A tradable employment quota

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Abstract

Discrimination of women in the labor market requires appropriate policy interventions. Affirmative action policies typically advocate the introduction of an employment quota uniformly applied to all firms. In a heterogeneous labor market such a policy may yield avoidable welfare losses. We propose a tradable employment quota showing its effects on wages, employment and welfare in a labor market with search frictions and taste discrimination. A tradable employment quota occurs to be a viable alternative yielding superior labor market outcomes.

Keywords: tradable employment quota, agent-based model, affirmative action policies, taste discrimination, labor market, search and matching

JEL-Classification: J71, J78, C63

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1 Introduction

Affirmative action policies very often take the form of employment quotas. Norway introduced a quota in 2003, and France, Iceland, and Spain have mandatory boardroom gender quotas forcing firms to have boards with 40% women by the years 2017, 2013, and 2015, respectively. Only recently, the European Parliament passed a proposal by the European Commission to break the glass ceiling. According to this envisaged bill, European firms have to appoint female directors in order to make supervisory boards two-fifths female by 2020.\(^1\)

As it is very likely that a uniform employment quota imposes larger adjustment costs on some firms than on others the question arises whether the goal of paving the way for more female employment can be achieved at lower costs. In particular, as the size of women’s labor supply is heterogeneous across occupations, sectors, and regions, some of the firms forced to fulfill a fixed quota will find it more difficult to hire women who match the vacancies than others. A more flexible instrument is called for that does not compromise on the overall goal of achieving a certain share of female employment. Such an instrument should allow firms to fall short of the quota if costs of compliance would become unreasonable, while allowing others to gain from employing relatively more women.

In this article we propose and analyze the labor market effects of a tradable employment quota. Borrowing from the experience with environmental regulation policies to combat excessive carbon dioxide emissions, we suggest to implement a mechanism that efficiently achieves a fixed share of women working in relation to men. The idea is to issue permits to firms that give them the right to employ men and make these permits tradable. With such an affirmative action policy firms would only be allowed to employ men up to a number that matches the stock of permits that they hold. As a particular firm would want to employ an additional man it would only be able to do so by purchasing an additional employment right. Firms being in excess of permits because they find it more profitable to employ a woman than to hold one of the permits will want to sell this right. Trading of permits between those firms that want to buy and those firms willing to sell would yield a market price of a permit reflecting the profitability of employing an additional man. While the overall supply of permits of an issuing body would determine the share of female employment in the economy, single firms could adjust more flexibly and still comply.

On the backdrop of the recent policy initiatives to install board quotas for

\(^1\)See the European Commission Database on Women and Men in Decision Making.
women, Table 1 assembles shares of female board members. With 16% the U.S. and the 27 (by 2007) EU member states fare equally in terms of female representation on firm boards. Japan, as another major industrialized country, has only 1% women on firm boards. A more closer look into single European countries reveals a large dispersion of female representation. In the three countries with the largest representation almost every third member is female, a share which, however, still falls short of Norway where a quota was introduced by 2003 already, forcing firms to comply by 2008. In the European countries that do worst not even every tenth position is held by a woman. Interestingly, the countries doing relatively well in terms of female board membership hardly have women leading the board or being a CEO. Data for Germany allows for a closer look into the within country distribution of female representation. Again, we find a large variance between firms. Among the companies listed in the DAX (the major German stock market index), seven women serve on the board of Henkel which is composed of 16 members, while no woman is serving on the board of Fresenius (a medical care company).

The introduction of a female board quota in Norway constituted a natural experiment that allowed for an analysis of firm reactions and their consequences more closely. At the time the law was introduced only 9% of women were on the boards of Norwegian firms. A legislated quota of 40% imposed a major change on the composition of Norwegian firm boards. Ahern and Dittmar (2012) use the pre-quota female representation across firms as an instrument for the changes of boards that followed the quota. For the days around the announcement of the law they find that stock returns fell by 3.52% for those firms with no female representation compared to firms that had at least one woman on the board. For the longer term, they estimate a decline in Tobin's Q of 12.4% as a response to a 10% forced increase in women representation on the boards. Overall they conclude that the constraint imposed had a large negative impact on firm value driven by the reorganizations of the boards. Drawing on the same policy change, Bohren and Staubo (2013) find that half of the firms that would have been affected by the gender quota chose to exit into another organizational form, thus avoiding exposition to the law. Also this piece of evidence suggests, at least indirectly, substantial costs of compliance that possibly could be diminished with a system of tradable permits to employ men.

In order to study whether a tradable employment quota is a feasible affirmative action policy and what labor market effects would possibly unfold we build an agent-based simulation model of the labor market and the market
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<td>Min [%]</td>
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</table>

Data source: European Commission Database on women and men in decision making for 2012 if not otherwise stated. (a) European Commission: Women on boards - Factsheet 2, Gender equality in member states; (b) Der Spiegel 48/2013, p.74; (c) Ahern and Dittmar (2012, p.143).
for permits. We study a labor market with a set of firms being allocated to multiple sectors. A fraction of the firms is characterized by taste discrimination against women as proposed by Becker (1957). The remaining fraction of firms is indifferent between men and women. Workers have sector specific skills meaning that their productivity does not fully unfold if they work in a sector that requires different skills than the ones embodied. Firms post vacancies to which workers apply and are matched. In this framework we study the effects of a tradable as opposed to a non-tradable employment quota on welfare and various other labor market indicators. Our main finding is that a tradable employment quota fares better in a heterogeneous labor market were firms are facing sectorally differentiated levels of female labor supply.

We use an agent-based model to analyze whether a permit solution may actually work and what labor market effects potentially emerge. Evaluating labor market policies using agent-based models has been suggested by Freeman (1998) already some time ago. Generally speaking an agent-based approach suits well for analyzing problems characterized by interacting heterogeneous agents. Moreover, agent-based modeling allows for a relatively detailed implementation of institutional arrangements. As we build a model with a sectoral structure hosting workers of different skill types to be employed by firms that may discriminate against women and, furthermore, will augment the labor market with a permit trading system, the agent-based approach seems to suit well for our purposes. Our approach may also be subsumed under what Roth (2002, p.1341) called “design economics” where he argues that computational techniques should be seen as complementarity to other tools applied to studying and designing markets, namely game-theory. One of the earliest attempts to analyze the effects of labor market institutions in an agent-based model can be found in Bergmann (1990). Others followed, with Tesfatsion (2001) working on wage setting or Neugart (2008) looking into training policies. Those and other contributions are surveyed in Neugart and Richardi (2014).

Building a computational model we touch upon various strands of the literature. Our theoretical explanation of men and women being treated differently draws on taste discrimination (Becker, 1957). The alternative explanation is statistical discrimination (Arrow, 1973; Phelps, 1972). Empirical work long evolved separately along these two explanations (Guryan and Charles, 2013). Only in recent years efforts have been made to test taste based explanations of discrimination against explanations pointing at statistical discrimination (See, e.g., Altonji and Pierret, 2001; Knowles et al., 2001). The jury still seems to be out and we do not make an attempt to resolve the issue here. There is also no particular reason, why we chose a model of taste discrimination. At this point, all that we need is some sort of
discriminatory behavior as a starting point to analyze the two affirmative action policies in comparison.

Welch (1976) was probably among the first dealing with affirmative action policies from a theoretical point of view. Equal employment opportunities as one proliferation of affirmative action policies have been studied in the framework of a search and matching model of the labor market by Kaas and Lu (2010). They find that if an imperfectly monitored equal employment opportunity legislation is combined with an equal pay obligation inequality increases.\textsuperscript{2} Contrary to them we do not look into a fixed quota but a tradable one.

While tradable permits have gained widespread attention in the area of environmental policies\textsuperscript{3}, there is little to no application in the area of labor market policies.\textsuperscript{4} This contribution may be seen as a first step into the analysis of such kind of affirmative action policies. Our starting point is a heterogenous labor market where lack of appropriate skills in certain segments may cause considerable adjustment costs following the introduction of a uniform quota. Thus, once more, it underscores the importance of a better understanding of the reasons why women do not make it into certain (and well paid) segments of the labor market such as top-level management positions (Bertrand et al., 2010).

In the following Section 2 we lay out our model and introduce the reader to the two affirmative action policies we are going to compare. After having described the parametrization and the simulation set-up in Section 3, we discuss labor market outcomes in a baseline specification of our model without policies in Section 4. The main purpose of this Section is to reveal the properties of our simulation model and put these into relation to the findings of the existing literature on labor market models with taste discrimination. Section 5 studies the effects of a tradable employment quota in comparison with a non-tradable quota on welfare and other labor market indicators and reports on the results of various robustness tests. In the last section we conclude and point towards desirable extensions of the current work.

\textsuperscript{2}Other contributions looking into the labor market consequences of equal pay legislation are Bowles and Eckstein (2002); Coate and Loury (1993); Kaas (2009). Further search and matching models with taste discrimination but without policy analyses can be found in Black (1995); Lang et al. (2005); Rosen (2003).


2 The model

2.1 A general description

Our model consists of a labor market hosting heterogeneous firms and workers, and a permit market. The labor market has a sectoral structure. Firms sitting in a particular sector have distinct skill needs. Workers are equipped with different sector specific skills. A worker’s productivity unfolds fully if she is employed in a sector that matches her skills. Workers employed by firms in other sectors lose part of their productivity. Labor demand for each firm is fixed. Vacancies are posted and workers apply. A fixed share of firms discriminates against women. Due to taste discrimination these firms will only employ women instead of men if wages of the former are sufficiently low. Firms send wage offers to the workers with highest profitability. Workers accept the best offer they get conditional on the wage being above their reservation wage.

We consider two affirmative action policies. Under a non-tradable employment quota every firm is allowed to only employ a share of men that does not exceed the quota. Alternatively, we implement a tradable quota issuing permits that give a firm the right to employ a man. The permit market is modeled as a central market maker to whom each individual firm submits its individual supply and demand schedule of permits. The central market maker aggregates these bids and asks up, and determines the market clearing price at which the permits are reallocated.

2.2 Labor market environment

We consider a partial labor market where firms’ labor demand is derived from aggregate product demand. Firms reside in $S$ sectors. Workers are equipped with sector specific skills. A worker employed at a firm in a sector with her specific skills unfolds full productivity $A$. Worker specific productivity declines as she is employed in a more distant sector. Sectors are allocated on a Salop circle, i.e., a worker’s productivity with specific skills in sector $k$, working in sector $s$ follows

$$p_{k,s} = \begin{cases} 
A - a \cdot |k - s| & \text{if } |k - s| \leq S/2 \\
A - a \cdot (S - |k - s|) & \text{else,}
\end{cases}$$  

(1)

with $0 < a < 1$, $k = 1, \ldots, K$, and $s = 1, \ldots, S$. As there are as many skill types as sectors we have $K = S$. Full productivity $A$ is sufficiently large so that a worker’s productivity never becomes negative.
2.3 Agents

2.3.1 Workers

The fixed total labor supply of size $I$ can be decomposed into a fraction $(1 - \sigma)$ of male workers and a fraction $\sigma$ of female workers. A worker $i$ has an individual reservation wage $w^r_i$ that is drawn from a uniform distribution with support $[0, A]$.

Workers send out $m > 1$ applications preferably to firms which value their sector specific skills. Unobservable characteristics orthogonal to their skill endowment make some sectors more attractive to a specific worker than others implying that a worker has also preferences over non-wage job characteristics. Thus, she may send an application to a firm in a sector which does not value her specific skills most. More formally, we recur to a discrete choice specification postulating that workers with specific skills in sector $k$ send out an application to a firm in sector $\tilde{s}$ with probability

$$
Prob_{k,\tilde{s}} = \frac{e^{\lambda p_{k,\tilde{s}}}}{\sum_{s} e^{\lambda p_{k,s}}},
$$

where $\lambda \geq 0$ drives the intensity of choice and the denominator sums up the exponentials of worker specific productivities in all sectors, respectively.

Workers accept job offers with attached wage offers above their reservation wage $w^r_i$. If a worker receives more than one job offer, she chooses the job offer with the highest wage.

2.3.2 Firms

Each sector is populated with $N$ firms. Each firm $j$’s, with $j = 1, \ldots, J$, labor demand $l$ is fixed. Within each sector there is a share $\mu > 0$ of discriminating firms. A discriminating firm has a dis-utility from hiring a female worker which is modeled with a discrimination coefficient $d$ as suggested by Becker (1957). The firm $j$ residing in sector $s$ has payoffs calculated as the sum of profits, which are productivities net of wage, minus discrimination costs over all workers $n_j$:

$$
\pi_{j,s} = \sum_{n_j} (p_{k,s} - d_g - w_{j,k,g,s}),
$$

where $g = M, F$ is the gender of the worker. For discrimination costs one has $d_M = d_F = 0$ for a non-discriminating firm and $d_F > 0$ for a firm that discriminates against an employed a woman.

Firms set male and female wages to maximize payoffs. Job offers are sent out including the worker specific wage offers. Then, the firm may face two
distinct situations: a) the firm is able to fill all the vacancies as no worker who received a job offer declined it, b) some workers who received a job offer declined it. Firms are facing a trade-off such that higher wage offers increase the likelihood that a vacancy can be filled and becomes productive. Higher wage offers, however, increase the wage bill and depress profits. Firms learn given their past experience on payoffs made and wage offers made how to best place themselves on this trade-off. To this end, each firm runs regressions of payoffs per job offer on the wage offers of the past $\tau$ iterations. For a positively estimated slope coefficient $\hat{\beta}$, a firm $j$ that resides in sector $s$ will adjust the wage offer $w^o$ for a worker coming from sector $k$ and of gender $g$ upwards by a firm specific parameter $\epsilon_j$ in iteration $t$ with respect to the previous iteration $t - 1$. For a negatively estimated slope coefficient the wage is adjusted downwards:

$$ w_{j,k,g,s,t}^o = \begin{cases} w_{j,k,g,s,t-1}^o + \epsilon_j & \text{if } \hat{\beta}_{j,k,g,s,t} > 0, \\ w_{j,k,g,s,t-1}^o - \epsilon_j & \text{if } \hat{\beta}_{j,k,g,s,t} < 0, \\ w_{j,k,g,s,t-1}^o & \text{else.} \end{cases} $$

(4)

The firm specific adjustment parameter $\epsilon_j$ is drawn from a uniform distribution with bounds $[\xi, \bar{\xi}]$. Wage offers are adjusted if they are within bounds $[0, A]$.

2.4 Policies

2.4.1 An employment quota

We consider an affirmative action policy where every single firm has to employ at least $\bar{n}_j$ women. In order to comply with the quota firms rank applicants by gender and payoffs. Again, the firm will send binding offers to the best workers taking into account the quota. As it turns out that after the hiring process expired the firm cannot comply, the firm withdraws its previous offers to male workers up to the point where the quota is fulfilled.

2.4.2 A market for a tradable employment quota

Alternatively, we simulate a market with permits for employing men. In this case, a firm is only allowed to employ as many men as it holds permits for employing male workers. There is a fixed number for permits $C$ for the whole economy. Initially every firm gets an equal share of the total number of permits. These permits can be sold and bought at a central clearing agency. For the clearing agency, we consider a central market maker who collects
ask and bid prices, determines the market clearing price in every period and reallocates the permits between the buying and selling firms.

A single firm’s offer curve for permits is constructed in the following way. All unused permits are offered at reservation price zero. The offer of that single firm increases by one more permit at a price equal to the payoff of the least profitable male worker. The second least profitable worker determines the price of yet an additional permit. As we move to even more profitable workers the full schedule of the offer curve for that particular firm is derived. Turning to the demand side the central market maker looks into a single firm that will ask for as many permits as there are more men employed than the firm holds permits currently. Permits are used to employ the most profitable male workers in the firm. The bid price for the first additional permit is the payoff of the most profitable male worker for whom the firm does not yet have a permit. The bid price for the second additional permit is the payoff of the second most profitable male worker for whom the firm does not yet have a permit, and so on.

Aggregating up the single firms’ supply and demand schedules the market marker constructs the aggregate supply and demand curves for the employment permits. She determines the market clearing price and reallocates the permits from those firms willing to sell at the going price to those willing to purchase permits at the going price. Firms that did not buy the required number of permits to employ all the men whom they made an offer have to revoke from actually employing these men.

2.5 Sequencing

The pseudocode outlined in Algorithm 1 gives the timing of the various actions. A particular iteration starts with each firm \( j \) posting \( l \) vacancies. Workers apply to firms with a positive number of vacancies, with each worker sending out \( m \) applications. Firms evaluate how high their wage offer should be to best optimize on the trade-off of actually attracting workers and not letting the wage bill increase by too much. Firms make binding job offers obeying the non-tradable employment quota including the wage they are willing to pay to the most profitable applicants. Workers choose the job with the best wage offer conditional on it being above their individual specific reservation wage. Firms that were not able to hire enough women to fulfill the quota withdraw their offers to male workers.

For the case where we are looking into an economy with a tradable employment quota firms observe how many workers they are able to attract and compare their stock of permits with the number of male workers willing to work for them. Each firm draws its individual supply and demand schedule
for the permits. The market maker aggregates these up and determines the market clearing price at which the permits are reallocated between firms. Firms not able to purchase the required number of permits for all the men who wanted to work for them withdraw their offers to the least profitable men.

Finally, the firms produce and observe their payoffs. At the end of each iteration all workers are dismissed and the cycle restarts.

3 Simulation set-up

3.1 Parametrization

In order to be able to compare the results from our simulation model with the outcomes from already existing analytical models we, first, set-up a simplified version with one sector only. Then we extend this model to five sectors. For the multi-sector version we simulate two policy scenarios with two different labor markets. First we look into an affirmative action policy which prescribes every single firm to employ at least 30% women. Then, we introduce a tradable employment quota. To this end 100 permits are equally distributed among the firms initially which then can be traded at a centralized clearing agency. The two labor markets within which the two policies are simulated differ with respect to the distribution of women across sectors. In one scenario women are equally distributed across sectors, in the other they are unequally distributed across sectors (while keeping the overall supply of women constant.)

There are 1,000 workers in the economy. Depending on whether we simulate a single- or a multi-sector model, sectors are populated with 100 or 20 firms, respectively. A firm posts 10 vacancies. Half of the firm population discriminates against women. The wage adjustment parameter $\tau = 10$ implies that firms learn over the past 10 iterations. They adjust wages from one iteration to the other between 2.5% and 10% of the maximum possible worker productivity. Table 2 summarizes all these parameters.

Each iteration $t$ as described in the Pseudocode is replicated for $T = 1,010$ times. This we call a single run. Every treatment consists of 100 runs. For our analysis of the simulation outcome we record the average of the last 10 observations of every run. Thus, we have 100 observations for every treatment.
Algorithm 1 Pseudocode of model implementation

create sectors
create workers
create firms
for \( t = 0 \) to \( T \) iterations do
  for all firms \( j = 1 \) to \( J \) do
    post vacancies
  end for
  for all workers \( i = 1 \) to \( I \) do
    send \( m \) applications
  end for
  for all firms \( j = 1 \) to \( J \) do
    adjust wage offer given past experience
  end for
  if economy has tradable employment quota then
    for all firms \( j = 1 \) to \( J \) do
      send job offers
    end for
  else
    for all firms \( j = 1 \) to \( J \) do
      send job offers to male and female applicants obeying employment quota
    end for
  end if
  for all workers \( i = 1 \) to \( I \) do
    if wage offer above reservations wage then
      accept best wage offer
    else
      decline
    end if
  end for
  if economy has tradable employment quota then
    for all firms \( j = 1 \) to \( J \) do
      draft supply and demand schedules for permits
    end for
    central market maker aggregates supply and demand schedules
    central market maker determines market clearing price
    central market maker reallocates permits
  end if
  for all firms \( j = 1 \) to \( J \) do
    if affirmative action policy is not fulfilled then
      firm withdraws offers to excess male workers
    end if
    produce
    dismiss all workers
  end for
end for
<table>
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<th>Parameters</th>
<th>Choices</th>
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<td>Number of applications per worker</td>
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</tr>
<tr>
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<td>Vacancies per firm</td>
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<td>Share of discriminating firms</td>
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<td>Discrimination coefficient</td>
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<td>Sectoral productivity decline</td>
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<tr>
<td>Quota</td>
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<td>Learning period</td>
<td>$\tau = 10$</td>
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<tr>
<td>Wage adjustment</td>
<td>$\epsilon = [0.05, 0.2]$</td>
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</table>

### 3.2 Difference-in-difference approach

A simple comparison of a tradable with a non-tradable quota would yield flawed results with respect to their labor market effects. Only if it was possible to issue the number of permits which exactly matches the restrictions that firms are facing from a uniformly applied quota the two policies would be comparable. However, as overall employment and the structure of employment by gender are endogenous, this particular number of permits which makes the policies comparable cannot be determined in advance.

As a solution we apply a difference-in-difference approach to analyze the policy effects in comparison. The procedure will be to compare the difference of the variables of interest arising from a non-tradable employment quota comparing an equal with and un-equal distribution of female labor supply across sectors, with the difference between the same variables under a tradable employment quota. Denote with $v$ the labor market variable of interest, with $ntq$ the policy of a non-tradable employment quota, with $tq$ the tradable employment quota, and with $eqFemDis$ whether female workers are equally or unequally ($UneqFemDis$) distributed across sectors. Then, the
policy effect $T$ writes:

$$T = (v(tq_{eqFemDis}) - v(tq_{UneqFemDis})) - (v(tq_{eqFemDis}) - v(tq_{UneqFemDis})) \quad (5)$$

4 Baseline scenarios without policy

4.1 One sector set-up

We start off with the one-sector version of our model without policy intervention comparing labor markets with and without discriminating firms. The simulation results are shown using box plots drawing on the 100 observations for each treatment as explained in the simulation set-up.

Figure 1 (a) shows the employment rates when there are no discriminating firms and, alternatively, when every second firm discriminates against women. Overall employment rates and employment rates by gender are equal for the non-discriminating scenario as it should be. Allowing for discriminating firms reduces overall employment with respect to the reference scenario where we only have non-disutility firms. The decrease in overall employment is driven by a sharp decline in female employment which, moreover, falls short of male employment. Turning to wages, see panel (b), reveals that female workers are paid less than male workers as we allow for disutility firms.

Both, the employment and the wage effects, can be explained by the increase in the relative demand for male workers as discriminating firms are introduced. These firms have a distaste for female workers making competition for male workers fiercer. Consequently, male workers’ wages increase and female wages decline. Although there is upward pressure on male wages, on average these wages are only slightly higher than in the non-disutility case because those men with relatively high reservation wages will enter the labor market now. By the same token, female employment is driven down as some women will withdraw from the labor market as the going wages have fallen below their reservation wage.

Disentangling the employment effects when we have 50% discriminating firms into the employment ratios for those firms that discriminate and those that do not discriminate yields Figure 1 (c). The discriminating firms have overall lower employment than the non-discriminating firms because they hire less women than men and the gender employment gap is larger at discriminatory firms than at non-discriminatory firms. Due to taste discrimination women earn lower wages at discriminatory firms than men. But there is also a small gender wage differential at non-discriminating firms as these firms face a relatively larger female supply.
Overall these simulations are in line with the findings of the existing literature on taste discrimination in search models of the labor market. As in Kaas (2009) and Kaas and Lu (2010) the simplified version of our simulation model generates employment segregation. The non-discriminating firms employ more women than men and the discriminating firms employ substantially more men. Comparable to Bowles and Eckstein (2002) wages for women are lower than those for men. Moreover, we can relate to the search and matching model with heterogeneous reservation wages by Burdett and Mortensen (1998) who argue for the emergence of a wage dispersion in such frameworks. The wage dispersion generated by our model is exemplified in Figure 8 panels (a) to (d). We plot the wages paid by gender and by firm type for a single run at iteration 1,000 for all workers employed. There is no single market wage, neither by gender nor by the type of firm.

Figure 1: Employment and wage effects for one-sector model; (a) total employment rates, (b) average wages, (c) employment rates descr. vs. non-discr. firms, (d) average wages descr. vs. non-discr. firms by gender.
Figure 2: Wage distribution for baseline run at iteration 1000, seed 2: (a) female wages at discriminating firms, (b) male wages at discriminating firms, (c) female wages at non-discriminating firms, and (d) male wages at non-discriminating firms

4.2 Multiple sectors

Extending our labor market model to multiple sectors and re-running the analysis shows the same employment and wage patterns by gender as in the one-sector version of the model. However, employment and wages have shifted down, see Figures 3 (a) and (b). This is due to the higher degree of frictions in a multi-sector labor market. Some workers may want to work in sectors not exactly matching their skill endowment. For these workers firms make lower wage offers given the lower productivity of these applicants. With uniformly distributed reservation wages overall less workers will accept the job offers driving down employment in this economy. A closer look into the wage and employment patterns by discriminating (figures not shown here) yields qualitatively the same results that we already could observe for the
labor market with a single sector

Now we introduce an unequal distribution of sector-specific skills for women holding the overall share of women supplying labor constant. The share of women increases as we move from one sector to the other from 0.1 in steps of 0.2 so that the fifth sector hosts a share of 0.9 women. We re-run the analysis for the unequal distribution of firms and compare it to the results for an equal distribution of firms. For ease of comparison Figures 4 (a) and (b) include the results for an equal distribution as already shown in the previous Figure. There occurs to be a slight decrease in overall employment as we move to an unequal distribution of women across sectors, and an increase in the gender employment gap. Wages slightly decline, both for men and women. Overall, however, the wage and employment patterns do not change qualitatively and can be explained on the same grounds as already done for the simpler versions of this model. The heterogeneous supply of women across sectors will be the labor market within which we run and compare the two affirmative action policies.

Figure 3: (a) Total employment rates and (b) average wages for multiple sector labor market.
Figure 4: (a) Total employment rates with discriminating firms, and (b) average wages with discriminating firms, for an equal and unequal distribution of women across sectors.

5 Policy evaluation

5.1 Results

The welfare effects of the two policies using the difference-in-difference approach from equation (5) can be seen in Table 3. We define welfare as the sum of all wages paid in the economy and all payoffs accruing to firms. The third row of Table 3 shows a decline in welfare as we move from a labor market with an equal distribution of women across sectoral skills to an unequal distribution applying a non-tradable employment quota of 40.021 units. Welfare also decreases for a tradable employment quota as we make the distribution of women over sectors unequal by 13.433. However, the decline is smaller so that the comparison of the welfare losses between the two policies (26.589) speaks for a tradable employment quota as the superior policy instrument.

These units may be interpreted in relation to total possible output in this economy. With 1,000 workers and a maximum per worker productivity of 2, the maximum of total units possible to produce in this economy is 2,000. Measured welfare falls short of this upper bound due to labor market frictions leaving vacancies unfilled, the allocation of workers to sectors where their productivity does not fully unfold, and the discriminatory behavior of firms.
### Table 3: Welfare analysis

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What stands behind these findings? Let us first look into the functioning of the permit market. Figure 5 shows a snapshot of the supply and demand schedules that the market maker is facing at a particular iteration given the decisions of all the firms how many permits to sell and buy for the labor
market with an unequal distribution of women across sectoral skills. The downward sloping market demand stems from aggregating up the individual firms’ demands for permits given prices. Similarly the upward sloping supply is the sum of permits firms are willing to sell at given prices. As explained earlier, the market maker chooses the price where supply and demand schedules cross and reallocates the permits from those willing to sell at the market clearing price to those firms willing to buy.

Figure 5: Bid-ask-diagram for permit trading market with an equal female labor supply across sectors at iteration 1000

The price for the permits and the traded volume as shown in Figure 5 is one observation of all the observations entering the box plots in Figures 6 (a) and (b). Here we compare the labor markets with an equal and an unequal distribution of women showing that fewer permits are traded in the former case. It occurs that with an unequal distribution of women the demand schedule shifts outwards as more firms are struggling to find women to fill the vacancies. But also the supply of permits goes up due to the unequal distribution of women across sectoral skills. The share of firms residing in sectors that have a relatively large supply of women are in excess supply of permits and want to sell. The outward shift of the supply of permits seems to be of the same magnitude since the permit prices hardly change (Figure 6 (b)).
About two thirds of the effect of a tradable employment quota on welfare accrues to changes in the wage sum. This effect we can disentangle into a significant employment and a non-significant wage effect (see Table 3). The drop in employment is less pronounced for the tradable quota as one moves from an equal to an unequal distribution of women across sectors if compared to the non-tradable quota. Without permits a firm wanting to produce may be constrained by the employment quota. There is a vacancy to be filled, and while there is no female applicant to fill the vacancy, a male worker would be willing to accept the job offer. However, the firm cannot employ him because the employment quota has to be obeyed. A tradable employment quota gives firms facing such a situation more flexibility. They may purchase a permit allowing them to employ an additional man, and they will do so as long as the additional male worker’s profitability covers the price of the permit. Thus, more vacancies can actually become productive with a tradable employment quota when female (and male) labor supply is distributed unequally as reflected in the non-decline of the male employment rate for the tradable quota. The increase in the employment rate also explains the effect of a tradable employment quota on payoffs as an otherwise unproductive vacancy is filled now, without an increase in the average wage rate.

5.2 Extensions and robustness

Besides making female labor supply unequal across sectors, one may argue that the share of discriminating firms is also unequally distributed across sectors. One could imagine that discrimination already unfolds as young women make their human capital investment decisions avoiding the acquisi-
tion of skills for sectors which are known to host firms having a taste for men. In such a scenario, the share of women and the share of discriminating firms would be negatively correlated across sectors. A version of our simulation model along these lines yields qualitatively similar results, i.e. a tradable employment quota is welfare improving.

In addition to the aforementioned extension of the simulation analysis we ran a series of robustness tests involving changes of the key parameters of our model. We were interested in whether our main result on the diff-in-diff effect on welfare survives. To this end we combined the two key policy parameters, i.e. the number of permits issued and the quota with one of the remaining parameters, respectively. The results of this exercise are summarized in Figures 7, 8, and 9. In all left columns of these figures we combine changes in the number of permits with one of the remaining parameters, and in the right columns we combine changes in the quota with one of the remaining parameters. The grids are over three values of each parameter, thus consisting of 9 combinations of parameters. The welfare effects of those nine parameter constellations are combined to a plane. The green planes show the mean effect on the diff-in-diff welfare measure of 100 repetitions. Upper and lower planes constitute the confidence interval. Figure 7 collects all parameters related to the adjustment behavior of firms and workers and the number of interations of each run. Figure 8 brings together parameters related to heterogeneity and frictions in the labor market, and 9 assembles all parameters on discriminatory behavior. Black dots are related to the parameter constellation that underlies the results in Table 3. The upshot of all three figures is that the qualitative results are robust to a large set of parameter changes. In all cases considered, welfare effects are significantly different from zero indicating that a system of tradable permits improves welfare.

6 Conclusions

Discrimination of women (as well as other labor market groups) calls for affirmative action policies. In an economy where women’s labor supply is heterogeneous across sectors or regions, an employment quota applied uniformly to firms may cause avoidable costs to society. Firms located in sectors or regions where the supply of female labor is relatively scarce may find it inherently difficult to comply with an employment quota whereas firms in other sectors where female labor supply is relatively strong will do better in terms of filling vacancies with female workers. Output losses may occur in sectors with relatively weak female labor supply as firms subject to the employment quota cannot fill up vacancies with men even if a woman cannot
be found.

We propose and analyze a flexible quota solution. As we argue, a tradable employment quota gives firms additional flexibility to hire men if female labor supply is insufficient. By issuing permits to firms allowing them to hire men and making these permits tradable across firms, firms in shortage of women will not be forced to abandon output. Rather they will try to purchase a permit that allows them to hire a man up to the point where this additional man’s profitability covers the costs of the permit. Equally, we will have firms in this market that will find it profitable to sell permits as they can easily fill their vacancies with women. An advantage of a tradable permit system is that it allows for a flexible adjustment at the firm level without having to compromise on the overall policy goal to achieve a certain share of female employment in the labor market. The scope of female employment in the economy can be managed at the aggregate level by issuing or withdrawing permits.

For analyzing the labor market effects of a tradable employment quota we developed an agent-based labor market model of heterogeneous workers and several sectors, hosting firms that may taste discriminate against women. The choice of a computational technique to analyze the policy proposal was motivated by our aim to show that a permit system may work in a realistic market context. Our simulation results suggest that a market for a tradable employment quota may emerge, and that a more flexible policy solution is actually improving welfare.

Although we did make an effort to implement features of the labor and permit market in considerable detail, we have been silent about the occupational or regional scope of a permit system. Given our discussion in the introduction on the recent moves to make shares of female workers legally binding for boards of firms, one may at first think of a permit market for that segment. In principle, however, we believe that a tradable employment quota would also work for other groups of occupations, may it be introduced nationally or for a set of countries as the European Union.

This brings us to our last point, i.e. the odds that a system of permit trading finds political support. We try to shed light on this question by, once more, drawing analogies to the case of environmental policies. Stavins (1998) presents an insightful discussion on how the main parties involved profited from a command-and-control environmental policy and had reasons to oppose a tradable permit system. Similar arguments may apply for a tradable employment quota. A crispy, fixed employment quota may be easier for politicians to communicate to the public which matters for symbolic politics. Moreover, assuming voters have limited information, once fixed regulations are introduced, firms and politicians can agree upon mutually beneficial ex-
emptions. The fact, that employment quotas have been introduced for a small segment of the labor market, very often for boards of publicly listed companies only, may evidence such a line of reasoning. It is also reported, that environmental interest groups were hostile towards market-based instruments in the beginning. One could imagine, that this could also become the fate of a tradable employment quota. But opposition to a market-based instrument may also arise for less philosophical reasons. Bureaucracies and legislators trained in law may lose expertise, and even control as implementation of the affirmative action policy is left to largely private decisions with a permit system. Thus, there are many reasons to expect that an affirmative action policy based on tradable permits will never be implemented. This is the more pessimistic outlook. A more optimistic outlook has a glance at the trading places for pollution rights in Chicago, Leipzig and other cities around the globe.
Figure 7: Robustness with respect to dynamic behavior of agents
Figure 8: Robustness with respect to labor market frictions and heterogeneity
Figure 9: Robustness with respect to extent of discrimination
References


