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## The Market for CEOs: Building Legacy and Feeling Empowered Matter

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# The Market for CEOs: Building Legacy and Feeling Empowered Matter

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## ABSTRACT

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# The Market for CEOs: Building Legacy and Feeling Empowered Matter\*

We develop a two-sided multidimensional matching model of the market for CEOs that allows for both pecuniary and non-pecuniary (amenity) compensation. The model is estimated by maximum likelihood estimation using matched CEO-firm data from Denmark. We show that CEOs have preferences for building legacy and gaining empowerment. The legacy mechanism explains why there is low mobility in the CEO market, even though firms demand general CEO skills. The empowerment mechanism explains why CEOs are willing to sacrifice significant pecuniary income to manage high equity firms. The overall conclusion is that job amenities matter in the market for CEOs.

**JEL Classification:** G30, M12, C78, C35, D22, D31, J3

**Keywords:** multidimensional matching, observed transfers, structural estimation, value of job amenities, taxation, CEO compensation, CEO performance

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*Your work is going to fill a large part of your life, and the only way to be truly satisfied is to do what you believe is great work. And the only way to do great work is to love what you do.*

— Steve Jobs, Co-Founder of Apple

## 1 Introduction

There is much evidence that CEOs are crucial for firm performance (Rosen [1981, 1982], Kaplan et al. [2012], Kaplan and Sorensen [2021], Bennedsen et al. [2020]). Moreover, to the extent that high performance firms led by talented CEOs are essential to the profitable development of innovations and economic opportunities, it is a matter of public interest that the right CEOs are matched to the right firms. Therefore, a deeper understanding of the CEO market can offer valuable guidance not only for general corporate strategies that impact who manages the firm, but also for public policies that impact CEO pay and assignment (Refer to Edmans and Gabaix [2016]). While much of the literature on CEO compensation has focused on pecuniary pay as the primary means by which firms compete for CEOs, in this paper, we apply a two-sided multidimensional matching model of the market for CEOs that includes both pecuniary and non-pecuniary (amenity) compensation. We show that amenities, which relate to the attributes of firms, are also an important form of compensation in the CEO market.

Our contribution is of importance as it both supports and reconciles key previous findings in the literature. First, a model of perfect competition with pecuniary compensation is a key starting point in the analysis of the CEO market (Gabaix and Landier [2008] and Tervio [2008]). In the simplest setting, the competitive model predicts that the most productive firms should be matched to the most talented CEOs. Therefore, given the tremendous increase in firm size over recent decades, the competitive model provides an important explanation of the rise in CEO pay. Competitive market analysis also offers explanation on how CEOs' skills can be applied across industries. Murphy and Zabojsnik [2004, 2007] find that there has

been an increase in the demand for general CEO skills, that are transferable across firms and industries (See also Frydman [2019] and Custódio et al. [2013]). This conclusion provides another important channel for how competitive market has pushed increases in CEO pay.

Following the logic of competitive models, if talented CEOs are scarce and demonstrate general skills, there should also be high mobility of talented CEOs across firms and industries. However, various studies have documented otherwise (See, for example, Graham et al. [2020]). In particular, Cziraki and Jenter [2020] argue that the low mobility of CEOs is at odds with the underlying idea that the most productive firms are attracting the most talented CEOs and that CEOs have general portable skills. Our paper addresses this puzzle by showing that CEOs derive a high amenity value from managing firms in industries where the CEOs have past experience, which we call ‘alma mater’ firms; And importantly, CEO productivity is not enhanced at their alma mater firms, suggesting that firms value general CEO skills rather than industry-specific ones. Consequently, our results reconcile the findings of Murphy and Zabojnik [2004, 2007], Frydman [2019], Custódio et al. [2013] and Cziraki and Jenter [2020]: there is low mobility in the CEO market; this is not because CEOs are more productive at their alma mater firms and industries, but rather because CEOs prefer staying in their alma mater firms. We interpret this result as the legacy effect: CEOs are willing to trade off a large amount of pecuniary pay for building a legacy in their industry.

Second, models of corporate governance also offer influential explanations for how firms compensate CEOs. One key idea of corporate governance theory is that firms institute different levels of oversight to their CEOs to balance the interests of the firm’s many stakeholders. In accordance with Jensen [1986]’s ‘control hypothesis’, a firm faces higher risks of financial distress when it uses high levels of debt financing. In this case, the CEO is under constant pressure to manage the firm efficiently in order to honor its debt obligations. Furthermore, the conflicts of interests between debt holders and equity holders can create investment distortions that directly affect a firm’s profitability. The board of directors has the responsibility to monitor the CEO and make sure that she acts in the best interest of the shareholders. Moreover, using high levels of debt financ-

ing in the firm's capital structure also invites market scrutiny. Corporate raiders often choose to replace the CEO in a hostile takeover. On the other hand, managing a firm with a high equity position can alleviate board and market oversight, thus giving the CEO more freedom to manage and to introduce more perks and benefits for herself and for the employees. From these considerations, we hypothesize that a CEO gets a positive amenity value from managing a firm with a high equity position, where she is more likely to feel empowered. This paper finds empirical support for this hypothesis. We indeed show that CEOs are willing to give up part of their salary to manage firms with high equity positions, suggesting that CEOs derive amenities from an empowered management position.

Before going into the discussion of our model, it is important to define pecuniary compensation and amenities. We define amenities as a form of compensation to the CEO that cannot be transferred into monetary units by conventional methods of accounting. For example, an amenity can be the enjoyment of managing a firm within an industry where the CEO has experience. This is contrasted by the CEO's pecuniary earnings, which will include all sources of compensation for which it is straightforward to calculate a monetary value, such as base wage, perks, for example, a company provided car, tax-free salary, anniversary and severance pay, the value of stock options, remuneration for board work, fees in connection with consulting work, lectures and the like. Importantly, pecuniary compensations are typically taxed as personal income by the tax authorities, whereas amenities are not taxed.<sup>1</sup>

Our modelling framework is simple. To draw our inferences of how different CEOs value the amenities of different firms, we develop a competitive model of the market for CEOs. In this model, CEOs are allowed to have different skills that are valued differently by different firms and have preferences over the amenities offered by different firms. Our model allows agents from both sides of the market to differ along multidimensional attributes. This means, for example, that CEOs can be distinguished using several traits, such as age, education, wealth, marital status, etc; and firms can also be distinguished using multiple characteristics, such as number of

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<sup>1</sup>Following this definition, fringe benefits, for example, a company provided car, extra insurance, are taxed. So it is part of pecuniary compensation, not amenities.

employees, imports, exports, etc. Additionally, our model allows for unobserved heterogeneity on both sides of the market. The key identifying assumption is ‘additive separability’ of the unobserved heterogeneity of the two sides, which was first proposed by Choo and Siow [2006], and is developed more formally for a broader range of applications by Galichon and Salanié [2021] and Chiappori et al. [2017], and is further developed to allow continuous agent types by Dupuy and Galichon [2014]. From this theoretical model, we follow Dupuy and Galichon [2021] and apply a maximum likelihood estimation (MLE) technique. This methodology allows us to separately identify the value of firm productivity and job amenities by fitting three features of our data simultaneously: i) the observed assignment of CEOs to firms, ii) wages and iii) firm productivity.<sup>2</sup>

Our methodology can account for frictions on transfers through taxation. We assume that the CEOs pay taxes on pecuniary income but not on amenities. This is of importance because ‘neutrality’ is a fundamental principle of optimal taxation (Furman [2008]). If a tax system is not neutral, economic inefficiencies emerge because resources are not directed at their ideal uses. In our model, in which we assume a competitive market, the fact that amenities are untaxed induces distortions in the market for CEOs: with high taxation, CEOs choose firms they enjoy working at rather than firms they are most productive at. As a result, the social welfare can be expressed as a weighted sum of total amenities and total pecuniary compensation, the weight on the latter part decreasing as taxation increases.<sup>3</sup> CEOs are typically in the top of the income distribution, therefore face high taxes. When we account for amenities, the tax system is decidedly not neutral. And this non-neutrality can only be inferred, because the amenities we identify cannot be directly observed in practice.<sup>4</sup> It is important to note that taxation has implications on equilibrium assignments (which CEO is

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<sup>2</sup>A method of identifying job amenities in random matching markets between labor and firms is developed by Sorkin [2018]. Sorkin [2018] finds a key role for amenities in worker compensation. Boyd et al. [2013] use a competitive matching model to infer that teachers enjoy an amenity (accept lower wages) when managing ‘easier’ classrooms, which they find are found in suburban rather than inner city communities.

<sup>3</sup>In a competitive CEO/firm matching model, if all forms of compensation are taxed at the same rate (tax neutrality), the equilibrium assignment of CEOs to firms will generally be efficient (Gabaix and Landier [2008]). The only possible distortion of taxes in this case is on the extensive margin (who enters/leaves the CEO market).

<sup>4</sup>The matching distortion of taxation is studied in Dupuy et al. [2020]



matched to which firm), but not on our estimates of firm productivity and amenities since we explicitly account for it.

Explicitly accounting for amenities in a multidimensional matching model is important for several reasons. First, ignoring amenities, the estimates of productivity parameters in an otherwise similar multidimensional matching model would be biased. To see this, note that, the equilibrium matching is increasing in both productivity and amenities, whereas the equilibrium wages are increasing in productivity but decreasing in amenities. As a result, when fitting matching data, one would attribute the positive effect of amenities to productivity, leading to an upward bias in productivity estimates. And when fitting wage data, one would attribute the negative effect of amenities to productivity, leading to a downward bias. There are, however, no reasons to expect the two sources of bias to offset each other. Second, as taxation increases, equilibrium matching and wages tend to reflect more amenities than productivity, see Dupuy et al. [2020]. Therefore, when ignoring amenities, i) the aforementioned biases in productivity estimates are likely to be larger in markets with high taxation (similarly, since CEOs are typically in a high tax category, this bias in productivity estimates can be nontrivial in the market for CEOs); and ii) comparing productivity estimates across markets with different levels of taxation would be difficult to do, as the differences that should be attributed to different levels of taxation would be wrongly interpreted as differences in productivity.

Denmark offers high quality data for the purposes of our study for several reasons. First, in order to infer amenities, we need an accurate measure of pecuniary compensation. The Danish personal income data are third-party reported to the tax office.<sup>5</sup> The Danish income and wealth information is considered of very high quality and widely used in academic research.<sup>6</sup> As mentioned before, our measure of CEOs' wage includes a comprehensive list of sources of income, with for instance fringe benefits, such as a company provided car, and the expected value of incentive pay-

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<sup>5</sup>Pay slip information is reported by employers. Assets and liabilities are reported by banks. Value of securities is reported by financial institutions, such as mutual funds and investment banks.

<sup>6</sup>See, for example, Kleven et al. [2011], Boserup et al. [2016], Leth-Petersen [2010] and Chetty et al. [2014]. For a more detailed description of the data, see Section 4 and Appendix B.

ments, such as stock options. Moreover, the Danish registered data also provides information on various CEO characteristics, such as the CEOs' age, education, gender, marital status, number of children, age of each child, net wealth, bank debt, tax value of property, bank deposit, financial investments in stocks, market value of bonds, investments in foreign financial markets, previous work experience, payout in private pension schemes.

Second, Statistics Denmark provides the link between workers and employers, and detailed measures on firm equity, profitability and performance.<sup>7</sup> The matched CEO-firm data made it possible for us to infer the values of non-pecuniary forms of income (amenities) using a method of inference that was developed by Dupuy et al. [2020] and Dupuy and Galichon [2021].

Third, our data contains the entire Danish population of CEOs and firms for the year 2011. Taking into account considerations of the institutional environment in Denmark where there is a large number of small and medium-sized firms with owner CEOs, we choose to focus on the CEOs of large firms (more than 250 employees). Denmark has one of the highest tax rates in the world. The Danish CEOs pay a marginal income tax rate of 56 percent. In this high tax environment, if amenities are important, there is likely to be a high level of distortion of the matching of CEOs to firms. Our tools of inference explicitly account for these distortions.

Fourth, the boundary of the CEO market is well defined in Denmark. Danish CEOs receive lower pay compared to the US and EU average, which is compounded by the fact that Denmark has one of the world's highest taxes. That Danish CEO talent rarely leaves Denmark can be attributed to a strong attachment to Danish culture and work-life balance. CEOs in Denmark might receive a lower paycheck, but they are compensated by quality state-funded education, good public services, free health care, and a comprehensive social safety net from working in this country, which they (and their family) cannot get working elsewhere. That Non-Danes do not enter the Danish CEO market can be attributed to the difficulty of the

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<sup>7</sup>Following the Danish Financial Statement Act, introduced in 1981 by the Danish business authority, all firms in Denmark have to submit annual reports, that consist of a management's review, an income statement/statement of profit or loss and other comprehensive income, a balance sheet, a statement of changes in equity, and a cash flow statement.

Danish language and other cultural barriers. Therefore, while the Danish economy is small, the CEO market should be well approximated by a closed market.

Overall, our result showing various job amenities matter to CEOs is in line with Focke et al. [2017], Yonker [2017], Edmans et al. [2021], Cziraki and Jenter [2020],<sup>8</sup> suggesting that CEOs' objectives are more than just maximizing the NPV of their incomes.

Given our estimates that CEOs place high amenity values on certain important firm characteristics, it is of interest to determine how CEO assignment and pay will change if the characteristics of firms in our sample were to change. We develop four counterfactual experiments that help illustrate how amenities shape the CEO market. The first two experiments directly manipulate the importance of two key amenities - the amenity for alma mater firms and the amenity for less oversight. The second two experiments are aimed at understanding how industry and trade policies might impact the CEO market given our estimates of how CEOs value the amenities of different firm types. The first considers the effects of an industry policy that causes a sector shift from a declining sector to an expanding sector. The second considers the effects of a trade war that shuts down the firm's exports.

The counterfactual experiments give the following results. First, we find that shutting down the amenity for alma mater firms leads to considerable mobility of CEOs across firms and also large increases in CEO salaries. In other words, the removal of this untaxed amenity brings about fundamental changes to both assignment and pay in the CEO market. Second, if we set the equity of all large firms in the CEO market to the 95th/5th percentile firm type, we find that CEOs' salaries fall/rise by a large amount with virtually no change in the assignment of CEOs to firms. This case shows that factors that result in a decrease in CEO oversight will lead to lower CEO pay and create virtually no changes in CEO assignments. Third, if we shut down the low productivity industry in favor of creating firms in the high productivity industry, we find much mobility of CEOs across all

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<sup>8</sup>Focke et al. [2017] show that CEOs accept lower pay when working for a more prestigious company, and Yonker [2017] shows that CEOs accept lower pay and are less likely to leave when working for firms in their home state.

industries. This outcome occurs because there now exists a larger set of CEOs who are primarily concerned with salary since firms in their alma mater industry have disappeared. Fourth, if we shut down firms' exports, we do not find much mobility of CEOs. This conclusion is due to the continued importance of the amenity for alma mater firms in attracting CEOs to firms, which is not changed if there is a trade shock.

A clear limitation of our methodology is that it assumes agents are risk-neutral and does not model explicitly incentives as derived from the principal-agent problem (see Holmstrom and Milgrom [1987], Edmans and Gabaix [2011]). However, a key asset of our model is that it allows us to consider multidimensional attributes on both sides of the market which affect amenities and productivity. So the incentive mechanisms that are explicitly modelled in Edmans and Gabaix [2011] can essentially be captured in our estimates of amenities. By including variables such as firms' equity, CEO net wealth and interaction terms between CEO and firm attributes, we provide flexible reduced-form answers to questions which are raised by these issues. For instance, Edmans et al. [2009], Edmans and Gabaix [2011] find that if utility is multiplicative in cash and effort, exerting effort will be more costly to a wealthy manager. We find that wealthier CEOs get less amenities when managing firms that export more. Assuming firms that export more require more efforts, our estimates suggest that wealthier CEOs require a higher monetary compensation to manage such a firm compared to, *ceteris paribus*, less wealthy ones. Note that this is corroborated by our other finding that more indebted CEOs, get more amenities managing firms that export more. This could be reflecting that indebted CEOs are more willing to put in the effort, and can be compensated with less pay. Still, we do think considering agents' risk preferences and modelling the principal-agent problem explicitly in our framework would constitute an important avenue for future research.

The paper is organized as follows. In the next section, we present the model. In the third section, we derive the MLE for the model parameters given data on CEO-firm matches. In the fourth section, we describe the Danish CEO market and the data used in our analysis. In the fifth section, we estimate the model and discuss the results. We consider counterfactual experiments in the sixth section, and we discuss how our analysis relates

to the literature in the seventh section. The final section concludes.

## 2 Model

We consider a matching model, that is close in spirit to Dupuy et al. [2020]. The key assumptions are that CEOs match one-to-one to firms and that utility is transferable through earnings, albeit imperfectly as the CEO earnings are subject to taxation.<sup>9</sup> In a significant departure from the existing literature on CEO pay (Edmans and Gabaix [2016]), our model takes into account the potential value of job amenities to CEOs.

### 2.1 Agents

CEOs, indexed by  $i$ , seek employment with firms, indexed by  $j$ . The CEOs and the firms are grouped into observable (to the analyst) types. The set of CEO types is  $\mathcal{X}$  and the set of firm types is  $\mathcal{Y}$ . A CEO  $i$  is said to be of type  $x_i \in \mathcal{X}$ , whereas a firm  $j$  is said to be of type  $y_j \in \mathcal{Y}$ . The first assumption of our model concerns the distribution of observable types.

**Assumption 1** *There is a continuous distribution of CEOs over  $\mathcal{X}$ , whose p.d.f. is denoted  $f(x)$ , and a continuous distribution of firms over  $\mathcal{Y}$ , whose p.d.f. is denoted  $g(y)$ . The market is large so that there is a large number of CEOs of any given observable type  $x$  and there is a large number of firms of any given observable type  $y$ . Firms and CEOs are in equal mass which we normalize to 1.*

### 2.2 Match values

The CEOs have preferences over types of firms. Following Dupuy et al. [2020], these preferences are additively separable into two terms

$$\alpha(x, y) + \sigma_1 \varepsilon_i(y).$$

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<sup>9</sup>Workers in the Danish labor market are subject to piece-wise linear taxation. CEOs of large firms (more than 249 employees) all earn wages that fall into the highest income tax bracket. Consequently, the observed market for CEOs can be seen as one where taxes are linear as in Dupuy et al. [2020].

The first term represents the systematic job amenity for a CEO of type  $x$  when managing a firm of type  $y$ . The second term represents the idiosyncratic value of a CEO  $i$ 's amenity of working for a firm of type  $y$ , where  $\sigma_1$  is a scaling factor.

Similarly, firms' output is also additively separable into two terms

$$\gamma(x, y) + \sigma_2 \eta_j(x).$$

The first term is the systematic output for a firm of type  $y$  when managed by a CEO of type  $x$ . The second term represents the idiosyncratic output of firm  $j$  when matched with a CEO of type  $x$ .  $\sigma_2$  is a scaling factor. The distribution of the idiosyncratic shocks for both CEOs and firms is given by Assumption 2.

**Assumption 2** *Idiosyncratic shocks  $\varepsilon_i(y)$  and  $\eta_j(x)$  follow Gumbel random processes à la Dupuy and Galichon [2014, 2021].*

The allocation of match values is as follows. Let us consider a firm  $j$  of observable type  $y_j = y$  and a CEO  $i$  of observable type  $x_i = x$ . If they match with each other, the profits of firm  $j$  are given by

$$\gamma(x, y) - w(x, y) + \sigma_2 \eta_j(x),$$

where  $w(x, y)$  is the gross earnings paid by a firm of type  $y$  when matched to a CEO of type  $x$ , whereas CEO  $i$ 's utility<sup>10</sup> is given by

$$\alpha(x, y) + T(w(x, y)) + \sigma_1 \varepsilon_i(y),$$

where  $T(w(x, y))$  is the net (post-tax) earnings of a CEO of type  $x$  when managing a firm of type  $y$ .<sup>11</sup> The function  $T()$  is determined by the tax system of the market under consideration and is known to all agents.

The tax systems in this model can be very general. We only need to impose the following assumption:

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<sup>10</sup>One might consider that each type of CEOs values monetary transfers differently. In this case, one might introduce in the model a different weight on the transfers for different types of CEOs. However, note that this model would be strictly equivalent to a model where there is a scaling factor on amenities that depends on CEOs' type  $x$ .

<sup>11</sup>Note that as in Dupuy and Galichon [2021], by the law of one price, equilibrium transfers only vary with observable types of CEOs and firms.

**Assumption 3** *The function  $T()$  is continuous and so that  $\lim_{w \rightarrow -\infty} T(w) = -\infty$ .*

## 2.3 Competitive market

The market is competitive, as specified in Assumption 4.

**Assumption 4** *All agents participate<sup>12</sup> and are price takers (monopolistic competition) and utility/profits maximizers. CEOs know  $\alpha(x, y)$ ,  $\gamma(x, y)$ ,  $T()$  and  $\sigma_1 \varepsilon_i(y)$ , and firms know  $\alpha(x, y)$ ,  $\gamma(x, y)$ ,  $T()$  and  $\sigma_2 \eta_j(x)$ .*

It follows from Assumption 4 that a firm  $j$  of type  $y_j = y$  solves the following program

$$\max_{x \in \mathcal{X}} \gamma(x, y) - w(x, y) + \sigma_2 \eta_j(x),$$

and a CEO  $i$  of type  $x_i = x$  solves

$$\max_{y \in \mathcal{Y}} \alpha(x, y) + T(w(x, y)) + \sigma_1 \varepsilon_i(y).$$

Denote  $\mu^F(x, y)$  as the density of firms of type  $y$  opting for a CEO of type  $x$ , i.e. so that  $x$  solves firms of type  $y$ 's problem. Denote  $\mu^C(x, y)$  as the density of CEOs of type  $x$  opting for firms of type  $y$ , i.e. so that  $y$  solves CEOs of type  $x$ 's problem. Each of these problems can be seen as a discrete choice problem and by an application of the Williams-Daly-Zachary theorem, one obtains the logit demand of firms of type  $y$  for CEOs of type  $x$  as

$$\mu^F(x|y) := \frac{\mu^F(x, y)}{g(y)} = \exp\left(\frac{\gamma(x, y) - w(x, y) - v(y)}{\sigma_2}\right), \quad (1)$$

where  $v(y) = \sigma_2 \log \int_X \exp\left(\frac{\gamma(x', y) - w(x', y)}{\sigma_2}\right) dx'$  and the logit demand of

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<sup>12</sup>Because of the logit structure of the model, it can be shown (see, Dupuy and Galichon [2014] and Dupuy and Weber [2021]) that this model is equivalent to an otherwise similar model, where agents are allowed not to participate in which case their reservation utility is  $-\infty$ .

CEOs of type  $x$  for jobs of type  $y$  as

$$\mu^C(y|x) := \frac{\mu^C(x,y)}{f(x)} = \exp\left(\frac{\alpha(x,y) + T(w(x,y)) - u(x)}{\sigma_1}\right), \quad (2)$$

where  $u(x) = \sigma_1 \log \int_Y \exp\left(\frac{\alpha(x,y') + T(w(x,y'))}{\sigma_1}\right) dy'$ .

## 2.4 Equilibrium

An equilibrium outcome is characterized by the following formal definition.

**Definition 1** *An outcome  $(\mu, w)$  is an equilibrium outcome if the gross wage  $w(x, y)$  is so that  $\mu^F(x, y) = \mu^C(x, y) = \mu(x, y)$  where  $u(x)$  and  $v(y)$  are solutions of the system*

$$\begin{aligned} \int_X \mu(x, y) dx &= g(y), \\ \int_Y \mu(x, y) dy &= f(x). \end{aligned}$$

Note that, under our standing assumptions, Theorem 1 in Galichon et al. [2019] applies, so that there exists a unique equilibrium outcome to our problem.<sup>13</sup>

In particular, rearranging equations (1) and (2) at equilibrium, one obtains

$$\alpha(x, y) + T(w(x, y)) = \tilde{u}(x) + \sigma_1 \log \mu(x, y) \quad (3)$$

$$\gamma(x, y) - w(x, y) = \tilde{v}(y) + \sigma_2 \log \mu(x, y) \quad (4)$$

where  $\tilde{u}(x) = u(x) - \sigma_1 \log f(x)$  and  $\tilde{v}(y) = v(y) - \sigma_2 \log g(y)$ .

Solving equation (4) for  $w(x, y)$  and plugging the solution into equation (3) gives

$$\alpha(x, y) + T(\gamma(x, y) - \tilde{v}(y) - \sigma_2 \log \mu(x, y)) = \tilde{u}(x) + \sigma_1 \log \mu(x, y). \quad (5)$$

This equation provides an implicit solution for the equilibrium matching

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<sup>13</sup>Indeed, as long as the function  $T(\cdot)$  satisfies assumption 3, agents face a proper bargaining set in the sense of Definition 1 in Galichon et al. [2019].



$\mu(x, y)$  given the potentials  $(\tilde{u}(x), \tilde{v}(y))$ . To derive an explicit expression for this equation, we need to specify the tax system represented in function  $T(\cdot)$ . In particular, the Danish tax system used in our empirical application is characterized by Assumption 5.

**Assumption 5** *The tax system is such that the net wage  $T(w(x, y))$  reads as*

$$T(w(x, y)) = (1 - \tau)w(x, y) + \delta t_1.$$

where  $\tau$  is the tax rate and  $\delta t_1$  is a lump sum.<sup>14</sup>

Let  $\mu(x, y)$  be the equilibrium matching under  $T(w(x, y)) = (1 - \tau)w(x, y) + \delta t_1$ . Plugging this expression into equation (5) gives

$$\alpha(x, y) + (1 - \tau)(\gamma(x, y) - \tilde{v}(y) - \sigma_2 \log \mu(x, y)) + \delta t_1 = \tilde{u}(x) + \sigma_1 \log \mu(x, y)$$

which solves for  $\mu(x, y)$  as

$$\begin{aligned} \log \mu(x, y) &= \\ M(\tilde{u}^t(x), \tilde{v}(y)) &: = \frac{\alpha(x, y) - \tilde{u}(x) + (1 - \tau)(\gamma(x, y) - \tilde{v}(y)) + \delta t_1}{\sigma_1 + (1 - \tau)\sigma_2}. \end{aligned}$$

As a by product, note that plugging this result into equation (4) and solving for the equilibrium gross wage  $w(x, y)$  as a function of the potentials  $(\tilde{u}(x), \tilde{v}(y))$  gives

$$w(x, y) = \frac{\sigma_1}{\sigma_1 + (1 - \tau)\sigma_2} (\gamma(x, y) - \tilde{v}(y)) - \frac{\sigma_2}{\sigma_1 + (1 - \tau)\sigma_2} (\alpha(x, y) - \tilde{u}(x) + \delta t_1). \quad (6)$$

## 2.5 Computing equilibrium matching and wages

We use the Iterative Proportional Fitting Procedure (IPFP) algorithm to find the equilibrium matching, given parameters  $\alpha(x, y)$ ,  $\gamma(x, y)$ ,  $\tau$ ,  $\sigma_1$  and  $\sigma_2$  and data  $f(x)$  and  $g(y)$ . The algorithm works as follows.

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<sup>14</sup>This formula can be derived as the net earnings of CEOs subject to a tax system with two income brackets, i.e.  $[0, t_1]$  and  $]t_1, \infty[$  where the tax rates on each interval is respectively  $\tau_0$  and  $\tau$ , where  $\delta = \tau - \tau_0$ . In practice, all CEOs of large firms in Denmark pay top tax. which means their gross earnings are larger than  $t_1$ . Their net earnings are then indeed  $T(w(x, y)) = (1 - \tau)w(x, y) + \delta t_1$ .

**Algorithm 1** Given parameters  $\alpha(x, y)$ ,  $\gamma(x, y)$ ,  $\tau$ ,  $\sigma_1$  and  $\sigma_2$  and data  $f(x)$  and  $g(y)$ ,

1. Initialization:  $t = 1$ , let  $\tilde{u}^{t-1}(x) = 0$  for all  $x \in \mathcal{X}$ .
2. At each iteration  $t$ , solve

$$\int_x M(\tilde{u}^t(x), \tilde{v}(y)) dx = g(y)$$

for  $\tilde{v}(y)$  for all  $y$  given  $(\tilde{u}^t(x))_{x \in \mathcal{X}}$ . Call this solution  $\tilde{v}^t(y)$ . Then solve

$$\int_y M(\tilde{u}(x), \tilde{v}^t(y)) dy = f(x)$$

for  $\tilde{u}(x)$  for all  $x \neq x_0$  given  $(\tilde{v}^t(y))_{y \in \mathcal{Y}}$  and call this solution  $\tilde{u}^{t+1}(x)$ .

3. Set  $t = t + 1$  and go back to 2, unless  $\max_{y \in \mathcal{Y}} |\tilde{v}^t(y) - \tilde{v}^{t-1}(y)| < \epsilon$  and  $\max_{x \in \mathcal{X}} |\tilde{u}^{t+1}(x) - \tilde{u}^t(x)| < \epsilon$ , where  $\epsilon$  is a tolerance parameter, in which case stop.
4. Compute the equilibrium wages using the solution for the potentials  $(\tilde{u}(x), \tilde{v}(y))$  into equation (6) to obtain

$$w(x, y) = \frac{\sigma_1}{\sigma_1 + (1 - \tau)\sigma_2} (\gamma(x, y) - \tilde{v}(y)) - \frac{\sigma_2}{\sigma_1 + (1 - \tau)\sigma_2} (\alpha(x, y) - \tilde{u}(x)) + \tilde{c} \quad (7)$$

where  $\tilde{u}(x)$  and  $\tilde{v}(y)$  are derived from the IPFP above, and

$$\tilde{c} = c - \frac{\sigma_2}{\sigma_1 + (1 - \tau)\sigma_2} \delta t_1$$

where  $c$  is a constant reflecting the normalization  $\tilde{u}(x_0) = 0$ .

### 3 Maximum Likelihood Estimation

The model described in the previous section can be estimated using maximum likelihood. In this section, we provide a sketch of the estimation procedure, starting by discussing the data that are required to estimate the model. We then discuss the parametric specification. And finally, we present the log likelihood function given the parameterization.

### 3.1 The structure of available data

We consider the context of an analyst having access to a sample of matches between CEOs and firms where the following information is available:

1. a list of CEOs whose identity is indexed by  $i = 1, \dots, N$ ,
2. a list of firms' whose identity is indexed by  $j = 1, \dots, N$ ,
3. who is matched to whom, i.e. a matching  $(\hat{\mu}_{ij})_{i,j}$  where  $\hat{\mu}_{ij} = 1$  if CEO  $i$  is matched with firm  $j$  and 0 otherwise with the convention that  $\hat{\mu}_{ij} = 1 (i = j)$  where  $1(\cdot)$  is the indicator function, with a slight abuse of notation  $\hat{\mu}_{ii} = \hat{\mu}(x_i, y_i)$ ,
4. for each CEO  $i$ , a vector of (observable) attributes  $x_i \in X$ , and his/her gross wage  $\hat{w}_{ii}$  which is assumed to be a noisy measure of  $w(x_i, y_i)$  where the noise follows a known (up to parameters) centered distribution,
5. for each firm  $j$ , a vector of (observable) attributes  $y_j \in Y$ , and firms' output denoted  $\hat{\Gamma}_j$  which is assumed to be a noisy measure of  $\gamma(x_i, y_i)$  where the noise follows a known (up to parameters) centered distribution,
6. the threshold  $t_1$  defining the top income bracket in the tax system and the tax rates  $\tau_0$  and  $\tau$  associated with the two income brackets  $[t_0, t_1]$ <sup>15</sup> and  $[t_1, \infty]$  on which tax rates  $\tau_0 \geq 0$  and  $\tau \geq \tau_0$  apply respectively.<sup>16</sup>

Note that without further assumptions, one can easily show that data on  $(\hat{\mu}_{ij})_{i,j}$ ,  $(\hat{w}_{ii})_i$ ,  $t_1$  and  $\tau$  identify the systematic amenity  $\alpha(x, y)$  up to a function of  $x$  and a scaling parameter  $\sigma_1$ , whereas data on  $\mu(x, y)$  and  $w(x, y)$  identify firm output  $\gamma(x, y)$  up to a function of  $y$  and a scaling parameter  $\sigma_2$ . Indeed, rewrite equations (4) and (3) gives

$$\alpha(x, y) = \tilde{u}(x) - T(w(x, y)) + \sigma_1 \log \mu(x, y) \quad (8)$$

$$\gamma(x, y) = \tilde{v}(y) + w(x, y) + \sigma_2 \log \mu(x, y). \quad (9)$$

<sup>15</sup> $t_0$  is the amount of tax-free allowances.

<sup>16</sup>Note that this tax system is characterized by the Danish tax system.

The right hand sides can be computed from the data up to a function  $\tilde{u}(x)$  (resp.  $\tilde{v}(y)$ ) and a scalar  $\sigma_1$  (resp.  $\sigma_2$ ). A more detailed description of the data is presented in Section 4.

Note also that the attributes of firms we do observe in our data, i.e. the firms' equity, import, export, net investment, and size, constitute the most likely candidates for the valuation of firms' amenities by CEOs. There might still be forms of amenities we cannot observe, such as for example, a nice office with ocean view but we believe those are second order. Note also that since our specification of the basis functions is very rich, the systematic part of amenity and productivity stays fully flexible. We have experimented with various specifications and our main results remained valid across those.<sup>17</sup> Note also that the magnitude the the scaling parameters  $\sigma_1$  and  $\sigma_2$  indicates the amount of heterogeneity necessary to rationalize the data.<sup>18</sup> Hence, the presence of unobserved attributes should manifest itself in different results being obtained for different values of the scaling parameters. We have experimented by using slightly different values of these parameters, the main results presented below are robust across those experiments.

## 3.2 Parametric specification

### 3.2.1 Defining job amenities and productivity

We parameterize the value of job amenities and productivity such that the match value functions of CEOs and firms are linear in parameters:

$$\alpha(x, y; A) = \sum_{k=1}^K A_k \times \varphi_k(x, y),$$

and

$$\gamma(x, y; \Gamma) = \sum_{k=1}^K \Gamma_k \times \varphi_k(x, y),$$

where  $\varphi_k(x, y)$  are basis functions.

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<sup>17</sup>We use likelihood-ratio tests to find the specification that best fits our data.

<sup>18</sup>As it is described in Section 5.1, we use a grid search to find the set of  $\sigma$  parameters that maximize our likelihood function.

In particular, defining the basis functions as (bi)linear in  $x$  and  $y$  gives,

$$\alpha(x, y; A) = \sum_l A_{l,1} y^{(l)} + \sum_{k,l} A_{kl,2} x^{(k)} y^{(l)},$$

and

$$\gamma(x, y; \Gamma) = \sum_{k=1} \Gamma_{k,1} x^{(k)} + \sum_{k,l} \Gamma_{kl,2} x^{(k)} y^{(l)}.$$

### 3.2.2 Latent variable specification of earnings and productivity

Let us further construct a latent wage structure. Let  $\hat{w}_i$  be the observed wage for CEO  $i$ .  $\hat{w}_i$  is equal to the predicted wage for that CEO at the firm he is matched to in the data, i.e.  $w_{ii} = w(x_i, y_i)$ , with an additive measurement error  $e_i^W$  which is assumed to follow a centered Gaussian distribution with variance  $s^2$ . Hence,

$$\hat{w}_i = w(x_i, y_i) + e_i^W$$

where  $w(x_i, y_i)$  is given by equation (7) and  $e_i^W \rightsquigarrow N(0, s^2)$ .

Similarly, using the observed measure of firm productivity, i.e.  $\hat{\gamma}_i$ , we adopt a latent productivity structure. For firm  $i$ , the observed productivity  $\hat{\gamma}_i$  is equal to the value specified in the model, i.e.  $\gamma_{ii} = \gamma(x_i, y_i; \Gamma)$ , with an additive measurement error  $e_i^P$  which is also assumed to follow a centered Gaussian distribution with variance  $t^2$ . Hence,

$$\hat{\gamma}_i = \gamma(x_i, y_i; \Gamma) + e_i^P$$

where  $e_i^P \rightsquigarrow N(0, t^2)$ .

It is important to note that since we have a measure of productivity, we are able to measure the direct effects of firms' attributes on productivity, i.e.  $\sum_l \Gamma_{l,1} y^{(l)}$ . We estimate these effects in the third term of our likelihood function.

## 3.3 Maximum likelihood

Let  $\lambda = (A, \Gamma, \sigma_1, \sigma_2, s^2, c, t^2)$  be the parameters of the model. Under the parametric structure described in the previous section, the log-likelihood

of observing a match  $\hat{\mu}_{ii}$  with transfer  $\hat{w}_i$  and productivity  $\hat{\gamma}_i$  is therefore decomposed into 3 terms.

The first term is the log-likelihood of observing the match  $\hat{\mu}_{ii}$  and simply reads as  $\log \hat{\mu}_{ii}$ . The second term is the log-likelihood of observing the transfer  $\hat{w}_i$  and reads as  $-\left(\frac{\hat{w}_i - w_{ii}}{2s^2}\right)^2 - \frac{1}{2} \log s^2$ . And the third term is the log-likelihood of observing the productivity  $\hat{\gamma}_i$  and reads as  $-\left(\frac{\hat{\gamma}_i - \gamma_{ii}}{2t^2}\right)^2 - \frac{1}{2} \log t^2$ .

It follows that the log-likelihood of observing the data  $(\hat{\mu}_{ii}, \hat{w}_i, \hat{\gamma}_i)_{i=1}^N$  can be written as

$$\begin{aligned} \log L(\lambda) &= \log L_1(\lambda) + \log L_2(\lambda) + \log L_3(\lambda) \\ &= \sum_{i=1}^N \log \hat{\mu}_{ii} - \sum_{i=1}^N \left(\frac{\hat{w}_i - w_{ii}}{2s^2}\right)^2 - \frac{N}{2} \log s^2 - \sum_{i=1}^N \left(\frac{\hat{\gamma}_i - \gamma_{ii}}{2t^2}\right)^2 - \frac{N}{2} \log t^2. \end{aligned}$$

## 4 Data and Empirical Issues

In this section, we describe the Danish CEO labor market and corporate governance practice, some features of the tax system and our matched CEO-firm data.

### 4.1 The CEO labor market and corporate governance practice in Denmark

CEO plays an important role in firm performance (Bertrand and Schoar [2003]). In a competitive labor market, firms are willing to offer generous compensation packages in order to attract the best and brightest candidates. In the US, CEO compensation always triggers national debates. A question business outlets like to ask every year is: how many executives made more than a million dollars this year? In Denmark, top executives receive lower pay. According to a CNBC report on CEO compensation<sup>19</sup>, total pay of top executives in Denmark is about 75% of the European average. It is even further below that of big economies like Germany, Britain

<sup>19</sup>CNBC (2013) executive compensation report: Lower CEO Pay and Better Results in Europe?

and Switzerland, where stricter corporate governance mechanism applies. This pay gap is compounded by the fact that Denmark has one of the world's highest taxes. Yet we see little sign of top executives from Denmark wanting to leave their country in search of better pay abroad. As the quote appears at the beginning of our paper, top executives derive large amenity value from their work. CEOs in Denmark might receive a lower paycheck, but they are compensated by the quality state-funded education, good public services, free health care, and a comprehensive social safety net from working in this country, which they cannot get working elsewhere.

The Danish labor market is characterized as "flexicurity", which is a mix of a flexible labor market and a generous social security system, maintained by active labor market policies.<sup>20</sup> Labor market participation is averaged 70% for the past two decades, according to Statistics Denmark. According to OECD report,<sup>21</sup> Denmark has one of the highest earning quality and the highest level of job turnover rates among OECD countries. Unemployment duration is typically short. And the report ranks Denmark at the top on the quality of working environment.

There is a large number of small and medium-sized companies in Denmark. Limited companies are the most typical forms of business. There are private limited companies and public limited companies. Private limited companies are required to have at least one manager, but do not need a board representation. It is a popular ownership structure for small- and mid-sized companies. It is often used as an easy way to setup new Danish subsidiaries for foreign companies. Public limited companies, on the other hand, require a two-tier board system and are subject to many other regulatory restrictions. For a detailed overview on the legislative framework, see Danish Companies Act.<sup>22</sup> Typically, a public limited company has three managing directors, one of them being the CEO. But the CEO cannot act as the chairman of the board. Many of the Danish firms are privately held. There is only a small amount of listed firms. The average size of firms in

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<sup>20</sup>For a detailed discussion on the Danish "flexicurity" model, see Andersen and Svarer [2007]

<sup>21</sup>OECD Job Strategy, OECD 2018

<sup>22</sup>Danish Act on Public and Private Limited Companies (the Danish Companies Act) In Danish: *lov om aktie- og anpartsselskaber (selskabsloven)*. It contains rules on Danish company incorporation, share capital, governing bodies, annual general meetings, auditing and management's liability.

Denmark is small relative to the other European countries.

The Danish corporate governance system is shaped by the Danish Public Companies Act from 1973. Denmark adopts a "two-tier" board system, a supervisory board whose responsibility is to monitor and control the managing directors, and a board of managing directors who are responsible for day-to-day operations. The supervisory board has the decision power for extraordinary matters. A unique feature of the Danish system is that managing directors are allowed to be on both tiers of the board.<sup>23</sup> More recently, the Danish parliament has introduced the Danish Companies Act (DCA) which came into force in March 2010. This act establishes the corporate governance regime for both private and public limited liability companies. Similar to the German type corporate governance system, employees have representation on the board, and managers are monitored by stakeholders of the firm, i.e. banks, large shareholders and closely related firms.

## 4.2 The Danish tax system

Denmark has one of the highest tax rates in the world. According to Statistics Denmark, the average annual income in Denmark is 282,647 DKK in 2011 (approximately \$52,827 at the average exchange rate for the corresponding year). The average Dane pays a total amount of 45 percent in income taxes.

The Danish tax system is progressive. Employees, including executives and registered executive management, are fully liable for taxes on their personal income and their remuneration. Each person pays a mandatory labor market contribution, that is 8% of the gross salary prior to any deductions. Taxation on personal income is then calculated on the amount after deduction of all relevant costs spent on obtaining and securing the income. On the remaining amount, each person has to pay a 8% contribution to the health care system, a municipal tax which averages to 24.9% depends on which municipality a person lives in, and a 0.73% church tax. For income below the top tax threshold, 389,900 (2011-level),<sup>24</sup> each person

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<sup>23</sup>Discussion on the Danish Corporate Governance system, see Rose [2006], Thomsen [2016]

<sup>24</sup>There was a tax reform in 2010. This reform aims at reducing marginal taxes on labor income. In particular, the bottom tax rate is reduced by 1.5 percentage point;



pays a bottom-tax of 3.67%. For income above the top tax threshold, each person pays a top-tax of 15%. All employees over 18 years of age have an annual personal allowance of 42,900 DKK that is tax exempted. The unused amount can be transferred to the spouse. Employees also have an employment allowance of the lower value between 4.25% of labor income and 13,600 DKK. The top marginal tax rate for labour income is 56% and the bottom tax rate is 40.9%.<sup>25</sup>

Capital income are also taxed. Negative net capital income, i.e. mortgage payments, below DKK 50,000 a year for singles (100,000 DKK for married couples) can receive a tax deduction at 33.5%. Whereas positive net capital income, i.e. yields from bonds and bank deposits, is taxed at the personal income tax rate. But for the first 40,000 DKK (80,000 DKK for married couples) positive net capital income, it is taxed at 37.3% regardless of the individual's personal tax rate. Share income and dividends are taxed at 27% on gains up to 48,600 DKK (2011-level), and at 42% on anything exceeding this amount.

Any cash remuneration, i.e. cash bonuses, fringe benefits, shares and options, severance pay, termination package, warrants, are all taxed at personal income tax rate. Taxation on remuneration in forms of options and warrants can be deferred until they are exercised. Under certain conditions, employee shares can be taxed at capital income tax rate.<sup>26</sup>

The Danish tax authority (SKAT) collects information on personal income, as well as individuals' financial and real asset holdings, and liabilities.<sup>27</sup> Those information are third-party reported, rather than self-

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the middle tax is abolished; and the top tax threshold is increased. The tax ceiling is reduced from 59% to 51.5%. However, taxation on personal income has been increased in this reform. Among others, taxation on fringe benefits, i.e. company paid multimedia (PC, telephone, broadband internet, newspapers), company car, employee shares and bonds, has been increased. Capital income tax is also adjusted. For more information on the tax reform, see *Danish Tax Reform 2010* by the Danish Ministry of Taxation and *Centrale beløbsgrænser i skattelovgivningen 2010-2017* by the Danish Ministry of Taxation.

<sup>25</sup>The Danish Ministry of Taxation, *Marginalskatteprocenter 1993-2021*

<sup>26</sup>For a detailed discussion on the law regarding the Danish executive remuneration, see "The Executive Remuneration Review: Denmark" by Michael Møller Nielsen, Helene Lønningdal and Lund Elmer Sandager. The Law Reviews, 16th November 2020.

<sup>27</sup>Pension contributions are not reported as part of wealth data in 2011, as pension was not subject to wealth taxation. This is not a major issue in our analysis. Because, first of all, there are strict limits on the amount that can be invested in tax-preferred pension accounts. Secondly, compared to base salary, bonus and other pecuniary benefits,

reported. Labor income is directly reported to the tax office by employers at the end of each month. At the end of each year, banks report the assets and liabilities of their customers. Financial institutions (i.e., mutual funds, investment banks) report the value of securities held by their clients. Land and real estate registry reports the value of land and property owned by individuals and businesses. The tax authority uses these information to compute labor income tax, wealth tax and generate pre-populated tax returns. The Danish income and wealth information is considered of a very high quality. Kleven et al. [2011] did a field experiment in Denmark where they randomly selected some tax filers to be thoroughly audited. Their result show that the tax evasion rate is close to zero for income subject to third-party reporting. The Danish income and wealth data is widely used in academic research to study a variety of topics: intergenerational wealth mobility (Boserup et al. [2016]), intertemporal consumption under credit constraints (Leth-Petersen [2010]), and retirement savings (Chetty et al. [2014]). Furthermore, the data is not censored or top-coded, which is an advantage as CEOs are likely to be in the top of the wealth distribution. Statistics Denmark then organizes and anonymizes the raw data and makes it available to researchers.

Firms in Denmark are subject to taxation on all income and are allowed deductions on certain business related expenses. The corporate income tax rate was 25% in 2011. There is no payroll tax in Denmark.<sup>28</sup> The Danish Financial Statement Act, introduced in 1981 by the Danish business authority, requires all firms in Denmark to submit annual reports, which consist of a management’s review, an income statement/statement of profit or loss and other comprehensive income, a balance sheet, a statement of changes in equity, and a cash flow statement.

### 4.3 Data and Sample

We exploit the administrative register-based data from Statistics Denmark that contains the entire Danish population of CEOs for the year 2011. In Appendix B, we provide a detailed description on our data sources, how we

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pension is typically a small fraction of income for CEOs.

<sup>28</sup>Some exceptions apply for companies carrying out specific VAT exempted activities.

merge the data sets and variable definitions. Follow our model assumption, we aim to select a competitive market where preference heterogeneity is an important feature. Considering the institutional environment in Denmark where there are a large number of small and medium-sized firms with owner CEOs, we choose to focus on the CEOs of large firms (more than 250 employees). Another reason for selecting this type of CEOs is that the yearly salary of the large-firm CEOs are all above the cutoff for the top marginal tax bracket. Therefore, a linear approximation of taxation on CEOs' wage is justified.

In order to infer amenity value in equilibrium, we need an accurate measure of the CEOs' pecuniary pay, not only his base salary, but also his entire remuneration package. This is a key advantage of using the Danish administrative register data. Our data on CEOs' wage income are comprehensive, and are of very high accuracy. CEO wage measures his total taxable wage income, which includes perks, tax-free salary, anniversary and severance pay, the value of stock options, remuneration for board work, fees in connection with consulting work, lectures and the like. This payslip information is directly reported by his employer, not self-reported, as mentioned earlier in Section 4.2.

For each CEO, we have information on his age, education, gender, marital status, number of children, age of each child, net wealth, bank debt, tax value of property, bank deposit, financial investments in stocks, market value of bonds, investments in foreign financial markets, previous work experience, payout in private pension schemes.

We then match the CEOs with his firms using a register that provides the key between workers and firms.<sup>29</sup> We have information on firms' number of employees, number of branches, shares of female employees, net investment, sector, value of exports, value of imports, equity value, value of fixed assets, ownership structure, Selling, General and Administrative Expenses (SG&A), total salary expenses.

Our sample contains 295 CEO-firm matches. The majority of firms in our sample are public limited firms (87%), some are private limited firms

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<sup>29</sup>For a person who works as CEO for more than one firm, we select his match as the firm that has the highest gross profit. There are only 2 individuals who works as CEO for multiple firms. Dropping them does not affect our estimates.

(5%), and some are cooperatives (2.4%). Our data is at CEO-firm level. One observation is defined as a match between one CEO and one firm, with detailed CEO and firm characteristics. Table 6 presents summary statistics for the variables used to estimate our model. We discuss model specification later in Section 5.1.

In our sample, the average CEO is 52 years old, has 16 years of schooling, owns 3.29 million DKK in net wealth, 1.41 million DKK in bank debt, and has a yearly salary of 2.64 million DKK. 87% of the CEOs are married. 94% of them are male. And 78% of the CEOs work for their alma mater industry. It is worth to note that danish CEOs have a similar social backgrounds, but slightly different educational profile compared to the ones from north America and other European countries. In our sample, around 65% of CEOs have a colleague degree. This is consistent with the finding of Ellersgaard et al. [2013] that university degrees do not appear to be the most essential selection criteria for becoming an executive in Denmark. Most Danish CEOs do not have degrees from elite universities. And it is not common for a Danish CEO to have a PhD degree. Instead, many Danish CEOs obtained the executive positions through multiple years of work experience.<sup>30</sup>

Firms in our sample have on average 992 employees, 64.3 million DKK in net investment. The average total export value of goods and services (incl. sales of certain VAT-exempted products) in those firms is about 683 million DKK. Firms' total import value is about 386 million DKK. Firms have on average 858 million DKK in equity and fixed assets that are worth 981 million DKK. The average firm earns gross profits of 895 million DKK.

## 5 Estimation Results

### 5.1 Model specification

Preference heterogeneity is an important characteristic when describing the CEO labor market. CEOs have different skill sets and personality traits, which are desired by different types of firms. An efficient allocation of CEOs

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<sup>30</sup>Ellersgaard et al. [2013] show that about one third of the Danish CEOs have sales or marketing backgrounds from many firms, before becoming a CEO.

to firms can create economic surplus (Rosen [1981, 1982]). To estimate our two-sided matching model, we first need to determine which characteristics should be used to distinguish between the agents on each side of the market. Rosen [1982], Gabaix and Landier [2008] find a strong complementarity between firm size and CEO talent. Pan [2017] shows that CEOs with conglomerate work experience are matched with more diversified firms and that CEOs with technical expertise are matched with R&D intensified firms. Kaplan et al. [2012], Kaplan and Sorensen [2021], Bertrand and Schoar [2003] provide empirical evidence that CEO personality traits are important for corporate actions and performance.

Following the guidance from the previous literature, we consider a list of potentially important attributes from both sides of the market to be included in our estimation. To distinguish CEOs, we consider CEOs' age, education, gender, marital status, number of children, age of each child, net wealth, bank debt, tax value of property, bank deposit, financial investments in stocks, market value of bonds, investments in foreign financial markets, previous industry experience, payout in private pension schemes. To differentiate firms, we use firms' number of employees, number of branches, shares of female employees, net investment, sector, value of exports, value of imports, equity value, value of fixed assets, ownership structure, Selling, General and Administrative Expenses (SG&A), total salary expenses.

We have estimated the model using various sets of attributes for CEOs and firms and used likelihood-ratio tests to select the set of variables that best describe the Danish CEO labor market in our setting. Based on these likelihood-ratio tests the set of attributes selected are: CEOs' age, marital status, gender, years of schooling, net wealth, bank debt; firms' number of employees, net investment, value of imports, exports, equity value, value of fixed assets. We present estimates of the direct effects of these variables on job amenities and productivity in Section 5.2.

We also include interaction terms between firm and CEO characteristics to estimate the match-specific effects on job amenities and productivity. Previous literature has mainly focused on the complementarity between firm size and CEO talent (see, for example, Rosen [1982], Gabaix and Landier [2008]). In this paper, we explore other complementarities that are

potentially important in the matching process. Performing likelihood-ratio test on different specifications regarding the interaction terms, we let net wealth, bank debt, and marital status from the CEO side to interact with number of employees, net investment and value of exports from the firm side. We present estimates of the interaction effects of these variables on job amenities and productivity in Section 5.2.

The measure of transfers is a CEO's total taxable wage income, that includes perks, tax-free salary, anniversary and severance pay, the value of stock options, remuneration for board work, fees in connection with consulting work, lectures and the like, whereas the measure of productivity is a firm's gross profit.

Finally,  $\sigma_1$  and  $\sigma_2$  are chosen so has to maximize the likelihood function using a grid search. The herewith selected values are  $\sigma_1 = 0.5$  and  $\sigma_2 = 0.5$ . It is worth noting that for many pairs of  $\sigma_1$  and  $\sigma_2$  values, our model specification predicts observed wages very well, with R-Squared greater than 0.5. And for several pairs of  $\sigma_1$  and  $\sigma_2$  values, the model also fits the firm performance very well, with a R-Squared greater than 0.8.  $\sigma_1$  and  $\sigma_2$  are set at 0.5 in the counterfactual analysis as well.

## 5.2 Estimation results

We apply the estimation strategy described in Section 3 to estimate the parameters of the model in the Danish CEO labor market in 2011. Overall, our estimation strategy describes the Danish CEO labor market well, with a R-Squared of 0.51 on observed wages, and a R-Squared of 0.85 on firm productivity. Table 1 presents the model estimates for both the direct and the interaction effects of CEOs' and firms' characteristics on job amenities and productivity. Wage and productivity are both measured in millions of Danish kroner.<sup>31</sup> In order to directly compare the relative importance of each coefficient and to facilitate international comparison, all continuous variables are standardized, such that the coefficients can be interpreted as the effect of one standard deviation change in a variable of interest on the job amenities and productivity of the match.

For job amenities, we find that CEOs derive substantial amenities from

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<sup>31</sup>In 2011, 1 USD = 5.36 DKK at the average exchange rate

managing a firm in his alma-mater industry, and are willing to give up 1.65 million DKK in pay to do the job (significant at 1% level). Additionally, CEOs derive amenities from managing a firm with higher equity value. A one standard deviation increase in firms' equity value increases the average amount that CEOs enjoy working for a firm by 1.06 million DKK. This might be because CEOs gain a stronger sense of job security managing a firm that uses less debt in its capital structure, see Jensen [1986]. Debt financing can lower firms' cost of capital due to the tax shield associated with it. But on the other hand, debt financing invites market scrutiny. In some cases, market scrutiny leads to hostile takeovers, in which the acquires often replace the existing CEO for an efficiency gain. Debt financing can also increase firms' financial distress risk. Managing a firm that uses less debt financing can alleviate a CEO's constant pressure to manage the firm efficiently in order to honor its debt obligations. A CEO can in turn institute more perks and benefits for himself and for the employees. Moreover, CEOs on average prefer managing firms with lower import values and firms with lower value of fixed assets. A one standard deviation increase in firms' value of fixed assets decreases the average amount that CEOs enjoy managing a firm by 0.86 million DKK. On average, CEOs need to be compensated by 0.28 million DKK to manage a firm whose import value is one standard deviation above the mean. Our results also show that married CEOs prefer managing a firm with less net investment value. A married CEO, on average, need to be compensated by 0.61 million DKK to manage a firm with net investment one standard deviation above average. Furthermore, we find that CEOs' enjoyment of managing a firm with large values of exports depends on their personal wealth. Wealthier CEOs whose net wealth is one standard deviation above the mean prefer managing a firm with lower exports value, and are willing to give up 0.74 million DKK for the job. However, more indebted CEOs, who has bank debt one standard deviation above the mean, derive large amenities, that is 3.97 million DKK, from managing a firm whose exports value is one standard deviation above average.

For productivity, it is important to note that while CEOs derive large amenities from managing a firm in their alma-mater industry, having a CEO who have experience in a firm's industry does not increase the firm's

productivity. Our result is consistent with the finding of Murphy and Zabojnik [2004, 2007] that firms value general skills more than firm-specific skills in the market for CEOs. Our results also show that firm productivity is hump-shaped over CEOs' life-cycle. This is consistent with the results from the human capital model of Becker [1964], Ben-Porath [1967], Mincer [1974], and the finding of Bennedsen et al. [2020], that predicts a flattening off and eventual decline of productivity as workers approach retirement. At early ages, productivity increases with CEOs' experience. On average, productivity increases by 0.7 million DKK when CEOs have 1 more year experience. Starting at age 53, productivity decreases with CEOs' experience. CEOs personal wealth has a positive effect on firm productivity. A one standard deviation increase in CEOs' net wealth increases productivity by 1.34 million DKK. On the other hand, CEOs' indebtedness is negatively correlated with productivity. A one standard deviation increase in CEOs' bank debt decreases productivity by 1.26 million DKK. Furthermore, we find that with an average CEO, a one standard deviation increase in the value of exports increases productivity by 552 million DKK, and this effect is positively correlated with CEOs' personal wealth. With a CEO whose net wealth is one standard deviation above the mean, the same increase in exports value increases productivity by 556 million DKK = 552 million DKK + 4 million DKK. But with a CEO who has bank debt one standard deviation above average, the same increase in exports value only increases productivity by 534 million DKK = 552 million DKK - 18 million DKK. Last but not the least, we find that firm size, net investment, value of import, exports are all important determinants of productivity.

These estimates will later be used to simulate the market under counterfactual policy experiments in Section 6.

## 6 Counterfactual Experiments

We carry out four sets of counterfactual experiments. The first experiment aims at quantifying the importance of job amenities in terms of experience - that is CEOs prefer to manage firms in the sector where they have experience - to the sorting of CEOs to firms. The second experiment aims at quantifying the importance of job amenities in terms of oversight to the



Table 1: Effect of CEOs' and firms' characteristics on job amenities and productivity (in Millions DKK)

|                               | Main effects                    | Number of employees             | Net investment (in DKK)         | Import (in DKK)                  | Export (in DKK)                  | Equity (in DKK)              | Fixed assets (in DKK)         |
|-------------------------------|---------------------------------|---------------------------------|---------------------------------|----------------------------------|----------------------------------|------------------------------|-------------------------------|
| <b>Job Amenities (Alpha)</b>  |                                 |                                 |                                 |                                  |                                  |                              |                               |
| Main effects                  |                                 | 0.00<br>(0.17)                  | 0.26<br>(0.20)                  | <b>-0.28</b><br><b>(0.13)</b>    | 0.57<br>(0.95)                   | <b>1.06</b><br><b>(0.29)</b> | <b>-0.86</b><br><b>(0.22)</b> |
| Age (in years)                |                                 |                                 |                                 |                                  |                                  |                              |                               |
| Age <sup>2</sup>              |                                 |                                 |                                 |                                  |                                  |                              |                               |
| Years of schooling (in years) |                                 |                                 |                                 |                                  |                                  |                              |                               |
| Net wealth (in DKK)           |                                 | 0.03<br>(0.28)                  | 0.08<br>(0.25)                  |                                  | <b>-0.74</b><br><b>(0.18)</b>    |                              |                               |
| Bank debt (in DKK)            |                                 | -0.40<br>(0.24)                 | -0.33<br>(0.26)                 |                                  | <b>3.97</b><br><b>(0.47)</b>     |                              |                               |
| Gender (1 male/0 female)      |                                 |                                 |                                 |                                  |                                  |                              |                               |
| Marital status (1 Married)    |                                 | -0.30<br>(0.22)                 | <b>-0.61</b><br><b>(0.20)</b>   |                                  | -0.05<br>(0.92)                  |                              |                               |
| Alma Mater                    | <b>1.65</b><br><b>(0.16)</b>    |                                 |                                 |                                  |                                  |                              |                               |
| <b>Productivity (Gamma)</b>   |                                 |                                 |                                 |                                  |                                  |                              |                               |
| Main effects                  |                                 | <b>579.36</b><br><b>(76.46)</b> | <b>495.30</b><br><b>(93.38)</b> | <b>363.73</b><br><b>(122.46)</b> | <b>551.63</b><br><b>(135.58)</b> | 371.65<br>(309.79)           | 370.71<br>(327.38)            |
| Age (in years)                | <b>6.18</b><br><b>(2.07)</b>    |                                 |                                 |                                  |                                  |                              |                               |
| Age <sup>2</sup>              | <b>-6.49</b><br><b>(2.12)</b>   |                                 |                                 |                                  |                                  |                              |                               |
| Years of schooling (in years) | 0.35<br>(0.24)                  |                                 |                                 |                                  |                                  |                              |                               |
| Net wealth (in DKK)           | <b>1.34</b><br><b>(0.42)</b>    | -0.52<br>(1.23)                 | -0.43<br>(1.11)                 |                                  | <b>3.67</b><br><b>(0.79)</b>     |                              |                               |
| Bank debt (in DKK)            | <b>-1.26</b><br><b>(0.55)</b>   | 1.74<br>(1.07)                  | 1.27<br>(1.12)                  |                                  | <b>-17.91</b><br><b>(2.13)</b>   |                              |                               |
| Gender (1 male/0 female)      | 1.81<br>(1.10)                  |                                 |                                 |                                  |                                  |                              |                               |
| Marital status (1 Married)    | 1.04<br>(1.03)                  | 1.06<br>(0.97)                  | 1.12<br>(0.88)                  |                                  | 3.03<br>(4.04)                   |                              |                               |
| Alma Mater                    | 0.72<br>(0.62)                  |                                 |                                 |                                  |                                  |                              |                               |
| Productivity constant         | <b>820.06</b><br><b>(57.82)</b> |                                 |                                 |                                  |                                  |                              |                               |
| Salary constant               | <b>16.49</b><br><b>(0.37)</b>   |                                 |                                 |                                  |                                  |                              |                               |

Notes: This table reports the estimates of the effect of CEO and firm characteristics on job amenities and firm productivity. wages and productivities are measured in millions of Danish kroner. In 2021, 1 DKK = 0.16 USD at the average exchange rate. All covariates, except for alma mater, are standardized to have a standard deviation of 1. Standard errors are in parentheses. The R-squared on wage is 0.52 whereas the R-squared on productivity is 0.85.

sorting of CEOs to firms. The third experiment gives some insights in how CEOs reallocate and what are the equilibrium wage gains/losses under a potential sectoral shift from a declining sector to an expanding sector. Finally, in the fourth experiment, we mimic a trade war and shed light on the new equilibrium matching between CEOs and firms following this trade war.

## 6.1 Equalizing (part of) job amenities across firms

In our estimation, we find that CEOs derive a large amenity (1.65 million DKK) from managing a firm in their alma-mater sector. In order to substantiate the importance of job amenities in terms of sector experience to the sorting of CEOs to firms, we answer the following question: suppose the amenity value of managing a firm within a CEO's preferred sector is equalized across all firms, what would be the new equilibrium assignment and wages? This question is relevant because once we remove the job amenity from managing a firm in a familiar sector, CEO can no longer be compensated through this amenity channel, they have to either be compensated by pecuniary pay or find a firm offering more of the remaining amenities.

First, we compute the equilibrium matching when the alma-mater parameter is set to 0 for all potential matches between CEOs and firms. Table 2A presents the result of this experiment. Removing amenity value from all firms creates considerable reshuffling in CEOs assignments. More than half (54.93%) of the CEOs switch firms. This reshuffling comes from both high productivity and low productivity firms. In this new equilibrium, CEOs wages also increase to 1,219 million DKK, compared to the predicted equilibrium wage 762 million DKK from the estimation sample. This corresponds to a 60% increase in CEOs wages. We conclude that the CEOs market adjust to the disappearance of alma mater amenity by both an important reshuffling of who manages which firm and a dramatic increase in pay.

We then repeat the computation, but this time, setting the alma-mater parameter to 1 for all potential matches between CEOs and firms. Table 2B presents the result of this experiment. We again observe the same pattern in terms of the equilibrium assignment but as expected we now observe a

dramatic drop in the equilibrium wages of 648 million DKK = 762 million DKK - 114 million DKK. This corresponds to a 85% decrease. In this case, CEOs can be compensated through amenities, therefore requires a lower pecuniary compensation.

This experiment confirms our finding that CEOs derive large amenity from managing a firm in the sector where he has experience. This amenity can to a large extent explain the relative low mobility of CEOs across firms/sectors and should be considered as an important form of CEO compensation.

Table 2A: Eliminate CEO's alma-mater industries AM = 0

| <b>Changes in CEO assignments</b>           | Percentage of CEOs who switched firms |             |
|---|---------------------------------------|-------------|
| All firms                                   | 54.93%                                |             |
| Low productivity firms                      | 55.48%                                |             |
| High productivity firms                     | 54.38%                                |             |
| <b>Changes in CEO wages</b>                 | Simulated sample                      | Main sample |
| Variance of CEO wages                       | 17.61                                 | 34.10       |
| Mean of CEO wages (millions DKK)            | 1218.80                               | 761.87      |
| <b>Changes in CEO amenities</b>             | Simulated sample                      | Main sample |
| Number of CEOs in their Alma Mater industry | 0.00                                  | 231.53      |

Notes: This Table reports changes in CEO assignments and variation in CEO wages caused by the counterfactual experiment where we force all CEOs out of their alma mater industries. The Table also report the number of CEOs work in their alma mater industry before and after the experiment. In this counterfactual analysis, all firms refer to all the 295 firms. Low productivity firms are the ones that have gross profit below the median of the 295 firms, whereas high productivity firms refer to the ones that are above the median. Variance and mean of wages are calculated based on the 295 firms.

## 6.2 Equity

Another key job amenity identified in our empirical analysis is that CEOs enjoy managing firms with high equity value. Following Jensen [1986]'s 'control hypothesis', firm equity is commensurate with stakeholder oversight such that firms with lower equity value are likely to experience more oversight. We consider two experiments where firm oversight is strengthened and weakened respectively. We then compute the new equilibrium matching under these experiments.

Table 2B: All firms are in CEO's alma mater industries  $AM = 1$

| <b>Changes in CEO assignments</b>           | Percentage of CEOs who switched firms |             |
|---|---------------------------------------|-------------|
| All firms                                   | 54.93%                                |             |
| Low productivity firms                      | 55.48%                                |             |
| High productivity firms                     | 54.38%                                |             |
| <b>Changes in CEO wages</b>                 | Simulated sample                      | Main sample |
| Variance of CEO wages                       | 17.61                                 | 34.10       |
| Mean of CEO wages (millions DKK)            | 113.57                                | 761.87      |
| <b>Changes in CEO amenities</b>             | Simulated sample                      | Main sample |
| Number of CEOs in their Alma Mater industry | 295.00                                | 231.53      |

Notes: This Table reports changes in CEO assignments and variation in CEO wages caused by the counterfactual experiment where we assign all firms in every CEO's alma mater industry. The Table also report the number of CEOs work in their alma mater industry before and after the experiment. In this counterfactual analysis, all firms refer to all the 295 firms. Low productivity firms are the ones that have gross profit below the median of the 295 firms, whereas high productivity firms refer to the ones that are above the median. Variance and mean of wages are calculated based on the 295 firms.

In the first experiment, all firms are given high equity value, corresponding to the 95th percentile firm equity, simulating a scenario where oversight is weakened for all firms. Table 3A presents the result of this experiment. Weakened oversight for all firms creates almost no reshuffling in CEO assignment, although it generates important changes in compensation. Under this new equilibrium, CEOs wages are reduced to 307 million DKK, compared to the predicted equilibrium wage 762 million DKK from the estimation sample. This corresponds to a 60% drop.

In the second experiment, all firms are given low equity value, corresponding to the 5th percentile firm equity, simulating a scenario where oversight is strengthened for all firms. Table 3B presents the result of this experiment. Strengthen oversight for all firms also creates no reshuffling in CEO assignment, yet average equilibrium wages increase to 960 million DKK, which corresponds to a 26% increase.

This experiment confirms our finding that CEOs enjoy managing firms with higher equity value and derive large amenity from it. It is also interesting to note that diminishing differences across firms in amenity in terms of oversight lead to low job mobility, but large fluctuations in CEO compensation, whereas equalizing amenity in terms of experience lead to

both high job mobility and significant changes in compensation.

Table 3A: Weaken oversight

| <b>Changes in CEO assignments</b>           | Percentage of CEOs who switched firms |             |
|---|---------------------------------------|-------------|
| All firms                                   | 0.00%                                 |             |
| Low productivity firms                      | 0.00%                                 |             |
| High productivity firms                     | 0.00%                                 |             |
| <b>Changes in CEO wages</b>                 | Simulated sample                      | Main sample |
| Variance of CEO wages                       | 34.41                                 | 34.10       |
| Mean of CEO wages (millions DKK)            | 306.90                                | 761.87      |
| <b>Changes in CEO amenities</b>             | Simulated sample                      | Main sample |
| Number of CEOs in their Alma Mater industry | 231.53                                | 231.53      |

Notes: This Table reports changes in CEO assignments and variation in CEO wages caused by the counterfactual experiment where we decrease the firms' oversight over the CEOs by increase the equity value of all firms to the 95th percetile of equity value. To be consistent with the rest of experiments, this table also report the number of CEOs work in their alma mater industry before and after the experiment. In this counterfactual analysis, all firms refer to all the 295 firms. Low productivity firms are the ones that have gross profit below the median of the 295 firms, whereas high productivity firms refer to the ones that are above the median. Variance and mean of wages are calculated based on the 295 firms.

Table 3B: Strengthen oversight

| <b>Changes in CEO assignments</b>           | Percentage of CEOs who switched firms |             |
|---|---------------------------------------|-------------|
| All firms                                   | 0.00%                                 |             |
| Low productivity firms                      | 0.00%                                 |             |
| High productivity firms                     | 0.00%                                 |             |
| <b>Changes in CEO wages</b>                 | Simulated sample                      | Main sample |
| Variance of CEO wages                       | 34.41                                 | 34.10       |
| Mean of CEO wages (millions DKK)            | 960.06                                | 761.87      |
| <b>Changes in CEO amenities</b>             | Simulated sample                      | Main sample |
| Number of CEOs in their Alma Mater industry | 231.53                                | 231.53      |

Notes: This Table reports changes in CEO assignments and variation in CEO wages caused by the counterfactual experiment where we increase the firms' oversight over the CEOs by decrease the equity value of all firms to the 5th percetile of equity value. To be consistent with the rest of experiments, this table also report the number of CEOs work in their alma mater industry before and after the experiment. In this counterfactual analysis, all firms refer to all the 295 firms. Low productivity firms are the ones that have gross profit below the median of the 295 firms, whereas high productivity firms refer to the ones that are above the median. Variance and mean of wages are calculated based on the 295 firms.

### 6.3 Sectoral shift from Construction to ICT

In the third policy experiment, we study how sectoral shifts from a declining sector to an expanding sector can induce a reallocation of CEOs and quantify the wage gains/losses at the new equilibrium.

To create a sectoral shift, we replace one-to-one low productivity firms from the construction sector, by clones of randomly selected high productivity firms from the Information and Communication Technology (ICT) sector. This gives us a counterfactual distribution of firms  $g^{C_1}(y)$  while the distribution of CEOs  $f(x)$  stays unchanged.

We then use Algorithm 1, taking parameters  $\alpha(x, y; A)$ ,  $\gamma(x, y; \Gamma)$ ,  $\tau$ ,  $\sigma_1$  and  $\sigma_2$  from the model estimation, and counterfactual data  $f(x)$  and  $g^{C_1}(y)$  to derive the counterfactual equilibrium  $(\mu^{C_1}, w^{C_1})$ .

Table 4 presents the result of this experiment. Sectoral shifts from declining to expanding sector triggered high job mobility under the new equilibrium. 57.46% of CEOs switch their assignments. This reallocation comes from both high and low productivity firms. In addition, we observe an increase in the mass of CEOs managing firms in their alma-mater sector which could reflect the fact that in our data, there are relatively more CEOs whose alma-mater is in the ICT sector than the manufacturing sector. As a result, the mean equilibrium wage decreases slightly<sup>32</sup>, reflecting that more CEOs are now compensated through the amenity channel.

### 6.4 Trade war

In the last policy experiment, we study how CEO-firm assignment changes under a trade war. To mimic a trade war, we replace the export value of all firms in our data with half of its actual value. This gives us a counterfactual distribution of firms  $g^{C_2}(y)$ . The distribution of CEOs  $f(x)$  is again unchanged.

Using the IPFP algorithm together with the parameters  $\alpha(x, y; A)$ ,  $\gamma(x, y; \Gamma)$ ,  $\tau$ ,  $\sigma_1$  and  $\sigma_2$  from the model estimation, and counterfactual data  $f(x)$  and  $g^{C_2}(y)$ , we compute the counterfactual equilibrium  $(\mu^{C_2}, w^{C_2})$

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<sup>32</sup>For a fair comparison, in this experiment, the equilibrium wage and number of CEOs in their alma-mater industry are computed based on the firms that exist both before and after the experiment.

Table 4: Replacing one-to-one construction firms by a random draw of ICT firms

| <b>Changes in CEO assignments</b>           | Percentage of CEOs who switched firms |             |
|---|---------------------------------------|-------------|
| All firms                                   | 57.46%                                |             |
| Low productivity firms                      | 56.92%                                |             |
| High productivity firms                     | 58.01%                                |             |
| <b>Changes in CEO wages</b>                 | Simulated sample                      | Main sample |
| Variance of CEO wages                       | 36.10                                 | 1.11        |
| Mean of CEO wages (millions DKK)            | 399.10                                | 547.37      |
| <b>Changes in CEO amenities</b>             | Simulated sample                      | Main sample |
| Number of CEOs in their Alma Mater industry | 201.04                                | 198.66      |

Notes: This Table reports changes in CEO assignments and variation in CEO wages caused by the counterfactual experiment where we replace all construction firms in our sample with a random draw of the same number of ICT firms. The Table also report the number of CEOs work in their alma mater industry before and after the experiment. In this counterfactual analysis, all firms refer to the 272 firms exist both before and after the experiment. Low productivity firms are the ones that have gross profit below the median of the 272 firms, whereas high productivity firms refer to the ones that are above the median. Variance and mean of wages are calculated based on the 272 firms.

under trade war.

Table 5 presents the results of this experiment. This table clearly shows that trade war generates a little amount of reshuffling in CEO assignments. As a result, the mass of CEOs working in their alma-mater sector is virtually unaffected. The new equilibrium CEO wages decrease modestly by 65 million DKK, corresponding to a 8.5% drop from the predicted equilibrium wage in the estimation sample.

## 7 Related Literature

There are two main perspectives on CEO compensation, which Edmans and Gabaix [2016] call the ‘rent extraction view’ and the ‘shareholder value view’ (See also Edmans et al. [2017]). They define the shareholder value view as putting emphasis on two key aspects of the CEO market. First, when evaluating CEO compensation, this view emphasizes the need to take into account dimensions such as market forces and competitive equilibrium. Second, this view allows for a relatively wide view of firm contracts, which are generally concerned with maximizing shareholder value. In the influen-

Table 5: Trade war - exports are reduced by 50% for all firms

| <b>Changes in CEO assignments</b>           | Percentage of CEOs who switched firms |             |
|---|---------------------------------------|-------------|
| All firms                                   | 1.33%                                 |             |
| Low productivity firms                      | 0.78%                                 |             |
| High productivity firms                     | 1.88%                                 |             |
| <b>Changes in CEO wages</b>                 | Simulated sample                      | Main sample |
| Variance of CEO wages                       | 2.14                                  | 34.10       |
| Mean of CEO wages (millions DKK)            | 696.87                                | 761.87      |
| <b>Changes in CEO amenities</b>             | Simulated sample                      | Main sample |
| Number of CEOs in their Alma Mater industry | 231.55                                | 231.53      |

Notes: This Table reports changes in CEO assignments and variation in CEO wages caused by the counterfactual experiment where we reduce the value of export by 50% for all firms in the sample. The Table also report the number of CEOs work in their alma-mater industries before and after the experiment. In this counterfactual experiment, all firms refer to all the 295 firms. Low productivity firms are the ones that have gross profit below the median of the 295 firms, whereas high productivity firms refer to the ones that are above the median. Variance and mean of wages are calculated based on the 295 firms.

tial rent extraction view, the key assumption is that boards controlling the firm might pursue objectives that are not in the interest of the shareholders (Bebchuk and Fried [2004]). Therefore, this view argues that external regulations that increase oversight over how these rents are extracted will generally be necessary to support the goals of shareholders and facilitate the sorts of market discipline that stakeholders can then impose on firm decisions. Positive developments in external regulations are necessary to make the hiring of CEOs by firms more closer aligned to the shareholder value view.

Our method falls most naturally under the shareholder value view, because we assume that the hiring of CEOs is driven by market forces that seek to maximize shareholder value. However, we are able to empirically evaluate some important hypotheses that are central to the debate over which view of the CEO market is most accurate (Frydman and Jenter [2010], (Cziraki and Jenter [2020])). For example, we find that there is an amenity for firms in a high equity position, which supports the idea that firms with more oversight pay their CEOs less (and not more as might be predicted by the rent extraction view of the CEO market). Furthermore, we show that an amenity for alma-mater firms offers a simple market based



argument for the low mobility of CEOs.

Several influential studies argue that the market for CEOs is well described by a matching market with perfect competition and no frictions (Tervio [2008], Gabaix and Landier [2008], Edmans et al. [2009]). While the basic models emphasize that the most talented CEOs should be matched with the largest firms, other influential studies also argue that firms' demand for managerial skills has shifted from firm-specific to general (and therefore transferable) skills (Murphy and Zabojnik [2004, 2007], Frydman [2019]). Our estimated matching model allows agents on both sides of the market to be differentiated using several characteristics instead of just a single one. For instance, we allow that the matching between CEOs and firms can depend on CEOs' age, marital status, education, net wealth and firms' size, exports, net investment, capital structure, etc. Most importantly, we identify the job amenity channel in a framework with taxation on transfers. While our results are in line with the general findings of the two streams of literature pioneered by Gabaix and Landier [2008] and Murphy and Zabojnik [2004], in our estimated model, we can also determine and measure the importance of amenities in CEO compensations.

Several other CEO market analysis have allowed for multi-dimensional matching in the CEO labor market, see, for example, Pan [2017] and Chen et al. [2020]. These studies have not considered the problem of identifying the possibility of firm amenities to the CEO nor the implications of taxes of earned income. That these studies do not address these issues, is due to differences in the underlying methods of inference. The previous models rely on the Maximum Score Estimation method developed by Fox [2007, 2010, 2018]. While these methods have a key advantage that they do not specify any structure on the error term, there is a trade-off in that the estimation results rely on the assumption of perfect transferable utility, which means that the market assignment of CEOs must be efficient. Of course, if tax neutrality is violated by the existence of untaxed amenities, market allocations will not be efficient. The methodology of Dupuy et al. [2020], which we apply, does not seek identification from the requirement that the market is efficient. Instead, identification follows from the assumption of separability, which means that the unobserved valuations of CEOs and firms are assumed to be uncorrelated. The importance of the separability

assumption for the identification of latent variables in matching models is developed in a several influential papers by Choo and Siow [2006], Galichon and Salanié [2021] and Chiappori et al. [2017].

Our estimation of the value of amenities for each CEO at each firm is related to the literature on compensating differentials (Rosen [1974]). Much of this literature follows a regression approach that seeks to identify the lower wage that a worker is willing to accept for any given amenity. Influential studies have found, for example, that workers are willing to accept lower wages in jobs with lower probability of death (Thaler and Rosen [1976]). Such studies typically seek to measure the value placed on an observed amenity such that it is possible to access valid controls where there are other jobs that are otherwise similar. The core challenge of which is that workers are not randomly assigned to jobs in the field (Hwang et al. [1992]). Some of these difficulties can be resolved by running controlled experiments. For example, Eriksson and Kristensen [2014] use a controlled experiment to show that there are trade-offs between wages and non-monetary rewards that could impact the sorting of workers to firms.

Our methods for analysing compensating differentials related to amenities for different firm characteristics are more closely related to recent studies that seek to identify amenities from observations on the pattern of assignments and wages. Like Sorkin [2018], we also infer compensating differentials from assignments and wages. However, in the Sorkin [2018] model, there are search frictions and the workers can respond to new offers over time. In this case, he can apply a revealed preference argument to infer the amenities of each firm. In a competitive market, this is not the case, because CEOs are assigned according to what constitutes a ‘stable allocation’ (Refer to Gale and Shapley [1962], Roth [2002]). However, in such a markets we are able to follow the methodology of Dupuy and Galichon [2021], Dupuy et al. [2020], which derives an identification strategy for the case of a perfectly competitive assignment of firms.

With regards to studying the employment, performance and compensations of managers using Danish data, there are several earlier studies by Eriksson [1999] and Lausten [2002]. These studies verify the hypothesis from the literature on tournaments, which suggests that poor performing managers will be replaced (Lazear and Oyer [2012]). Similar findings are

found in other CEO/management markets (Kaplan [1997]). Verification of the tournament hypothesis also supports the shareholder valuation view of the CEO market. While we do not consider CEO turnover, the estimates from the study of turnover are consistent with our findings from a cross-section of CEOs and firms that the more productive firms pay more talented CEOs higher wages.

## 8 Conclusions

It is important for economic performance that firms are well managed. Therefore, given that talented managers are in short supply, it is relevant to understand the main mechanisms by which firms attract managers from the pool of managerial talent. In order to measure how CEO compensation attracts CEOs to a firm, we have argued that it is important to account for the amenities offered by each firm and to understand how different CEOs value these amenities. Our estimates suggest that CEOs receive high amenity compensations for working at a firm in their ‘alma mater’ industry, which we interpret as a preference for building a legacy in their industry. We also find that CEOs derive amenity value from working at a firm with high equity. Since high equity is associated with less shareholder oversights, this finding suggests that CEOs are willing to give up a considerable amount of salary to gain empowerment. Consequently, firms that offer these amenities are able to pay their CEOs lower wages than firms without these amenities. Consistent with previous studies, we also estimate that CEO skills are generally heterogeneous and portable.

To further illustrate the importance of amenities, we considered two counterfactual experiments that directly impacted the amenity for alma mater firms and the amenity for firms with high equity. In our estimated model, we find that eliminating the amenity for working at an alma mater firm would push CEO salaries much higher and that there would also be large changes in CEO assignments. Our estimated model also predicts that decreasing the equity of high equity firms will lead to large increases in CEO salaries but will not change the overall CEO assignment. The latter result is due to the estimated result that the alma mater amenity is a strong incentive that holds CEOs to their current industry and the estimated

result that all CEOs react positively to the strong amenity incentive to manage higher equity firms over lower equity firms.

Previous research about the market for CEOs has not offered estimation results with regards to how different CEOs weigh the amenities offered by different firms. As we have discussed in our review of the literature, this neglect is mainly due to methodological difficulties that have been recently resolved by Dupuy and Galichon [2021], which draws on some important results obtained by Choo and Siow [2006], Galichon and Salanié [2021], Dupuy and Galichon [2014] and Chiappori et al. [2017]. We are now able to estimate a model of the CEO market, which is close in both spirit and formalities as earlier works by Gabaix and Landier [2008] and Tervio [2008]), but which also allows us to introduce taxation, job amenities and multidimensional attributes of agents on both sides of the market. The application of these methods also requires that we have administrative matched CEO/firm data that measures the observable characteristics of each firm and CEO. Importantly, for our methods, it is important that we have accurate and comprehensive measures on CEOs pecuniary pay and firm profits. We obtain this information from the Danish tax authority. Our estimates square well with the relevant predictions of the ‘shareholder value’ view of the market for CEOs (Refer to Edmans and Gabaix [2016]). Furthermore, our findings help resolve some puzzling facts with regards to this view.

We can point to several avenues for future research. First, it will be useful to assess how the market for CEOs might differ across international boundaries. There are several reasons why this research will be of interest. First, it would be of interest to learn whether the qualitative conclusions of this paper can be supported in other markets. We argue that amenities are a driver of CEO assignments and thus it is important that the estimated amenities have the correct sign with regards to theories that motivate why such attributes are considered to be amenities to the CEOs. The hypothesis that CEOs will assign a positive amenity to working at a high equity firm is an example. Another reason to study the CEO market in other countries is to determine if there are quantitative differences between these markets that could be measured by estimates that follow the procedures used in the present paper. For example, we might expect

that the high taxation of CEO income in Denmark drives amenity compensation to be more important than in other countries with lower taxation. Furthermore, the value of amenities might also depend on differences in corporate governance practices and cultures across countries. For example, different practices and cultural norms might also impact how CEOs value the amenity benefits of high equity, alma mater firms relative to pecuniary forms of compensation. Nevertheless, we believe that Denmark is a useful starting point for such inquiries, because the market is relatively closed with regards to other CEO markets. In particular, Denmark is a small country with a difficult language. Therefore, almost all Danish firms are managed by Danish speaking CEOs. Furthermore, given that most Danish people put a high value on Danish work-life balance, there is very little mobility of CEO talent out of Denmark.

A second topic for further research is to look for natural experiments as a means to quantify how the key parameters of our model might change in response to changes in relevant external factors. For example, changes in taxation or the methods of corporate governance over time could easily impact how CEOs value different firm amenities. Furthermore, economic factors that affect some firms more directly than others, such as international trade and industrial policies, might lead to changes in the distribution of firm types that offer amenities that are valued by CEOs. To illustrate some relevant hypotheses with regards to the latter factors, we considered two counterfactual experiments. First, we used our estimated model to generate the hypothesis that a trade war will have a moderate negative impact on CEO wages but little effect on CEO assignment. Second, we used our estimated model to generate hypothesis with regards to industrial policy that replaces firms in a declining industry with firms in the expanding industry sector. In this case, we found that the impact of such a policy would cause large increases in CEO wages and large changes in CEO assignments, because the alma mater amenity is not valued by the displaced CEOs. Future work that investigates natural experiments relating to these sorts of hypothesis could be used to derive additional evidence that supports (or rejects) our general claim that amenities which are tied to key firm characteristics are an important source of CEO compensation.

A third topic for further research is to better integrate dynamic decision

making and longitudinal data into the analysis of the market for CEOs with taxes and non-pecuniary compensation. For example, an explicit dynamic model might be better suited for drawing inferences about the role that firing might play in incentivizing higher quality CEOs to accept the position of CEO at a firm. This conclusion would also require that we consider how different CEOs evaluate risks as well as their own talent. Furthermore, in a dynamic analysis it becomes relevant to consider whether CEO and firm types might change over time. For example, given that we estimate that CEOs like some firm types more than others, we might expect that CEOs push firms under their command to become more like their most favoured type firm. In other words, there will be many challenges related to moving from our simple static model to more general dynamic models and data, but there are also opportunities to make additional progress with regards to understanding the role of amenities in the CEO market. Since we have shown that a simple static analysis delivers results that are both statistically and economically significant, the estimates from our basic model could serve as a useful benchmark for these more ambitious studies.

Overall, our findings demonstrate that amenities, such as legacy and empowerment, are a key driver in the market for CEOs. These results point to a number of important considerations: CEOs objectives are much richer than just maximizing the NPV of their income; other than pecuniary compensations, a corporate board must evaluate amenities when attempting to attract or retain a CEO. Our results also contribute to understanding the nature of CEO pay and assignment in a high tax country like Denmark.

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# Appendix

## A Tables

Table 6: Summary statistics of CEOs' and firms' characteristics - main sample

|                               | Mean     | Std      |
|-------------------------------|----------|----------|
| <b>CEOs:</b>                  |          |          |
| Age (in years)                | 51.57    | 8.81     |
| Years of schooling (in years) | 15.74    | 2.47     |
| Net wealth                    | 3.29E+06 | 1.08E+07 |
| Bank debt                     | 1.41E+06 | 4.33E+06 |
| Gender (1 male/0 female)      | 0.94     | 0.23     |
| Marital status (1 Married)    | 0.87     | 0.34     |
| Salary                        | 2.64E+06 | 2.88E+06 |
| <b>Firms:</b>                 |          |          |
| Number of employees           | 991.84   | 2468.97  |
| Net investment                | 6.43E+07 | 1.77E+08 |
| Import                        | 3.86E+08 | 1.07E+09 |
| Export                        | 6.83E+08 | 2.63E+09 |
| Equity                        | 8.58E+08 | 3.05E+09 |
| Fixed assets                  | 9.81E+08 | 3.09E+09 |
| gross profit                  | 8.95E+08 | 2.50E+09 |
| N = 295                       |          |          |

## B Data

### B.1 Data Sources

**CEO characteristics.** We merge several administrative registers made available by Statistics Denmark to obtain the CEO-firm matches and a series of comprehensive information on the CEOs and firms.

To identify CEOs, we use the ISCO-08 classification code (International Standard Classification of Occupations).<sup>33</sup> We obtain a list of CEOs' Civil Personal Registration (CPR) Number<sup>34</sup> from this step. Using these CPR numbers, we add detailed information about the CEO from several other administrative registers. CEO characteristics include: demographic information such as age, gender, education, marital status, number of children, age of each child, from the Danish civil registration system (CPR Registeret); income and financial information, such as wage, perks, tax-free salary, anniversary and severance pay, the value of stock options, remuneration for board work, fees in connection with consulting work, lectures and the like, net wealth, bank debt, from the Danish tax authority (SKAT); and real estate information such as the size and tax value of each registered property from the real estate statistics register (Ejendomsstatistik Registeret).

**CEO-Firm matches.** We then match the CEOs with his firms using the register FIDA that provides the key between workers and firms. For a person who works as CEO for more than one firm, we select his match as the firm that has the highest gross profit. The firm identifier is the *Centrale Virksomhedsregister* (CVR) number assigned by the Central Business Register for all legal entities. Our data is at CEO-firm level. One observation is defined as a match between one CEO and one firm, with detailed CEO and firm characteristics.

**Firm characteristics.** Finally, we add firm level statistics using FIRM

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<sup>33</sup>The Danish version of the ISCO-08 code is referred to as DISCO codes. we use a variable called `disco08-alle-indk` to identify CEOs for the year 2011. We double check the worker's primary job function using the variable `pstill` and assure the consistency of coding using DISCO code from two different registers.

<sup>34</sup>CPR number is a unique time-consistent personal identification number for all Danes and residents of Denmark. Statistics Denmark replace them by anonymized ID-numbers to ensure confidentiality

(Generel firmastatistik). This register covers active firms from all industries and sectors. It integrates information from three different types of reports: balance sheet, income statement and employment statistics.

## B.2 Variable Definition

**Age:** reports a CEO's age on 1st January 2011;

**Marital status:** Marital status = 1 indicates that a CEO is married (including separated couples) or the CEO is involved in a registered partnership, or the CEO has a cohabiting partner. Otherwise, Marital status = 0;

**Gender:** gender = 1 indicates that it is a male CEO. Gender = 0 indicates that it is a female CEO;

**Education:** reports a CEO's highest level of educational attainment. This variable is originally defined in categories based on the International Standard Classification of Education (ISCED). We then translated these categories into years of schooling. Primary education, 10 years of schooling; preparatory courses, 10 years of schooling; Upper secondary education, 11 years of schooling; High school and apprenticeship education, 12 years of schooling; Shorter cycle higher education, 14 years of schooling; vocational bachelors education, 15 years of schooling; Bachelor's degree, 16 years of schooling; Master's degree, 18 years of schooling; PhD, 21 years of schooling.

**Net wealth:** is calculated as property value + the value of securities + savings and checking account balance - mortgage loans - bank debt - other debts. All these values are reported by third parties to the Danish tax authority as their prevailing market value at the end of the year. For example, banks report the assets and liabilities of their customers; financial institutions (i.e., mutual funds, investment banks) report the value of securities held by their clients. Land and real estate registry reports the value of land and property owned by individuals and businesses. This variable doesn't include cash, large durable (such as cars, boats, and private airplanes), non-corporate business assets, unlisted securities (i.e., bearer bonds, unlisted equities, and shares of housing cooperatives), assets held abroad (foreign real estate and foreign bank accounts), and inter-personal debts. See a detailed

documentation of the Danish wealth data in Jakobsen et al. [2020];

**Bank debt:** debts to banks measured on 31st December. This variable includes debt to banks, pension funds, insurance and finance companies, credit card schemes and student debt administered by banks.

**Wage:** Total taxable wage income, include perks, tax-free salary, anniversary and severance pay, the value of stock options, remuneration for board work, fees in connection with consulting work, lectures and the like.

**Number of employees:** indicates the number of people employed in the company at the end of November. For employees, statistics Denmark require them to meet the following requirements: during the year in question, the employee has received a salary corresponding to at least 80 hours of work; the employee was not registered as fully unemployed in the last week of November; and the employee has legal residence in Denmark at the end of the year.

**Net investment:** Total investment inflow minus total investment outflow, measured in Danish kroner.

**Import:** The company's total import value. All amounts are measured in kroner without VAT.

**Export:** Total export value of goods and services as well as sales of certain VAT-exempted products, measured in Danish kroner.

**Equity:** Equity at the end of the accounting year. This variable is calculated as total assets minus the sum of liabilities and other debt obligations.

**Fixed assets:** Total value of fixed assets. This variable includes assets that are intended for permanent ownership or operation of the company, i.e., buildings, machinery, patents, licenses and long-term investments of financial nature, i.e., shares and bonds.

**Productivity:** the firm's gross profit. This variable is calculated as the turnover minus the consumption of goods minus the purchase of labor (wage) and sub-contractors, measured in Danish kroner.