with Fixed Effects	Full model with Fixed Effects	Baseline IV model	Baseline IV model with Fixed Effects	Full IV model with Fixed effects
Ln (Wage)	(1)	(2)	(3)	(4)	(5)	(6)
Ln (VA p/worker)						
Upper Man.	0,17062***	0,15311***	0,02871**	0,21360***	0,21937***	0,02935***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Middle Man.	0,17704***	0,15147***	0,02106***	0,19040***	0,19696***	0,02204***
	(0,000)	(0,000)	(0,000)	(0,001)	(0,001)	(0,001)
Sup. / Team L.	0,19168***	0,16481***	0,02032***	0,20196***	0,19878***	0,02023***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
High-Skilled	0,15281***	0,13075***	0,01529***	0,17218***	0,17016***	0,02473***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,001)
Skilled	0,13608***	0,11756**	0,01209***	0,13493***	0,13858***	0,01168***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Semi-Skilled	0,09318***	0,08545***	0,01026***	0,08673***	0,10335***	0,01193***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Non-Skilled	0,06158***	0,06755***	0,00781***	0,06773***	0,09835***	0,00684***
	(0,000)	(0,000)	(0,000)	(0,001)	(0,000)	(0,001)
Interns	0,07824***	0,06952***	-0,00695***	0,08765***	0,09354***	-0,01419***
	(0,001)	(0,001)	(0,001)	(0,001)	(0,001)	(0,001)
Ln (Barg. Wage)						
Upper Man.	0,10571***	0,09439***	0,03886***	0,08937***	0,07918***	0,05173***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,005)
Middle Man.	0,16968***	0,12851***	0,04459***	0,16531***	0,11897***	0,05967***
	(0,001)	(0,001)	(0,000)	(0,001)	(0,001)	(0,005)
Sup. / Team L.	0,16506***	0,13241***	0,05603***	0,16344***	0,13000***	0,06505***
	(0,001)	(0,001)	(0,000)	(0,001)	(0,001)	(0,005)
High-Skilled	0,32696***	0,25463***	0,04644***	0,31124***	0,24233***	0,03672***
	(0,001)	(0,001)	(0,000)	(0,001)	(0,001)	(0,005)
Skilled	0,32975***	0,26094***	0,04597***	0,33856***	0,27115***	0,05385***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,005)
Semi-Skilled	0,40151***	0,31747***	0,04406***	0,41913***	0,33331***	0,04783***
	(0,001)	(0,001)	(0,000)	(0,001)	(0,001)	(0,005)
Non-Skilled	0,47515***	0,36569***	0,04575***	0,47570***	0,36430***	0,05231***
	(0,001)	(0,001)	(0,001)	(0,001)	(0,001)	(0,005)
Interns	0,43875***	0,35235***	0,06454***	0,43446***	0,36001***	0,08238***
	(0,002)	(0,002)	(0,001)	(0,002)	(0,002)	(0,006)
Observations	14 063 660	14 063 660	13 369 448	14 048 886	14 048 885	13 287 077
R2	0,64	0,67	0,95	0,64	0,52	0,04
F-statistic	345 089,90	212 080,55	20 530,05	3,40E+05	2,10E+05	10 798,06
Year fixed effects	No	Yes	Yes	No	Yes	Yes
Sector Fixed Effects	No	Yes	No	No	Yes	No
Worker Fixed Effects	No	No	Yes	No	No	Yes
Firm Fixed Effects	No	No	Yes	No	No	Yes
Job Fixed Effects	No	No	Yes	No	No	Yes

Note: Other controls used in the models that are not displayed in this table, can be found in the appendix (Table A1.) The level of significance is given by "*", with *** indicating significance for all values and zero "*" indicating that the estimation is not statistically relevant. The variation of sample sizes is due to largest connected set necessary for the fixed effect estimation.

The same tendency is not observed for the bargained wage, as the elasticity of wages with respect to the bargained wage tends to decrease with the level of skill. As the bargained wage is composed by the mode of the wages of workers under the same job-title, controlling for outside options, the overall trend in the models indicates that the wages of lower-skilled professionals are more strongly anchored to their outside options, reflecting greater bargaining power of workers in the upper categories of qualifications.

The following tables present the main empirical findings of this study. Table 5. presents the results of the wage-setting models extended for desirability, where the main results are found. Table 6 presents the results of the Gelbach-style decompositions that were computed to understand the relative importance of the mechanisms through which desirability impacts wages.

The results presented in Table 5 concern the various specifications of the wage-setting models extended for desirability, defined by equations (3.16) to (3.21). The effect of desirability on wages is measured through variations in the percentile of PageRank scores and, through the interaction with qualification, it allows for heterogeneity among workers in different skill groups. For example, in the baseline model shown in column (1), a one-percentile increase in a firm's PageRank score is associated with an average wage increase of approximately 0.36% for Upper Management workers. As the coefficients for the higher skill groups indicate positive reactions of wages (approximately 0.26% for Middle Managers and 0.16% Supervisors and Team Leaders) to increases in desirability, it can be said that for top-skilled professionals, more desirable firms tend to pay higher wages, with the cumulative effects able to reach up to approximately 43.9%, 30.2% and 17.7% for Upper Management, Middle Management and for Supervisors and Team Leaders, respectively, over the full distribution (0^{th} to 100^{th} percentile). In the case of lower skilled workers, the effects appear to be the opposite. Semi-qualified workers, non-qualified workers and interns all tend to register a decrease in wages related to an improvement in desirability, in the baseline model. The negative response of wages to higher desirability for lower-skilled workers indicates that firms may register an increase in wage-setting power, utilizing desirability as a compensation differential.

However, these results do not stand for any other specifications of the model with exception of the baseline instrumental variable model, displayed on column (4). Nevertheless, for all specifications of the model it is possible to identify trends in the response of wages to variations of desirability. Despite not being perfectly monotonic in all

model specifications, the evidence suggests that more qualified workers experience stronger wage gains when they are employed in more desirable firms.

Table 5. Wage Determination Models extended for Desirability

	Baseline OLS model	Baseline model with Fixed Effects	Full model with Fixed Effects	Baseline IV model	Baseline IV model with Fixed Effects	Full IV model with Fixed Effects
Ln (Wage)	(1)	(2)	(3)	(4)	(5)	(6)
PageRank percentile						
Upper Man.	0,00364***	0,00379***	0,00049***	0,00327***	0,00339***	0,00045***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Middle Man.	0,00264***	0,00280***	0,00063***	0,00256***	0,00257***	0,00062***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Sup. / Team L.	0,00163***	0,00192***	0,00043***	0,00159***	0,00180***	0,00042***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
High-Skilled	0,00065***	0,00093***	0,00026***	0,00057***	0,00080***	0,00025***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Skilled	0,00018***	0,00048***	0,00020***	0,00021***	0,00043***	0,00021***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Semi-Skilled	-0,00005***	0,00021***	-0,00002**	-0,00000	0,00017***	-0,00001*
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Non-Skilled	-0,00005***	0,00019***	0,00002	-0,00004***	0,00012***	0,00002
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Interns	-0,00019***	0,00014***	0,00001	-0,00023***	0,00005*	0,00005**
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Observations	14 063 661	14 063 660	13 301 765	14 048 886	14 048 885	13 287 077
R2	0,64	0,67	0,95	0,64	0,52	0,04
F-statistic	313 451,34	193 507,55	9 170,38	3,40E+05	1,90E+05	9 104,68
Year fixed effects	No	Yes	Yes	No	Yes	Yes
Sector Fixed Effects	No	Yes	No	No	Yes	No
Worker Fixed Effects	No	No	Yes	No	No	Yes
Firm Fixed Effects	No	No	Yes	No	No	Yes
Job Fixed Effects	No	No	Yes	No	No	Yes

Note: The complete development of each specification of the model can be found in the Annex (Table A2.). The level of significance is given by "*", with *** indicating significance for all values and zero "*" indicating that the estimation is not statistically relevant. The variation of sample sizes is due to largest connected set necessary for the fixed effect estimation.

The effects of desirability on wages can be overestimated in the baseline specifications of the model, provided by columns (1) and (4), as the fixed effects employed in further specifications of the model control and capture some of the effects on wages resulting from increases on firm desirability.

In the full specification without instrumental variables, reported in column (3), the relationship between firm desirability, measured using PageRank percentiles, and wages is

found to differ significantly across skill groups. Among the top of the skill group distribution, the estimated marginal effects are 0.043% for Supervisors and Team Leaders, 0.063% for Middle Management, and 0.050% for Upper Management. While these incremental changes are modest, their cumulative effects become economically meaningful when considering broader movements in firm desirability. Applying the appropriate exponential transformation[1], a shift from the 25th to the 75th percentile in the firm PageRank distribution is related to wage gains of 2.18% for Supervisors and Team Leaders, 3.20% for Middle Management, and 2.53% for Upper Management. Over the full distribution, from the least to the most desirable firms, the wage premiums increase to 4.39%, 6.50%, and 5.13%, respectively. When considering the rest of the skill-group distribution, the magnitude of wage returns to firm desirability is generally lower. High-Skilled workers exhibit a marginal effect of 0.026% per percentile increase in PageRank, followed by 0.020% for Skilled workers, and a slightly negative coefficient (–0.002%) for Semi-Skilled workers. When evaluating the respective cumulative effects, a movement from the 25th to the 75th percentile is associated with wage increases of 1.31% for High-Skilled workers and 1.00% for Skilled worker[1]s, while Semi-Skilled workers experience a slight decline of 0.10%. Across the full distribution, the gains rise to 2.63% and 2.02% for High-Skilled and Skilled workers, respectively, while remaining negative (–0.20%) for Semi-Skilled workers. Together, these findings reveal a clear relation between wages and desirability, with workers in managerial positions and higher skill levels benefiting more consistently and substantially from employment in more desirable firms.

The full model with IV, detailed in column (6), reveals a clear stratification in the wage returns to firm desirability across occupational hierarchies. Among managerial roles, a one-percentile increase in a firm's PageRank score is associated with statistically significant wage gains of approximately 0.042% for Supervisors and Team Leaders, 0.062% for Middle Management, and 0.045% for Upper Management. Though modest in marginal terms, these effects accumulate meaningfully across the firm distribution. A transition from the 25th to the 75th percentile in firm desirability connects to wage increases of approximately 2.15%, 3.21%, and 2.29% for the respective groups, while a full-range shift from the bottom to the top percentile yields cumulative gains of 4.28% for Supervisors and Team Leaders, 6.43% for Middle Managers, and 4.60% for Upper Management. In contrast, the relationship

[1] As the dependent variable is in logarithmic form, to correctly quantify the semi-elasticity it is necessary to transform the estimate, by $(e^{\beta * \Delta} - 1)\ x\ 100$.

between firm desirability and wages is markedly weaker across occupational skill groups. High-Skilled workers experience a marginal effect of 0.025% per percentile increase in PageRank, with cumulative gains of 1.27% from the 25th to the 75th percentile and 2.53% across the full distribution. Skilled workers receive a slightly lower return of 0.021%, corresponding to 1.06% and 2.12%, respectively, while the effect for Semi-Skilled workers is effectively zero (–0.001%), amounting to –0.05% and –0.10% over the same intervals.

The overall findings suggest that higher-skilled workers, who occupy managerial-level roles, tend to benefit more from being employed in more desirable firms, when compared to lower skilled workers, a trend that is verified in all specifications of the model.

The Gelbach-style decomposition, which is displayed on Table 6., shows the different channels on which firm desirability associates with wages. Whereas the estimates for the full model, (column 2) represent time-varying worker characteristics, the estimates for the worker component reflect worker quality, or in other words, the importance of worker-specific characteristics to wage setting. Moreover, the job component (column 4), by being defined through job-title, reflects the change in wage category, which reflects compensation differentials. Finally, the firm component detailed in column (5) reflects the compensation policies of firms.

Table 6. Gelbach-style Decomposition of Desirability Components

	Base	Full	Worker	Job	Firm
PageRank percentile	(1)	(2)	(3)	(4)	(5)
Upper Man.	0,00415***	0,00044***	0,00297***	0,00023***	0,00051***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Middle Man.	0,00296***	0,00062***	0,00200***	-0,00017***	0,00050***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Sup. / Team L.	0,00217***	0,00042***	0,00126***	0,00013***	0,00036***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
High-Skilled	0,00066***	0,00024***	0,00014***	-0,00003***	0,00031***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Skilled	0,00040***	0,00021***	-0,00025***	-0,00005***	0,00049***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Semi-Skilled	0,00009***	-0,00002**	-0,00044***	-0,00002***	0,00056***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Non-Skilled	0,00006***	0,00002	-0,00033***	-0,00024***	0,00062***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Interns	0,00013***	0,00005***	-0,00028	-0,00030***	0,00066***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Observations	13 287 076	13 287 076	13 287 076	13 287 076	13 287 076

Note: The estimates for both the base and full model differ from the previously presented ones due to the homogeneization of the samplesize, a crucial step for the decomposition. The level of significance is given by "*", with *** indicating significance for all values and zero "*" indicating that the estimation is not statistically relevant.

Regarding Table 6, the findings indicate that worker characteristics are more strongly rewarded at the top of the skill distribution. Higher-skilled workers exhibit positive

coefficients for the worker component, suggesting that their attributes carry more weight in the compensation. In contrast, lower-skilled workers tend to display negative coefficients, implying that individual characteristics are not as valued at the lower end of the distribution. The predominantly negative estimates reported in column (4) further suggest that some workers are willing to accept positions in lower occupational categories in order to be employed by more desirable firms. This implies that more attractive firms offer greater compensation differentials, particularly for lower-tier positions. As for the firm component, it captures compensation policies implemented across the entire organization. Naturally, given that wages at the top of the qualifications pyramid tend to be higher than wages at the bottom, an equal compensation policy will have a bigger effect on workers on the lower end of the distribution, hence the diminishing effect of such policies as qualifications increase.

Table 7. Relative Contributions of Desirability Components

	Worker	Job	Firm	Full
Upper Man.	71,43%	5,64%	12,34%	10,59%
Middle Man.	67,82%	-5,77%	16,94%	21,01%
Sup. / Team L.	58,14%	6,20%	16,33%	19,33%
High-Skilled	21,13%	-4,85%	47,01%	36,70%
Skilled	-63,51%	-13,64%	125,18%	51,97%
Semi-Skilled	-481,70%	-17,31%	618,41%	-19,40%
Non-Skilled	-567,06%	-409,85%	1049,75%	27,16%
Interns	-219,60%	-241,19%	521,98%	38,81%

Note: The estimates are calculated by dividing each component estimate by the estimate for the base model, presented in Table 6.

Table 7. reinforces the conclusions drawn from Table 6. The results suggest that the lower remuneration of worker-specific characteristics, as well as the drop in category of work measured by job-title for lower-qualified workers is compensated through across-board compensation policies of firms. This means that firms that pay higher wages from top to bottom tend to reduce the remuneration of worker characteristics. Despite desirability being more than wages, the evidence suggests that workers prefer to work in a lower category of work in a more desirable firm than working in a higher category in a less desirable firm, due to the better compensation policies and compensation differentials, which potentially leads to higher wages.

Moreover, the evidence suggests that workers may exhibit a preference for firms with greater wage inequality, provided this is associated with higher compensation across the

board. As evidenced by the firm component in the decomposition, lower skilled workers, when working in more desirable firms, tend to benefit more from better compensation policies than highly skilled workers. Nevertheless, as desirability tends to be more heavily associated with wage increases in the higher end of the skill distribution, highly skilled workers tend to benefit more from working in more desirable firms than lower skilled workers. As both groups of workers naturally show a preference towards more desirable firms, and such firms tend to pay more inequal wages, it can be said that workers, in general, show a preference for wage inequality.

5. Conclusion

Understanding the determinants and dynamics of wages is a central question in labour economics. Whereas traditional models tend to emphasize the roles of productivity, education and experience, more modern approaches highlight the importance of labour market frictions, firm-specific characteristics and unobservable attributes, such as job quality and employer reputation as determinants of wages. This dissertation aims to contribute to the existing literature on wage determination by measuring firm desirability and examine its impact on wages, using an innovative algorithmic approach, based on Google's PageRank.

PageRank, an algorithm originally developed to rank webpages based on the quantity and quality of links that point to it, is adapted for its use in the context of the labour market. By considering firms as the equivalent to webpages in the original conceptualization of the algorithm and workers as equivalent to links, it is possible to construct a ranking of firms based on their desirability. In this setting, the desirability of firms is given by the flow of workers, pondered by the desirability of the firm of origin.

Using employer-employee matching data for Portuguese workers and firms for the temporal horizon of 2013 to 2022, the abovementioned metric of firm desirability is constructed, based on the flow of workers between firms. The scope of the study encompasses analysis of different nature. First, the metrics of desirability are analysed to understand the determinants of firm desirability. Secondly, existing models of wage determination are analysed not only to understand the importance of productivity and outside options in the determination of wages, but also to set the empirical framework to the focal point of the dissertation. The mentioned wage-setting models are then extended for desirability, producing the main findings of this dissertation. The analysis of the effects of firm desirability also encompasses Gelbach-style decompositions, which allow to understand the channels on which desirability affects wages.

This study primarily aims to analyse the effects of workplace desirability on wages, while also seeking to deepen the understanding of the underlying determinants of the desirability component. The study of the desirability component indicates that there is more to desirability than wages. When considering the desirability model (Table 1.), it is possible to observe that the elasticity of desirability (measured by PageRank) in respect to wages is approximately 0.007%, whereas other components such as dimension, measured by the number of employees and productivity, measured by the value added per worker, yield higher elasticities. The decompositions of variance and mean employed on the desirability model

reinforce the abovementioned conclusions. Considering the variance decomposition (Table 2.), the results indicate that the firm component explains approximately 32.53% of the variance of the desirability measure whereas wages register a relative contribution of 0.011%. The mean decomposition presented on Table 3. leads to similar results, with the wage component explaining close to 5%. As for the other components, worker, contract and firm, their relative importance is approximately 15.9%, 22.81% and 56.1%, respectively. Therefore, the evidence suggests that the main drivers of firm desirability are firm-specific characteristics, such as dimension or productivity.

Regarding the relation between wages and desirability (Table 5.), the analysis reveals that firm desirability has a statistically significant and economically meaningful relation with wages, particularly for higher-skilled workers. According to the fully specified model with fixed effects and instrumentation, a one percentile increase in firm desirability, as measured by the PageRank-based score, is associated with a wage increase of approximately 0.045% for upper management, while middle management and supervisory roles see gains of around 0.062% and 0.042%, respectively. These effects, though modest at the margin, accumulate meaningfully across the desirability distribution, meaning that, all other things equal, moving from a firm at the 25th percentile to one at the 75th percentile can result in wage gains between approximately 2.12% and 3.15% for high-skilled workers. In contrast, non-skilled workers exhibit negligible wage effects, with some specifications showing even slightly negative coefficients, suggesting that increased desirability can function as a compensating differential, meaning that these workers may accept lower wages in exchange for superior non-wage job attributes. The Gelbach-style decompositions add to the understanding of the relation between desirability and wages by identifying and quantifying the drivers through which desirability associates itself with wages. The results of the decompositions show that lower-skilled workers' characteristics are less compensated than higher-skilled workers', as well as showing that for the most part of the skill distribution, workers prefer to work in more desirable firms, even if that means that their job is of a lower category. This only happens because the firm compensation policies, measured by the firm component in the decomposition, are applicable to all workers in the firm, meaning that lower-skilled workers, which tend to have lower wages, highly benefit from those policies, compensating the non-favourable compensation of characteristics and the lower category of contract.

As evidenced, more desirable firms tend to offer better firm wide compensation policies. Such policies tend to highly benefit lower skilled workers, as reflected in the firm component

of the Gelbach decomposition. Nevertheless, the overall increases in wages related to increases in desirability tends to benefit highly skilled workers, namely those who occupy managerial roles. Despite increases in desirability being predominantly associated with positive variations of wages for lower skilled workers, this relation is much more pronounced at the top of the skill distribution, indicating that wage inequality tends to be related to desirability. As both sets of workers naturally develop a preference for more desirable workplaces, it can be said that workers tend to have a preference for inequality, provided that such inequality is accompanied by an overall firm wide wage increase.

The overall effect of desirability on wages can either be positive or negative, depending on the rate of exchange of non-pecuniary attributes for pecuniary attributes. In this study, the evidence suggests that higher paying firms also offer better non-pecuniary attributes which is reflected on the firm-wide compensation policies of more desirable firms, which compensate for a lower remuneration of worker characteristics as well as a drop in wage category. As the overall increase in wages associated with desirability is higher for higher-skilled workers than for lower-skilled workers, it is possible to infer that more desirable firms lead to more wage inequality. In sum, despite desirability being more than remuneration, it leads to a different human resource policy, as firm compensation policies are the main driver for workers to prefer more desirable firms. This preference, despite benefiting workers in general, benefits more the ones that occupy managerial positions, raising concerns about the effects of desirability on wage inequality.

The findings of this dissertation carry important implications for both academic research and policy discussions on wage inequality and labour market functioning. By introducing a measurable proxy for firm desirability, a predominantly unobservable factor, this study highlights that non-pecuniary attributes, such as firm size, reputation, and working conditions, can significantly influence wage determination. These effects are not homogeneous, as the response of wages to increases in desirability systematically benefits higher-skilled workers, potentially contributing to an increase in wage inequality. For policymakers, the findings suggest that labour market intervention solely focused on monetary compensation potentially miss on a considerable part of the compensation structure, especially in cases where non-pecuniary job attributes serve as compensation differentials.

Despite its findings and overall contribution to labour market literature, this study also presents some limitations. While the use of an adapted version of PageRank provides a

powerful framework for quantifying desirability, it only captures the preferences of workers through job transitions. Although fixed effects are employed, the potential for simultaneity and worker sorting into more desirable firms remains a challenge.

Future research could address these limitations in several ways. One promising direction would be to incorporate survey-based preference data, capturing workers' subjective evaluations of job attributes alongside revealed preferences. This would allow for a greater understanding of the desirability component, which could prove crucial to confer more realism to the models and to how non-pecuniary attributes influence wages. Other potential developments of this study might focus on the impacts of desirability on wage inequality or other possible implications. Another extension could involve exploiting exogenous shocks, such as sudden changes in firm leadership, media scandals, or regulatory events that may alter desirability independently of wages. Moreover, future work might consider heterogeneous effects across industries, explore gender-specific responses to desirability, or investigate how desirability interacts with remote work trends or digital transformation.

In sum, this dissertation provides a foundational step toward understanding the role of firm desirability in wage determination. By integrating a network-based measurement of desirability into wage-setting models, it opens new paths for research on labour market frictions and compensation structures. Further exploration and refinement of these ideas, especially the desirability component, can help build more inclusive and realistic models of how wages are determined in the modern context of labour markets. Nevertheless, the evidence of the study indicates a majorly positive and meaningful relation between firm desirability and wage setting. Higher-skilled workers tend to benefit more from this relation than lower-skilled workers, who can register a slight decrease on wages as a response to an increase in desirability, indicating that there are cases where firm desirability can serve as a compensation differential. Regarding the desirability component, the study reveals that firm desirability is influenced by more than just wages. The models suggest that firm-level characteristics play a central role, particularly the size of the firm, which emerges as the primary explaining factor of variations in desirability.

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Annex

The following table presents the full estimations of the wage determination models.

Table A1. Wage Determination Models

	Baseline OLS model	Baseline model with Fixed Effects	Full Model with Fixed Effects	Baseline IV model	Baseline IV model with Fixed Effects	Full IV Model With Fixed effects
Ln (Wage)	(1)	(2)	(3)	(4)	(5)	(6)
Ln (VA p/worker)						
Upper Man.	0,17062***	0,15311***	0,02871**	0,21360***	0,21937***	0,02935***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Middle Man.	0,17704***	0,15147***	0,02106***	0,19040***	0,19696***	0,02204***
	(0,000)	(0,000)	(0,000)	(0,001)	(0,001)	(0,001)
Sup. / Team L.	0,19168***	0,16481***	0,02032***	0,20196***	0,19878***	0,02023***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
High-Skilled	0,15281***	0,13075***	0,01529***	0,17218***	0,17016***	0,02473***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,001)
Skilled	0,13608***	0,11756**	0,01209***	0,13493***	0,13858***	0,01168***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Semi-Skilled	0,09318***	0,08545***	0,01026***	0,08673***	0,10335***	0,01193***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Non-Skilled	0,06158***	0,06755***	0,00781***	0,06773***	0,09835***	0,00684***
	(0,000)	(0,000)	(0,000)	(0,001)	(0,000)	(0,001)
Interns	0,07824***	0,06952***	-0,00695***	0,08765***	0,09354***	-0,01419***
	(0,001)	(0,001)	(0,001)	(0,001)	(0,001)	(0,001)
Ln (Barg. Wage)						
Upper Man.	0,10571***	0,09439***	0,03886***	0,08937***	0,07918***	0,05173***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,005)
Middle Man.	0,16968***	0,12851***	0,04459***	0,16531***	0,11897***	0,05967***
	(0,001)	(0,001)	(0,000)	(0,001)	(0,001)	(0,005)
Sup. / Team L.	0,16506***	0,13241***	0,05603***	0,16344***	0,13000***	0,06505***
	(0,001)	(0,001)	(0,000)	(0,001)	(0,001)	(0,005)
High-Skilled	0,32696***	0,25463***	0,04644***	0,31124***	0,24233***	0,03672***
	(0,001)	(0,001)	(0,000)	(0,001)	(0,001)	(0,005)
Skilled	0,32975***	0,26094***	0,04597***	0,33856***	0,27115***	0,05385***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,005)
Semi-Skilled	0,40151***	0,31747***	0,04406***	0,41913***	0,33331***	0,04783***
	(0,001)	(0,001)	(0,000)	(0,001)	(0,001)	(0,005)
Non-Skilled	0,47515***	0,36569***	0,04575***	0,47570***	0,36430***	0,05231***
	(0,001)	(0,001)	(0,001)	(0,001)	(0,001)	(0,005)
Interns	0,43875***	0,35235***	0,06454***	0,43446***	0,36001***	0,08238***
	(0,002)	(0,002)	(0,001)	(0,002)	(0,002)	(0,006)
Tenure						

Upper Man.	0,00889***	0,01386***	0,00802***	0,00995***	0,01462***	0,00748***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Middle Man.	0,00821***	0,01187***	0,00778***	0,00822***	0,01172***	0,00614***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Sup. / Team L.	0,00357***	0,00585***	0,00417***	0,00354***	0,00558***	0,00378***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
High-Skilled	0,01130***	0,01257***	0,00796***	0,01137***	0,01234***	0,00668***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Skilled	0,00648***	0,00734***	0,00634***	0,00637***	0,00694***	0,00552***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Semi-Skilled	0,00690***	0,00847***	0,00757***	0,00692***	0,00817***	0,00661***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Non-Skilled	0,00155***	0,00425***	0,00613***	0,00141***	0,00377***	0,00562***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Interns	0,01479***	0,01443***	0,01373***	0,01467***	0,01440***	0,01270***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Tenure2						
Upper Man.	-0,00019***	-0,00030***	-0,00033***	-0,00024***	-0,00033***	-0,00028***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Middle Man.	-0,00011***	-0,00020***	-0,00032***	-0,00011***	-0,00020***	-0,00024***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Sup. / Team L.	-0,00001**	-0,00007***	-0,00020***	-0,00001***	-0,00006***	-0,00018***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
High-Skilled	-0,00019***	-0,00019***	-0,00030***	-0,00019***	-0,00018***	-0,00023***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Skilled	-0,00005***	-0,00008***	-0,00024***	-0,00005***	-0,00007***	-0,00019***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Semi-Skilled	-0,00008***	-0,00012***	-0,00024***	-0,00008***	-0,00011***	-0,00020***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Non-Skilled	0,00003***	-0,00004***	-0,00018***	0,00003***	-0,00003***	-0,00015***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Interns	-0,00034***	-0,00033***	-0,00048***	-0,00034***	-0,00033***	-0,00042***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Age						
Upper Man.	0,05276***	0,04370***		0,04550***	0,03662***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Middle Man.	0,04020***	0,03960***		0,03915***	0,03701***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Sup. / Team L.	0,03595***	0,03394***		0,03507***	0,03305***	
	(0,000)	(0,000)		(0,000)	(0,000)	
High-Skilled	0,00735***	0,01261***		0,00668***	0,01230***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Skilled	0,01111***	0,01488***		0,01196***	0,01588***	

	(0,000)	(0,000)		(0,000)	(0,000)	
Semi-Skilled	0,01040***	0,01197***		0,01106***	0,01278***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Non-Skilled	0,00292***	0,00535***		0,00309***	0,00567***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Interns	0,00818***	0,01035***		0,00825***	0,01085***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Age2						
Upper Man.	-0,00035***	-0,00026***	-0,00029***	-0,00027***	-0,00018***	-0,00028***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Middle Man.	-0,00033***	-0,00032***	-0,00029***	-0,00032***	-0,0029***	-0,00029***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Sup. / Team L.	-0,00031***	-0,00029***	-0,00031***	-0,00030***	-0,00028***	-0,00029***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
High-Skilled	-0,00001***	-0,00007***	-0,00030***	0,00000	-0,00007***	-0,00028***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Skilled	-0,00009***	-0,00014***	-0,00029***	-0,00010***	-0,00015***	-0,00027***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Semi-Skilled	-0,00010***	-0,00012***	-0,00029***	-0,00011***	-0,00013***	-0,00027***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Non-Skilled	-0,00003***	-0,00006***	-0,00029***	-0,00003***	-0,00006***	-0,00027***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Interns	-0,00008***	-0,00012***	-0,00029***	-0,00008***	-0,00012***	-0,00027***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Education						
Upper Man.	0,08178***	0,04887***		0,06450***	0,02993***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Middle Man.	0,03877***	0,01887***		0,03600***	0,01280***	
	(0,001)	(0,001)		(0,001)	(0,001)	
Sup. / Team L.	0,02677***	0,01413***		0,02596***	0,01345***	
	(0,000)	(0,000)		(0,000)	(0,000)	
High-Skilled	-0,00519***	-0,01146***		-0,00699***	-0,01262***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Skilled	0,01072***	0,00392***		0,01145**	0,00453***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Semi-Skilled	0,00661***	0,00339***		0,00739***	0,00389***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Non-Skilled	0,01318	0,01032***		0,01317***	0,00988***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Interns	-0,01110***	-0,00822***		-0,01087***	-0,00781***	
	(0,001)	(0,001)		(0,001)	(0,001)	
Education2						
Upper Man.	-0,00161***	-0,00055***		-0,00105***	0,00006***	

	(0,000)	(0,000)		(0,000)	(0,000)	
Middle Man.	0,00004*	0,00075***		0,00013***	0,00092***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Sup. / Team L.	0,00115***	0,00137***		0,00115***	0,00136***	
	(0,000)	(0,000)		(0,000)	(0,000)	
High-Skilled	0,00174***	0,00186***		0,00179***	0,00187***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Skilled	0,00072***	0,00074***		0,00068***	0,00070***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Semi-Skilled	0,00055***	0,00046***		0,00051***	0,00043***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Non-Skilled	-0,00034***	-0,00032***		-0,00034***	-0,00031***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Interns	0,00113***	0,00082***		0,00110***	0,00078***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Female						
Upper Man.	-0,17457***	-0,15654***		-0,16578***	-0,14946***	
	(0,001)	(0,001)		(0,001)	(0,001)	
Middle Man.	-0,10267***	-0,10372***		-0,10155***	-0,10187***	
	(0,001)	(0,001)		(0,001)	(0,001)	
Sup. / Team L.	-0,10067***	-0,10374***		-0,09838***	-0,10126***	
	(0,001)	(0,001)		(0,001)	(0,001)	
High-Skilled	-0,11607***	-0,11353***		-0,11325***	-0,11142***	
	(0,001)	(0,001)		(0,001)	(0,001)	
Skilled	-0,11361***	-0,10585***		-0,11308***	0,10509***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Semi-Skilled	-0,10582***	-0,09358***		-0,10647***	-0,09424***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Non-Skilled	-0,06861***	-0,06740***		-0,06736***	-0,06654***	
	(0,001)	(0,001)		(0,001)	(0,001)	
Interns	-0,05302***	-0,05132***		-0,05136***	-0,05054***	
	(0,001)	(0,001)		(0,001)	(0,001)	
Observations	14 063 66	14 063 660	13 369 448	14 048 886	14 048 885	13 287 077
R2	0,64	0,67	0,95	0,64	0,52	0,04
F-statistic	345 089,90	212 080,55	20 530,05	3,40E+05	2,10E+05	10 798,06
Year fixed effects	No	Yes	Yes	No	Yes	Yes
Sector Fixed Effects	No	Yes	No	No	Yes	No
Worker Fixed Effects	No	No	Yes	No	No	Yes
Firm Fixed Effects	No	No	Yes	No	No	Yes
Job Fixed Effectss	No	No	Yes	No	No	Yes

Note: The level of significance is given by "*", with *** indicating significance for all values and zero "*" indicating that the estimation is not statistically relevant.

The results point for a positive response of wages to an increase in tenure, for all workers, in all specifications of the model. The marginal effects are strongest at the base, with workers belonging to the category of interns registering the highest semi-elasticities of wages with respect to tenure. As the coefficients regarding tenure^2 are consistently negative for all specifications, the model indicates diminishing returns to tenure. These findings mean that early in a worker's tenure, they register positive responses in wages due to an increase in tenure, but that effect seems to fade over time.

Regarding age, the evidence suggest that the marginal effects are strongest at the top, as the three highest qualification groups (Upper Management, Middle Management and Supervisors and Team Leaders) register the more pronounced response of wages to increases in a worker's age. Just as tenure, the results suggest diminishing returns to age, indicating that in an early stage of a career, workers register increases in wages as a response to an increase in their age, an effect that, over time, seems do diminish.

Controlling for education does not allow to draw any significant conclusions. Apart from the higher-skilled groups consistently registering the more pronounced positive reaction of wages to an extra year of education, the disparity of the results does not lead to any significant conclusion.

When controlling for gender, it is possible to observe that female workers, on average, earn less than male workers, all other things equal. Furthermore, as the estimates become more negative as qualifications increase, the evidence suggests that the gender wage gap is larger among more qualified workers. This shows that in lower qualification groups, women earn slightly less than men but, as qualifications increase, the differential appears to become larger, reflecting a bigger wage gap at the top of the worker's pyramid.

Table A2. represents the full wage determination models, extended for desirability. In this model, the controls are the same as the wage determination model, with the addition of the desirability measure, which has been discussed in the main text.

Table A2. Wage Determination Models extended for Desirability

	Baseline OLS model	Baseline model with Fixed Effects	Full Model with Fixed Effects	Baseline IV model	Baseline IV model with Fixed Effects	Full IV Model With Fixed effects
Ln (Wage)	(1)	(2)	(3)	(4)	(5)	(6)
PageRank pct						
Upper Man.	0,00364***	0,00379***	0,00049***	0,00327***	0,00339***	0,00045***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)

Middle Man.	0,00264***	0,00280***	0,00063***	0,00256***	0,00257***	0,00062***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Sup. / Team L.	0,00163***	0,00192***	0,00043***	0,00159***	0,00180***	0,00042***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
High-Skilled	0,00065***	0,00093***	0,00026***	0,00057***	0,00080***	0,00025***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Skilled	0,00018***	0,00048***	0,00020***	0,00021***	0,00043***	0,00021***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Semi-Skilled	-0,00005***	0,00021***	-0,00002**	-0,00000	0,00017***	-0,00001*
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Non-Skilled	-0,00005***	0,00019***	0,00002	-0,00004***	0,00012***	0,00002
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Interns	-0,00019***	0,00014***	0,00001	-0,00023***	0,00005*	0,00005**
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Ln (VA p/worker)						
Upper Man.	0,15972***	0,14219***	0,01577***	0,20594***	0,21022***	0,02899***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Middle Man.	0,16891***	0,14265***	0,01454***	0,18361***	0,18858***	0,02142***
	(0,000)	(0,000)	(0,000)	(0,001)	(0,001)	(0,001)
Sup. / Team L.	0,18789***	0,16060***	0,01441***	0,19837***	0,19410***	0,02011***
	(0,000)	(0,000)	(0,000)	(0,001)	(0,000)	(0,000)
High-Skilled	0,15138***	0,12806***	0,01439***	0,17124***	0,16662***	0,02486***
	(0,000)	(0,000)	(0,000)	(0,001)	(0,000)	(0,001)
Skilled	0,13596***	0,11639***	0,01221***	0,13459***	0,13658***	0,01195***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Semi-Skilled	0,09376***	0,08516***	0,01046***	0,08700***	0,10257***	0,01232***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Non-Skilled	0,06196***	0,06693***	0,00650***	0,06812***	0,09749***	0,00725***
	(0,000)	(0,000)	(0,000)	(0,001)	(0,001)	(0,001)
Interns	0,07991***	0,07029***	-0,00238***	0,09062***	0,09568***	-0,01322***
	(0,001)	(0,001)	(0,001)	(0,001)	(0,001)	(0,001)
Ln (Barg. Wage)						
Upper Man.	0,09656***	0,08448***	0,06722***	0,08042***	0,06992***	0,04674***
	(0,000)	(0,000)	(0,005)	(0,000)	(0,000)	(0,005)
Middle Man.	0,16271***	0,12093***	0,06334***	0,15797***	0,11180***	0,05257***
	(0,001)	(0,001)	(0,005)	(0,001)	(0,001)	(0,005)
Sup. / Team L.	0,16011***	0,12491***	0,06891***	0,15865***	0,12298***	0,05999***
	(0,001)	(0,001)	(0,005)	(0,001)	(0,001)	(0,005)
High-Skilled	0,32652***	0,25387***	0,04990***	0,31104***	0,24270***	0,03377***
	(0,001)	(0,001)	(0,005)	(0,001)	(0,001)	(0,005)
Skilled	0,33340***	0,26244***	0,05084***	0,34233***	0,27310***	0,05125***
	(0,000)	(0,000)	(0,005)	(0,000)	(0,000)	(0,005)

	Semi-Skilled	0,40734***	0,32076***	0,05110***	0,42499***	0,33653***	0,04828***
		(0,001)	(0,001)	(0,005)	(0,001)	(0,001)	(0,005)
	Non-Skilled	0,48194***	0,37035***	0,05331***	0,48246***	0,36884***	0,05215***
		(0,001)	(0,001)	(0,005)	(0,001)	(0,001)	(0,005)
	Interns	0,44449***	0,35484***	0,06458***	0,43893***	0,36030***	0,08088***
		(0,002)	(0,002)	(0,005)	(0,002)	(0,002)	(0,005)
Tenure							
	Upper Man.	0,00945***	0,01442***	0,00749***	0,01049***	0,01516***	0,00746***
		(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
	Middle Man.	0,00841***	0,01212***	0,00613***	0,00843***	0,01196***	0,00610***
		(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
	Sup. / Team L.	0,00332***	0,00571***	0,00375***	0,00329***	0,00545***	0,00372***
		(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
	High-Skilled	0,01110***	0,01253***	0,00671***	0,01117***	0,01230***	0,00665***
		(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
	Skilled	0,00637***	0,00731***	0,00548***	0,00626***	0,00692***	0,00549***
		(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
	Semi-Skilled	0,00681***	0,00847***	0,00658***	0,00683***	0,00818***	0,00656***
		(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
	Non-Skilled	0,00152***	0,00430***	0,00557***	0,00138***	0,00382***	0,00557***
		(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
	Interns	0,01460***	0,01442***	0,01256***	0,01444***	0,01433***	0,01262***
		(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Tenure2							
	Upper Man.	-0,00022***	-0,00032***	-0,00028***	-0,00026***	-0,00035***	-0,00028***
		(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
	Middle Man.	-0,00012***	-0,00021***	-0,00024***	-0,00012***	-0,00021***	-0,00024***
		(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
	Sup. / Team L.	0,00000	-0,00006***	-0,00018***	-0,00000	-0,00006***	-0,00017***
		(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
	High-Skilled	-0,00019***	-0,00019***	-0,00023***	-0,00019***	-0,00018***	-0,00022***
		(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
	Skilled	-0,00005***	-0,00007***	-0,00018***	-0,00005***	-0,00006***	-0,00018***
		(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
	Semi-Skilled	-0,00008***	-0,00012***	-0,00020***	-0,00008***	-0,00011***	-0,00020***
		(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
	Non-Skilled	0,00003***	-0,00004***	-0,00015**	0,00003***	-0,00003***	-0,00015***
		(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
	Interns	-0,00034***	-0,00033***	-0,00042***	-0,00033***	-0,00032***	-0,00042***
		(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Age							
	Upper Man.	0,05009***	0,04102***		0,04281***	0,03398***	

	(0,000)	(0,000)		(0,000)	(0,000)	
Middle Man.	0,03829***	0,03763***		0,03715***	0,03514***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Sup. / Team L.	0,03474***	0,03260***		0,03391***	0,03177***	
	(0,000)	(0,000)		(0,000)	(0,000)	
High-Skilled	0,00760***	0,01253***		0,00701***	0,01232***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Skilled	0,01146***	0,01522***		0,01230***	0,01620***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Semi-Skilled	0,01075***	0,01249***		0,01139***	0,01326***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Non-Skilled	0,00309***	0,00567***		0,00327***	0,00596***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Interns	0,00857***	0,01086***		0,00865***	0,01132***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Age2						
Upper Man.	-0,00032***	-0,00022***	-0,00029***	-0,00023***	-0,00014***	-0,00029***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Middle Man.	-0,00030***	-0,00029***	-0,00029***	-0,00029***	-0,00027***	-0,00029***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Sup. / Team L.	-0,00029***	-0,00027***	-0,00029***	-0,00028***	-0,00026***	-0,00029***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
High-Skilled	-0,00001***	-0,00007***	-0,00028***	-0,00000	-0,00007***	-0,00028***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Skilled	-0,00001***	-0,00014***	-0,00027***	-0,00010***	-0,00015***	-0,00027***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Semi-Skilled	-0,00010***	-0,00013***	-0,00027***	-0,00011***	-0,00014***	-0,00027***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Non-Skilled	-0,00003***	-0,00007***	-0,00027***	-0,00003***	-0,00007***	-0,00027***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Interns	-0,00009***	-0,00012***	-0,00027***	-0,00009***	-0,00013***	-0,00027***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Education						
Upper Man.	0,07515***	0,04141***		0,05773***	0,02270***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Middle Man.	0,03554***	0,01573***		0,03257***	0,00984***	
	(0,001)	(0,001)		(0,001)	(0,001)	
Sup. / Team L.	0,02598***	0,01313***		0,02518***	0,01250***	
	(0,000)	(0,000)		(0,000)	(0,000)	
High-Skilled	-0,00509***	-0,01175***		-0,00679***	-0,01273***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Skilled	0,01104***	0,00402***		0,01177***	0,00465***	

	(0,000)	(0,000)		(0,000)	(0,000)	
Semi-Skilled	0,00691***	0,00371***		0,00768***	0,00419***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Non-Skilled	0,01329***	0,01050***		0,01327***	0,01006***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Interns	-0,01031***	-0,00765***		-0,01008***	-0,00728***	
	(0,001)	(0,001)		(0,001)	(0,001)	
Education2						
Upper Man.	-0,00144***	-0,00035***		-0,00087***	0,00026***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Middle Man.	0,00014***	0,00084***		0,00023***	0,00102***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Sup. / Team L.	0,00118***	0,00141***		0,00118***	0,00140***	
	(0,000)	(0,000)		(0,000)	(0,000)	
High-Skilled	0,00174***	0,00187***		0,00178***	0,00188***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Skilled	0,00070***	0,00073***		0,00066***	0,00069***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Semi-Skilled	0,00053***	0,00044***		0,00049***	0,00041***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Non-Skilled	-0,00035***	-0,00033***		-0,00035***	-0,00032***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Interns	0,00109***	0,00078***		0,00106***	0,00075***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Female						
Upper Man.	-0,16946***	-0,15295***		-0,16071***	-0,14608***	
	(0,001)	(0,001)		(0,001)	(0,001)	
Middle Man.	-0,10320***	-0,10477***		-0,10194***	-0,10282***	
	(0,001)	(0,001)		(0,001)	(0,001)	
Sup. / Team L.	-0,10303***	-0,10593***		-0,10065***	-0,10343***	
	(0,001)	(0,001)		(0,001)	(0,001)	
High-Skilled	-0,11603***	-0,11348***		-0,11313***	-0,11148***	
	(0,001)	(0,001)		(0,001)	(0,001)	
Skilled	-0,11336***	-0,10559***		-0,11290***	-0,10497***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Semi-Skilled	-0,10524***	-0,09281***		-0,10604***	-0,09353***	
	(0,000)	(0,000)		(0,000)	(0,000)	
Non-Skilled	-0,06800***	-0,06665***		-0,06674***	-0,06577***	
	(0,001)	(0,001)		(0,001)	(0,001)	
Interns	-0,05195***	-0,05069***		-0,04999***	-0,04953***	
	(0,001)	(0,001)		(0,001)	(0,001)	
Observations	14 063 661	14 063 660	13 301 765	14 048 886	14 048 885	13 287 077

R2	0,64	0,67	0,95	0,64	0,52	0,04
F-statistic	313 451,34	193 507,55	9 170,38	3,40E+05	1,90E+05	9 104,68
Year fixed effects	No	Yes	Yes	No	Yes	Yes
Sector Fixed Effects	No	Yes	No	No	Yes	No
Worker Fixed Effects	No	No	Yes	No	No	Yes
Firm Fixed Effects	No	No	Yes	No	No	Yes
Job Fixed Effectss	No	No	Yes	No	No	Yes
I.V.	No	No	No	Yes	Yes	Yes

Note: The level of significance is given by "*", with *** indicating significance for all values and zero "*" indicating that the estimation is not statistically relevant.

Here, as the presented model is an extension of the previously presented and described model for wage determination (represented in table A1.), the conclusions drawn from the previous model are also valid for this one.

As such, the response of wages to marginal increases in tenure is strongest at the base, contrary to what happens with age, where the response is more pronounced at the top of the qualification groups. Both controls show diminishing rates of return, as evidenced by the negative coefficients regarding the quadratic form of the controls ($tenure^2$, age^2). Once more, the effects of an extra year of education on wages seem to be stronger at the top. Nevertheless, the remaining estimates do not allow to set a trend, which means that there are no consistent and valid conclusions to be drawn by controlling for education. The gender wage gap is also evidenced by the estimates of the various specifications of this model. Here, once more, the coefficients regarding gender show that female workers, on average, tend to earn less than male worker, all other things equal. As the coefficients become more negative as qualifications improve, the findings point to a widening gender wage gap with respect to qualifications.

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