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## Gender discrimination at the top and product market competition

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## **Gender Discrimination at the Top and Product Market Competition**

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# Gender Discrimination at the Top and Product Market Competition\*

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## Abstract

We show that increasing the intensity of product market competition can reduce discrimination against female managers, even in an environment in which all employers have a preference for discrimination. The reason is that due to the glass ceiling effect, female managers will, on average, be more skilled than male managers and will therefore, on average, be more beneficial for the firm when product market competition is intense. Using detailed matched employee-employer data, we find that (i) more intense competition leads to relatively higher wages for female managers and (ii) the share of female managers is higher in firms in more competitive industries.

*Keywords:* Discrimination; Management, Competition, Gender

*JEL classification:* J7, L2, M5

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# 1. Introduction

We examine how the intensity of product market competition affects labor market discrimination against female managers. It is well known in the discrimination literature that greater product market competition will reduce discrimination when employers who discriminate compete with employers who do not discriminate (Becker 1971, Arrow 1973). The reason is that discriminators will see their profits fall and eventually exit the product market.

However, some types of discrimination or prejudicial preferences are also more widely shared in the population, and increased product market competition will then not suffice to eliminate discrimination through this exit effect. The reason is that in such cases, there will be too few non-discriminators in the market to force out the discriminators. We argue that this more general preference for discrimination is more likely to be present for managerial positions (as opposed to non-managerial positions), as articulated in the literature on the “glass ceiling”—a barrier of prejudice and discrimination that excludes women from higher level leadership positions.<sup>1</sup> The general presence of the glass ceiling has been explained based on attitudes within the workplace suggesting that workers prefer male to female supervisors (Simon and Landis 1989) and that many males and male managers remain unconvinced that females can be effective leaders.<sup>234</sup>

In this paper, we propose a model where firms hire managers and compete in oligopolistic product markets, and where all employers have a preference for discrimination. Our theoretical model has the following main ingredients. Each firm hires a manager whose wage is determined via Nash bargaining, from which the firm and the manager share the surplus generated from hiring the manager. The manager can be either male or female, but firms have a preference for hiring a male manager. The individual can invest in managerial skills. Hiring an individual who possesses managerial skills improves a firm’s profitability.

We first establish that discrimination results in female managers being offered lower wages than male managers of the same skill. The reason is that the lower wage compensates for the employer’s perceived disutility of hiring a female manager. This, in turn, implies that

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<sup>1</sup>See, for instance, Federal Glass Ceiling Commission, 1995; Morrison, White, & Van Velsor, 1987). Eagly et al. (2002) identify two forms of prejudice: (a) perceiving women less favorably than men as potential occupants of leadership roles and (b) evaluating behavior that fulfills the prescriptions of a leader role.

<sup>2</sup>See Bowen, Swim, and Jacobs (2000), Eagly et al. (2002), Sczesny (2003), and Sutton and Moore (1985).

<sup>3</sup>The shortage of female managers has been ascribed to a variety of causes, including women’s family responsibilities (Greenhaus and Parasuraman 1999) and inherited tendencies for women to display fewer of the traits and motivations that are necessary to attain and achieve success in high-level positions (Browne 1999, Goldberg 1993). This problem would then likely be worse at higher levels of the hierarchy.

<sup>4</sup>Discrimination is often identity specific and, therefore, occupation specific. For instance, a male security guard might not want to work with a female security guard but might not have a problem working around a better paid female teacher (Akerlof and Kranton 2000).

only highly talented women will invest in a managerial career and, thus, that the average skill level will be higher among female managers than among male managers. This is the glass ceiling effect.

Next, we ask how changes in the intensity of product market competition affect managerial wages. The extant literature on discrimination and product market competition has used different measures of product market competition, such as the number of firms in an industry, the Herfindahl index, or the level of import competition as measured by import tariffs, to explore the relationship between product market competition and discrimination. Here, we will instead focus on a more general mechanism of how increased product market competition affects discrimination. Following Boone (2008a,b) and Norbäck and Persson (2012), we define increased product market competition as changes in industry characteristics that may increase the relative profitability of more efficient firms in an industry. We show that if a firm hires a new manager (female or male) with sufficiently strong firm-specific managerial skills, he or she can mitigate the negative impact of increased competition on the firm's profits, such that profits increase compared to a benchmark in which the firm retains its initial (male) manager with weaker managerial skills. We label this the skill-biased competition effect.

A key result in our model is then that when the new manager is equipped with strong firm-specific managerial skills, the skill-biased competition effect increases the surplus generated by hiring the manager. Consequently, the manager's wage will then increase in product market competition. However, when the new manager has managerial skills that are only moderately better than the initial manager, increased product market competition may weaken the firm's profits relative to the benchmark under the initial manager. The skill-biased competition effect then reduces the surplus from hiring and hence the managerial wage. This formalization of the intensity of product market competition has the advantage of being consistent with different types of structural changes in an industry such as reduced entry barriers, reduced product differentiation and market integration.<sup>5</sup>

Under the assumption that an individual's ability cannot be perfectly observed, we then derive empirical predictions from the model. We show that if the discrimination hurdle is sufficiently high, increasing product market competition will lead to stronger average increases in wages among female managers than among male managers. The reason is as follows: When the discrimination hurdle is sufficiently high, the glass ceiling effect will imply that female managers will, on average, have higher managerial skills than male managers. This is because only female workers with sufficiently high innate talent will then find it worthwhile

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<sup>5</sup>In standard oligopoly models, these results can be shown to arise from the interplay of the direct and strategic effects of increased product market competition on firm profits.

to invest in a managerial career. Combining the result that female managers on average will be equipped with stronger managerial skills (the glass-ceiling effect), with the result that more skilled managers are will benefit more from increased intensity of product market competition (the skill-bias competition effect), the model predicts that female managers' wages will, on average, increase more than average wages of male managers. Moreover, since the skill-biased competition effect increases the return on investing in managerial skills for females, increased product market competition should also increase the incidence of female managers in firms.

We then take these predictions to our data. The standard approach to estimate wage discrimination attempts to control, to the greatest extent possible, for the characteristics of the individual worker and the firm at which the individual is employed and then estimate the average wage difference between male and female workers. Even with detailed information on personal characteristics, such as IQ or other scores on various tests, there is always a risk of omitted variable bias, as measuring all dimensions of personal characteristics is very difficult. Our identification strategy instead builds on our theoretical prediction that when discrimination is sufficiently strong, increased product market competition affects female managers' wages more positively than male managers' wages. The reason is yet again that the glass ceiling effect implies that female managers - on average - need to be more skilled than male managers, and hence, they are more likely to gain from increased product market competition through the skilled-biased competition effect.<sup>6</sup>

To empirically test the main predictions of our model we use detailed matched employer-employee data for Sweden spanning the period 1996-2009. In our main regressions, we estimate whether male and female managers' wages are affected differently by competition for managers who stay in the same firm over time using spell fixed effects, which control for unobserved individual managerial skills and firm characteristics associated with the firm. This allows us to test our main prediction that, conditional on individual characteristics, female managers' wages increase by more on average than male managers' wages as product-market competition intensifies. This result stems from the fact that female managers see their wages increasing in product-market competition increases while male managers' wages are unaffected by product market competition.

Male managers face no discrimination and a male manager can therefore have any innate ability: low, medium or high. The estimate of how male managers' wages react to

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<sup>6</sup>When the discrimination hurdle is low, increasing the intensity of product market competition can reduce the incentive for women to become managers. Why? When the discrimination hurdle is low, the glass ceiling effect is weaker, and more mediocre females become managers. As mediocre managers are less able to cope with more intense product market competition, their wages may decrease, and thereby, their incentives to pursue a training program decline.

increased product market competition will be a weighted average of all types of managers, where managers of lower ability or skill see their wages decline in competition while top level managers see their wages increase in competition, with the average effect being zero. In contrast, since female managers face discrimination, and therefore need higher skills to reach a position as manager, the estimate of how female managers' wages react to increased product market competition will contain higher weights on top managers whose wages increase in competition. This explains the positive effect of competition on female managers wages.

As predicted, we find that the incidence of female CEOs and the share of female managers in firms increase in product market competition. Interestingly, we find no effect of the intensity of product market competition on wage inequality for lower skilled groups. In fact, we find no effect of increased product market competition on the wages of groups other than managers. This is consistent with our theoretical model since low-skilled groups will only marginally affect the profitability of the firm, and low-skilled groups' wages are to a large extent determined jointly with the conditions in many markets.<sup>7</sup>

Our paper contributes to literature on discrimination and competition. In his pioneering theoretical contribution, Becker (1971) assumed that discriminatory employers may suffer disutility from employing women and showed that these employers pay lower wages to women than to men. Moreover, in a non-segregating equilibrium, all female workers receive a lower wage than men, regardless of whether they work for an employer with or without discriminatory preferences. Arrow (1973) showed that in equilibrium, non-discriminatory employers employ more women at below-productivity wages than their discriminatory counterparts and therefore gain a competitive advantage and that increased competition will force out discriminatory corporate owners. Rosen (2003) shows that discrimination may persist if employees and employers face search costs and firms have some market power. We contribute to this literature by showing that increased product market competition can reduce discrimination even in a setting in which all agents discriminate. Thus even though exit of discriminators do not play a role in our model, increased intensity of product market competition can still reduce wage discrimination and make female managers more present in firms. The reason is that the cost of discriminating high-skilled females increases when the intensity of product market increases.

Our paper also contributes to the empirical literature on discrimination and product market competition. Black and Strahan (2001) examine the deregulation of the banking sector in the US and find that wage differentials between females and males decrease when

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<sup>7</sup>We should therefore expect weak or no effects of the extent of competition in an industry on the wages of low-skill workers.

competition increases. They also find that the share of female managers increases. Black and Brainerd (2004) find that increased import competition increases the relative wages of females, but only in industries with low competitive intensity. Heyman, Svaleryd and Vlachos (2013), using the Boone (2008) measure of intensity of product market competition, find that the share of female workers increases after takeovers in industries in which the intensity of product market competition is low. They also find that increased industry level product market competition leads to a small increase in the share of women employed in firms in these industries. We contribute to this literature by, based on the general Boone measure of the intensity of product market competition, focusing on the impact on gender wage differences across executive positions.

## 2. Theory

Consider a market served by a set of firms,  $\mathcal{J} = \{1, \dots, j, \dots, n\}$ . Firms hire unskilled workers for production. Production also requires the services of a manager. Initially, each firm has a *male* manager with low innate talent,  $\theta = 0$ . The following sequence of events then unfolds:

In stage 0, nature allocates to each firm a trainee who may later be offered the manager position, replacing the initial (male) manager. Trainees may be male or female. Denote by  $\mathcal{M}$  and  $\mathcal{F}$  the set of male and female trainees, respectively. A trainee has innate talent  $\theta$  drawn from a distribution  $g(\theta)$  over the interval  $\theta \in [0, \theta^{\max}]$ . The density function,  $g(\theta)$ , is identical for men and women.

In stage 1, the talent,  $\theta$ , of each trainee is revealed. We will distinguish between talent (which we take to be innate) and firm-specific skills (which can be acquired). Each trainee can choose to invest in a trainee program to generate firm-specific managerial skills. For simplicity, the trainee program is associated with a fixed effort cost,  $I$  (arising from, for example, training, education, or overtime).

In stage 2, provided that the trainee has invested in firm-specific skills, each firm chooses whether to replace the old male manager with its now experienced and educated trainee. If a firm chooses to hire its trainee as the manager, wage negotiations take place according to a Nash bargaining protocol in a setting in which discrimination against female managers occurs at an exogenous fixed cost,  $D$ .

In stage 3, firms compete in an oligopolistic product market with an exogenous intensity of product market competition denoted  $C$ . We now solve the model by backward induction.



### 2.1. Stage 3: Product market

In the product market interaction, firm  $j$  chooses an action (a quantity or a price)  $x_j \in R^+$  to maximize its direct product-market profit,  $\pi_j(x_j, x_{-j} : \varphi_j)$ , which depends on its own and its rivals' actions,  $x_j$  and  $x_{-j}$ , and the firm-specific skill of its manager,  $\varphi_j = \varphi_j(\theta|Z)$ . Thus, we let  $\varphi_j(\theta|Z)$  be the firm-specific management skill of firm  $j$ 's manager, where  $\theta$  is the manager's innate talent and where  $Z = \{0, I\}$  is an indicator for whether he - or she - has invested in the trainee program. The firm-specific management skill level of the manager in firm  $j$ ,  $\varphi_j$ , equals zero if  $Z = 0$  (i.e., if the potential trainee did not invest in managerial skills) or if  $\theta = 0$  (i.e., the initial manager remains in charge). However, if the trainee has invested in the trainee program, the management skill level in firm  $j$  equals  $\varphi_j(\theta|Z = I) = \theta$ .

Each firm's specific management skill level is common knowledge. The vector  $(\varphi_j, \varphi_{-j})$  captures the management skill levels at firm  $j$  and at firm  $j$ 's rivals. We assume that there exists a unique Nash equilibrium in actions,  $\mathbf{x}^*(\varphi_j, \varphi_{-j})$ , defined from

$$\pi_j(x_j^*, x_{-j}^* : \varphi_j) \geq \pi_j(x_j, x_{-j}^* : \varphi_j), \quad \forall x_j \in R^+. \quad (2.1)$$

We will assume that product market profits are always positive. Using expression (2.1), firm  $j$ 's reduced-form profit is  $\pi_j(\varphi_j, \varphi_{-j}) \equiv \pi_j(x_j^*(\varphi_j, \varphi_{-j}), x_{-j}^*(\varphi_j, \varphi_{-j}) : \varphi_j)$ . We make the following assumption regarding reduced-form profits:

**Assumption A1** *Firm  $j$ 's reduced-form profit is increasing in its own manager's firm-specific skill,  $(\frac{\partial \pi_j(\varphi_j, \varphi_{-j})}{\partial \varphi_j} > 0)$ , and decreasing in rival firms' management skill levels,  $(\frac{\partial \pi_j(\varphi_j, \varphi_{-j})}{\partial \varphi_{-j}} < 0)$ .*

Recall that the firm-specific skills of firm  $j$ 's manager,  $\varphi_j = \varphi_j(\theta|Z)$ , depend on his or her innate talent ( $\theta$ ) and his or her investment in managerial skills ( $Z$ ). To simplify notation, we will write profits directly as functions of the manager's talent. The firm's profit then equals  $\pi_j(\theta)$  if the manager has both high innate talent and has invested in the trainee program and  $\pi_j(0)$  if the manager is either of low talent (the old manager) or did not invest in the trainee program. Intuitively, Assumption A1 then implies that firm  $j$  earns a *higher profit* if it employs a manager with *higher firm-specific managerial skills*:  $\pi_j(\theta) > \pi_j(0)$ .

### 2.2. Stage 2: Wage setting and hiring decisions

In stage 2, conditional on having invested in firm-specific managerial skills, the trainee bargains with the firm over the wage for employment as the manager. If they agree on a wage that leaves both parties with a positive surplus, the trainee is hired. If no agreement

can be reached, or if the trainee has not invested in managerial skills, the firm retains its current manager at wage  $w(0)$ .<sup>8</sup> The latter wage is a competitive wage determined in the economy-wide labor market. It is therefore also the outside option for the trainee.

### 2.2.1. Hiring a female skilled manager

If the trainee is a woman, the Nash bargaining product is

$$\max_{w_j} [\pi_j(\theta) - \alpha D - w_j - (\pi_j(0) - w(0))]^{1/2} \times [w_j - (1 - \alpha)D - w(0)]^{1/2}, \quad \theta \in \mathcal{F} \quad (2.2)$$

where, without loss of generality, we assume equal bargaining strength.

The wage negotiation in (2.2) takes into account that female managers are subject to discrimination. This is captured by a fixed discrimination cost,  $D$ . Negative attitudes toward female managers may impose additional costs on firms, for example if workers resent female managers. We assume that the firm bears a fraction  $\alpha \in (0, 1)$  of the discrimination cost,  $D$ . A female manager may also experience disutility in her work. This may reflect attitudes by colleagues or society against female managers.<sup>9</sup>

If an agreement is struck, firm  $j$  pays the female manager wage  $w_j$  and earns profit  $\pi_j(\theta)$ . Note that since firm  $j$  bears a cost from discrimination,  $\alpha D > 0$ , it will never employ a female trainee who did not invest in obtaining firm-specific management skills. Thus, if no agreement is reached, the initial *male* manager with low talent remains at wage  $w(0)$ , in which case the firm earns profit  $\pi_j(0)$ . We further discuss the wage of the initial male manager below. The female trainee may work in the firm, or elsewhere, at the outside wage,  $w(0)$ .

To proceed, it is convenient to define  $S_j(\theta)$  as the surplus created by a manager with firm-specific skills  $\theta$  in a *benchmark without discrimination*,  $D = 0$ :

$$S_j(\theta) = \frac{1}{2} [\pi_j(\theta) - \pi_j(0)]. \quad (2.3)$$

Note that the surplus must be increasing in the firm-specific skills of the manager from Assumption 1,  $S'_j(\theta) > 0$ .

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<sup>8</sup>If the trainee has not invested in managerial skills, the firm may also hire this worker at the same wage,  $w(0)$ .

<sup>9</sup>We thus express her disutility in monetary terms. Disutility may also be due to a family situation in which women take greater responsibility for their family and children, resulting in a stressful situation when coping with overtime and greater responsibilities. We capture this by assuming that the female manager faces a cost from discrimination being the remaining fraction,  $1 - \alpha \in (0, 1)$ , of the fixed discrimination cost,  $D$ .

Solving the bargaining problem in (2.2), the negotiated wage for a hired *skilled female manager* is then

$$w_j^*(\theta \in \mathcal{F}) = w(0) + S_j(\theta) - \left(\frac{2\alpha-1}{2}\right) D \quad (2.4)$$

where the first term is the outside wage, the second term is her share of the increase in profits generated by improved management quality, and the third term reflects how the cost of discrimination is shared between the firm and the female manager. Note that if the firm takes on a higher share of the costs of discrimination,  $\alpha > 1/2$ , she will have to take a pay cut. If, by contrast, she is more adversely affected than the firm,  $\alpha < 1/2$ , the firm will need to compensate her for this disutility.

### 2.2.2. Hiring a male skilled manager

If the trainee is a male and has invested in firm-specific managerial skills, his negotiated wage if hired as the manager is simply

$$w_j^*(\theta \in \mathcal{M}) = w(0) + S_j(\theta), \quad (2.5)$$

since there is no discrimination against male managers,  $D = 0$ .

If no agreement is made, the initial male manager again remains in charge. Assuming that there are many male individuals of innate low ability, it is easy to verify that the wage negotiation between the firm and the old manager will then yield the outside wage,  $w(0)$ . The simple reason is that the old manager cannot create a surplus, i.e.,  $S_j(0) = 0$  from (2.3).

Using the negotiated wages in (2.4) and (2.5), we arrive at the following result.

**Lemma 1.** *Suppose that a trainee replaces the old male manager. If there is discrimination against female managers,  $D > 0$ , and the larger share of the discrimination cost falls on the firm,  $\alpha > 1/2$ , a hired male manager earns more than a hired female manager with identical firm-specific skills,  $w_j^*(\theta \in \mathcal{M}) > w_j^*(\theta \in \mathcal{F}) > w(0)$ .*

### 2.3. Stage 1: Career decision

In stage 1, the trainee in each firm makes his or her career choice, i.e., he or she makes the decision of whether to invest in firm-specific managerial skills at cost  $I$ , internalizing that skilled managerial work will lead to a wage increase from  $w(0)$  to  $w_j^*(\theta|\theta \in h)$  for  $h \in \{\mathcal{M}, \mathcal{F}\}$ .

It follows that the trainee will choose the career path if the surplus generated from the Nash bargaining exceeds the investment cost, that is, if

$$\begin{cases} w_j^*(\theta \in \mathcal{F}) - (1 - \alpha)D - w(0) > I, \\ w_j^*(\theta \in \mathcal{M}) - w(0) > I. \end{cases} \quad (2.6)$$

Using the negotiated wages (2.4) and (2.5) in (2.6) and replacing each inequality with an equality, we can obtain the critical level of innate talent necessary to make the costly investment in firm-specific skills for a career as a manager worthwhile:<sup>10</sup>

$$\begin{cases} S_j(\theta^{\mathcal{F}}) = I + \frac{D}{2}, \\ S_j(\theta^{\mathcal{M}}) = I. \end{cases} \quad (2.7)$$

This leads to the following proposition:<sup>11</sup>

**Proposition 1.** *Suppose that there is discrimination against female managers,  $D > 0$ . Then, in equilibrium, a female trainee will, all else equal, need a higher threshold level of talent than a male trainee to pursue a career as a manager (invest in the trainee program),  $\theta^{\mathcal{F}} > \theta^{\mathcal{M}}$ .*

Equation 2.7 reveals that since female managers face a cost of discrimination ( $D/2$ ), female trainees face a glass ceiling when pursuing a career as a manager. Female trainees will, in equilibrium, need to possess a higher minimum level of talent than male trainees to be hired as a manager,  $\theta > \theta^{\mathcal{F}} > \theta^{\mathcal{M}}$ . It is only when a woman has very high talent that the firm can compensate her through a high wage (generated by a higher surplus,  $S_j(\theta)$ ). The result that female trainees need greater talent to invest in firm-specific skills and pursue managerial work will be referred to as the “*glass ceiling effect*”. The glass ceiling effect is illustrated in Figure 2.1(i). In the next section, we will explore how product market competition affects the glass ceiling.

## 2.4. Product market competition and managerial wages

We begin this section by introducing product market competition into the model. In the next section, we will show how variation in product market competition can be used to identify wage discrimination against female managers in the data.

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<sup>10</sup>If firm  $j$  agrees to hire a female manager, the net surplus is  $S_j(\theta) - \frac{D}{2}$ , and thus, if a female talented worker invests in managerial skills, there will always be an agreement.

<sup>11</sup>Note that this result is independent of which of the parties bears the cost of discrimination, i.e., independent of  $\alpha$ . The reason is that the trainee will always obtain half of the surplus in the wage bargaining, and thus, the cost of discrimination is always shared equally.

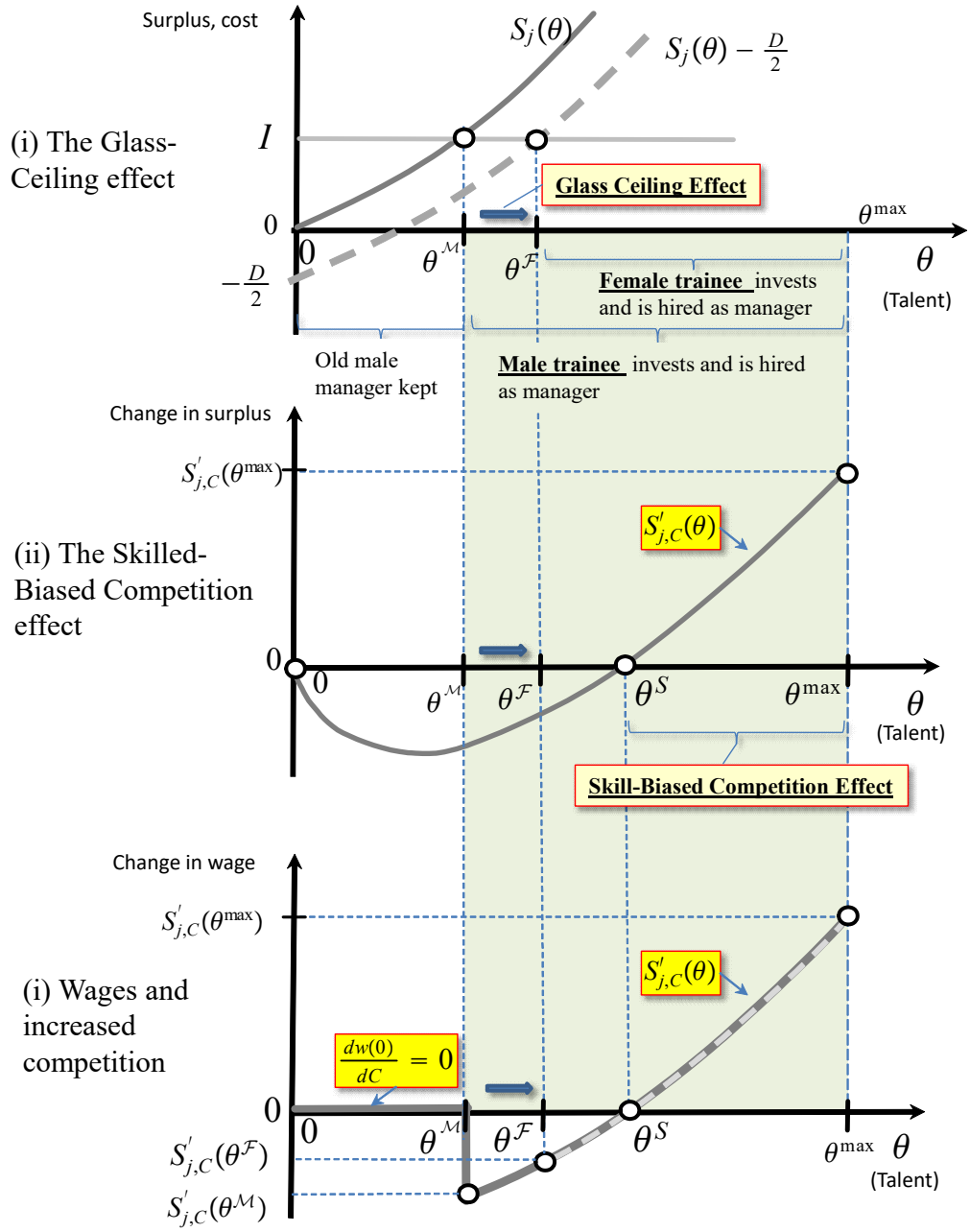


Figure 2.1: Investing in firm-specific skills: the Glass-Ceiling Effect and the Skill-Biased Competition effect.

### 2.4.1. Intensity of product market competition

How does the intensity of product market competition affect the gender gap in the wages of managers?<sup>12</sup> Let  $C$  denote the intensity of product market competition in the industry in stage 3.<sup>13</sup> We may think of the intensity of product market competition being determined by nature in stage 0 and then being common knowledge for all players. Alternatively, we can assume that the agents form expectations over the level of product market competition in stage 3. In the latter case, nature would determine the amount of product market competition before the actual product market interaction in stage 3 but after the trainee has made his or her investment decision in stage 1 and the wage negotiations have taken place in stage 2.

The impact of the intensity of product market competition on a manager's wage,  $w_j^*(\theta \in h)$ , will depend on how the intensity of product market competition affects the surplus created by the manager,  $S_j(\theta)$ . From (2.3), this will, in turn, depend on how the intensity of product market competition,  $C$ , affects a firm's profits,  $\pi_j(\theta)$ . We will make the following assumption, which builds on the work in Boone (2008a,b) and Norbäck and Persson (2012).

**Assumption A2:** *A firm with a manager that has a sufficiently high firm-specific skill can mitigate the negative impact of stronger product market competition on the firm's profits: (i) There exists a unique  $\delta \in (0, \theta^{\max})$  such that  $\frac{d}{d\theta} \left( \frac{d\pi_j(\theta)}{dC} \right) < 0$  for  $\theta < \delta$  and  $\frac{d}{d\theta} \left( \frac{d\pi_j(\theta)}{dC} \right) > 0$  for  $\theta > \delta$ , and (ii)  $\frac{d\pi_j(\theta^{\max})}{dC} > \frac{d\pi_j(0)}{dC} < 0$ .*

The first part of Assumption A2 captures the notion that if a firm has a manager with sufficiently strong firm-specific managerial skills, he or she can dampen the negative impact of increased competition on the firm's profits compared to the *benchmark* case in which the firm retains its initial manager with weak managerial skills. Conversely, with weaker firm-specific skills, stronger competition leads to a reduction in the surplus, that is, product market profits under a manager with low firm-specific skills will decline more in competition than in the benchmark case with the initial manager.<sup>14</sup>

Assumption A2 leads to the following Lemma.

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<sup>12</sup>Several measures of the intensity of product market competition are used in the literature. Greater product market competition may come from having more firms in the market, reduced collusion, or import competition from firms that supply goods or services at lower wage costs. Greater product market competition may also stem from reduced product differentiation. Here, we do not specify the source of the variation in product market competition but instead model the impact of competition on the reduced profit function.

<sup>13</sup>The intensity of product market competition can be thought to be determined in stage 0, before the career choice in stage 1 and the subsequent wage negotiation in stage 2 and the product market interaction in stage 3.

<sup>14</sup>Norbäck and Persson (2012) provide an extensive discussion and proofs for Assumption A2 where cost-reducing innovations and product market competition affect product market profits.

**Lemma 2.** *Suppose that Assumption A2 holds. Then, there exists a unique firm-specific skill level of the manager,  $\theta^S \in (0, \theta^{\max})$ , such that (i)  $S'_{j,C}(\theta^S) = S'_{j,C}(0) = 0$ , (ii)  $S'_{j,C}(\theta) < 0$  for  $\theta \in (0, \theta^S)$  and  $S'_{j,C}(\theta) > 0$  for  $\theta \in (\theta^S, \theta^{\max}]$ .*

Lemma 2 is illustrated in Figure 2.1(ii). Note that the change in the surplus from increased competition,  $S'_{j,C}(\theta)$ , is a strictly convex function in the talent of the manager,  $\theta$ . Importantly, the surplus first declines in competition,  $S'_{j,C}(\theta) < 0$ , when the manager lacks sufficient talent ( $\theta < \theta^S$ ). The direct effect of stronger competition then dominates any strategic effects,  $S'_{j,C}(\theta) = \frac{d\pi_j(\theta)}{dC} - \frac{d\pi_j(0)}{dC} < 0$ . However, when the manager has a sufficiently high talent ( $\theta > \theta^S$ ) the surplus created is increasing in competition,  $S'_{j,C}(\theta) = \frac{d\pi_j(\theta)}{dC} - \frac{d\pi_j(0)}{dC} > 0$ . Profits then decline less from stronger competition with a highly skilled manager (or may even increase) than without him or her, as a highly talented manager endowed with strong firm-specific skills gives the firm an advantage over its competitors.<sup>15</sup> We will label this result, whereby the surplus increases in competition when the manager has sufficiently strong firm-specific skills, the *skill-biased competition effect*.

We can now combine the *glass-ceiling effect* associated with Proposition 1 and the *skilled-biased competition effect* in Lemma 2 to determine how managers' wages react to increasing competition. For illustrative purposes, suppose that  $\theta^F < \theta^S$  holds. As a benchmark, start with the case in which the firm has a male manager. From (2.5), when varying the level of his innate ability, competition then has the following effect on the manager's wage:

$$\frac{dw_j(\theta \in \mathcal{M})}{dC} = \begin{cases} \frac{dw(0)}{dC} = 0, & \theta \in [0, \theta^{\mathcal{M}}), \\ S'_{j,C}(\theta) < 0, & \theta \in [\theta^{\mathcal{M}}, \theta^S), \\ S'_{j,C}(\theta) = 0, & \theta = \theta^S, \\ S'_{j,C}(\theta) > 0, & \theta \in (\theta^{\mathcal{M}}, \theta^{\max}]. \end{cases} \quad (2.8)$$

Expression (2.8) is illustrated in Figure 2.1(i): A male trainee will only find it worthwhile to invest in firm-specific managerial skills if his innate talent exceeds  $\theta^{\mathcal{M}}$ . In the region  $\theta \in [0, \theta^{\mathcal{M}})$ , he will not invest in firm-specific skills, and the firm will retain the initial male manager with low firm-specific skills,  $\theta = 0$ . The (initial male) manager is then simply paid the outside general equilibrium wage,  $w(0)$ , which - by definition - is independent of the level competition in a particular industry. Thus, whenever firm  $j$  has a trainee with low innate

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<sup>15</sup>Typically, the impact of competition on a firm's profit can be decomposed into a direct effect and a strategic effect. The direct effect is negative and stems from a reduction in the product market price. Since a firm that has a more skilled manager will sell and produce more, this negative direct effect is more detrimental for a larger firm. However, the strategic effect is typically positive: When the manager has strong firm-specific skills, the firm obtains a relative advantage over its weaker competitors. These effects are analyzed in detail in Norbäck and Persson (2012).

ability,  $\theta \in [0, \theta^M)$ , the managerial wage will not be affected by competition,  $\frac{dw(0)}{dC} = 0$ .<sup>16</sup>

However, the male trainee will invest in firm-specific managerial skills when his innate talent exceeds  $\theta^M$ . If his innate ability is still below the threshold  $\theta^S$ , his acquired firm-specific skills will not be sufficient to take advantage of increasing competition, and his wage will decline in competition,  $\frac{dw_j(\theta \in \mathcal{M})}{dC} = S'_{j,C}(\theta) < 0$ . In contrast, when his innate talent is above  $\theta^S$ , the trainee program provides him with strong firm-specific skills. As this gives the firm a strong advantage over its rivals, the surplus is now increasing in competition, and subsequently, his wage will be increasing in competition,  $\frac{dw_j(\theta \in \mathcal{M})}{dC} = S'_{j,C}(\theta) > 0$ .

The impact of competition on a female manager's wage is very similar but exhibits an important difference: Discrimination and the *glass ceiling effect* imply that a firm will not hire female managers of low innate talent,  $\theta < \theta^F$ . Therefore,

$$\frac{dw_j(\theta \in \mathcal{F})}{dC} = \begin{cases} \frac{1}{2}S'_{j,C}(\theta) < 0, & \theta \in [\theta^F, \theta^S), \\ \frac{1}{2}S'_{j,C}(\theta) = 0, & \theta = \theta^S, \\ \frac{1}{2}S'_{j,C}(\theta) > 0, & \theta \in (\theta^S, \theta^{\max}]. \end{cases} \quad (2.9)$$

## 2.5. Identifying discrimination against female managers

Let us now make predictions about how competition affects managerial wages and, in particular, if the impact of competition on the managerial wage differs between male and female managers. When taking these predictions to the data, we will need to take into account that in the empirical analysis, we will not have perfect information on managers' firm-specific skills or knowledge (generated, for example, by their innate talent, trainee programs and education). We will instead make use of the distribution of innate talent,  $g(\theta)$ , and derive our predictions in terms of expected changes in managerial wages from stronger competition.

### 2.5.1. The intensive margin

Suppose that we take the trainee's investment choice in stage 1 as given, treating the cutoffs  $\theta^F$  and  $\theta^M$  as fixed, and vary the actual product market competition in stage 3. How does this affect the managerial wage? As we will show below, this will correspond to the estimates in a wage regression in which we apply *spell fixed effects*, i.e., we examine the impact of competition on managers who stay with the same firm over time. As noted above, treating the cutoffs  $\theta^F$  and  $\theta^M$  as fixed can also be thought of as the trainees making their investment decision based their expected level of future competition.

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<sup>16</sup>Again, since there are many such potential managers available in the economy, no surplus is created,  $S_j(0) = 0$ .



To proceed, let  $\mathbb{E}[w_j^*|\theta \in \mathcal{M}]$  be the expected wage of a male manager in firm  $j$  and let  $\mathbb{E}[w_j^*|\theta \in \mathcal{F}]$  be the expected wage in firm  $j$  if it has a female manager. Using Proposition 1, and Equations 2.4 and 2.5, we have

$$\mathbb{E}[w_j^*|\theta \in \mathcal{F}] = w(0) - (2\alpha - 1)\frac{D}{2} + \int_{\theta^{\mathcal{F}}}^{\theta^{\max}} S_j(\theta)g(\theta|\theta \in \mathcal{F})d\theta, \quad (2.10)$$

$$\mathbb{E}[w_j^*|\theta \in \mathcal{M}] = w(0) + \int_{\theta^{\mathcal{M}}}^{\theta^{\max}} S_j(\theta)g(\theta)d\theta. \quad (2.11)$$

Note that while a male manager can have any innate ability  $\theta \in [0, \theta^{\max}]$  and hence be represented by the density  $g(\theta)$  over its full support, female managers can only be present in the interval  $\theta \in [\theta^{\mathcal{F}}, \theta^{\max}]$ , as they are subject to discrimination. Hence, we use a truncated density,  $g(\theta|\theta \in \mathcal{F})$ , for female managers in (2.10), i.e.,<sup>17</sup>

$$g(\theta|\theta \in \mathcal{F}) = \frac{g(\theta)}{1 - G(\theta^{\mathcal{F}})} > g(\theta), \text{ for } \theta \in [0^{\mathcal{F}}, \theta^{\max}]. \quad (2.12)$$

We can then state our main proposition in this paper:

**Proposition 2.** *If discrimination is significantly severe, i.e., if  $D$  is sufficiently large, stronger product market competition,  $C$ , will*

- (i) *increase the expected wage for a female manager,  $\frac{d\mathbb{E}[w_j^*|\theta \in \mathcal{F}]}{dC} > 0$ ,*
- (ii) *decrease wage discrimination against female managers,  $\frac{d\mathbb{E}[w_j^*|\theta \in \mathcal{F}]}{dC} - \frac{d\mathbb{E}[w_j^*|\theta \in \mathcal{M}]}{dC} > 0$ ,*  
*and,*
- (iii) *have an ambiguous effect on the expected wage of a male manager,  $\frac{d\mathbb{E}[w_j^*|\theta \in \mathcal{M}]}{dC} \leq 0$ .*

This proposition shows that when there is severe discrimination, increasing competition will increase the expected wage of a female manager relative to that of a male manager. The intuition stems directly from the *glass ceiling effect*, which forces female managers to possess significantly higher firm-specific skills than male managers. However, then female managers

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<sup>17</sup>This truncated distribution is also shown in Figure 2.2(ii), below. Consider the cutoff for female trainees,  $\theta^{\mathcal{F}}$  in Figure 2.2(ii). Label the area under density  $g(\theta)$  to the left of  $\theta^{\mathcal{F}}$  as "A" and the area under density  $g(\theta)$  to the right of  $\theta^{\mathcal{F}}$  "B". For  $g(\theta)$  to be a probability distribution, areas A and B must sum to unity. Since female trainees cannot be managers unless their innate talent is at least  $\theta^{\mathcal{F}}$ , the area A is not feasible for female managers. For the truncated distribution  $g(\theta|\theta \in \mathcal{F})$  to be a probability distribution, we need to multiply  $g(\theta)$  by  $1/(1 - G(\theta^{\mathcal{F}})) > 1$ , where  $g(\theta|\theta \in \mathcal{F})$  is only feasible in the region  $\theta \in [0^{\mathcal{F}}, \theta^{\max}]$ . In essence, this procedure "adds" area A "on top" of area B.

are also more likely to reap the benefits from the *skill-biased competition effect*, which states that it is only the most skilled managers who benefit from competition in terms of a rising wage. Below, we provide a detailed proof of the proposition before turning to testing it in the data.

**Male managers** Start with the expected wage of a male manager. Combining (2.8) and (2.11), the expected change in the wage of a *male manager* from increasing competition is

$$\frac{d\mathbb{E}[w_j^*|\theta \in \mathcal{M}]}{dC} = \int_{\theta^{\mathcal{M}}}^{\theta^S} S'_{j,C}(\theta)g(\theta)d\theta + \int_{\theta^S}^{\theta^{\max}} S'_{j,C}(\theta)g(\theta)d\theta. \quad (2.13)$$

The intuition behind (2.13) is shown in Figure 2.2. Figure 2.2(i) depicts the investment decision for the trainee (male or female). Figure 2.2(ii) depicts the density,  $g(\theta)$ , by which the change in wage for each innate talent type,  $\theta$ , is weighted in the integral (2.13). Figure 2.2(iii) depicts the change in the weighted managerial wage,  $S'_{j,C}(\theta)g(\theta)$ .

Again, for all realizations of innate talent below the threshold  $\theta^{\mathcal{M}}$ , the trainee does not invest in firm-specific skills. The firm retains the old male manager who is paid the outside wage, which is not affected by competition. From Figure 2.1(iii), we know that if the trainee invests in firm-specific skills, while the skills he brings to the firm are below the threshold  $\theta^S$ , the surplus - and, hence, his wage - declines in competition,  $S'_{j,C}(\theta) < 0$ . Male managers of medium innate talent therefore see their wages declining in competition. However, when we are above the threshold  $\theta^S$ , the surplus is increasing in competition,  $S'_{j,C}(\theta) > 0$ , hence increasing the wage of male managers with high innate talent.

**Female managers** Combining (2.9) and (2.10), the expected change in the wage of a *female manager* from increasing competition is

$$\frac{d\mathbb{E}[w_j^*|\theta \in \mathcal{F}]}{dC} = \int_{\theta^{\mathcal{F}}}^{\theta^S} S'_{j,C}(\theta)g(\theta|\theta \in \mathcal{F})d\theta + \int_{\theta^S}^{\theta^{\max}} S'_{j,C}(\theta)g(\theta|\theta \in \mathcal{F})d\theta. \quad (2.14)$$

The expression (2.14) is deceptively similar to that for male managers in (2.13). However, note that the *glass ceiling effect* implies that *female trainees need higher innate talent than male trainees* to invest in firm-specific skills,  $\theta^{\mathcal{F}} > \theta^{\mathcal{M}}$ . This is key to understanding how increased competition will tend to reduce wage discrimination against female managers.

Suppose that wage discrimination implies that female managers, on average, earn less

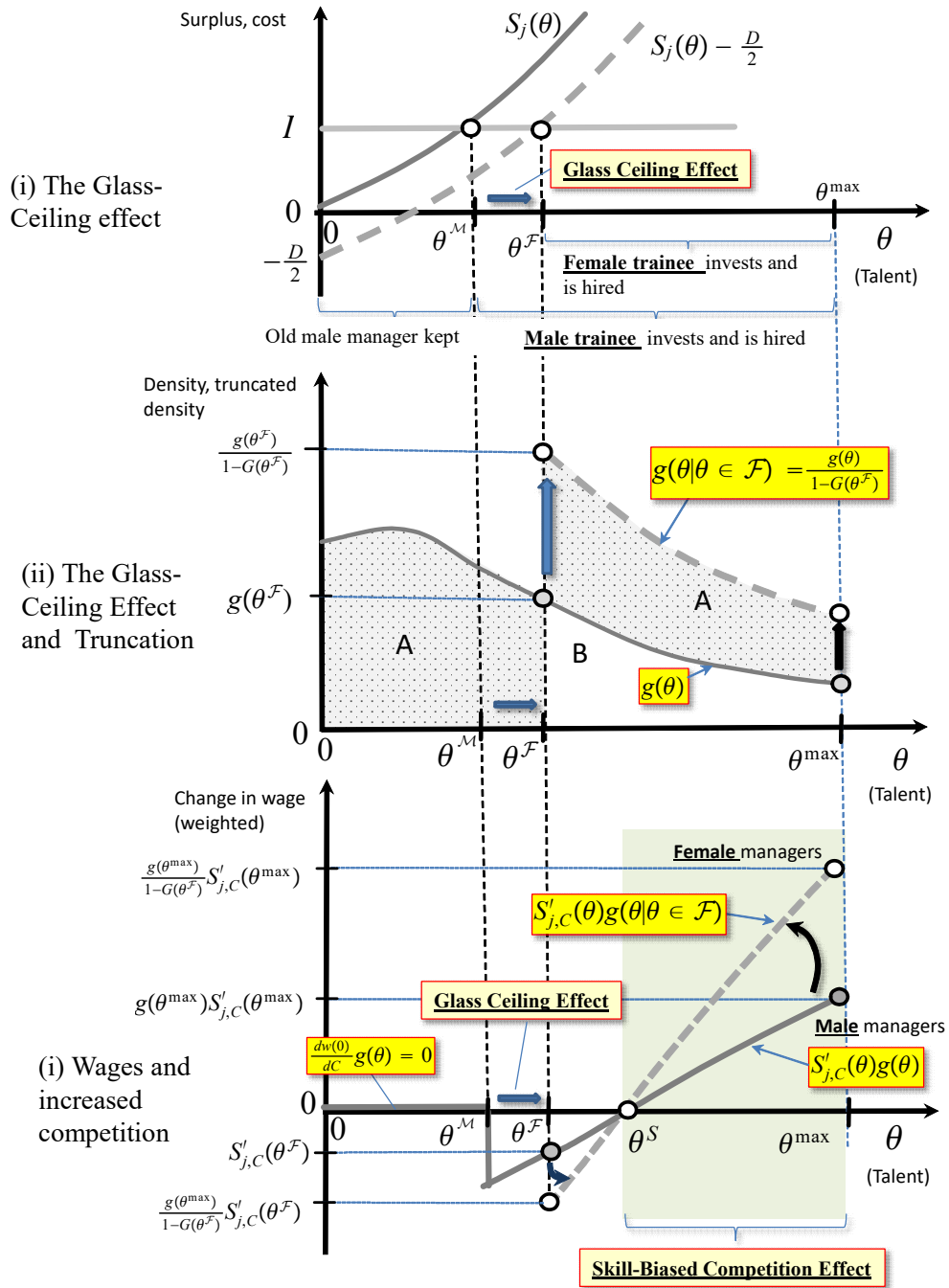


Figure 2.2: Illustrating how the Glass-Ceiling Effect and the Skill-Biased Competition Effect combine to cause increased product market competition to have different impacts on the expected wage of female and male managers.

than male managers,  $\mathbb{E}[w_j^*|\theta \in \mathcal{F}] - \mathbb{E}[w_j^*|\theta \in \mathcal{M}] < 0$ .<sup>18,19</sup> We can then use (2.13) and (2.14) to calculate the impact of stronger competition on wage discrimination:

$$\begin{aligned}
\frac{d(\mathbb{E}[w_j^*|\theta \in \mathcal{F}] - \mathbb{E}[w_j^*|\theta \in \mathcal{M}])}{dC} = & - \int_{\theta^{\mathcal{M}}}^{\theta^{\mathcal{F}}} \underbrace{S'_{j,C}(\theta)}_{(-)} g(\theta) d\theta \\
& + \int_{\theta^{\mathcal{F}}}^{\theta^S} \underbrace{S'_{j,C}(\theta)}_{(-)} \underbrace{[g(\theta|\theta \in \mathcal{F}) - g(\theta)]}_{(+)} d\theta \\
& + \int_{\theta^S}^{\theta^{\max}} \underbrace{S'_{j,C}(\theta)}_{(+)} \underbrace{[g(\theta|\theta \in \mathcal{F}) - g(\theta)]}_{(+)} d\theta. \quad (2.15)
\end{aligned}$$

Skill-biased comp                      Glass ceiling

Since male trainees are not discriminated against, they require a lower critical innate talent to invest in firm-specific managerial skills than do female trainees,  $\theta^{\mathcal{M}} < \theta^F$ . Furthermore, since increased competition leads to a lower surplus,  $S'_{j,C}(\theta) < 0$ , for wages in the interval  $\theta \in [\theta^{\mathcal{M}}, \theta^F]$ , the wage of male managers declines in this region. Hence, the expected wage difference between female and male managers must also decline. This is shown by the first line in (2.15) and illustrated in Figure 2.2(iii).

The last line in (2.15) also contributes to a decline in wage discrimination: When the manager has strong firm-specific skills,  $\theta > \theta^S$ , the skill-biased competition effect contributes to generating a larger surplus,  $S'_{j,C}(\theta) > 0$ , and the wage of a manager increases. In the last line of (2.15), we see that this skill-biased competition effect is amplified by the glass ceiling effect for female managers, as the truncated talent distribution in (2.12) assigns a larger weight to female managers in this region,  $g(\theta|\theta \in \mathcal{F}) > g(\theta)$ . This is also shown in Figure 2.2(iii), where the locus of the weighted change in wage for a female manager,  $S'_{j,C}(\theta)g(\theta|\theta \in \mathcal{F})$ , twists counter-clockwise around  $\theta^S$ , making the density-weighted increase in wage larger for females,  $S'_{j,C}(\theta) [g(\theta|\theta \in \mathcal{F}) - g(\theta)] > 0$ .

Turning to the middle line in (2.15), truncation finally gives a higher weight to the reduction in wages for female managers when the skill-biased competition effect is negative,  $S'_{j,C}(\theta) < 0$ . This effect, which is shown in Figure 2.2(iii) for the interval  $\theta \in [\theta^F, \theta^S]$ , introduces ambiguity in the sign of (2.15).

Let us now turn to the main claim of the proposition: Under sufficiently severe discrim-

<sup>18</sup>I.e., let  $D > 0$ , and assume that a larger share of the discrimination cost falls on the female manager,  $\alpha > 1/2$ , such that female managers, conditional on firm-specific managerial skills, earn less,  $w_j(\theta \in \mathcal{F}) < w_j(\theta \in \mathcal{M})$ .

<sup>19</sup>As we show, truncation effects may imply that the average female manager earns more than the average male manager. The data in the next section show, however, that this is not the case.

ination, stronger product market competition must lead to a decline in wage discrimination against female managers. To see this, note that if we increase the cost of discrimination,  $D$ , it is clear from Figure 2.2(i) that female trainees will need to possess greater innate talent to invest in firm-specific skills (i.e., shifting down the locus  $S_j(\theta) - D/2$ , not shown in Figure 2.2(i)). Formally, differentiating the upper line in (2.7), we obtain

$$\frac{d\theta^{\mathcal{F}}}{dD} = \frac{1}{2S'_{j,\theta}(\theta)} > 0 = \frac{d\theta^{\mathcal{S}}}{dD}, \quad (2.16)$$

(+)

where the latter equality follows from the fact that the cutoff  $\theta^{\mathcal{S}}$  is independent of discrimination.

Thus, when shifting the cutoff  $\theta^{\mathcal{F}}$  toward  $\theta^{\mathcal{S}}$  in Figure 2.2(iii), fewer and fewer female managers are subject to a negative skilled-biased competition effect,  $S'_{j,\theta}(\theta) < 0$ . Stronger discrimination will eventually eliminate the middle line in (2.15), such that wage discrimination - as measured by the difference in expected wage between male and female managers,  $\mathbb{E}[w_j^*|\theta \in \mathcal{F}] - \mathbb{E}[w_j^*|\theta \in \mathcal{M}]$  - must unambiguously decrease in competition, i.e.,  $\frac{d(\mathbb{E}[w_j^*|\theta \in \mathcal{F}] - \mathbb{E}[w_j^*|\theta \in \mathcal{M}])}{dC} > 0$ . Note that this effect results from the fact that a female manager's expected wage will unambiguously increase in competition due to (2.14), as stronger discrimination eliminates the first term as  $\theta^{\mathcal{F}}$  moves toward  $\theta^{\mathcal{S}}$ . Since male managers are not subject to discrimination, the impact of stronger competition on the wage of male managers in (2.15) remains ambiguous.<sup>20</sup>

### 2.5.2. The extensive margin

Proposition 2 shows that discrimination may lead female managers' wages to increase relative to those of male managers under increasing competition. This suggests that stronger competition should also make women more likely to choose the career path and pursue managerial work.

We have the following proposition:

**Proposition 3.** *If discrimination against female managers is sufficiently severe, i.e., if  $D$  is sufficiently high, an increase in the level of product market competition,  $C$ , will increase the probability that a firm has a female manager.*

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<sup>20</sup>If the investment cost,  $I$ , declines, while the cost of discrimination,  $D$ , increases, so as to reduce the threshold  $\theta^{\mathcal{M}}$  at an unchanged threshold  $\theta^{\mathcal{F}}$ , the region where a male manager's wage is unaffected by competition shrinks. This would increase the first term in (2.15) and strengthen our result that wage discrimination declines in competition.

To see this, suppose that a share  $\phi_{\mathcal{F}}$  of all firms are endowed with a female trainee, whereas a share  $1 - \phi_{\mathcal{F}}$  are endowed with a male trainee. Then, the probability that a firm will have a female manager is simply the cumulative probability that female trainees invest in firm-specific skills times the share of firms endowed with female trainees:

$$\text{Prob}_j[\theta \in \mathcal{F}] = [1 - G(\theta^{\mathcal{F}})] \times \phi_{\mathcal{F}}. \quad (2.17)$$

Differentiating (2.17) with respect to competition (or the expected competition that trainees in, stage 1, perceive to be present in stage 3), we then have

$$\frac{d\text{Prob}_j[\theta \in \mathcal{F}]}{dC} = -\phi_{\mathcal{F}} \times g(\theta^{\mathcal{F}}) \times \frac{d\theta^{\mathcal{F}}}{dC}. \quad (2.18)$$

We can now sign the change in the cutoff  $\theta^{\mathcal{F}}$  by differentiate the upper line (2.7) with respect to the intensity of competition,  $C$ , and talent,  $\theta$ ,

$$\frac{d\theta^{\mathcal{F}}}{dC} = -\frac{S'_{j,C}(\theta)}{S'_{j,\theta}(\theta)}. \quad (2.19)$$

(+)

From Lemma 2, we have that the surplus increases in competition if the manager has sufficiently high firm-specific skills,  $S'_{j,C}(\theta) > 0$  if  $\theta > \theta^S$ . From (2.16), we know that the minimum talent necessary to make an investment in firm-specific skills worthwhile for female trainees increases in discrimination,  $\frac{d\theta^{\mathcal{F}}}{dD} > 0$ . Thus, if discrimination is sufficiently severe, such that  $\theta^{\mathcal{F}} > \theta^S$  holds, the probability that a firm has a female manager increases in competition,  $\frac{d\text{Prob}_j[\theta \in \mathcal{F}]}{dC} > 0$ .<sup>21</sup>

**Discussion** We have assumed that only one trainee is assigned to each firm. It is also possible to allow for competition between male- and female trainees within the firm. We could think of a situation in which the firm contemplates replacing the existing male manager with a new female or male manager. If the female trainee faces discrimination, the skill-biased competition effect and the glass-ceiling effect will tend to disproportional increase the wage of the female manager in such a setting. The reason is that the female trainee, facing discrimination, needs to possess greater innate talent to be able to outcompete the male rival trainee<sup>22</sup>

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<sup>21</sup>Note however, that if  $\theta^M < \theta^{\mathcal{F}} < \theta^S$ , we could actually find that female participation as managers declines in competition since the marginal female trainee's relative wage compensation is declining in competition.

<sup>22</sup>To see this, note that the wage of the female manager will, in such an environment, be determined such that  $w_j^*(\theta \in \mathcal{F}) = w(0) + S_j(\theta) - \left(\frac{2\alpha-1}{2}\right) D$ , where  $S_j(\theta) = \frac{1}{2}(\pi_j(\theta) - \pi_j(\theta_M))$ , and where  $\theta_M$  is the existing

We have also assumed that a trainee cannot move between firms, i.e., the acquired managerial skill is highly firm-specific. What would happen if the management skills were more general? Introducing competition over potential managers would make the analysis more involved, but our skill-biased competition effect and the glass-ceiling effect will also be present in such a setting. We may then think of a bilateral bargaining framework in which the manager bargains with two firms. In such a setting, a manager having higher skills will increase the wage for two reasons. First, the reservation wage will increase since the outside wage offer will increase in skills. Second, the profit absent having the talented manager, will decrease for the firms. It then follows that increased product market competition will increase the difference between high skilled and less skilled managers (the skill-biased competition effect). Since female managers due to the glass-ceiling effect need a higher skill than male managers, female wages will gain on average increase more than will male managers' wages when the intensity of competition increases.<sup>23</sup>

### 3. Empirical Analysis

We now turn to the empirical analysis. We first describe the Swedish matched employer-employee data and provide some descriptive statistics. We then describe how we take the model's predictions to the data.

#### 3.1. The Swedish linked employer-employee data

To examine how product market competition affects discrimination, we will use detailed register-based, matched employer-employee data from Statistics Sweden (SCB). The database comprises firm, plant and individual data, linked with unique identification numbers and cover the period from 1990 to 2009. The firm data contain detailed information on all Swedish firms, including variables such as value added, capital stock (book value), number of employees, wages, ownership status, sales, and industry. Moreover, the Regional Labor Market Statistics (RAMS) provide plant-level information on education and demographics, which we aggregate to the firm level. RAMS include data on all Swedish plants. The data on individuals originate from Sweden's official wage statistics and contain detailed information on a representative sample of the labor force, including full-time equivalent wages, education, occupation, and gender.<sup>24</sup>

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male manager's skill level. The equilibrium wage will then have the properties described above.

<sup>23</sup>To formalize this argument, the bilateral bargaining approach adopted by Horn and Wolinsky (1988) might be suitable.

<sup>24</sup>The worker data originate from the Swedish annual salary survey (Lönestrukturstatistiken). The survey's sampling units consist of firms included in Statistics Sweden's firm data base (FS). A representative sample

All data sets are matched by unique identification codes. To make the sample of firms consistent across the time periods, we restrict our analysis to firms with at least 20 employees in the non-agricultural private sector, which are available throughout the period.

### 3.1.1. Relative wages and the share of women

Before presenting the econometric analysis, let us first briefly explore the main differences between men and women in the data. Panel A of Table 1 reports descriptive statistics at the firm level for the firms in our matched employer-employee data set over the period 1996-2009 (firms with at least 20 employees). For these firms, we have detailed information at the worker level on, e.g., education and occupation status, implying that we can calculate the share of women at the firm level with different occupations and education levels.

Panel A reveals a slight increase in the share of women over the period (comparing the two sub-periods 1996-2002 and 2003-2009). Approximately one-third of the workers are females. A number of additional interesting observations can be made from Panel A: The share of women with high education is higher than the total share of highly educated workers. Hence, women are, on average, more educated than males. The share of women with higher education also increases significantly over the period, from approximately 29 percent in 1996 to approximately 42 percent in 2009 (32 percent in the 1996-2002 period and 38 percent in the 2003-2009 period). Even more interesting is that the share of female managers shows a distinct increase: During the period 1996–2002 the average share of female managers was 16 percent. By the later period, 2003–2009, this share had increased to 21 percent. Nevertheless, the share of female managers remained considerably below the total share of women, 34 percent, in the latter period. Furthermore, only 13 percent of the firms had a female CEO during this period.

*Table 1*

Panel B adds descriptive statistics at the worker level. The panel illustrates that there are significant differences in the wages of male and female workers. During the period 1996-2002, a male worker had, on average, an approximately 16 percent higher wage than a women (the average monthly wage for a male was approximately SEK 20,300 per month, whereas the

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of firms is drawn from FS and stratified according to industry affiliation and firm size (number of employees). The sample size consists of between 8,000 and 11,000 firms. The Central Confederation of Private Employers then provides employee information to Statistics Sweden on all its member firms that have (i) at least ten employees and (ii) are included in the sample. Firms with at least 500 employees are examined with probability one. The final sample includes information on approximately 50 percent of all employees in the private sector and is representative of the Swedish labor force. See [www.scb.se](http://www.scb.se) for further details on the data.



corresponding wage for a women was SEK 17,500).<sup>25</sup> This wage difference declines somewhat during the later period, 2003–2009, where the wage advantage for men is approximately 15 percent.

One important and difficult question is of course what lies behind observed gender wage differences. One explanation is based on human capital theory, focusing on productivity differences and on gender differences in observed characteristics such as formal education and labor market experience. Another explanation is based on discrimination, where observed wage gaps are taken as evidence of gender discrimination in wages. This would be the case if the gap were to persist after controlling for a variety of characteristics that measure individual productivity. In terms of the explained and unexplained parts of the gender wage gap, the unexplained part is sometimes interpreted as evidence of discrimination, but it could of course also reflect unobserved heterogeneity.

Using comparable data across different countries, Weichselbaumer and Winter-Ebmer (2005) find a 50 percent decline in gender wage differentials from the 1960s to the 1990s. This change is mostly attributed to an increase in women’s productive characteristics during this period. However, they still find that men earn 25 percent more than women with the same observable characteristics and that this residual wage gap has remained fairly constant.

Blau and Kahn (2006) present micro data evidence on gender wage gaps in the US. Using data from the Panel Study of Income Dynamics (PSID), they report a 20.3 percent raw wage differential between male and females in 1998. A decomposition shows that the unexplained part of the gender difference is equal to 41 percent, whereas the remaining part is due to various observables such as education, labor market experience, occupation and industry affiliation. Taken together, the results indicate that if females had the same characteristics as males and worked in the “same” firms, then the “adjusted” wage gap would be 9 percent.

To see how observed and unobserved characteristics influence gender wage gaps in Sweden, we examine whether the wage difference between male and female workers is due to factors such as education, work experience, occupation and firm or industry characteristics. We run the following regression:

$$\log(w_{ijt}) = \gamma_0 + \gamma_1 \cdot \text{wom} + \mathbf{X}'\boldsymbol{\gamma} + \mathbf{Z}'\boldsymbol{\lambda} + \theta_t + \vartheta_h + \varepsilon_{ijt} \quad (3.1)$$

where  $\log(w_{ijt})$  is the log wage of worker  $i$  in firm  $j$  at time  $t$ ,  $\mathbf{X}$  is a vector of observable time-varying worker characteristics,  $\mathbf{Z}$  is a vector of observable time-varying firm characteristics,  $\theta_t$  is an year fixed effect,  $\vartheta_h$  is an industry fixed effect, and  $\varepsilon_{ijt}$  is the error term. Our main interest is in the estimated coefficient on  $\gamma_1$ , which gives us the percentage difference in

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<sup>25</sup>Wages are expressed as full-time equivalent monthly wages (in 1995 prices).

wages for female and male workers

The dependent variable is measured as full-time equivalent wages. Time-varying worker characteristics include experience, experience squared, and dummy variables for educational attainment and occupation. Turning our attention to the firm, time-varying characteristics include capital intensity, firm size (number of employees), and the share of high-skill workers (i.e., the share of the labor force with at least 3 years of post-secondary education).

The results from the individual wage regressions for the period 1996–2009 are presented in Table 2. Column 1 reports results for the estimated gender wage gap when only year fixed effects are included. We then add different controls. Inspecting the various specifications reported in Table 2a reveals that adding detailed controls only reduces the wage differential from approximately 15 percent to slightly below 10 percent ( $\hat{\gamma}_1 \approx -0.147$  in column one, while  $\hat{\gamma}_1 \approx -0.094$  in column six in Table 2). Similar results are also found in Table 2b where we analyze different managerial positions. For all types of managerial positions we find large and significant estimated gender wage gaps that persist after controlling for a variety of firm and individual characteristics.

*Table 2a and 2b*

Recent studies have shown that even with more detailed information on individuals (extracted from siblings, using information from military test scores, etc.), one will still fail to reject  $\gamma_1 < 0$ .<sup>26</sup> Is this remaining wage difference then due to discrimination against women? While possible, one cannot - in general - rule out that the any remaining wage difference is explained by omitted variables reflecting individual heterogeneity. Indeed, the fundamental problem in all studies that attempt to identify discrimination against women from the estimates of different versions of Equation (3.1) is that individual fixed effects cannot be used.

We will circumvent this problem using our theoretical framework. In particular, we will make use of Proposition 2, which states that under significant discrimination, the expected wage of female managers should increase relative to that of male managers, that is, when there is discrimination against women in top managerial work, increased product market competition should reduce wage discrimination against female managers. As we will see below, the fact that we estimate changes in wages separately for male and females allows us to control for individual fixed effects.

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<sup>26</sup>See, e.g., a recent study by Keloharju et al. (2016) using very detailed Swedish data. See also Albrecht et al. (2015), who analyze glass ceiling effects in Sweden using detailed micro data. They report a narrowing of the gender gap during the period from 1998 to 2008, but that there is still a distinct glass ceiling phenomenon for white-collar workers in 2008.

### 3.1.2. Estimating the level of competition

The explanatory variable that we are mainly interested in is product market competition. Measuring product market competition is no easy task. The level of product market competition is affected by the number of firms in the market, the degree of product differentiation, the level of tacit or explicit collusion between firms, and whether firms compete in prices or quantities. The empirical literature has attempted to measure competition using aggregate measures such as the Herfindahl index, or the aggregate market share of the largest firms in the industry. These measures have been subject to substantive criticism. For instance, an industry with two firms may be very competitive if the two firms are competing intensely in prices. However, an industry with ten firms may exhibit little competition if firms sell products that consumers do not perceive to be close substitutes or if the firms collude.

We will use a relatively new measure of product market competition developed by Boone (2008a,b). It has been used extensively in the finance literature, and it is produced by the World Bank as a measure of banking competition.<sup>27</sup> Boone's measure of competition focuses on how firm profits react to changes in marginal cost, positing that in a more competitive industry, firms should, on average, react more negatively to shocks to own costs. Boone's profit elasticity is estimated in each industry  $r$  and year  $t$  from the following firm-level regression:

$$\log(\pi_{jt}) = \mu_j + \mu_t + C_{rt} \times \log(AC_{jt}) + \varepsilon_{jt}, \quad (3.2)$$

where  $\pi_{jt}$  is the profit of firm  $j$  in industry  $r$  in year  $t$ . Profits are measured as the log of value added net of the firm's wage bill. Ideally, we would use the log of a firm's marginal cost as a regressor to obtain the profit elasticity with respect to costs,  $C_{rt}$ . However, due to the problem of isolating marginal costs in accounting data, we will need to use average variable cost (measured as a firm's total wage bill plus the cost of materials as a share of total sales). We also control for unobserved heterogeneity by adding firm-specific effects,  $\mu_j$ , and time-specific effects,  $\mu_t$ . Note that a higher estimated elasticity (higher absolute value),  $C_{rt}$ , indicates that the industry is characterized by a higher degree of competition.

### 3.1.3. Product market competition and the wage of female workers

Proposition 2(i) posits that if discrimination is sufficiently severe, female managers should, on average, experience an increase in their wages if competition increases (i.e.,  $\frac{dE[w_j^*|\theta \in \mathcal{F}]}{dC} > 0$  in Equation 2.13). We can test this prediction by estimating the following regression on female workers' wages that explicitly controls for characteristics that are common to the worker and

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<sup>27</sup>See <http://www.worldbank.org/en/publication/gfdr/background/banking-competition>. See also Heyman et al. (2013) for another study that uses the Boone measure of product market competition.

the firm:

$$\log w_{ijt}(i \in \mathcal{F}) = \alpha_{\mathcal{F}} + \beta_{\mathcal{F}} \hat{C}_{rt} + \varsigma_{ij} + \varsigma_t + \mathbf{X}' \gamma_{\mathcal{F}} + \varepsilon_{ijt}, \quad (3.3)$$

where  $\log w_{ijt}(i \in \mathcal{F})$  is log monthly wage of a female worker  $i$  in firm  $j$  in year  $t$ .  $\varsigma_{ij}$  is a "spell" fixed effect for each unique firm-individual combination, which implies that we are following a female worker employed at the same firm over time. The spell fixed effect is a time-invariant unobservable component of each unique employer-employee combination. This approach allows us to control for both unobserved individual- and firm-specific factors.  $\varsigma_t$  is a time-specific effect. Note that we are interested in how an increase in competition, as measured by the estimated Boone elasticity,  $\hat{C}_{rt}$ , affects the wage through the estimated coefficient  $\beta_{\mathcal{F}}$ . Equation (3.3) also includes a vector,  $\mathbf{X}$ , of time-varying firm characteristics as controls, such as firm size, capital intensity, and the share of skilled workers. Finally, we also control for (squared) worker experience.<sup>28</sup>

#### 3.1.4. Product market competition and the wage of male workers

As male workers are not subject to discrimination, Proposition 2(ii) shows that the impact of competition on male managers' wages is ambiguous (i.e.,  $\frac{d\mathbb{E}[w_j^*|\theta \in \mathcal{M}]}{dC} \gtrless 0$  in Equation 2.13). However, Proposition 2(iii) posits that when severe discrimination is present, female managers' wages should increase relative to those of male managers (i.e.,  $\frac{d(\mathbb{E}[w_j^*|\theta \in \mathcal{F}] - \mathbb{E}[w_j^*|\theta \in \mathcal{M}])}{dC} > 0$  in Equation 2.15).

To test these hypotheses, we also estimate the corresponding wage equation for male workers:

$$\log w_{ijt}(i \in \mathcal{M}) = \alpha_{\mathcal{M}} + \beta_{\mathcal{M}} \hat{C}_{rt} + \varsigma_{ij} + \varsigma_t + \mathbf{X}' \gamma_{\mathcal{M}} + \varepsilon_{ijt}. \quad (3.4)$$

Due to the glass ceiling effect of discrimination, female managers need greater inherent talent to invest in firm-specific skills and take up the job as manager. Since only the top managers will be able to reap the benefit from stronger competition in terms of a higher salary from the skill-biased competition effect, we would expect that  $\beta_{\mathcal{F}} = \frac{d\mathbb{E}[w_j^*|\theta \in \mathcal{F}]}{dC} > 0$  and  $\beta_{\mathcal{F}} > \beta_{\mathcal{M}} = \frac{d\mathbb{E}[w_j^*|\theta \in \mathcal{M}]}{dC}$  if strong discrimination against women is present.

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<sup>28</sup>Note that education is essentially time invariant and is therefore subsumed in the worker-firm fixed effects. Experience is constructed as age minus the number of years of schooling minus seven. Because the years of schooling rarely change in the sample, when both spell and year fixed effects are included, experience varies directly with the year fixed effects, that is, the impact of experience on wages is captured by the year fixed effects. Therefore, experience is excluded from the regression equation.

### 3.1.5. Product market competition and hiring female managers

If female managers see their wages increase in competition,  $\beta_{\mathcal{F}} > 0$ , this should also encourage more female workers to invest in firm-specific skills to pursue a career as a manager. Indeed, this is predicted by Proposition 3, which we will test by estimating the following firm-level regression:

$$share_{it} = \nu_{\mathcal{M}} + \nu_{\mathcal{M}}\hat{C}_{rt} + \varsigma_i + \varsigma_t + \mathbf{X}'\boldsymbol{\gamma} + \varepsilon_{it}, \quad (3.5)$$

where  $share_{it}$  is the share of female managers in firm  $i$  in year  $t$ . The main explanatory variable of interest is product market competition ( $C_{rt}$ ), where we expect  $\nu_{\mathcal{M}} > 0$  under strong discrimination. We also include a vector,  $\mathbf{X}$ , of time-varying firm characteristics (identical to that used above). All of the estimations also include firm fixed effects,  $\varsigma_t$ , to control for unobserved firm heterogeneity and year fixed effects,  $\varsigma_i$ , that control for common macro-level shocks. Finally,  $\varepsilon_{it}$ , is the error term.

## 3.2. Results

### 3.2.1. The intensive margin: Wages

Table 3 shows the results from separately estimating (3.3) and (3.4). The two first columns report the estimates using all individuals in the data, irrespective of occupation. These regressions are based on over 8 million individual-year observations, consisting of over 2 million individual-firm pairs ("spells"). From these specifications, we find that the Boone elasticity, measuring the level of competition, is statistically insignificant. This is the case for both men and women. This is also what is to be expected. For the vast majority of individuals, the level of competition in the industry in which they are employed should have no effect on their wage since their wages are determined in a nation-wide competitive labor market. This is further validated in columns three and four, which report the results for individuals who are not managers.

*Table 3*

Columns (5)-(10) present the results for employees holding different management positions. Here, we find interesting gender differences. Columns five and six are estimated on all types of managerial positions, comparing men and women. The results reveal a clear difference in the impact of stronger competition on wages for male and female managers. When product market competition increases through an increase in the Boone elasticity, this leads to a statistically significant increase in the wage of female managers,  $\hat{\beta}_{\mathcal{F}} > 0$ , whereas

we cannot reject the null hypothesis of no effect of competition on male managers' wages,  $\hat{\beta}_{\mathcal{M}} = 0$ .

These estimates give strong support to the predictions of Proposition 2: Due to the glass ceiling effect of discrimination, female workers need greater innate talent than male workers to invest in firm-specific skills and take a job as a manager. Since only top managers will be able to reap the benefits from stronger competition through the skill-biased competition effect, female managers are then more likely to see their wages increase when competition increases, which is confirmed in the estimates. Further support for the asymmetry between male and female managers is given in columns seven and eight, which repeat the estimation for managers below the CEO level, while columns nine and ten depict the results for CEOs. Interestingly, the impact of competition on female managers' wages is the strongest for the highest positions in the firm. The size of the estimated effect is twice as large for CEOs as for lower managerial positions.

In Table 4, we re-estimate Equations (3.3) and (3.4) for different size classes of firms. This does not qualitatively change the results. We do however find that it is primarily at the CEO level that the differences persist. Again, this is consistent with our proposed model, which stresses that the selection or glass ceiling effect may be more impactful for women in top positions.

*Table 4*

In Table 5, we use an alternative measure of competition, namely European Union (EU) import tariffs. One potential critique of the Boone measure of competition is endogeneity. There may be other factors that change over time and are correlated with the Boone measure but have little to do with competition. While our estimates are solidly grounded in theory, such concomitant changes jeopardize the causal interpretation of the estimates. One may then argue that lower import tariffs should lead to increased competition and, therefore, that the variation in import tariffs could serve the same role as the Boone elasticity while offering the advantage of that it seems less associated with endogeneity problems. The main advantage of using tariffs is that they can be considered as exogenous after 1995, when Sweden joined the European Union. It is unlikely that a small country such as Sweden has a substantial impact on the level of tariffs set by the EU. In addition, tariffs set at the EU level are not affected by conditions in Swedish industries. We aggregate the six-digit HS tariff data from the UNCTAD TRAINS database up to the three-digit level of SNI (the Swedish Industrial Classification) using trade shares as weights.<sup>29</sup> Specifically, to construct

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<sup>29</sup>SNI roughly corresponds to Standard Industrial Classification (SIC).

the industry-level import tariffs, the shares of Swedish imports in 1996 (the first year in the sample) are used as weights. We note that import tariffs were reduced over the sample period and that tariff reductions vary across industries. The tariff data are only available for the manufacturing sector.

Starting with regressions on all employees, independent of occupation, (columns 1-2) and on all non-managers (columns 3-4), we find no effect of competition and no gender differences. These results are in accordance with the results in Table 3. Similar results are found for employees with lower-level management positions and in estimations in which we pool all managers (columns 5-8). These results differ from those of the corresponding specifications in Table 4.

Continuing with the impact on CEOs, columns 9-10 reveal that the asymmetry between males and females remains for CEOs, where higher import tariffs (worsening competition) lead to a reduction in the wages of female CEOs. Again, for male CEOs, there is no statistically significant effect of import tariffs on their wages.

*Table 5*

### **3.2.2. The extensive margin: hiring**

The results thus far are in accordance with female employees being discriminated against at the top positions in firms. This discrimination is identified by the fact that the variation in product market competition differently affects female and male managers: The expected wage of a female manager increases in competition, whereas the expected wage of a male manager is not affected by competition. Our theoretical framework explains this differential impact of competition through the glass ceiling effect, which implies that costly discrimination only allows the most talented women to become managers, and the skill-biased competition effect, which posits that it is only the most talented managers who are able to take advantage of increased product market competition (extracting a surplus from increased competition).

If the combination of the glass ceiling effect and the skill-biased competition effect generates higher wages for female managers when competition increases, then the comparative statics results in Proposition 3 suggest that increased competition may also lead to an increasing share of firms with female managers and CEOs. We argue above that we can test this by estimating Equation 3.5. The results are presented in Table 6.

*Table 6*

The results in column 1 of Table 6 show that there is no effect on the overall share of women in a firm, although there seems to be a positive and significant effect on the share of women, excluding managers, as seen in column two. However, as shown in column 7, where we control for the share of women at the industry level, this result seems to be partly driven by industries having inherent differences in the share of women.

Regarding the results on the share of female managers, the share of non-CEO managers or whether the firm has a female CEO, we obtain consistent evidence that an increase in product market competition is associated with a larger presence of female executives, as predicted by the theory. Similar to our results above on individual wages, the results are strongest for CEOs (columns 5 and 10).

## 4. Conclusion

In this paper, we have proposed a model of discrimination with hierarchically differentiated jobs. We have shown that increased product market competition can mitigate discriminatory behavior, even in environments where all employers are discriminators. When the group that is discriminated against possesses sufficiently valuable talents, as experts and managers do, severe discrimination will then be too costly for employers. Hiring and wages will then increase for groups discriminated against in top-level jobs when the intensity of product market increases.

Our main empirical result is that increasing product market competition is associated with a narrowing gender wage gap for employees in different managerial positions. This result is in accordance with the theoretical model and lends support to a glass ceiling effect of discrimination, whereby female workers need greater innate talent than male workers to invest in firm-specific skills and to take a job as a manager. Since only top executives will be able to reap the benefit of stronger competition, female managers are then more likely to see their wages increase than male managers, when competition increases, which is also confirmed in our results. Our default measure of competition is based on research by Boone (2008a,b) and analyzes the response of firms' within-industry profits to changes in marginal costs. An industry in which the elasticity of profits to costs is high is considered competitive according to this measure. As a robustness check, we also use changes in import tariffs as a measure of product market competition and find similar results.

We also find evidence for higher shares of female executives (again for both non-CEO managers and CEOs) in firms in industries in which product market competition increases. This can be explained from the skill-biased competition effect and the glass-ceiling effect: It is only the most talented managers who are able to take advantage of increased product



market competition, while discrimination implies that only the most talented women can become managers (while male managers can be of any talent). The skill-biased competition effect and glass-ceiling effect also explain our main finding of a narrowing wage gap, driven by female managers' wages increasing in product market competition, and male managers' wages being unaffected by changes in product market competition.

Our findings suggest that increased product market competition can work as a (imperfect) substitute for other policies intended to remove discriminatory barriers. One advantage of increased product market competition is that it both mitigates discrimination behavior and induces the most talented individuals from the group being discriminated against to pursue investment in their careers. A potential problem with, for example, quotas is that it benefits all members of the group that is subject to discrimination, both the talented and the less talented, and might thus entail inefficiencies. Extending the theoretical exercise to a welfare analysis of different policies finally seems as a fruitful avenue for future research.

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## Tables

**Table 1. Descriptive statistics**

Source	Variable	All years (1996–2013)		1996–2002		2003–2009	
		Mean	SD	Mean	SD	Mean	SD
A. Firms Position	Share of women	0.33	0.23	0.32	0.23	0.34	0.24
	Share high-edu.: women	0.36	0.29	0.32	-0.29	0.38	0.29
	Share medium-edu.: women	0.33	0.25	0.33	0.24	0.34	0.25
	Share low-edu.: women	0.33	0.3	0.34	0.3	0.33	0.31
	Share female managers	0.19	0.25	0.16	0.23	0.21	0.26
	Share female CEOs	0.12	0.28	0.09	0.25	0.13	0.29
	Competition	4.24	1.41	4.28	1.45	4.19	1.38
	Number of employees	326	1161	342	1260	312	1071
	Capital intensity	0.98	0.43	1	4.31	0.97	4.37
	Share high-skilled	0.25	0.23	0.22	0.21	0.28	0.24
	Age	40.78	5.19	40.26	5.1	41.22	5.23
	Number of observations	41,183		18,852		22,331	
B. Individual level	Wage (in logs)	9.94	0.33	9.87	0.31	10.02	0.33
	Wage (in logs): women	9.85	0.29	9.77	0.26	9.93	0.29
	Wage (in logs): men	10	0.34	9.92	0.32	10.07	0.34
	Work experience	22.56	12.58	22.47	12.44	22.64	12.71
	Number of observations	1,298,218		6,216,633		6,765,556	

Notes: Share high-edu.: women is share of women with least three years of university studies, Share medium-edu.: women is share of women with at least upper secondary school and Share low-edu.: women is share of women with at least compulsory school. Competition is based on Boone measure (see Section 3 for details), Capital intensity is Capital stock/Number of employees, Firm size is number of employees and Share skill high is share of the labor force with at least 3 years of post-secondary education. Firm level statistics on workers education stem from aggregated plant level data on education. Data on individual workers' education stem from individual register data on education. Wages at the worker level are gross real monthly full-time-equivalent wages (in 1995 SEK).

**Table 2a. Gender differences in wages, 1996-2009 (all employees)**

	1	2	3	4	5	6
=1 if female	-0.147*** (0.006)	-0.156*** (0.005)	-0.144*** (0.005)	-0.105*** (0.005)	-0.092*** (0.004)	-0.094*** (0.004)
=1 if finished 9 years of primary school		0.013*** (0.004)	0.041*** (0.005)	0.015*** (0.003)	0.017*** (0.003)	0.016*** (0.002)
=1 if 2 years of secondary school		0.058*** (0.007)	0.075*** (0.010)	0.028*** (0.004)	0.031*** (0.004)	0.027*** (0.003)
=1 if 3 years of secondary school		0.110*** (0.012)	0.218*** (0.012)	0.092*** (0.005)	0.093*** (0.004)	0.087*** (0.004)
=1 if 4 years of secondary school		0.227*** (0.013)	0.281*** (0.011)	0.103*** (0.007)	0.115*** (0.005)	0.097*** (0.005)
=1 if college degree		0.430*** (0.015)	0.518*** (0.014)	0.241*** (0.009)	0.248*** (0.007)	0.229*** (0.007)
=1 if doctoral degree		0.683*** (0.026)	0.767*** (0.025)	0.436*** (0.022)	0.431*** (0.015)	0.407*** (0.016)
Experience			0.026*** (0.001)	0.018*** (0.001)	0.017*** (0.001)	0.017*** (0.001)
Experience/100^2			-0.040*** (0.002)	-0.028*** (0.001)	-0.026*** (0.001)	-0.026*** (0.001)
Capital intensity						0.001 (0.001)
Log firm size						0.003 (0.002)
Share skill high						0.191*** (0.030)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Occupation fixed effects	No	No	No	Yes	Yes	Yes
Industry fixed effects	No	No	No	No	Yes	Yes
R <sup>2</sup>	0.12	0.30	0.40	0.56	0.59	0.60
No. of obs.	12,982,189	12,901,343	12,901,343	12,604,820	12,558,919	12,558,918

Notes: Dependent variable is log full-time equivalent wages. Capital intensity is Capital stock/Number of employees, Firm size is number of employees, Share skill high is share of the labor force with at least 3 years of post-secondary education. Standard errors are clustered at the individual level. \*\*\*, \*\*, \* show significance at the 1%, 5%, and 10% level, respectively.

**Table 2b. Gender differences in wages, 1996-2009 (executive positions)**

	Type of position					
	All managerial		Managerial below CEO		CEOs only	
=1 if female	-0.167*** (0.002)	-0.148*** (0.002)	-0.125*** (0.002)	-0.127*** (0.002)	-0.454*** (0.007)	-0.219*** (0.005)
=1 if finished 9 years of primary school		0.050*** (0.005)		0.041*** (0.005)		0.058*** (0.015)
=1 if 2 years of secondary school		0.078*** (0.004)		0.065*** (0.004)		0.094*** (0.014)
=1 if 3 years of secondary school		0.239*** (0.004)		0.211*** (0.004)		0.300*** (0.015)
=1 if 4 years of secondary school		0.296*** (0.005)		0.259*** (0.005)		0.353*** (0.017)
=1 if college degree		0.555*** (0.005)		0.486*** (0.004)		0.665*** (0.016)
=1 if doctoral degree		0.678*** (0.009)		0.612*** (0.008)		0.795*** (0.028)
Experience		0.043*** (0.000)		0.039*** (0.000)		0.048*** (0.001)
Experience/100 <sup>2</sup>		-0.064*** (0.001)		-0.059*** (0.001)		-0.069*** (0.002)
Capital intensity		0.005*** (0.000)		0.005*** (0.000)		0.001* (0.001)
Log firm size		-0.008*** (0.000)		-0.002*** (0.000)		-0.007*** (0.002)
Share skill high		0.383*** (0.006)		0.381*** (0.006)		0.478*** (0.019)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Occupation fixed effects	No	Yes	No	Yes	No	Yes
Industry fixed effects	No	Yes	No	Yes	No	Yes
No. of obs.	794,298	794,298	692,707	692,707	101,591	101,591
R <sup>2</sup>	0.13	0.47	0.17	0.49	0.12	0.54

Notes: Dependent variable is log full-time equivalent wages. Capital intensity is Capital stock/Number of employees, Firm size is number of employees, Share skill high is share of the labor force with at least 3 years of post-secondary education. Standard errors are clustered at the individual level. \*\*\*, \*\*, \* show significance at the 1%, 5%, and 10% level, respectively.

**Table 3. Product market competition (Boone) and relative wages: Individual-level estimates by gender 1996-2009**

	Type of position									
	All		Non-managerial		All managerial		Managerial below CEO		CEOs only	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Competition	0.148 (0.155)	0.159 (0.179)	0.159 (0.151)	0.157 (0.191)	0.147 (0.110)	0.499** (0.222)	0.099 (0.111)	0.342* (0.198)	0.302 (0.274)	0.707*** (0.241)
Experience/100^2	-0.035*** (0.000)	-0.031*** (0.000)	-0.033*** (0.000)	-0.029*** (0.000)	-0.064*** (0.000)	-0.046*** (0.000)	-0.064*** (0.000)	-0.049*** (0.000)	-0.047*** (0.000)	-0.026*** (0.000)
Capital intensity	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.001 (0.002)
Log firm size	0.005 (0.006)	-0.000 (0.003)	0.005 (0.006)	-0.001 (0.003)	0.002 (0.004)	0.004*** (0.001)	0.001 (0.004)	0.005*** (0.001)	0.017 (0.010)	0.012** (0.005)
Share skill high	0.117** (0.055)	0.111*** (0.036)	0.091* (0.049)	0.091*** (0.033)	0.060** (0.023)	0.066** (0.031)	0.048** (0.022)	0.085*** (0.031)	0.223*** (0.042)	0.046 (0.064)
R <sup>2</sup>	0.40	0.43	0.37	0.42	0.49	0.47	0.51	0.49	0.29	0.28
No. spells	2,275,488	1,451,939	2,111,681	1,388,023	201,468	59,595	180,077	51,881	31,469	11,256
No. obs.	8,258,078	4,596,236	7,434,113	4,329,862	632,687	161,574	556,838	135,835	75,849	25,739

Notes: Dependent variable is log full-time equivalent wages. Competition is based on Boone measure (see Section 3 for details). Capital intensity is Capital stock/Number of employees. Firm size is number of employees, Share skill high is share of the labor force with at least 3 years of post-secondary education. Standard errors are clustered by industry. \*\*\*, \*\*, \* show significance at the 1%, 5%, and 10% level, respectively.

**Table 4. Product market competition (Boone) and relative wages: Individual-level estimates by gender and firm size 1996-2009**

	Type of position and firm size group																	
	All managerial, 50+		All managerial, 100+		All managerial, 250+		Managerial below CEO, 50+		Managerial below CEO, 100+		Managerial below CEO, 250+		CEOs only, 50+		CEOs only, 100+		CEOs only, 250+	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Competition	0.150 (0.112)	0.498** (0.228)	0.140 (0.119)	0.504** (0.237)	0.148 (0.135)	0.542** (0.267)	0.099 (0.113)	0.348* (0.203)	0.084 (0.120)	0.343 (0.208)	0.076 (0.136)	0.353 (0.239)	0.308 (0.293)	0.689*** (0.245)	0.277 (0.289)	0.657** (0.269)	0.295 (0.333)	0.727** (0.291)
Experience/ 100^2	-0.064*** (0.000)	-0.046*** (0.000)	-0.065*** (0.000)	-0.046*** (0.000)	-0.066*** (0.000)	-0.047*** (0.000)	-0.064*** (0.000)	-0.049*** (0.000)	-0.065*** (0.000)	-0.049*** (0.000)	-0.066*** (0.000)	-0.050*** (0.000)	-0.049*** (0.000)	-0.026*** (0.000)	-0.048*** (0.000)	-0.026*** (0.000)	-0.046*** (0.000)	-0.027*** (0.000)
Capital int.	0.000 (0.001)	0.000 (0.001)	0.001 (0.002)	0.001 (0.002)	0.001 (0.002)	0.001 (0.002)	0.000 (0.001)	0.000 (0.001)	0.001 (0.002)	0.000 (0.002)	0.001 (0.003)	0.000 (0.002)	0.001 (0.001)	0.002 (0.003)	0.003 (0.002)	0.003 (0.003)	0.002 (0.002)	0.001 (0.003)
Log firm size	0.001 (0.004)	0.004*** (0.001)	0.005 (0.012)	0.003 (0.006)	0.002 (0.014)	0.003 (0.006)	0.000 (0.004)	0.005*** (0.001)	0.003 (0.013)	0.006 (0.005)	0.000 (0.014)	0.004 (0.006)	0.013 (0.009)	0.011*** (0.004)	0.027 (0.019)	0.011 (0.011)	0.017 (0.021)	0.009 (0.011)
Share skill high	0.076*** (0.027)	0.081** (0.035)	0.074** (0.035)	0.103** (0.042)	0.069* (0.040)	0.128*** (0.042)	0.060** (0.025)	0.099*** (0.035)	0.057* (0.030)	0.113** (0.043)	0.048 (0.035)	0.117** (0.044)	0.303*** (0.052)	0.075 (0.065)	0.367*** (0.061)	0.097 (0.087)	0.408*** (0.077)	0.157** (0.069)
R <sup>2</sup>	0.496	0.469	0.504	0.470	0.513	0.475	0.515	0.487	0.521	0.487	0.530	0.491	0.299	0.284	0.306	0.283	0.310	0.287
No. spells	191,006	56,802	173,805	52,116	148,827	45,091	172,199	49,572	157,662	45,500	135,389	39,415	28,358	10,623	24,895	9,823	21,149	8,401
No. obs.	608,729	155,560	561,052	144,072	490,081	126,977	539,204	130,984	499,484	121,052	437,460	106,686	69,525	24,576	61,568	23,020	52,621	20,291

Notes: Dependent variable is log full-time equivalent wages. Competition is based on Boone measure (see Section 3 for details). Capital intensity is Capital stock/Number of employees, Firm size is number of employees, Share skill high is share of the labor force with at least 3 years of post-secondary education. Standard errors are clustered by industry. \*\*\*, \*\*, \* show significance at the 1%, 5%, and 10% level, respectively.



**Table 5. Product market competition (import tariffs) and relative wages: Individual-level estimates by gender 1996-2009**

	Type of position									
	All		Non-managerial		All managerial		Managerial below CEO		CEOs only	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Competition	-0.001 (0.018)	0.002 (0.011)	0.005 (0.015)	0.006 (0.009)	-0.002 (0.009)	-0.005 (0.012)	0.001 (0.008)	0.001 (0.011)	-0.005 (0.019)	-0.111** (0.051)
Experience/ 100 <sup>2</sup>	-0.029*** (0.000)	-0.029*** (0.000)	-0.027*** (0.000)	-0.026*** (0.000)	-0.061*** (0.000)	-0.052*** (0.000)	-0.059*** (0.000)	-0.051*** (0.000)	-0.067*** (0.000)	-0.070*** (0.000)
Capital intensity	0.004*** (0.001)	0.004*** (0.001)	0.004*** (0.001)	0.004*** (0.001)	0.005*** (0.001)	0.003*** (0.001)	0.005*** (0.001)	0.003*** (0.001)	0.003* (0.001)	0.003 (0.002)
Log firm size	0.032*** (0.007)	0.022*** (0.004)	0.032*** (0.008)	0.021*** (0.004)	0.013* (0.008)	0.008 (0.005)	0.015** (0.007)	0.009* (0.005)	0.013 (0.018)	0.025 (0.025)
Share skill high	0.164* (0.084)	0.160*** (0.056)	0.119* (0.069)	0.122*** (0.035)	0.034 (0.024)	0.040 (0.037)	0.033 (0.023)	0.040 (0.032)	0.125* (0.061)	0.141 (0.169)
R <sup>2</sup>	0.41	0.47	0.39	0.46	0.50	0.52	0.52	0.53	0.34	0.37
No. spells	990,316	393,662	911,852	372,479	90,739	16,271	82,028	14,837	13,018	2,154
No. obs.	4,232,266	1,502,356	3,799,480	1,404,535	307,125	46,820	274,652	42,211	32,473	4,609

Notes: Dependent variable is log full-time equivalent wages. Competition is based on import tariffs (see Section 3 for details). Capital intensity is Capital stock/Number of employees, Firm size is number of employees, Share skill high is share of the labor force with at least 3 years of post-secondary education. Standard errors are clustered by industry. \*\*\*, \*\*, \* show significance at the 1%, 5%, and 10% level, respectively.

**Table 6. Product market competition (Boone) and share of female employees. All employees: firm level estimates 1996-2009**

	Type of position									
	All	Non-managerial	All managerial	Managerial below CEO	CEOs only	All	Non-managerial	All managerial	Managerial below CEO	CEOs only
Competition	0.034 (0.043)	0.157** (0.072)	0.359** (0.168)	0.281* (0.155)	0.748*** (0.195)	-0.007 (0.040)	0.124* (0.070)	0.323* (0.169)	0.257* (0.152)	0.719*** (0.194)
Log firm size	0.002 (0.002)	-0.001 (0.002)	0.005 (0.003)	0.003 (0.004)	0.017** (0.007)	0.002 (0.002)	-0.001 (0.002)	0.005 (0.003)	0.002 (0.004)	0.016** (0.007)
Capital intensity	-0.000 (0.001)	0.000 (0.001)	0.000 (0.000)	-0.001 (0.001)	0.000 (0.001)	-0.000 (0.001)	0.000 (0.001)	0.000 (0.000)	-0.001 (0.001)	0.000 (0.001)
Share skill high	0.010 (0.019)	0.019 (0.023)	0.043 (0.039)	0.079* (0.046)	-0.024 (0.047)	0.009 (0.019)	0.015 (0.023)	0.039 (0.040)	0.076 (0.046)	-0.030 (0.049)
Share skill high (industry level)						0.078*** (0.009)	0.111*** (0.020)	0.117** (0.048)	0.081* (0.046)	0.164** (0.065)
No. of obs.	191,502	40,983	35,806	33,022	23,578	191,502	40,983	35,806	33,022	23,578
R <sup>2</sup>	0.005	0.007	0.034	0.030	0.012	0.007	0.013	0.035	0.031	0.012

Notes: Dependent variable is share of females. Competition is based on Boone measure (see Section 3 for details). Capital intensity is Capital stock/Number of employees, Firm size is number of employees, Share skill high is share of the labor force with at least 3 years of post-secondary education. Standard errors are clustered by industry. \*\*\*, \*\*, \* show significance at the 1%, 5%, and 10% level, respectively.