THE NETWORK ANTIDOTE: AN AGENT-BASED MODEL OF DISCRIMINATION IN LABOR MARKETS *

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Abstract

This study shows that large inequality in employment can be pervasive in the labor market even when there are no differences in average quality between different worker categories and employers only strive for high quality workers. By simulating hiring through an agent-based model, we show that social networks might have a different impact on discrimination depending on the type of ties. While worker referrals have a U-shaped effect, with a few referrals reducing discrimination, the structure of business recommendations does not play a crucial role. We found that certain social network mechanisms might decrease discrimination compared with a market composed of atomized employers as networks can allow employers to overcome the sampling bias. We also found that ties between workers and employers that are characterized by their affective content decrease discrimination more than ties that are characterized purely by information exchange.

Keywords: discrimination; labor market; social networks; referrals; hiring.
JEL: J71; D85; Z13.

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INTRODUCTION

Employer discrimination means the differential treatment of a certain social category, in particular in hiring, wages, and allocated jobs (Petersen and Saporta, 2004). Discrimination may or may not be purposeful and may be motivated by prejudice (attitudes), stereotypes (beliefs), and racism (ideologies), but is distinct from these as it is, by definition, manifested in decisions (Quillian, 2006; Pager and Shepherd, 2008). It can have a statistical nature if it is based on objective differences of means. For instance, following well-documented differences between men and women in average emotional support for children (e.g., de Waal, 2005), trusting a woman more than a man when searching for a baby-sitter should be viewed as a “rational” statistical discrimination which is similar to pricing practices of insurance companies based on hazard categories. In case of asymmetry of information, statistical discrimination might also be supported by credible signals. Signals such as educational attainment, other qualifications, and suits for lawyers are reliable and used as bases for discrimination. On the other hand, the production of these signals by the applicants requires investments such as spending years and completing exams in education, paying for expensive suits, and maintaining a friendly character. These signals are expensive and also costly to fake, which makes them credible sources of information (e.g., Frank, 2007; Spence, 1973; 1974; Gambetta, 2009). Discrimination might be channeled by apparently harmless social practices. For instance, hair color should not make a difference in car driving or in task performance in secretary work, still, blond women are widely labeled as clumsy, less effective, and they are subject to many derogating jokes (e.g., Benokraitis, 1997). Although recognizable traits (e.g., gender, ethnicity, hair color) are often irrelevant for job quality as there is no statistical basis to distinguish members of different categories, employers use them “as inexpensive screening devices when hiring for jobs, particularly skilled jobs, in the belief (correct or not) that race and sex status are, on average, related to productivity. Individual workers are stereotyped as qualified or not, with more attention given to their membership in a race or sex group.” (Kaufman, 2002: 550). Previous findings showed that employers tend to overrate men’s credentials and performance and underrate women’s credentials and performance in various occupations (Langton and Pfeffer, 1994; Heilman, 1995; Witkowski and Leicht, 1995; Valian, 1998; McBrier, 2003; Heilman and Parks-Stamm, 2007).

There is no doubt about the serious negative societal and economic consequences of inequality in employment. They contribute to the reproduction of social inequality (Reskin, 2000) and provide roots for stigmatizing and other forms of social conflict. Inequality in employment creates disinvestment incentives for disadvantaged groups (Allport, 1954; Arrow, 1973; Akerlof, 1976; Coate and Loury, 1993). If a category is deemed by discrimination as unqualified, no incentive exists to achieve quality, the prophecy about differences between categories self-fulfils and prejudice is perpetuated (Allport, 1954; Arrow, 1973; Akerlof, 1976; Coate and Loury, 1993; Blau, Ferber and Winkler, 1998). Difficulties of groups who suffer from discrimination accumulate and there might be spillover effect across domains and time (Coate and Loury, 1993; Lundberg and Startz, 1998; Pager and Shepherd, 2008).

This paper shows that discrimination can emerge and be maintained even considering perfectly neutral employers who have no “taste” for discrimination (Becker, 1971[1957];
Welch, 1967) and considering no differences in mean quality and quality distribution of the workers (Phelps, 1972). This way we provide a minimal explanation of discrimination in job hiring. Although job hiring is not the only terrain of discrimination, it is sufficiently simple and general to be studied through formal models, as the hiring decision is binary and the outcome is observable. Although inequality is widely recognized in wages and firing (Mong and Roscigno, 2010), there is also empirical evidence that it is present in hiring (Petersen, 2009; Lazear, 1991; Epstein, 1992).

By looking at an ideal-typical situation, our study can enrich empirical research on discrimination by showing the expected magnitude of discrimination without any initial difference in mean qualities and considering fair intentions of employers. In such conditions, explanations that are based on statistical differences and prejudices cannot explain large observed differences.

In particular, we examined the unintended consequences of networks for hiring. We looked at how social network mechanisms, which are of key importance in hiring decisions, relate to discrimination. The important role of social networks, especially weak ties, is well documented for getting a job (Granovetter, 1973; 1974; Lin, Ensel, and Vaughn, 1981; Wegener, 1991). The fact that social embeddedness of labor market relations (Granovetter, 1985) can cause labor market segregation is also widely acknowledged (e.g., Stovel and Fountain, 2009). Our aim was to illustrate the structural conditions that favor discriminatory practices and more importantly, whether hiring via networks increased unbiased judgments and equal employment rates. For this, we have created an agent based model that allowed us to experiment and systematically explore conditions and mechanisms that could not be separated or determined clearly in empirical research (e.g., Macy and Willer, 2002; Abdou and Gilbert, 2009; Squazzoni, 2012). By modeling the hiring processes, we showed that hiring via social networks could have a different impact depending on the type of ties that are used.

To look at discrimination in labor markets, we distinguished between a macro level discrimination, i.e., the objective extent to which groups are disproportionally hired, and a micro level discrimination, i.e., the average extent to which individual employers hire employees from the same group. In addition, in close relation to observed inequality, we also looked at labor market segregation by measuring the concentration of group members in jobs offered by employers connected to each other. Micro level empirical findings showed a considerable level of labor market segregation. Even within certain segments of the labor market, there is further segmentation (Smith, 1983). Men and women in the same occupation are sorted into different organizations and segregated by job titles. For example, it is frequent that certain works are assigned exclusively to men in some organizational settings and women in other, such as for female waitresses and male waiters in restaurants (Bielby and Baron, 1986). In their sample, Bielby and Baron (1986) found that while all but 24 of the 290 establishments employed workers in a mixed occupation, only 144 enterprises employed both men and women. This also confirmed the citation of Bielby and Baron (1986: 786-787) from Joan Walcott Scott about 19-century textile factories: the specific jobs done by men and women differed from mill to mill, but the separation of male and female work was almost universal.

Even when men and women are not segregated occupationally, they are segregated organizationally. These forms of segregation cannot be explained by optimal choices of employers or by the voluntary choice of workers to work in segregated settings (Bielby
Bielby and Baron (1986: 781) concluded that statistical discrimination by employers had a far greater impact on segregation than labor supply constraints did. Labor market segregation can occur also in the lack of qualitative differences between the groups. Tassier and Menczer (2008) showed the emergence of labor market segregation in a wide range of conditions with worker referrals, even when workers’ quality was ruled out. They varied characteristics of the referral network and found that regular networks allowed for better containment of job information inside a group than random networks in a segregated population.

**RESEARCH HYPOTHESES**

Social networks can be used in job hiring for two reasons. *First*, the affective content of relationships can create obligations that make hiring and recommending friends more likely. Indeed, in this case, individuals tend to consider seriously the welfare of friends and acquaintances. This can disrupt the basic logic of a “perfect” market as affective motivations can replace meritocratic processes in hiring and result in suboptimal allocations (Ioannides and Loury, 2004; Petersen, Saporta, and Seidel, 2000; Tassier and Menczer, 2008). For instance, the extended use of informal job search methods may have a negative effect on the rate of mobility from low status to high status jobs (McBrier, 2003: 1212). If one of the groups has a better access to informal job search, then this is detrimental for the other group, as in the case of referrals from the “old boys” network in a wide range of fields (Rogers, 2000; McBrier, 2003; McDonald, 2011).

When referral networks are used and they are highly segregated, for instance, by ethnic group membership, they cause labor market segregation (Model, 1993; Tilly, 1998; Elliott, 1999; 2001). Members of a particular ethnic group tend to recommend their friends with the same ethnic background, which might reinforce their disadvantaged position and exclude them from better jobs (Wilson, 1987). Disadvantaged groups, especially with language deficiencies rely on in-group referrals more than advantaged (majority) groups, so diminishing their mobility chances (Elliott, 1999; 2001; Green, Tigges, and Diaz, 1999). Therefore, the deficit of minorities does not depend on the fact that they would rely less on networks in finding a job. Rather, it depends on the fact that they extensively rely on a “wrong network” that does not offer them good jobs (see Fernandez and Fernandez-Mateo, 2006).

To sum up, when hiring via social networks in a market is important, we should expect that discrimination of the disadvantaged group will be higher. On the other hand, other research found scant evidence that network mechanisms cut off minorities from employment (Fernandez and Fernandez-Mateo, 2006) and showed that “occupational enclaves” did not necessarily trap ethnic workers with language deficiencies, but provided them an opportunity to start working and familiarize with the labor market (Chavez, Mouw, and Hagan, 2011).

Therefore, we hypothesized that referral networks and discrimination were related as follows: The more friends employers hire, the higher the labor market segregation is. Moreover, as the social network of workers is segregated, when referral networks will be important for hiring, we should expect that individual employers will hire employees of the same group, so increasing micro level discrimination.
Given that the social network of workers is segregated by group membership, the density of the social network among workers is not expected to play a positive role for equal job chances. Dense social networks will make recommendations more likely that favor in-group members and diminish the importance of hiring from the market. Therefore, we expect that the density of the segregated social network of workers increases discrimination at the micro level and might result in macro level discrimination.

Secondly, network ties are also important channels of information for hiring through which information asymmetry can be reduced. As information about quality and opportunities spread via social networks, this can bring the market to higher efficiency. It is widely documented that social networks are important to access information on available jobs (Granovetter, 1974; Calvó-Armengol and Jackson, 2007), and screening candidates (cf. Montgomery, 2001; Marsden and Gorman, 2001). Recommendations from social network contacts can provide additional information otherwise inaccessible (Fernandez, Castilla, and Moore, 2000; Elliott, 2001). In this perspective, it is rather odd that work on referral networks is primarily concerned with referrals by workers and neglects the role of recommendations coming from other employers. At job interviews, recommendations from other employers are certainly seriously considered. For instance, a survey of personnel officers found that recommendations from a manager were more important for hiring than objective signals, such as high school grades (Crain, 1984; Rosenbaum et al., 1990; Spoonley, 2008: 27).

Following previous findings on the positive role of information on efficiency (e.g., Uzzi 1996) we expect that dense business networks could reduce information asymmetry between employers and employees and promote market efficiency. For employment, business contacts are important to judge the labor market potential of the employee properly. Business ties could be exploited also to attract highly skilled workers with reliable credentials. On the other hand, one might argue that economic agents are opportunistic and therefore might give inflating recommendations to lower the economic potential of their close rivals (Williamson, 1975; Rosenbaum et al., 1990). We have neglected these strategic considerations. Besides the sake of simplicity, we assumed that reliable and trustful business partners would risk future loss of trade and collaboration by providing false recommendations to their partners. As long as costs of maintenance and indebtedness increase, employers can harvest information benefits from trusting partnerships (Granovetter, 1985; Uzzi, 1996; 1997). Less is known about how the structure of information exchange between employers affects labor market segregation and discrimination.

Without complete information, business network ties transmit information concerning previously employed employees. Information exchange happens between chief executives of firms, human resource managers, public officials or academic professors during informal discussions, but also with a provision of recommendation letters. As rumors about exceptionally high performers or absolutely unreliable workers spread quickly beyond the company walls, evaluation could be distorted. Furthermore, if requested, reliable business partners often provide advice that is seriously considered for hiring. Close relations between firms can imply that best employees, whose quality could be directly observed during partnership, are hired more frequently by a partner company. As a consequence of purposeful or unintended information exchange between employers, the typical career path of employees, in particular of best performers, does not take place
in the “free market”, but occurs between partner companies. However, discrimination is not a necessary by-product of this process, especially in case of dense business networks that are able to correct for local information biases. Furthermore, employers might recommend individual workers and exchange information about individual performances, but they cannot do this very extensively about each worker they employ. Key decision makers categorize individual employers, communicate their past employment experience, and discuss prejudices about group of employers with each other. So, the social network of employers even becomes a channel for spreading stereotypes and group reputation (Katz and Braly, 1933; Lyons et al., 2007). If group reputation matters, i.e., when evaluation of group members of unknown quality is also based on the ongoing rumor about average group quality, then in dense business networks, individual sampling biases are further corrected and therefore we can expect more balanced and appropriate evaluations.

Therefore, we have hypothesized that a larger density of employer relations correlates with less biased employment policies and higher market efficiency. We expect that the effect of density on discrimination takes a smooth gradual functional form: for each level of interconnectedness, extra business ties should improve the situation.

THE MODEL

In our model, we considered job hiring decisions for fixed terms in a stable labor market with a fixed set of employers complemented by a fixed set of workers (applicants). We considered one recognizable trait in the population of workers and two social categories of this trait with a fixed category membership ($N_1=N_2$). We assumed that there was a surplus of labor supply in the market. There were more workers than jobs ($J$) in each period, i.e., $N_1+N_2 > J$, but the surplus was not exaggerated.

As we were interested only in the discriminatory practices of employers, we assumed one-sided matching; where employers chose workers and workers automatically accepted any offer. We assumed that employers were perfectly neutral and did not belong to any of the social categories. Given that we were not interested in wage discrimination, wage competition and in the behavior of the supply side of the labor market, we did not make any differentiations between jobs offered.

We assumed that workers varied in their quality, but the variation was independent of group membership. We explored two configurations. In the default configuration, we drew integer values for individual quality from a uniform random distribution in \{0, 1, ..., 19\}. In the other configuration, individual quality could take any value and were drawn from a normal distribution with a mean of 9.5 and standard deviation of 3, irrespectively of group membership. We assumed that individual quality was fixed and did not increase with employment.

The goal of employers was to fill vacant positions in their firms. In each contract period (year), employers were asked to fill a predefined number of positions by hiring workers. For sake of simplicity, employers filled up available positions randomly. We assumed that employers did not have information about individual quality of workers until they hired them. After hiring, the worker’s individual quality was remembered by the employer for a given period of time, indicated by the memory parameter $m$. This implied that employers have information on a larger pool in the first terms, but the pool size had
an upper constraint such that employers did not keep record of the quality of workers whom they employed for a long time. This could be due to turnover in human resource management, destroying old records, or for any other reason. Limited memories prevented the system from becoming a market with full information.

Employers used different channels for hiring. We assumed that employers gave priority to workers in-house who had a quality above their expected standards. We assumed that quality standards were fixed over time and did not vary among employers.

We distinguished two types of friendship relations that were relevant for hiring: friendship ties between employers and workers and friendship ties that connected workers in-house with other workers. We assumed that friendship created obligations between employers and workers. Friends received priority in employment, if they were not employed before. On the other hand, we assumed that friends were not re-employed if they did not meet the quality standards or their quality was below group reputation scores. It is important to note that we assumed fair employers who could have friends from both groups with equal probability. Employer-worker ties were fixed over time independently of work experience and worker quality.

Friendship ties between workers were important for hiring through worker referrals. In-house employees could recommend their unemployed friends to their employers for a job. Note that friendship was independent of quality. Therefore, we did not “hardwire” a tendency for homophily based on quality. On the other hand, we assumed that friendship ties between workers were strongly homophilous with regard to group membership. Just like in other cases, if the recommended worker turned out to be of low quality, the employer hired somebody else.

Moreover, employers could obtain true information on individual quality of previously hired workers of business partners and hired them if they were unemployed. We considered business ties as mutual relations that were fixed over time and did not imply any costs for the partners involved. Therefore, business ties were channels of information about individual quality, but depending on the strength of influence in network ties (captured by a “group gossip” parameter $g$), they also shaped group reputation. We assumed that each employer formed and updated group reputation in each contract term. Group reputation was the aggregation of individual quality information the employer encountered weighted by the reputation information the employer received from business partners. Therefore, it was unique to each employer and calculated as a weighted mean of individual experience (average quality of previously hired workers from the given group) and social influence from business partners.

In a given contract period, employers were selected in a random sequence to fill one of their jobs. This procedure was repeated until vacancies were available. When an employer was selected, the hiring decision followed this procedure:

1. **Re-hiring**: The employer checked previous employees and re-hired the one with the highest quality without a new contract; if this quality met his standards and exceeded group reputation scores.¹

2. **Hiring friends**: In case the vacancy could not be filled, the employer hires an unemployed friend with unknown quality randomly.

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¹ It is worth noting that re-hiring also in the case of equality decreased randomness in the results, but did not change our conclusions qualitatively.
3. **Business recommendations:** In case the job was still not filled, one unemployed worker, who had the highest quality from previously hired workers of business partners was selected; if this quality met the standards of the employer and was higher than group reputation scores.

4. **Worker referrals:** In case the job was still not filled, one unemployed friend of recently employed workers of unknown quality was hired a) randomly or b) in order of the quality of referents.

5. **Hiring from the market:** In case the job was still not filled; one unemployed worker of unknown quality was hired randomly from the group with higher reputation. If group reputation was equal, an unemployed worker with unknown quality was randomly selected.²

Note that our model ignored many aspects that economists would consider central to any hiring decision. In particular, the model included no turnover cost and legal restrictions on firing, which existed in many countries. It also ignored differential wages. In our view, both of these factors would tend to lead employers to stick with employees who were good enough rather than the best ones. It is worth noting that our employers were satisficers rather than optimizers as they kept all workers in house who had a quality higher than a threshold determined by the employer standards and group reputation.³

**Operationalization**

To measure discrimination, we created a *macro level discrimination index* that looked at inequality in employment at the macro level. For equal group sizes and no differences in average quality, we defined the index as

\[
\delta = \begin{cases} 
1 - \frac{H_1}{H_2} & \text{if } H_1 \leq H_2, \\
1 - \frac{H_2}{H_1} & \text{if } H_2 < H_1,
\end{cases} 
\]  

where \(H_i \leq N_i\) was the number of hired workers from category 1. The index took the value of 0 when no discrimination took place and 1 when all jobs were filled with workers belonging to the same category.

Note that \(\delta\) had the following undesired property: if the total number of jobs \(J\) exceeded group size \(N=N_1=N_2\), the index could not take the value of 1 even in the case of perfect discrimination. Therefore, if \(J\geq N\), an adjusted discrimination index \(\delta^*\) was calculated as follows:

² It is worth noting that we explored various algorithms to assure that auxiliary assumptions in the hiring procedure did not alter results. We also manipulated the sequence of steps 2-4 for testing the robustness of our results (not reported). We compared various mechanisms, by switching on and off steps 2-4.

³ Our agent based model has been implemented in NetLogo (Wilensky, 1999) and is freely available at the Open ABM repository (http://www.openabm.org). Our model has also been re-implemented in Repast to verify implementation coherence and to check internal validity. No difference has been found between the results of the two implementations.
The discrimination indexes $\delta$ and $\delta^*$ measured the presence of discrimination in favor of one of the groups at the macro level. However, when they had low values, this did not necessarily mean the lack of discrimination at the level of firms. If all employers were perfect discriminators and they perfectly discriminated groups randomly, then the $\delta$ index provided a low value.

To solve this problem, we created a micro level index $\delta_i$ that measured discrimination locally. The $\delta_i$ index simply compared the inequality in employment at the level of each individual employer and took the average of its distortion. It was calculated for each employer like $\delta$, and then individual scores were averaged. The $\delta_i$ index took 0 if nobody discriminated and 1 if everyone discriminated perfectly one or the other groups. We defined $\delta_i$ as:

$$
\delta_i = \frac{1}{n} \sum_{i=1}^{n} \delta_{ii}
$$

where

$$
\delta_{ii} = \begin{cases} 
1 - \frac{H_{i1}}{H_{i1} - (J - N)} & \text{if } H_{i1} \leq H_{i2} \\
1 - \frac{H_{i2}}{H_{i1} - (J - N)} & \text{if } H_{i2} < H_{i1}
\end{cases}
$$

where $H_{i1}$ was the number of hired workers by employer $i$ from category 1 and $n$ was the number of employers.

A labor market segregation measure was built to compare pairwise similarity of labor force composition of business partners. When business partners with identical composition (same proportion of hired workers from each category) were connected and nodes that were dissimilar were not connected, the labor market segregation index took the value of 0. The principle was that the higher the similarity between connected nodes, the higher the labor market segregation index. For a random network with a random employee composition, the index took the value of 0. However, the random network with random employment was not the least segregated network. When perfectly dissimilar nodes were connected and perfectly similar nodes were not connected, the index took the value of -1.

The next step was to consider both the extent of deviation from the workers’ random allocation to jobs and from the random network between employers. To do this, we let workers to be randomly distributed among employers and explored this distribution. Then, for a given density of employer contacts, we constructed a random network that
connected employers. In the random network, we calculated the pairwise similarity $e_{ij}$ of connected nodes and took the average of $e_{ij}$ values for all $ij$ connections ($e^*$). We simulated this process to obtain the expected value of average pairwise similarity $E(e^*)$ for the given network density. $E(e^*)$ characterized the ideal-typical case of zero labor market segregation in a random graph with a random distribution of the labor force in jobs. Finally, for an observed network and employment profile, the labor market segregation index was calculated on the difference between the observed average pairwise similarity ($e$) and the ideal-typical case $E(e^*)$, similar to the logic of Freeman’s (1978) segregation index. Our index took 1 in case of perfect similarity ($e=1$), 0 in case of expected similarity ($e=E(e^*)$), and -1 in case of perfect dissimilarity ($e=-1$). Therefore, we defined a labor market segregation index $S^*$ as:

$$S^* = \begin{cases} 
  e - E(e^*) & \text{if } e \geq E(e^*) \\
  1 - E(e^*) & \text{if } e < E(e^*) \\
  E(e^*) - e & \text{if } e < E(e^*) + 1 
\end{cases}$$  \hspace{1cm} (4)

In order to determine the pairwise similarity $e_{ij}$ of directly connected nodes $i$ and $j$, we denoted the proportion of workers of category 1 hired by employer $i$ by $p_{1i}$ and the proportion of hired workers of category 2 by $p_{2i}=1-p_{1i}$. If employers were perfectly similar ($p_{1i}=p_{1j}$), then $e_{ij}=1$. Vice-versa ($p_{1i}=1$ and $p_{1j}=0$), $e_{ij}=-1$. If one hired from both groups equally and the other hired from category 1 only ($p_{1i}=p_{2i}$ and $p_{1j}=1$), then $e_{ij}=0$. We calculated $e_{ij}$ for the simplest case of equal group sizes $N_1=N_2$ as:

$$e_{ij} = 1 - 2|p_{1i}-p_{1j}|.$$  \hspace{1cm} (5)

In order to interpret $S^*$, we considered the actual density of the network. Low or high values of labor market segregation are relatively meaningless when employers are relatively isolated and comparison of networks with different densities is problematic. For this reason, we compared labor market segregation only between business networks of the same density.

RESULTS

Emergence of discrimination in an atomized market

First, we considered a simple case where the emergence of discrimination without group differences could be demonstrated easily. Inspired by Thomas Schelling’s work (e.g., 1969; 1978), we aimed at providing a logical illustration of how profit-oriented and neutral hiring decisions of employers could lead to a considerable level of unintended discrimination.

Let us consider a simple scenario where there were no network effects and hiring was based only on the personal experience of the employer. In this case, employers did not re-hire workers below their quality standards or below the higher group reputation score. Low quality workers were replaced by new workers from the group with higher...
reputation. When workers were re-hired, it means that employers were satisfied with them and/or they quality were higher than what expected from their group reputation. Although there was no initial reason to believe that such an optimization could produce discrimination, our results showed that even under these ideal-looking conditions, employers could become perfect discriminators.

<table>
<thead>
<tr>
<th>Year</th>
<th>Group 1 workers</th>
<th>Group 1 n of new entrants / Group 1 reputation</th>
<th>Group 2 workers</th>
<th>Group 2 n of new entrants / Group 2 reputation</th>
</tr>
</thead>
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<td>14</td>
<td>10</td>
<td>3</td>
<td>3</td>
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<tr>
<td></td>
<td>k f</td>
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<td>9.00</td>
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<tr>
<td>2</td>
<td>11 6</td>
<td>14 10</td>
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<td>14 10</td>
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<td>10.25</td>
<td>k f</td>
<td>12.00</td>
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<tr>
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<td>0</td>
<td>16 12 8</td>
<td>4 4</td>
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<td></td>
<td>k</td>
<td>14.00</td>
<td>k f f</td>
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<tr>
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<td>14 10 6</td>
<td>3</td>
<td>16</td>
<td>14 0</td>
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<td>16 18 15 15 9 1</td>
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<td>10.00</td>
<td>k k k k f</td>
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</table>

Table 1. Labor composition of a firm with 6 jobs over time.

Notes: The firm keeps quality records for one term (m=1), so group reputation is calculated as the average of quality of employees in the previous term. (If nobody was employed, the previous group reputation was used.) New workers are drawn from a random uniform distribution from the group with the higher reputation. A higher group reputation is indicated in bold. Individual quality is bold if kept in house (k) and not bold otherwise (f).

Let us illustrate this with the decisions of a single employer with a poor memory (m=1) offering six jobs (Table 1). In the first hiring period, the employer hired three workers from both groups randomly. The quality of workers was drawn from a random uniform distribution. A small difference between the average qualities occurred naturally due to random sampling. Therefore, one group (Group 1 in Table 1) could have a slightly higher reputation. In the second hiring period, new workers were hired from this group. However, the average quality of new Group 1 workers was below the average quality of workers from Group 2 who were kept in house. Therefore, the reputation of Group 2 was higher and resulted in hiring four new employees from Group 2 in the third year. Yet
again, the average quality of the new workers was below the reputation of Group 1 (14), and therefore in Year 4 there was another change of fortune. By the time of the fifth contract term, employees were only selected from one of the groups. There was no way back. The difference of group reputation was significant onward.

In short, after quick switches in groups’ fortunes, one group gained an overall dominance, which remained stable over time. This means that perfect discrimination could be the result of the rational search of fair employers. Note that the emergence of perfect discrimination shown in Table 1 is a robust result for small firm sizes. A larger firm size makes it more difficult to tip to hiring from only one category, because the large number of newcomers destabilizes the dominant group reputation.

Controlling variables: the level of unemployment, memory, time horizon, and employer standards

After this illustration, we briefly summarized the effects of our auxiliary model parameters in our agent based simulation. In an ideal case, these should have no effect. We checked the effect of the values of the unemployment rate, the employer memory, and its time horizon. We found that higher unemployment (increasing competition for jobs) increased the discrimination index $\delta$. However, this was simply due to the calculation with $\delta$, instead of the adjusted discrimination index $\delta^*$ in the range of $J\geq N$. Using the adjusted measure $\delta^*$, there was no increasing effect of unemployment. The unadjusted discrimination index and the micro level discrimination index had lower values for smaller unemployment as almost everyone was employed. Therefore, there was no difference in employment rates. In case of $J<N$, there was no effect of unemployment on the unadjusted discrimination index $\delta$.

Next, we explored the effect of the memory parameter $m$ on discrimination. We expected that good memory led to lower discrimination, because better records helped a closer approximation of average group quality. As expected, longer memories decreased discrimination, with a large drop between $m=1$ (erasing all records of fired workers after one year) and $m=2$ (deleting quality records two years after dismissal), in particular. Similarly, one could expect that if we took a sufficiently long time perspective, employers could correct for their initial prejudices and biased experiences. We found that this was wrong. In the first year of employment, all employers hired from the groups randomly. Therefore, the index values for the first year in Figure 1 were equal to the baseline that one would obtain in case of random hiring decisions. The micro level discrimination then gradually increased over time for all memory levels (Figure 1) irrespectively of the distribution of worker quality. In case of small firm sizes, every employer was soon conditioned by sampling bias and started to strongly discriminate among workers ($\delta_i=1$). Note that when the micro level index increased, there was also a larger bias at the macro level in favor of one of the groups. Macro level discrimination stabilized around a value that corresponded to an average of 61%-39% discrepancy in employment. Note that our findings do not depend on choosing the uniform distribution as a default characteristic of individual quality.
Figure 1. Mean values and 95% confidence intervals of the $\delta$ discrimination index (below) and of the micro level $\delta_i$ discrimination index (above) across for a normal and a uniform distribution of worker quality, 1000 runs each per values of time horizon (horizontal axis); 28000 runs in total.

Notes: 6 jobs per employer, no business contacts, maximum standards (19), no worker referrals, the memory parameter $m$ is varied with values of \{1; 2; 3; 4; 5; 6; 8; 10; 15; 20\}. Parameter values that are fixed here and in all displayed figures: 15 employers, and 200 workers.

Quite a few previous studies on discrimination claimed that structural opportunities at the start of the career were detrimental for later chances in the labor market (McBrier, 2003; Rosenblum and Rosenblum, 1990; Rosenfeld and Sørensen, 1979). Theoretical studies claimed that subtle initial differences or positional advantages were enlarged during the self-organizing dynamics and employment prospects of groups were persistently different (Calvó-Armengol and Jackson, 2004; 2007). Therefore, we carefully checked the evolution of discrimination and labor market segregation over time and correlated data from the first contract year with later outcomes. Our results showed that the initial discrimination index was not a strong determinant of the final discrimination index. This was due to the frequent changes of fortune in the first contract years, as shown in Figure 1.

Our results showed that higher employer standards led to higher discrimination rates. This relation occurred both at the micro and the macro level. Furthermore, higher employer standards implied higher labor market segregation. While there was no difference between discrimination rates if low or medium standards were assumed, index values increased for high standards. This was a robust result across a wide range of parameter values.

Affective content: friendship between employers and workers
The next step was to extend the agent-based model by introducing friendship ties between employers and workers. We assumed that due to their affective content, these ties were unavoidable assets and burdens for the employers. They were assets in the sense that employers hired friends and could keep them committed if friends had high quality, while did not re-hire them if their quality turned out to be low. Friendship ties were burdens because unemployed friends with unknown working quality should receive priority at the hiring decisions.

It is important to note that at the set up of friendship ties between employers and workers, we did not assume any bias, i.e., employers had the same probability to have a link to workers in Groups 1 and 2. We manipulated the density of the bipartite friendship network between employers and workers and examined how the extent to which employers hired friends affected discrimination.

Our results showed that, under any parameter combination, discrimination did not increase with the increasing density of the bipartite friendship network. *Vice versa, if fair employers had and hired more friends, this helped to diminish discrimination* (see Figure 2). There was a drop in the discrimination indexes if employers had more friendship ties to employees. The drop was larger when employer standards were higher. For the higher employer standards, every employer was a perfect discriminator if they did not hire worker friends, and the discrimination rate was minimal if employers were friends with approximately 10% of the workers. In general, in case of a large density of employer-worker friendship ties, employers hired new workers only from their balanced friendship networks and not on the market.
Interestingly, hiring friends induced employers to behave more fairly compared with the situation where this type of social contacts did not exist, i.e., when employers relied on an extended and unbiased social network. In this case, their network pool was sufficiently large to ensure a suitable amount of workers with the required skills. To sum up, our results showed that commitment to friends, which was not driven by market incentives, efficiently reduced information asymmetry and consequently even discrimination.

Another interesting finding was that, independently of the density of the social network of workers, the density of the bipartite friendship ties had a strong effect on discrimination (Figure 3). Indeed, we found that the denser was the bipartite network, the lower the discrimination was. With no friendship ties between employers and workers, there was a stronger micro level discrimination, which decreased to a fair level thanks to hiring friends and worker referrals provided by friends hired before.

The social network of workers

Previous work would bring us to believe that the increasing density of a segregated social network of workers could increase micro level discrimination. To test this, we manipulated the density of the segregated social network of workers. In the simulation setup of the social network, together with the required density, there were two perfectly segregated components of the social network among workers with an equal size. Within each component, ties were drawn randomly. Ties between the segments were created only above the critical value of density so that no more ties were possible within the components. During the hiring process, workers who were recently employed by an employer could “refer” their friends if jobs were open. Therefore, now employers could
even pick friends of previously hired workers and benefit from the worker referral mechanism. Results showed that discrimination quickly dropped with a few worker referrals (see Figure 3). This outcome was stable with or without business networks and in any kind of business networks. On the other hand, many worker referrals that characterized the denser worker network were detrimental for discrimination, especially in the lack of bipartite friendship ties.

![Mean values of the $\delta$ discrimination index (above) and the $\delta_i$ micro level discrimination index across 100 runs for each parameter combination (32000 for each part of the figure). Values are averaged for the density of social networks among workers and for the density of the bipartite friendship network between employers and workers. On the left: hiring in which no worker had a priority for referrals, on the right: hiring in which recommendations by workers with a higher quality were hired first.](image)

**Notes**: 5 jobs per employer, random business network with a density of 0.1333; $m=5$, maximum employer standards (19); $g=0$ and $g=0.1$, 100 years per run.

This means that we found an interesting and robust U-shaped effect of social network density. Discrimination was higher in the complete lack and in the presence of sufficient ties among workers, and it was lower if only a couple of ties (40-100 ties in the numerical example of Figure 3 with 200 workers) were present. This U-shaped effect occurred in
each network type, for all values of business network density and for all kinds of different specifications of the reputation mechanism.

It is worth noting that understanding the U-shaped effect is not easy. Results showed that a couple of ties between the workers (on average less than one) had an effect similar to the effect of employer-worker friendship ties. Indeed, the selection pool was enlarged and so discrimination dropped. More ties among workers gave rise to the expected effect induced by the segregation of contacts. This means that employers repeatedly hired from a dense circle of a single group of employees.

We found that labor market segregation did not increase by increasing the importance of referral hiring. On the other hand, labor market segregation showed a relatively stable and fair value across the parameter values of referral density and social network density, except for the lack of networks, when labor market segregation was higher. Our explanation is that business contact networks were the only information channel and alone they could not balance the outcome, as happened with referral networks. Furthermore, if worker ties were used for recommendations, the effect of employer standards on discrimination was diminishing. We found that employer standards had a stronger impact on discrimination rates both at the micro and at the macro level where social network ties among workers were not present.

**Information exchange: business networks**

As regards to the effect of network ties between employers on discrimination, we assumed that business contacts were fixed over time and did not imply any costs. As discussed before, business ties could be exploited to acquire important information about in-house worker quality. Therefore, these ties were as means to hire more skilled workers. Consequently, it was expected that the density and structure of business contacts could have an effect on discrimination. Our hypothesis was that higher density of business networks would have determined lower discrimination.
employers were connected to one single “star”.

Employer standards for different employer standards. Separation could spread more easily. Separate components and low cohesion of the differences in the macro level discrimination index. The effect of business networks was created uniform beliefs in the business network. If key actors had biased beliefs, then discrimination could spread more easily. Separate components and low cohesion of the business network could explain the development of local regimes and labor market segregation, with a larger potential that local regimes were different.

Notes: 6 jobs per employer, random business network, no ties between employers and workers, $m=30$, 100 years per run.

As shown in Figure 4, we found that business network density decreased discrimination at the micro level, but only to a moderate extent. Small differences in the micro level discrimination index by the density of business contacts did not aggregate into significant differences in the macro level discrimination index. The effect of business networks was generally weak when compared with the impact of employer standards and worker referrals. Furthermore, business network density had a positive impact on the macro level discrimination index when employer standards increased. This small interaction effect was present under a wide range of conditions, despite the fact that the micro level discrimination index decreased by business network density slightly even for higher employer standards.

These results indicated that the direct exchange of information about workers between employers could not have a strong effect on discrimination, thereby leaving the problem of information asymmetry in the labor market unsolved. Employers still showed bias, which were based on the overrepresentation of a few highly skilled in-house workers, especially in case of high standards.

We also explored the role of topological features of the business network on discrimination. This was to check whether the presence of central actors could rapidly create uniform beliefs in the business network. If key actors had biased beliefs, then discrimination could spread more easily. Separate components and low cohesion of the business network could explain the development of local regimes and labor market segregation, with a larger potential that local regimes were different.

We built various business network structures. *Star networks* were included as extreme cases of high centralization. For instance, in a “perfect” star network with $n-1$ links, all employers were connected to one single “star”. *Regular networks* were included as
extreme cases of low centralization. An example of a regular network with $n-1$ links is a line network. In the network labeled as “2 segments”, two components of equal size were created with an equal probability of all possible ties within the segments, i.e., the components themselves were random networks. Similarly, in the network called “regular components”, we created two separate components, but with a regular structure internally (e.g., a line and a circle for $n-1$ links).

We found that there was no difference in discrimination rates between network types for any employer standards and for any density of worker networks. Not only networks that were single components had the same discrimination rate, but segmented structures (2 segments and regular components) did not differ for discrimination from other networks. The lack of business network effects was confirmed both with and without referral contacts between employers and workers. While the density of employee-employer networks had a slight impact on discrimination, the type of the network of employers did not. Furthermore, our results indicated no significant difference between network types in the short, medium, and long run. There also was no difference in the path dependence for any parameter combination. This meant that the initial discrimination rate in a star network was not a better or worse predictor of the final discrimination index than in other types of network.

Note that discrimination rates were low in the co-presence of business networks, employer-worker contacts, and worker social networks. Without worker referrals discrimination rates were higher, but still there was no difference between different business network structures. This means that between business partners, individual experiences took place more independently than expected and pairwise similarity of hiring choices between business partners was at a medium level. The choices of business partners were positively correlated, but only weakly. In contrast, without referral networks and exchange of group reputation, pairwise similarity in all types of business networks dropped to around zero, which indicated that simply merging available information on workers did not necessarily lead to correlated choices of employers.

Therefore, we must conclude that for a given density, with or without worker referrals, network centralization and segmentation of business contacts did not make any significant difference for discrimination. To test this, we explored other types of business contact structures, including cohesive blocks, segmented blocks connected with a single bridge, and regular networks with some imperfections. For a given density of $n-1$, no significant differences in the discrimination measure $\delta$ were found. There was no difference between business networks also for larger networks ($n=150$) and for any employer standards. The same was true for the discrimination index between business network types, under any level of unemployment. Even the difference in the variance of discrimination between business network types was not significant. In short, the fact that network forms of employers did not affect discrimination was a robust result.

Furthermore, we examined the effect of business network types on labor market segregation. Differences in $S^*$ were very small. We found slightly higher labor market segregation in the star network with or without worker referrals. Differences between network types in labor market segregation were small, but significant and consistent across a wide range of parameter values. Our results showed that it is not the structural cohesion that made a difference for labor market segregation. The star network showed a slightly higher labor market segregation as pairwise disagreement between connected
pairs was most frequent in this type of structure. On the other hand, regular networks minimized pairwise disagreement given a fixed density as they allowed agents to coordinate better locally.

**SUMMARY AND CONCLUSIONS**

This paper showed that discrimination can also occur and be prevalent in the lack of statistical differences between the groups and in the absence of prejudice. We showed that discrimination persists even when the mean quality of groups is the same and all employers are intentionally unbiased, just strive for quality and rely on their personal experiences. Discrimination can be an unintended consequence of a rational hiring process similar to other judgment bias caused by available information during repeated sampling (cf. Simon, 1955; 1956; Denrell, 2005; Fiedler and Justlin, 2006; Denrell and Le Mens, 2007; Le Mens and Denrell, 2011). Therefore, statistical differences and built-in preferences and prejudices cannot be considered as the only mechanisms responsible for inequality in the employment rates of different groups. This contrasts with the economists’ view, where discrimination should not persist if beliefs were incorrect as employers not sharing false beliefs would gain a competitive advantage (Arrow, 1973; Aigner and Cain, 1977). Indeed, there is little empirical evidence that employer practices reflect efficient and rational responses to differences in skills and turnover costs (Bielby and Baron, 1986).

The finding that discrimination can occur also under ideal circumstances has serious empirical implications. Inequality in the labor market will never be ruled out perfectly and a perfectly balanced market will never occur. On the other hand, just like the natural level of unemployment does not imply that unemployment does not need to be cured, policies should fight against discrimination practices. Our results suggest that efficient policies should concentrate on providing better information about the quality and skills of the labor force, help to disentangle reliable signals that require investments from visible signals that do not, and highlight observed disparities in employment with regard to the latter. However, there is no guarantee that more information about sampling bias can neutralize them and so help to eradicate discrimination (e.g., Le Mens and Denrell, 2011). Unlike urban legends that blame network referrals for labor market deficiencies, we found that social networks, and especially those used to hiring friends, might actually help to reduce discrimination. Previous studies showed that social networks were highly relevant for discriminatory norms and practices. This was because network referrals were equalized with partiality towards friends and acquaintances. Our study shows that this bias could be largely compensated by the function of channeling reliable information in trusted relationships. When commitment does not hold for poorly performing friends and so the influence of friendship has some limitation, hiring friends could be a profitable strategy for employers.

Given that social networks of workers are typically segregated, labor market segregation is an obvious consequence of an extended use of referral hiring. We hypothesized that if employers tended to hire more frequently their friends and worker referrals played an important role in job hiring, then micro level discrimination could increase and the labor market becomes strongly segregated. On the contrary, our results showed that hiring friends can diminish discrimination. The reason is that friendship relationships, which
show a balanced composition, can make hiring from both groups unavoidable. Consequently, hiring friends can reduce bias in individual experiences of employers and inequality, so contributing to higher market efficiency. Therefore, the predominantly negative view on social network effects on the labor market efficiency should be reconsidered.

Furthermore, we found that an increased density and segmentation of the social network of workers does not contribute to higher discrimination. In the presence of no or only a few employer-worker friendship ties, the density of the workers’ referral network could have a U-shaped effect on discrimination. This means that discrimination was lower if only a couple of ties between workers were used for referrals. Our explanation was that in these cases, there is an information benefit for the employers and no negative effect due to the proliferation of referrals from a segregated social network.

Then, we investigated whether information transmission through business ties could solve the problem of asymmetric information in the hiring process. Largely neglected in previous research, business networks are important sources of recommendations. We expected that a dense exchange of information between employers would have decreased discrimination. We found that a higher density of the business network decreased micro level discrimination to a moderate extent. After all, business networks, which are explicitly used for information exchange, had a weaker effect on discrimination and market efficiency than employer-worker friendship relations. Our results implied that if employers could select their partnerships, information returns do not rationalize costly investments in an extensive build-up of a business partnership network. Vice-versa, balanced friendship relations that are not maintained and used for the sake of market success, provide a more efficient way for correcting for sampling bias and resolve the problem of asymmetric information.

We also explored the role of the topological features of the business network on discrimination. On average, largely different business networks did not show differences in rate and spread of discrimination. For a given density, all types of business networks achieved the same level of discrimination and labor market segregation, either in the short or in the long run.

Obviously, our study has certain limitations that could be relaxed in subsequent developments and also has problems of external validity. Empirical situations are much more complex and an abstract model could only provide ‘what-if’ type of answers about fundamental mechanisms. For instance, we were interested in the unintended consequences of the use of networks during the hiring process and studied them under fair and “clean” circumstances. On the other hand, network mechanisms could be radically different if employers were primarily prejudiced, had friends only in one group, or there were statistical differences of quality between the groups.

Finally, we have concentrated on certain structural factors that might contribute to discrimination at hiring decisions. It is probable that other structural mechanisms might accentuate these effects. Furthermore, we limited our analysis to the case of one category of workers over another for hiring decisions that could be extended to multiple categories (e.g., ethnicity), more dimensions (e.g., hair color and gender) and for instance, for wage decisions.
References


