Job Search Networks and Ethnic Segregation in the Workplace [1]

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Abstract

This paper presents novel evidence on the existence and productivity of referral-based job search networks of ethnic minority workers. Using unique matched employer-employee data, we first show that minority workers are considerably more likely to work with workers from the same minority group (i.e. with workers who are likely to be network members) than they are with majority workers or with workers from other minority groups. We then provide evidence that ethnic minority workers earn higher wages, and are less likely to leave their firms, if they work in firms with a higher share of co-workers of the same minority group and are therefore more likely to have obtained the job through a referral. The wage effect is particularly pronounced for young workers whose productivity is more uncertain, strongest for workers who have just entered the firm, and amplified if the co-workers from the same minority group are better educated. These findings support the hypothesis that, through referrals, job search networks help to reduce informational deficiencies in the labor market and lead to productivity gains for workers.

Key Words: Job Search Networks, Referrals, Segregation

JEL Classification: J61, J63, J31

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1 Introduction

Several studies show that at least one third of employees have obtained their current job through family members or friends, pointing towards the importance of informal social networks in the job search process.[2] Such networks have the potential to enhance the efficiency of the labor market by reducing informational uncertainties and thus search frictions. Information can be exchanged in at least two ways: among potential employees, by informing each other about job opportunities (see e.g. models by Topa, 2001, and Calvo-Armengol and Jackson, 2004, 2007), or between employees and employers, by providing information about the productivity of network members to the employer (see e.g. the referral models by Simon and Warner, 1992, and Montgomery, 1991). However, so far little is known about how job search networks actually operate, and whether they lead to efficiency gains.

In this paper, we present novel evidence on the existence and productivity of job search networks, concentrating on referral-based models in which employees provide employers with information about potential job market candidates that employers otherwise would not have. Similar to Borjas (1992, 1995) and Bertrand et al. (2000), we define networks to operate along ethnic minority-group dimensions. In contrast to these papers, and most existing work, our focus is on the workplace. In the first part of the empirical analysis, we test for a key implication of job search networks: workers from the same ethnic minority group (i.e. workers who are likely to belong to the same network), should cluster together in the same workplace. Our data is uniquely suited to do this. They come from social security records, and allow us to follow all workers and all

[2] See, for instance, Granovetter (1974, 1995), Corcoran et al. (1980), Holzer (1988), Gregg and Wadsworth (1996), and Addison and Portugal (2002).

firms covered by the social security system in one large West German metropolitan area over a 20 year period. Based on two widely-applied segregation measures, we find that minority workers are considerably more likely to work with workers from the same minority group than they are with majority workers or with workers from other minority groups. We also show that ethnic segregation at the workplace declines with time in the labor market, pointing towards less reliance on ethnicity-based networks for job search purposes as minorities become more experienced.

In the second part of the empirical analysis, we turn to the productivity of job search networks. We first investigate whether minority workers earn higher wages in firms with a higher share of co-workers from their own group. The underlying idea here is that these workers are more likely to have been referred to their employer by one of their co-workers and should therefore, according to the referral models by Montgomery (1991) and Simon and Warner (1992), be of higher productivity. We also examine whether a higher share of co-workers from the same minority group reduces the probability of a worker leaving her firm as one would expect if, as in the model by Simon and Warner (1992), referred workers are better matched with their firms. Measuring these wage and job turnover effects is difficult due to the non-random sorting of workers into firms. An important innovation of our paper is to address these issues by taking advantage of the extensive longitudinal information on the universe of workers and firms in our data. We find that, once we account for non-random sorting, minority workers earn higher wages and are less likely to leave their firms if the share of co-workers from the own group is higher, suggesting that job search networks are productive.

We then present additional evidence that is supportive of referral-based job search networks. First, wage effects are concentrated among workers who have just joined the firm and decline with

tenure at the firm. Second, wage effects are strongest for young workers whose productivity is particularly uncertain and who therefore have the most to gain from a referral. Finally, the wage effects are larger if the co-workers from the same ethnic group are better educated.

We interpret these findings as strong evidence for the hypothesis that, through referrals, job search networks help to reduce informational deficiencies in the labor market and lead to productivity gains for workers. In contrast, alternative explanations for ethnic segregation at the workplace, in particular productivity spillovers and taste-based discrimination, cannot account for all of our findings.

Our paper is related to two main strands in the literature. First, it adds to the literature on ethnic segregation. Unlike this paper, most of this literature has focused on residential, as opposed to workplace, segregation.[3] An early literature has provided some evidence that segregation is associated with significantly poorer economic outcomes of ethnic minority groups (see e.g. Cutler and Glaeser, 1997, who focus on blacks, and Chiswick and Miller, 1995, who focus on immigrants). More recent work, however, has challenged this view, arguing that these findings are due to non-random selection of individuals into areas (see Edin et al., 2003, Damm, 2009), and that residential segregation leads to an increase in employment probabilities and wages of minorities.[4] Our findings point to the possibility that these gains are, at least in part, created at the level of the firm, through referral-based networks that reduce search frictions.

Similar to us, Carrington and Troske (1998), as well as the series of papers by Hellerstein and

[3] Studies that analyze ethnic segregation at the residential level include Musterd (2005), Cutler et al. (2008b), and Semyonov and Glikman (2008).

[4] In line with these findings, Munshi (2003) provides evidence that Mexicans who belong to a larger network in the U.S. are more likely to be employed and hold a higher paying non-agricultural job. Similarly, Cutler et al. (2008a) show that there are beneficial effects of segregation for immigrants in the U.S., in particular for groups with high human capital levels.

Neumark (2003, 2008) and Hellerstein et al. (2007), analyze *firm*-level segregation of minority groups in the U.S. These papers focus on blacks and Hispanics, while we, similar to Åslund and Nordström Skans (2009), investigate firm level segregation by ethnicity, distinguishing between many different groups. Moreover, unlike these papers, we focus on job search networks as a potential explanation for firm level segregation, and provide novel evidence on the benefits of such segregation.

Our paper is also related to the literature on job search networks. Most of the existing evidence on such networks comes from surveys where workers are asked how they found their current job (see Ioannides and Datcher-Loury, 2004, for an excellent overview of the literature). Granovetter (1974) was one of the first to document the widespread use of friends and relatives in the job search process. The existing evidence on how the usage of friends and relatives in the job search process affects wages is so far mixed[5], and this literature has found it difficult to deal with the problem that employees and employers who rely more on networks may not be randomly selected (see, for instance, Mouw, 2003). The longitudinal nature of our data allows us to make important progress on this issue.

Recent research by Bayer et al. (2008) and Hellerstein et al. (2008) use a similar approach to ours, and test whether network members cluster together in the same work-location or firm. These papers define networks very locally, as individuals living very closely together. Kramarz and Nordström Skans (2007) focus on the importance of *family*-based networks during the transition from school to work, and analyze whether firms are more likely to hire children of current

[5] For instance, Marmaros and Sacerdote (2002) report that individuals who received help from fraternity/sorority contacts were more likely to obtain high-paying jobs. Holzer (1987), in contrast, finds no positive wage effects. Patel and Vella (2007) provide evidence that new arrivals of immigrants choose the same occupations as their countrymen, and that this occupational choice is positively associated with their earnings.

employees than otherwise similar job market candidates. We complement their analysis by analyzing ethnicity-based networks, defined as individuals of the same ethnic group living in a larger metropolitan area. We go beyond these papers by presenting novel evidence on the productivity of networks and on the heterogeneity of this effect, thereby providing more direct evidence of the hypothesis that job search networks serve to reduce search frictions in the labor market.

The structure of the paper is as follows. In the next section, we provide an overview of the main ethnic minority groups in Germany and describe the data. In Section 3, we first briefly outline the referral models of Montgomery (1991) and Simon and Warner (1992) that underline our analysis, and then explain our empirical methods. In Section 4, we document several pieces of evidence that are consistent with the presence and importance of referral-based job search networks in the labor market. In Section 5, we explore potential alternative explanations for our findings. We conclude in Section 6.

2 Background and Data

2.1 Minority Groups in Germany

Large-scale immigration to Germany started in the mid-1950s as a result of the strong economic growth in (West-) Germany at that time. Immigrants originated from Turkey, Yugoslavia, Italy, Greece, Spain and Portugal. Following the recession in 1973/1974, the active recruitment of immigrants came to a hold; however, subsequent immigration of family members continued. The second big immigration wave to Germany was a result of the collapse of the Former Soviet Union and the political changes in Eastern Europe in the late 1980s and 1990s. The main immigrant

groups of this period were, on the one hand, ethnic German immigrants (so-called *Aussiedler*), mostly from Poland and the Former Soviet Union, and, on the other hand, refugees from the wars in Former Yugoslavia.[6]

In official statistics, immigrant status is based on citizenship, rather than place of birth.[7] This is also the definition for minorities we use in our analysis. Consequently, individuals with foreign citizenship who were born in Germany are included among the "ethnic minority" populations. In 1990, the overall minority population in Germany was around 5.3 million, or 6.7% of the overall population.[8] By 2000, this number had increased to around 7.3 million, or 8.9% of the overall population. The biggest groups come from Germany's traditional guest worker countries Turkey, Yugoslavia, Italy and Greece, who make up more than 50% of Germany's overall minority population in both 1990 and 2000. The groups that experienced the largest (relative) increases between 1990 and 2000 were immigrants from the Former Soviet Union (from 0.3% to 3.8%), Central and Eastern Europe (from 2.8% to 3.4%), and Former Yugoslavia (from 12.4% to 15.2%).

The share of foreign citizens that were born in Germany is highest for individuals from countries of the first migration wave, Turkey, Italy and Greece, at around 18-19% in 2000. Overall, however, only 11.0% of working-age foreign citizens living in Germany in 2000 were born in the country.

[6] For more detailed information on the different migration waves and their historical background, see Bauer et al. (2005).

[7] Until 1 January 2000, citizenship in Germany was exclusively based on descent (ius sanguinis) and individuals born in Germany by non-German parents were not automatically granted German citizenship. Naturalization of adults was possible after 15 years of legal residence. Since 1 January 2000, children born by non-German parents who have legally lived in Germany for at least eight years are automatically granted German citizenship.

[8] Figures are based on numbers from the German Statistical Office and own calculations on the basis of the German Microcensus.

2.2 Data and Sample Selection

The data used in our analysis come from Social Security Records covering more than two decades, from 1980 to 2001. They comprise every man and woman covered by the social security system, observed at the 30th of June in each year. Not included are civil servants, the self-employed, and military personnel.[9] The data contain unique worker and establishment identifiers[10], as well as an unusually wide array of background characteristics, such as education[11], occupation, industry, and citizenship. The citizenship variable is very detailed, and allows us to distinguish, for instance, between citizens of Russia, Belarus, and the Ukraine.

Our data set has a number of advantages over the data used by Hellerstein and Neumark (2008), whose analysis is based on an approximately 5% sample of workers from the 1990 Census.[12] First, we are able to follow workers, and their co-workers, over time. Second, while Hellerstein and Neumark's (2008) data set oversamples large firms and only identifies a (random) subset of workers in each firm, we observe every worker in every firm, which ensures our findings are representative for both firms and workers, and allows us to precisely calculate the ethnicity composition of each firm's workforce. Third, we break down ethnicity to a far more detailed level, distinguishing between 162 different groups.

From this data base, we have initially selected all workers aged between 15 and 64 working

[9] In 2001, 77.2% of all workers in the German economy were covered by social security and are hence recorded in the data (Bundesagentur für Arbeit, 2004).

[10] Throughout the paper, we use the terms workplace, establishments, and firms interchangeably.

[11] To improve the consistency of the education variable in our data, we apply the imputation algorithm suggested by Fitzenberger et al. (2006).

[12] One of the contributions of the series of papers by Hellerstein and Neumark (2003, 2008) and Hellerstein et al. (2007, 2008) lies in the non-trivial matching of respondents of the 1990 and 2000 Decennial Census Long Forms to establishments drawn from the Census Bureau's Business Register, using the employer's name and address information provided by the Census respondents.

in one of the four largest metropolitan areas in Germany: Hamburg, Cologne, Frankfurt, and Munich. This strategy is motivated as follows. First, it allows us to focus on the sorting of ethnic minorities into firms within cities. Any ethnic segregation at the firm level is therefore not driven by residential sorting of ethnic minorities into cities. Second, mobility to and from these cities is fairly low, around 3.0% in one year and 6.9% in 5 years. Hence, we can think of these cities as local labor markets. Third, ethnic minorities are concentrated in large cities; while 23.2% of ethnic minorities live in the four largest cities, only 13.9% of Germans do so. Throughout the paper, we focus on findings for Munich. The Munich metropolitan area consists of 10 districts (*Kreise*), 222 municipalities (*Gemeinden*), and is approximately 70 miles in diameter. Baseline results for the other three metropolitan areas are similar, and can be found in the appendix (Table A.1).

Table 1 reports some summary statistics of our sample. For 1990, our sample comprises 1,036,747 workers, working in 73,265 firms. Of those, 13.4% have foreign citizenship. We refer to these as minority workers. By 2000, the number of minority workers has increased by 28,055, raising their share in the workforce to 15.6%. The largest minority groups in 2000 are from Former Yugoslavia (25.3%), Turkey (17.2%) and Austria (11.1%). The last three columns in the upper panel of Table 1 show the educational attainment of minority workers. Individuals, in particular those from the guest worker countries Turkey, Yugoslavia, Italy, and Greece, are considerably less educated than Germans: about 13.0% of German workers have no post-secondary education (we label these workers as low-skilled), compared with 41.2% of the minority workers. The share of workers with a college degree (which we label as high-skilled) is 20.2% for German, but only 8.9% for minority workers.

3 Methodology

3.1 Theoretical Background

Our analysis is best viewed within the theoretical framework of the job referral models developed by Simon and Warner (1992) and Montgomery (1991). The central feature of both models is that workers provide otherwise unobservable information about the productivity of their network members to the employer. In the model by Simon and Warner (1992), productivity is match-specific, and a recommendation from a network member reduces the uncertainty of the firm-worker match.[13] In the model by Montgomery (1991), workers are either low- or high-ability, and high-ability workers are more likely to be connected to high-ability than to low-ability workers. Due to this "inbreeding bias", employers, who observe workers' abilities only after hiring them, can infer something about a new worker's potential ability if this worker has been referred by an existing worker. In equilibrium, firms hire through referrals if the worker who made the referral is of high-ability, and through the external market otherwise.

A key implication of both models is that members of the same network cluster together in the same workplaces. In the first part of our empirical analysis, we test for such workplace segregation using two widely-applied measures of segregation, the index of dissimilarity and the index of co-worker segregation. We describe these measures in the following section, and report results in Section 4.1.

The models have a number of additional implications that refer to the level of the firm. Most importantly, both models predict that workers who obtained their job through a referral earn

[13] Pinkston (2008) provides some empirical evidence that is consistent with this hypothesis.

higher wages. In the model by Montgomery (1991), this is because these workers are on average of higher ability. In the model by Simon and Warner (1992), this is because these workers are on average better matched with their firms. The model by Simon and Warner (1992) additionally predicts that referred workers are less likely to leave the firm, due to their higher match quality. We investigate these key implications in the second part of our empirical analysis by testing whether minority workers earn higher wages, and are less likely to leave the firm, in firms with a higher share of co-workers from their own group, and are therefore more likely to have obtained their job through a referral. In Section 3.3, we describe in detail how we account for the systematic sorting of minority groups into firms that typically plagues this type of analysis. We report our baseline results in Section 4.2.1.

There are a number of additional implications of referral-based job search networks that relate to the heterogeneity of the productivity effect of networks. First, referrals provide an explanation why workers who have just joined a firm receive higher wages if the share of co-workers from the own group in the firm is higher. However, referrals do not provide a straightforward explanation why wages of incumbent workers should increase if workers from the own group enter the firm. To test this hypothesis, we examine whether wage effects are stronger for new entrants into a firm than for incumbent workers.

Second, referrals are particularly valuable if the candidate's productivity is very uncertain. Research by, for instance, Farber and Gibbons (1996) and Altonji and Pierret (2001) highlights that this is the case for young workers who have just entered the labor market, and that the uncertainty declines as employers learn more about workers' productivity with time in the labor market. We investigate this issue by comparing the wage effects of workplace segregation for young

workers aged under 30 with those of older workers aged above 30.

Third, in a matching model, a larger uncertainty of the worker's productivity implies a larger opportunity for future wage growth since workers are partially insured against low realizations of their productivity by leaving the firm (Jovanovic 1979, 1984). Consequently, workers will be the choosier the lower the uncertainty of the match. Therefore, wages at the start of an employment relationship should be the higher and wage growth by tenure should be the lower, the lower uncertainty. Hence, if a higher share of co-workers of the own type indicates a higher probability of having obtained the job through referrals, and if this reduces the uncertainty about the match, we would expect that initial wages are increasing and wage growth by tenure is decreasing in this share.

Finally, Montgomery's (1991) model predicts that only referrals from high-ability workers generate job offers and lead to higher wages. In line with this hypothesis, we test whether wage effects are larger if the co-workers from the same ethnic group are better educated. The results for the heterogeneity of network effects are reported in Section 4.2.3.

3.2 Measuring Segregation

There are a number of different measures in the economic and sociological literature that have been used to assess the extent of segregation between different groups (see, for instance, Cutler et al., 1999, and Massey and Denton, 1988, for a discussion of these measures). We consider two of these measures, the traditional index of dissimilarity proposed by Duncan and Duncan (1955) and the co-worker segregation index used by Hellerstein and Neumark (2008).

3.2.1 The Index of Dissimilarity

The Duncan index (Duncan and Duncan, 1955) is the most widespread measure of segregation or dissimilarity. For illustration, suppose we are interested in the segregation between German workers and minority workers, irrespective of their citizenship. The index is then calculated as follows:

$$\text{IoD}^O = \text{index of dissimilarity} = 1/2 \sum_{i=1}^{N} |\frac{EthMin_i}{EthMin_{total}} - \frac{German_i}{German_{total}}| \cdot 100,$$

where i refers to the unit of analysis, in our case firms. The superscript "O" refers to the observed (rather than the random) index; see below. This index relates the share of the overall minority workforce that works in a particular firm to the share of the overall German workforce working in the same firm. The index ranges from 0 (no segregation) to 100 (complete segregation), and can be interpreted as the percentage of minority workers that would have to move to different firms in order to produce a completely even distribution.

3.2.2 The Index of Co-Worker Segregation

The co-worker segregation index, used by Hellerstein and Neumark (2008), is based on the shares of co-workers with which an individual worker works that belong to specific groups. Consider again the segregation between German and minority workers. In a first step, we calculate for each minority and German worker in our data the percentage of his or her co-workers that belong to a minority group. Note that we exclude each worker herself from the calculation so that the

analysis only covers firms that employ at least two workers.[14] In a second step, we then average these percentages separately for minority and German workers in our data. Following the notation used by Hellerstein et al. (2007), we denote these averages by H_H and W_H, respectively. The "isolation index" H_H shows the average percentage of minority workers' co-workers who are from a minority group, while the "exposure index" W_H shows the average percentage of German workers' co-workers who are from a minority group. The difference between the two, $CW^O = H_H - W_H$, measures the extent to which minority workers are more likely to work with other minority workers than majority workers are. The superscript "O" indicates, as before, that this measure captures observed segregation in the data. If all minority workers only worked with other minority workers, then $H_H = 100$, $W_H = 0$ and $CW^O = 100$, and the two groups of workers would be fully segregated. On the other hand, if the percentage of co-workers that are from minority groups were the same for minority and majority workers, then $H_H = W_H$ and $CW^O = 0$, and there would be no co-worker segregation.

3.2.3 Random Segregation

In small samples, some segregation may occur even if workers were randomly assigned to different firms, especially if firms are small. To take this into account, we follow Carrington and Troske (1997) and calculate a measure of the two segregation indices that would be observed under random allocation. For this purpose, we assign each worker in the data randomly to one of the firms and then compute the two segregation indices as described before. We do this repeatedly and

[14] As Hellerstein and Neumark (2008) point out, the exclusion of each worker herself ensures that if workers were randomly assigned to firms, the unconditional co-worker segregation index would be zero as well as invariant to the sizes of the firms in the sample.

take the average of the generated indices, which we denote by IoD^R and CW^R.[15] The difference $IoD^O - IoD^R$ $(CW^O - CW^R)$ represents segregation that goes beyond that occurring under random allocation. Scaling this by the maximum possible non-random segregation, the effective dissimilarity and co-worker segregation indices are given by:

$$IoD = \frac{IoD^O - IoD^R}{100 - IoD^R} \cdot 100 \quad \text{and} \quad CW = \frac{CW^O - CW^R}{100 - CW^R} \cdot 100.$$

3.2.4 Conditional Segregation

Part of the reason why minority workers may be more likely to work with each other could be that they have different skill levels than majority workers, and workers of the same skill are more likely to work together in the same workplace, independent of their group affiliation. For example, if minority workers were predominantly low-skilled and firms had either a 100% low- or a 100% high-skilled workforce, then low-skilled minority workers would tend to cluster in the same firms – those that require low-skilled workers – and we would observe positive segregation. This segregation, however, would be solely due to the different skill composition of the two groups.[16] To deal with this, we compute "conditional" segregation measures by first calculating the observed dissimilarity and co-worker segregation indices as describe above. However, to calculate the random segregation indices, we now randomly allocate workers to firms within skill groups, such as education (or occupation or industry). While the unconditional random segregation index will be zero in large

[15] We run 10 simulations for each random segregation measure. For an analytical way to calculate the random co-worker segregation index see Åslund and Nordström Skans (2008). Note that the random segregation index is typically not computed for the index of dissimilarity.

[16] Bayer et al. (2004) find that differences in sociodemographic characteristics, in particular in terms of eduction, income and language skills, explain a sizeable fraction of residential segregation by race in the San Francisco Bay Area in 1990.

samples of workers within establishments, this does not hold in the conditional case if the skill structure of minority workers differs from that of majority workers. This in turn affects the overall measure of effective segregation. Our findings refer to the year 2000, unless otherwise noted.

3.3 Measuring the Productivity of Networks

After analyzing the extent of ethnic segregation across firms, we turn to the productivity of networks and test whether minority workers earn higher wages (and have lower turnover) if they work in a firm with a higher share of co-workers from the same minority group. We estimate the following model:

$$\ln w_{ijt} = \alpha_0 + \alpha_1 S_{ijt}^{own} + X'_{ijt}\beta + \gamma_t + v_{ijt}, \tag{1}$$

where $\ln w_{ijt}$ is the log daily wage of worker i in firm j at time t. The key parameter of interest is α_1, the impact of the share of co-workers from the same ethnic group on worker i's log-wage. To define co-workers from the same minority group, we use the finest classification in the data (for instance, the co-workers belonging to the same minority group as a French worker are other French workers, and not other West Europeans). X_{ijt} is a vector of control variables, including the share of co-workers from other ethnic groups (with a foreign citizenship) and, depending on the specification, additional worker and firm characteristics. Finally, γ_t denote year fixed effects, and v_{ijt} is an unobserved error term.

The problem with estimating equation (1) by OLS is that minority workers may systematically sort into firms with a higher share of co-workers of the same ethnic group, leading to biased estimates of α_1. For instance, if low-ability minority workers are more likely to work in firms with

a higher share of co-workers of their own type, then α_1 will be downward biased. The same holds if low-wage firms are more likely to employ more minority workers of the same type. To deal with these concerns, our preferred specification controls for both fixed worker (δ_i) and fixed firm (f_j) effects. This specification yields a consistent estimate of α_1 if the sorting of workers into firms is driven only by time-invariant worker and firm heterogeneity, implying that the error term v_{ijt} in (1) can be decomposed as:

$$v_{ijt} = \delta_i + f_j + \varepsilon_{ijt}, \tag{2}$$

where ε_{ijt} is an i.i.d. error term. Identification comes from workers moving between firms, and exploits variation in the exposure to co-workers of the same minority groups over time within firms, conditional on worker fixed effects. In our baseline sample, 33.7% of the workers switch firms at least once, and in 91.1% of firms at least one worker has joined or left the firm over the sample period. 89.1% of the firm effects – these firms employ 98.5% of the workforce – are identified relative to each other. For minority workers, 17.6% of the total variation in the share of co-workers of the own type is within workers, 14.3% within firms, and 6.7% within firm-worker spells.

Estimating fixed worker and firm effects in large samples as ours is computationally intensive, which has prompted Abowd et al. (1999) to rely on approximate solutions. We instead employ the algorithm proposed by Abowd et al. (2002) that calculates the exact solution of equations (1) and (2).[17] This procedure does not yield standard errors. We obtain these via bootstrapping with 30 repetitions.

[17] The algorithm is based on the iterative conjugate gradient method and exploits that, due to the large number of dummy variables, the design matrix is sparse.

When estimating (1) we pool all workers in our sample, and interact all variables in (1) with a dummy variable indicating whether the worker is from a minority group. Including Germans in the estimation sample implies that both ethnic minority and German workers are used to estimate the fixed firm effects, leading to more precise estimates.

Our estimation sample covers the years 1990 to 2001, ensuring that we can compute firm tenure (for the first 10 years accurately to the year, calculated from 1980 onwards) for all workers in each year. We further restrict the analysis of wages to low- and medium-skilled workers because of wage censoring. This affects up to 50% of the high-skilled, but only 9.7% of the medium-skilled and 3.4% of the low-skilled.[18] Our share variable refers to all workers in the firm, and is computed before these sample restrictions are imposed.

4 Results

We first present findings regarding the extent of ethnicity-based networks. We then investigate whether networks are productive.

4.1 Existence of Networks

4.1.1 Workplace Segregation

Table 2 shows our two measures of minority segregation in firms for the year 2000. Panel A reports results using the index of dissimilarity and Panel B using the index of co-worker segregation. We first report the observed segregation index, then the random segregation index, and finally the

[18] We drop these censored observations from the sample.

effective segregation index. The first column shows the unconditional segregation measures at the firm level. The effective index of dissimilarity is 34.2, indicating that about one third of minority workers would have to be moved in order to achieve an even distribution. The effective co-worker segregation index is 17.7, which is comparable in magnitude to what Hellerstein et al. (2007) find for Black-White (16.8) and Hispanic-White (20.4) workplace segregation within U.S. cities in the same year. It is also comparable to the estimate reported by Åslund and Nordström Skans (2009) for immigrant firm level segregation in Sweden (14.6).[19]

In order to be better able to interpret these figures, we report our two measures of segregation at the industry level in column (2), distinguishing 12 broad industries. Both the effective dissimilarity and the co-worker segregation index drop, from 34.2 to 14.4 and from 17.7 to 2.6, respectively. This indicates that minority segregation at the firm level is not adequately explained by the sorting of minority workers into industries. In column (3), we present our two measures of minority segregation at the municipality level.[20] Again, minority segregation at the firm level considerably exceeds that at the residential level.

How much of the segregation can be explained by differences in the skill structure between minority and majority workers, and the clustering of low- and high-skilled workers into low- and high-skill firms? In columns (4) to (6) of Table 2, we report our conditional segregation measures. As described above, this conditioning does not affect the observed segregation measures, but leads to changes in the indices that would occur under random allocation of workers to firms. We first

[19] Own calculations, based on Table 2 in their paper.

[20] Here, our sample is restricted to workers who work and live (as opposed to work only) in the Munich metropolitan area. In 2000, 81.9% of those working in the Munich area also live in that area. Our findings for other parts of the analysis are similar if we impose the restriction of both living and working in the Munich metropolitan area throughout the paper.

condition only on gender and education, distinguishing between three education groups (column (4)). The index of dissimilarity slightly drops from 34.2 to 28.8, and the co-worker segregation index from 17.7 to 16.4. If we additionally condition on the industry in which a worker is working, both indices decrease further to 23.6 and 14.4, respectively (column (5)). In the last column, we condition on gender, education and a detailed set of 88 occupations. This reduces the indices further to 18.6 and 11.7. We have also conditioned on the particular municipality the worker is living in order to control for potential residential segregation of immigrants and natives within the Munich area, restricting the sample (as in column (3)) to individuals who reside and work in the Munich area (results not reported). This reduces both indices only slightly, from 33.6 to 29.7 and 18.4 to 17.3, respectively.

We conclude from these findings that segregation of minority workers across firms is substantial, even within skill-, gender-, industry-, and occupation groups. Overall, differences in observable skills between minority and majority workers can explain at most 46% (index of dissimilarity) or 34% (index of co-worker segregation) of the observed firm level segregation.

In Table A.1, Panel A, in the appendix, we report the effective index of dissimilarity and co-worker segregation, conditional on gender and education, for the three other metropolitan areas, Frankfurt, Cologne, and Hamburg. The findings for these labor markets are very similar to those for the Munich labor market.

We have also computed the effective index of dissimilarity and co-worker segregation separately for workers with different educational attainment. By far the most segregated group is the group of low-educated workers with a dissimilarity index of 41.7 and a co-worker segregation index of 21.9, compared to only 17.4 and 6.1 for college-educated workers. This pattern mirrors the finding

that ethnic residential segregation as well as the use of friends and relatives in the job search process, is particularly pronounced for the less-skilled (see, for example, Borjas, 1998, Ioannides and Datcher-Loury, 2004, and Wahba and Zenou, 2005).

In what follows, we will focus on indices that condition on gender and education only. We do so because workers are unlikely to alter their education (and gender) once they have entered the labor market. Workers' industries, occupations, and residential choices after labor market entry, in contrast, are endogenous and could be affected by job search networks.

4.1.2 Segregation across Minority Groups

So far, we have reported measures of segregation between majority and minority workers, irrespective of their particular citizenship. But if firm level segregation is indeed a consequence of job search networks, we would expect that an individual from a specific minority group is more likely to work with individuals from the same group than with those from other groups. That is, we would expect Turkish workers to predominantly work with other Turkish workers, etc.

We investigate this in Table 3, where we show the effective index of dissimilarity, conditional on gender and education, for each possible pair of different groups of minority workers. We focus on the index of dissimilarity because unlike the index of co-worker segregation, this index is scale-invariant. This makes it easier to compare the extent of segregation across groups which vary in terms of their size.[21] The first key insight from the table is that we observe segregation not only between minority groups and majority workers, but also between different minority groups. For instance, Italian workers are similarly segregated from Turkish (36.1) and Polish workers (39.0)

[21] We find the same patterns if we use the index of co-worker segregation instead.

as they are from German workers (33.9). Central and Eastern European workers are as removed from Turkish (35.6) and Italian workers (31.6) as they are from German workers (30.3).

A second important insight from Table 3 is that a common language background is a key determinant of minority segregation in firms. The group with which German workers are the least segregated are Austrian workers with a dissimilarity index of only 16.8, by far the lowest of all indices across the eighteen groups. Similarly, Yugoslavs are the least segregated with Bosnians (6.9) and Croatians (6.9), who all speak Serbo-Croatian, and Russians are the least segregated with other Russian-speaking immigrants from the Ukraine, Belarus, Kazakhstan, and Kyrgyzstan which we have, due to the relatively small sample sizes, aggregated into one category.

Overall, the results are consistent with the hypothesis that workers from the same minority group belong to the same network, and that ethnicity-based networks may span different countries if these countries share the same language.

4.1.3 Segregation within Firms and over Time

A key component of the network model by Montgomery (1991) is the "inbreeding bias", i.e. high-skilled workers are more likely to be connected to other high-skilled workers than to low-skilled workers. Hence, networks may not only be ethnicity-based, but also skill-based. In this case, we would expect ethnic minorities to be not only segregated across firms, but also within firms by skill. To address the possibility of within-firm segregation, we calculate the index of co-worker segregation under two opposing scenarios with respect to the degree of interaction between workers of different skill types within firms.[22] Full interaction means that every worker interacts in the

[22] We focus on the index of co-worker segregation because unlike the index of dissimilarity, this index is directly based on interactions among co-workers.

same way with any other worker, irrespective of the skill-type of the other worker relative to one's own type. This assumption underlies all segregation indices reported so far. No interaction, in contrast, assumes that workers only interact with other co-workers of the same skill type.

Table 4 shows the corresponding results for the overall minority population, using two different measures of the worker's skill, either based on educational attainment or on being a blue-collar or a white-collar worker. The first column shows some mild evidence for within-firm segregation according to both skill-type measures, with the index of co-worker segregation increasing from 16.4 in the case of full interaction to 18.1 (education) and 16.8 (blue vs. white) in the case of no interaction, respectively.

We would expect within-firm segregation to be more important in large than in small firms. In the remaining columns, we therefore break down the analysis by firm size, distinguishing between small firms (less than 50 employees), medium-sized firms (50-500 employees), and large firms (more than 500 employees). In small firms (column (2)), the index does not change much, implying that here minority and majority workers are not segregated based on their education or blue- and white-collar status. For large firms, in contrast, the increase in the index is substantial, from 9.9 in the scenario of full interaction to 14.7 and 13.4 in the scenario of no interaction, respectively.

If networks are responsible for the workplace segregation, we might also expect ethnic minorities to become less segregated over time as they start adopting to the German labor market and hence rely less on their ethnicity-based networks for job search purposes. We investigate this in Table 5. We follow minorities of different groups that are observed in the German labor market for the first time in the years 1989/1990 over an eleven-year period until 1999/2000. In the table, we report the effective index of dissimilarity, conditional on gender and education, by ethnic minority group

and time in the labor market. Due to the cohort selection, this sample is younger on average than our baseline sample (30.8 years versus 38.3 years). Clearly, segregation strongly declines with time in the labor market, from 45.3 at labor market entry to 23.1 ten years later.[23] This pattern is visible for all ethnic minority groups, including Austrians (whose native language is German) and ethnic minorities from the former guest worker countries Turkey, Italy and Greece, for which the 1989/1990 cohorts will include a substantial number of second generation immigrants who have been educated in Germany.

4.2 Productivity of Networks

4.2.1 Baseline Results

The results on workplace segregation are consistent with job search networks that are ethnicity- and skill-based, and that are particularly important for young workers who have just entered the labor market. Next, we investigate whether job search networks are productive, by analyzing whether a greater exposure to co-workers of the own type in the firm increases wages and lowers turnover.

We test this implication by estimating equation (1), starting with a simple OLS regression that, besides the own minority share variable, only controls for year fixed effects, and the share of co-workers from a different ethnic minority group (Table 6, Panel A, column (1)). The estimate on the own share variable of -0.339 implies that for a minority worker, a 10 percentage point increase in the share of co-workers from the same minority group, say from 10% to 20%, is associated

[23] These findings could potentially be biased if there is a selective withdrawal from the labor market and/or selective return migration. We find the same pattern if we restrict the sample to workers who entered the labor market in 1989/90 and are still observed working in 2001, suggesting that this is not a concern.

with a wage decrease of 3.4%. Including a full set of control variables[24] reduces this parameter estimate in magnitude to -0.140 (column (2)). For comparison, based on cross-sectional regressions, Hellerstein and Neumark (2003) and Åslund and Nordström Skans (2009) find corresponding coefficient estimates for the own share variable of Hispanic workers in the U.S. and immigrant workers in Sweden of -0.099 and -0.097, respectively.

The significant reduction in our parameter estimate due to the inclusion of control variables suggests that the sorting of workers into firms is important, and that OLS estimates are therefore biased. Indeed, controlling for worker fixed effects in column (3) leads to a substantial further reduction in the magnitude of the estimated parameter. The impact of the share of co-workers from the same ethnic group on wages, however, remains negative. It turns positive if we include a full set of fixed firm effects instead of the fixed worker effects (column (4)).

As described in Section 3.3, our preferred final specification includes both worker and firm fixed effects and is shown in column (5). The estimate implies that an increase in the share of co-workers from the same minority group by 10 percentage points (which, for instance, corresponds to one more minority worker of the own type in a firm of 10 employees) increases the wage of minority workers by 0.23%. To put a 10 percentage point increase into perspective, in our sample the standard deviation of the share of ethnic minority workers with the same citizenship in a firm is 19 percentage points. Hence, a one standard deviation increase in this share raises wages by 0.44%. This is about two thirds of Edin et al.'s (2003) estimate for the impact of a one standard deviation increase in the share of immigrants of the own type in the neighborhood on log-earnings

[24] These covariates are: the log of the firm size, industry dummies, 5 firm tenure categories (0 years, 1-2 years, 3-4 years, 5-9 years, ≥10 years), age, age squared, education dummies and a gender indicator.

(0.66%).[25] A 10 percentage point increase also corresponds roughly to the difference between the average share of ethnic minority workers with the same citizenship observed in our estimation sample (11.7%), and the average share obtained after randomly (and unconditionally) allocating workers to firms (2.8%).

These findings point to the importance of taking into account the non-random sorting of workers into firms. The estimates in Table 6, Panel A, imply that the share of minority individuals from the same group in the firm is slightly negatively correlated with both the fixed worker effect (-0.0076) and the fixed firm effect (-0.0475). This mirrors the findings by Edin et al. (2003), Cutler et al. (2008a), and Damm (2009) at the residential level, who, like us, find that without taking account of sorting, ethnic segregation is associated with negative labor market outcomes.

We have also investigated whether the wage effects differ by worker's skill. In line with the finding by Edin et al. (2003) at the residential level, we find that it is predominantly low-skilled workers who benefit from firm level segregation: while an increase in the own share does not significantly affect wages of the medium-skilled, it raises wages of the low-skilled by 0.57%.

In Panel B of Table 6, we re-estimate equation (1), now using an indicator variable that takes the value 1 if the worker leaves his current firm within the next year as the dependent variable. The OLS results in columns (1) and (2) show that a higher share of ethnic minority workers with the same nationality increases the probability that a minority worker leaves the firm. However,

[25] Edin et al. (2003) specify the ethnic concentration as the logarithm of the share of immigrants from the same country of origin. In their IV earnings regression that exploits the random allocation of immigrants to neighborhoods, the coefficient on this variable is 0.012 (Table III). The mean share of neighbors of the same type is 0.33%, and the standard deviation is 0.24%. Hence, evaluated at the mean, a one standard deviation increase in the share of neighbors of the own type raises earnings of immigrants by 0.66% ($0.012 * [\ln(0.0033 + 0.0024) - \ln(0.0033)]$). The number they report is $0.87\%(0.012 * 0.0024/0.0033)$, which is a first order approximation and slightly larger than the exact estimate.

once we control for both worker and firm fixed effects, the result changes: an increase in the share of co-workers from the same group by one standard deviation (19 percentage points) now reduces the probability of leaving the firm by 0.86%, or 3.3% of the baseline annual turnover rate for ethnic minority workers of 26.1%.

We display findings for the three other metropolitan areas in Table A.1, Panel B (wages) and C (turnover). In all these labor markets, the impact of the share of co-workers from the same ethnic group on wages and turnover is similar in magnitude.

Even after controlling for unobserved worker and firm heterogeneity, our estimates may still be biased if there are firm level minority-specific demand shocks that attract minority workers into firms and, at the same time, raise their wages. Under this scenario the share of co-workers from other ethnic groups ("other share") should likewise increase wages and lower turnover. We, however, find that the "other share" estimates, though less robust in terms of magnitude, are consistently smaller (in absolute magnitude), and sometimes even have the opposite sign, than the "own share" estimates (Table A.1, Panel B and C). Minority-specific demand shocks are therefore not be the driving force for why co-workers of the same ethnic group increase wages and reduce turnover.

4.2.2 Robustness Checks

We perform a number of robustness checks in Table 7. For comparison, column (1) in Panel A shows our baseline estimate from Table 6, column (5), that conditions on fixed worker and fixed firm effects. This specification includes Germans in the estimation sample (see Section 3.3), and therefore restricts the fixed firm effect to be the same for the minority and German population.

In column (2), we estimate equation (1) for minorities only and therefore allow for a minority-specific fixed firm effect. The share of co-workers from the same group in the firm continues to have a positive effect on wages of minority workers. In columns (3) and (4) of Panel A, we restrict the sample to firms with more than 10 employees and to firms with less than 500 employees, respectively. The point estimate of the own share variable is considerably higher if small firms are excluded, suggesting that the benefits from segregation are larger in larger firms. A possible explanation for this finding is that the variation in workers' productivity is higher in larger firms, which increases the value of the additional information obtained through referrals.[26]

In Panel B, column (1), we exclude small minority groups from the sample.[27] This hardly changes our estimate. In columns (2) and (3) of Panel B, we use the logarithm of the number of minority group co-workers, instead of the share, as explanatory variables. In column (2), we assign a value of -1 to minority workers who have no co-worker of the own type, whereas in column (3) we drop these observations from the sample. Both specifications yield similar results: a greater exposure to individuals from the same group increases wages of minorities. Finally, column (4) of Panel B suggests that the impact of the share of co-workers of the own type is non-linear, with workers benefitting from an increase in the share of their own type up until the share reaches 55%, and losing thereafter.[28] This specification implies that, evaluated at the mean share of 0.117, a one-standard deviation increase in the share variable raises wages by 0.86% which is considerably larger than our baseline estimate of 0.44%. Hence, our linear baseline specification is likely to

[26] Consistent with this hypothesis, Dustmann and Schönberg (2009) find that asymmetric information between incumbent and outside firms plays a larger role in large firms.

[27] We exclude groups with less than 10,000 wage observations for the years 1985 to 2000, corresponding to a share among the employed minority population of less than 1%.

[28] In our sample, less than 5% of ethnic minority workers work in firms with such a high own share.

understate the benefits from ethnic workplace segregation. A possible explanation for this non-linear effect is that employees first refer network members whom they know best. Hence, the first referred worker may be better matched with the firm than the second or third referred worker.

4.2.3 Heterogeneity in the Productivity of Networks

The findings so far suggest that, through referrals, job search networks are productive. Next, we present a number of additional findings that support this hypothesis. As discussed in Section 3.1, referral-based job search networks should lead to stronger wage effects for workers who recently joined a firm, but not necessarily to any wage effects for incumbent workers. In columns (1) and (2) of Panel A in Table 8, we allow the impact of the share of co-workers of the own ethnic group to differ between entrants and incumbents. In line with the theoretical predictions, the positive impact of the share of co-workers of the own group is considerably stronger for entrants than for incumbents.

In columns (3) and (4) of Table 8, Panel A, we test a second implication of referral-based job search networks: due to a higher degree of uncertainty, young workers (defined as workers younger than 30) should benefit more from working with ethnic minority workers of the own type than older workers. Our results confirm this prediction: a 10 percentage point increase in the share of ethnic minority co-workers of the own type raises wages of young workers by 0.68%, but slightly reduces wages of older workers by 0.1%.

In Panel B of Table 8, we test for an important implication of the referral model by Simon and Warner (1992): referrals should increase wages particularly at the beginning of the employment relationship, and this effect should decline with tenure. Unlike in our baseline results in Table 6

(and in Table 8, Panel A), we restrict the sample to workers whom we observe from the start of the employment relationship onwards, and the share of ethnic minority workers of the own group now refers to that at the start of the employment relationship. We report results that condition on fixed firm effects only (column (1)), as well as results that condition on both fixed firm and worker effects (column (2)). The results support the referral model by Simon and Warner (1992): the specification including both fixed firm and worker effects implies that a one standard deviation increase of 19 percentage points in the minority share of the own type raises wages at the start of the employment relationship by about 0.86%, and that this effect dissipates very quickly with tenure.

In a final step, we explore a key implication of the referral model by Montgomery (1991) that only referrals from high-ability workers generate job offers and lead to higher wages. We test this prediction by including the interaction between the share of co-workers from the same ethnic group as the worker himself and the quality (measured as years of education) of these co-workers as additional regressors in equation (1). To make sure that it is really the quality of the own ethnic group that affects the impact of the share of own-type co-workers on wages, we also include the interaction between the share variables and the average quality of German co-workers. The coefficients on the share variables now refer to the case when co-workers are of average quality of minority workers.[29] Results are reported in Table 8, Panel C, where we condition either on fixed firm effects only (column (1)), or on both fixed firm and fixed worker effects (column (2)). In line with the referral model by Montgomery (1991), we find that the positive impact of the share of

[29] That is, we subtract the mean years of education of ethnic minority workers from the mean years of education of the individual's co-workers in the firm. To compute years of education, we assume that low-, medium-, and high-skilled workers have 10, 13, and 18 years of education, respectively.

co-workers from the same group on wages is larger if these co-workers are better educated. The coefficient on the interaction between the share of co-workers of the own type and the average quality of Germans, in contrast, is smaller in magnitude. These findings confirm existing evidence in the context of residential segregation by Edin et al. (2003) and Cutler et al. (2008a).

5 Alternative Explanations

Our results indicate the existence of referral-based job search networks, and show that these networks are productive. There may, however, be alternative explanations that could, in principle, drive some of our empirical findings, in particular productivity spillover effects and taste-based discrimination.

5.1 Productivity Spillovers

An alternative to job search networks as an explanation for the observed ethnic segregation at the workplace are productivity spillover effects: minority workers may be more productive if they work with employees of their own ethnic group than if they work with workers from other ethnic groups or natives. An important reason why this may be the case is that individuals from the same ethnic group share the same culture and language.[30] Productivity spillover effects can explain why minority workers are about as removed from minority workers from other groups as they are from majority workers. They also provide a natural explanation for the strong impact of language on

[30] While such productivity spillover effects, or peer effects, have been extensively studied among pupils in schools, they have received relatively little attention among co-workers in firms. The research that does exist typically focuses on a particular industry (and often a particular firm within that industry); examples include supermarket scanning (Mas and Moretti, 2009) and soccer (Ashworth and Heyndels, 2007).

ethnic workplace segregation (Table 3). Productivity spillover effects can also account for our findings that minority workers earn higher wages and have a lower turnover rate in firms with a higher share of co-workers of their own type (Tables 6 and 7).

There are, however, a number of findings that are difficult to reconcile with a model of productivity spillover effects. For instance, a model of productivity spillover effects has difficulties in explaining the clustering of Austrians in the Munich labor market. While Germans are more likely to work with Austrians than with immigrants from any other country, Austrians are nevertheless segregated from Germans–although both groups speak the same language and are culturally very similar (Table 3). We have also computed segregation indices for Germans working in Munich who originate from other German cities.[31] Any workplace segregation of these workers is likewise difficult to rationalize with productivity spillovers due to language or cultural similarity. We find that these workers, just like Austrians, are also segregated from workers from Munich. For instance, the index of dissimilarity for the year 2000, conditional on gender and education, of individuals from Frankfurt, Cologne, and Hamburg, relative to individuals from Munich, are 26.3, 22.3, and 28.1, respectively.

A model of productivity spillovers also has difficulties in explaining our finding that ethnic segregation declines with time in the labor market for all ethnic groups, including the Austrians (Table 5). Hence, the decline is unlikely to be driven by immigrants picking up German language skills as they become more experienced. Finally, a model of productivity spillovers predicts that incumbent workers should earn higher wages as workers from the same ethnic group join the firm.

[31] We define individuals from (from outside) Munich as individuals who were working in (outside) the Munich area the first time they entered the German labor market.

We, however, find that, as predicted by a model of job search networks, wages of incumbent workers are largely unaffected by changes in the share of co-workers of the same minority group (Table 8, Panel A).

5.2 Discrimination

Another explanation for the observed ethnic segregation in the workplace is taste-based discrimination. We distinguish between customer, employee, and employer discrimination.

5.2.1 Customer Discrimination

According to the theory of customer discrimination, customers prefer to shop in firms that employ workers of their own type.[32] Consequently, just like a model of job search networks and productivity spillover effects, a model of customer discrimination provides an explanation for our findings in Table 3 that there are "Turkish", "Greek", and "Polish" firms, rather than "minority" and "German" firms. However, if customer discrimination was the only explanation for the observed ethnic segregation in firms, we should see segregation only in industries where employees have direct contact with customers. Calculations of the effective dissimilarity and co-worker segregation index for each of our twelve industries show that while ethnic firm level segregation is among the highest in service industries, it is also strong in industries with low customer contact, such as manufacturing and construction.[33] Hence, customer discrimination cannot be the only explanation for minority

[32] Existing empirical evidence on customer discrimination typically comes from audit studies (e.g. Page, 1995), or the sport industry (e.g. Kahn and Sherer, 1988). In line with a model of customer discrimination, Holzer and Ihlanfeld (1998) find that the racial composition of an establishment's customers affects the race of who gets hired.

[33] The corresponding values of the dissimilarity and co-worker segregation index between Germans and all minorities, conditional on gender and education, are 26.3 and 20.5 in "other services", 31.6 and 19.4 in "professional, medical and business services", 22.7 and 13.9 in "low tech manufacturing", and 31.7 and 23.7 in "Construction",

segregation at the firm level.

5.2.2 Employee Discrimination

An alternative explanation for the ethnic segregation in firms is employee discrimination: ethnic minority workers prefer to work with workers from their own ethnic group.[34] Such a model provides another explanation for why ethnic minority workers are about as removed from workers from other ethnic groups as they are from natives (Table 3). However, if employee discrimination was the only explanation for the observed segregation of ethnic minority workers across firms, then the theory of compensating wage differentials would predict that ethnic minority workers earn lower wages if their firm employs a larger share of workers from their own ethnic group. We, however, find the opposite (Table 6 and 7). While this does not rule out that employee discrimination contributes to ethnic segregation in firms, it does imply that it is not the dominating force.

5.2.3 Employer Discrimination

Finally, the ethnic segregation in firms could be due to employer discrimination: some employers derive a disutility from hiring ethnic minority workers, while others do not. In this case, ethnic minority workers will choose to work for employers who have no (or little) prejudice against them (Becker 1971).[35] Unlike a model of job search networks, productivity spillovers, or customer

respectively.

[34] The empirical evidence on employee discrimination is so far limited. Ragan and Tremblay (1988) find that, consistent with a model of employee discrimination by race, the presence of at least one white worker increases the wage of black workers, while the presence of at least one black worker increases the wage of white workers. However, little attempt is made to account for the non-random selection of workers into firms.

[35] Most existing research in this area has focused on the black-white wage gap (e.g. Black, 1995, Hellerstein et al., 1999). A recent study that provides empirical support for Becker's model of taste-based discrimination is Charles and Guryan (2008).

or employee discrimination, such a model predicts that minorities should be segregated from natives, but not from workers from other ethnic groups. Hence, a model of taste-based employer discrimination does not provide an immediate explanation for our finding in Table 3 that ethnic minority workers are about as unlikely to work with workers from other minority groups as they are to work with Germans.

Further, the simple Becker model of taste-based employer discrimination implies complete minority segregation: firms should either employ only Germans, or only minorities. This implication is clearly not reflected by our data, as only 18.2% of Germans work in firms with no minorities, and only 6.0% of ethnic minorities work in firms with no Germans.[36]

We therefore conclude that, just like a model of productivity spillover effects, models of taste-based discrimination can account for some, but not all, of our findings.

6 Conclusion

This paper provides a novel analysis of the existence and importance of job search networks of ethnic minorities. We concentrate on referral-based models in which employees provide employers with information about potential job market candidates that they otherwise would not have. We first test for an important implication of such networks: network members should cluster together in the same firms. In line with this prediction, we find that minority workers are more likely to work with workers from their own ethnic group than with workers from other ethnic groups, or

[36] This stark prediction will no longer hold in more complex models. For instance, in the model by Mondal (2007), minorities (in his application black workers) may choose to work for a discriminating firm because they are particularly well-matched with this firm. One key implication of this type of model is that ethnic segregation should increase with time in the labor market, as workers learn about which firms are prejudiced. We, however, find the opposite (Table 5).

with natives.

We then provide evidence that job search networks are productive. Once we take into account the non-random sorting of workers into firms, we find that a greater exposure to co-workers from the same minority group, and hence a greater probability of having obtained the job through a referral, increases wages and decreases turnover of minority workers. We further show that the positive impact of networks on wages is particularly pronounced for new entrants into a firm, and declines with tenure in the firm. Moreover, it is stronger for younger than for older workers who have the most to gain from a referral. Finally, it is amplified if the co-workers from the same ethnic group are better educated. These findings support the hypothesis that, through referrals, job search networks help to reduce informational deficiencies in the labor market and lead to productivity gains for workers.

In contrast to this paper, most existing research on ethnicity-based networks has focused on the existence and implications of ethnic segregation at the neighborhood level. In line with our results, Edin et al. (2003) find that earnings of immigrants, especially those of low-skilled immigrants, are higher if they live in neighborhoods with a larger share of individuals from the own ethnic group. Our findings point to the possibility that these gains are in fact created at the firm level, and that one reason why immigrants are segregated into neighborhoods is because it is optimal for them to cluster together in the same firms. A simple back-of-the-envelop calculation suggests that the positive impact of *workplace* segregation on wages of ethnic minority workers can indeed go a long way in explaining the positive impact of *residential* segregation on immigrants' earnings found by Edin et al. (2003): if the wage gains at the residential level were in fact purely generated at the firm level, Edin et al. (2003) should find that a one standard deviation increase in the share of

own-type immigrants in the neighborhood raises wages by 0.82%.[37] This is close to their estimate of 0.66%.

[37] This number is computed as follows. If the share of immigrants of the own type in the neighborhood has no direct impact on immigrants' earnings, then we can think of the regressions estimated by Edin et al. (2003) as mis-specified, and the coefficient on the share of same-type immigrants in the neighborhood will be equal to the impact of the corresponding share in the firm (we find that a one standard deviation increase in this variable raises wages by 0.44%), times the coefficient from a regression of the firm share on the neighborhood share (which in our data is 1.87 for the year 2000). These calculations assume that both the relation between firm share and neighborhood share and the impact of the own share on wages on the firm level are the same in the two countries.

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Table 1: Descriptive Statistics

	Share of Workforce		Share Educational Attainment in 2000		
	1990	2000	low	medium	high
Germans	86.6%	84.4%	13.0%	66.9%	20.2%
Ethnic Minorities	13.4%	15.6%	41.2%	49.9%	8.9%
N workers	1,036,747	1,067,680			
N firms	73,265	81,900			
Ethnic Minorities only					
Former Yugoslavia	27.6%	25.3%	42.5%	55.7%	1.8%
Turkey	20.3%	17.2%	56.4%	41.6%	2.0%
Austria	15.9%	11.1%	14.0%	70.4%	15.7%
Italy	8.0%	7.6%	42.8%	50.9%	6.3%
Greece	6.6%	5.8%	60.7%	35.0%	4.3%
Poland	1.5%	2.1%	35.6%	54.2%	10.2%
Former Soviet Union	0.1%	1.2%	36.5%	40.4%	23.1%
Other Western Europe	6.9%	8.1%	27.4%	43.4%	29.2%
Central and Eastern Europe	4.4%	6.4%	30.4%	58.0%	11.7%
Asia	3.5%	6.8%	53.9%	34.9%	11.2%
North America	2.0%	1.6%	22.7%	41.7%	35.6%
Africa	1.3%	3.4%	58.4%	35.1%	6.6%
Central and South America	0.6%	1.1%	40.1%	41.5%	18.4%
Others	1.5%	2.2%	29.7%	59.3%	11.0%

Note: The table reports descriptive statistics for the years 1990 and 2000. Low-skilled workers are workers without post-secondary education. Medium-skilled workers are workers who completed an apprenticeship. High-skilled workers are workers with a college or university degree.
Sources: Social Security Data, Munich, 1990 and 2000.

Table 2: The Extent of Segregation, 2000

	Unconditional			Conditional, Firm		
	(1) Firm	(2) Industry	(3) Municipality	(4) Gender, Education	(5) plus Industry	(6) plus Occupation
Panel A: Index of Dissimilarity						
Observed Segregation	47.2	14.7	23.4	47.2	47.2	47.2
Random Segregation	19.7	0.3	1.1	25.8	30.9	35.1
Effective Segregation	**34.2**	**14.4**	**22.5**	**28.8**	**23.6**	**18.6**
Panel B: Index of Co-worker Segregation						
Observed Segregation						
Isolation Index	30.5	17.8	20.4	30.5	30.5	30.5
Exposure Index	12.8	15.2	16.7	12.8	12.8	12.8
Segregation Index	17.7	2.6	3.7	17.7	17.7	17.7
Random Segregation						
Isolation Index	15.6	15.6	17.3	16.8	18.8	21.3
Exposure Index	15.6	15.6	17.3	15.4	15.0	14.5
Segregation Index	0.0	0.0	0.0	1.5	3.8	6.8
Effective Co-worker Segregation	**17.7**	**2.6**	**3.7**	**16.4**	**14.4**	**11.7**

Note: The table reports measures of firm, industry, and residential segregation between ethnic minority workers and Germans based on the index of dissimilarity (Panel A) and the index of co-worker segregation (Panel B). For each index, we report the observed segregation in the data, the random segregation that would result if individuals were randomly allocated to firms, and the effective (net of random) segregation. The isolation index in Panel B shows the average percentage of minority workers' co-workers who belong themselves to an ethnic minority. The exposure index shows the average percentage of German workers' co-workers who are minority workers. Columns (1) to (3) present unconditional measures of firm, industry, and residential segregation. Columns (4) to (6) report conditional measures of firm segregation, where we first condition on gender and three education groups (column (4)). We then additionally condition on 11 industry dummies (column (5)) or 88 occupation dummies (column (6)).
Source : Social Security Data, Munich, 2000.

Table 3: Ethnic Segregation, Country of Origin, and Language

	Germany	Austria	Western Europe	Yugo-slavia	Bosnia-Herzo-govina	Croatia	Central- and Eastern Europe	Russia	Other Russian-Speaking Countries	Poland	Turkey	Italy	Greece	Africa	Central and South America	North America	Asia	Other
Germany	**0**	**16.8**	28.7	36.9	48.8	34.3	30.3	32.9	41.5	34.9	41.0	33.9	44.9	40.7	21.7	26.8	41.5	22.8
Austria		**0**	23.6	31.2	47.9	37.1	30.0	36.3	44.0	36.5	40.0	32.5	42.4	38.8	15.1	23.7	38.8	26.4
Western Europe			0	43.0	50.2	42.8	34.4	30.6	37.2	42.3	45.2	33.7	45.9	33.0	7.9	-2.3	34.1	30.1
Yugoslavia				**0**	**6.9**	**6.9**	23.4	29.8	29.9	26.6	24.3	30.7	30.2	29.9	26.3	47.1	34.5	20.8
Bosnia-Herzegovina					**0**	**1.3**	29.3	38.1	40.0	34.1	26.5	39.6	29.2	26.4	34.6	62.9	30.0	33.2
Croatia						**0**	26.1	28.1	29.3	29.0	27.7	38.8	34.9	31.8	25.9	52.4	33.4	24.5
Central and Eastern Europe							0	23.2	31.0	20.1	35.6	31.6	39.8	23.8	21.3	40.5	26.1	22.8
Russia								**0**	**-3.4**	30.2	32.8	36.6	34.2	23.9	22.6	31.5	24.4	31.5
Other Russian Speaking Countries									**0**	34.7	32.6	43.6	41.1	27.3	26.4	39.2	28.1	36.7
Poland										0	36.3	39.0	43.5	32.8	29.5	48.5	34.3	28.4
Turkey											0	36.1	16.4	27.2	29.0	47.8	35.7	25.7
Italy												0	35.6	32.3	20.7	41.2	36.8	24.9
Greece													0	25.8	28.3	47.8	33.6	31.2
Africa														0	5.8	38.2	10.5	23.8
Central and South America															0	13.7	6.7	18.5
North America																0	39.1	33.8
Asia																	0	25.3
Other																		0

Note : The table reports the pairwise effective index of dissimilarity, conditional on gender and education, between different ethnic groups.
Source : Social Security Data, Munich, 2000.

Table 4: Segregation within Firms by Firm Size

	Index of Dissimilarity			
	(1) All Firms	(2) Small Firms	(3) Medium Firms	(4) Large Firms
Education				
Full Interaction	16.4	22.5	15.7	9.9
No Interaction	18.1	21.8	17.4	14.7
Blue vs. White Collar				
Full Interaction	16.4	22.4	15.7	9.9
No Interaction	16.8	20.9	15.5	13.4

Note: The table compares measures of firm-level segregation that do not take into account segregation within firms ("Full Interaction") with those that do ("No Interaction"). We report results by firm size based on the effective index of co-worker segregation, conditional on gender and education. Small firms are firms with less than 50 employees, medium-sized firms are firms with 50 to 500 employees, and large firms are firms with more than 500 employees. Full interaction means that every worker interacts in the same way with any other worker, irrespective of the skill-type of the other worker relative to one's own type. No interaction only allows workers to interact with other co-workers of the same type.

Source : Social Security Data, Munich, 2000.

Table 5: Segregation by Time in the Labor Market

	1 Year	3 Years	5 Years	7 Years	9 Years	11 Years
Country of Citizenship						
Austria	54.4	40.7	34.2	32.9	29.0	19.0
Turkey	51.1	37.5	35.3	32.7	27.9	25.4
Italy	69.5	55.6	53.0	49.4	42.0	32.6
Greece	58.8	52.0	47.6	44.8	42.1	37.7
Former Yugoslavia	53.3	41.8	33.3	30.6	27.1	23.8
Other Western Europe	55.4	42.8	35.9	32.5	28.6	23.2
Central and Eastern Europe + Poland + Former Soviet Union	56.2	46.0	39.7	35.0	35.4	31.6
All	45.3	34.4	31.3	30.1	26.4	23.1

Note: The table reports the effective index of dissimilarity between Germans (of all experience groups) and ethnic minority workers by time in the labor market, conditional on gender and education.
Source : Social Security Data, Munich, cohort of workers who entered the labor market in 1989/1990.

Table 6: The Impact of Firm-Level Segregation on Wages and Turnover

	(1) OLS, No Controls	(2) OLS, Controls	(3) Fixed Worker Effects	(4) Fixed Firm Effects	(5) Fixed Worker and Firm Effects
Panel A: Wages					
Own Share	-0.339	-0.140	-0.044	0.025	0.023
	(0.004)**	(0.003)**	(0.003)**	(0.002)**	(0.003)**
Panel B: Turnover					
Own Share	0.207	0.062	0.055	-0.050	-0.045
	(0.003)**	(0.002)**	(0.005)**	(0.004)**	(0.008)**

Note: Panel A and B report the impact of the share of ethnic minorities from the same and other ethnic groups in the firm on wages and turnover decisions of minority workers. In column (1), we additionally control only for the worker's minority status and year fixed effects. In column (2), we add controls for firm and worker characteristics whose effect is allowed to vary by minority status. The covariates are: 5 firm tenure categories (0 years, 1-2 years, 3-4 years, 5-9 years, ≥10 years), the log of the firm size, age, age squared, industry dummies, education dummies and a gender indicator. We then add fixed worker effects (column (3)), fixed firm effects (column (4)), and both fixed worker and fixed firm effects (column (5)).
Coefficients with * are statistically significant at the 5 percent level, those with ** at the 1 percent level.
Source : Social Security Data, Munich, 1990 to 2001.

Table 7: The Impact of Firm-Level Segregation on Wages: Robustness Checks

Panel A	(1) Baseline	(2) Different Fixed Firm Effects	(3) Small Firms Excluded	(4) Large Firms Excluded
Own Share	0.023	0.018	0.046	0.018
	(0.003)**	(0.003)**	(0.005)**	(0.003)**
Panel B	(1) Small Groups Excluded	(2) lnN	(3) lnN Zeros Dropped	(4) Squared
Own Share	0.026	0.010	0.010	0.073
	(0.003)**	(0.000)**	(0.001)**	(0.006)**
Own Share Squared				-0.066
				(0.006)**

Note: The table presents several robustness checks on the impact of the share of ethnic minorities from the same and other ethnic groups in the firm on wages of ethnic minority workers. For comparison, we first display our baseline results from Table 8, column (5), in Panel A, column (1). Panel A, column (2) restricts the sample to minority workers, and thus allows the fixed firm effect to vary by minority status. In Panel A, columns (3) and (4), we exclude firms with less than 10 employees and firms with more than 500 employees, respectively. In Panel B, column (1), we drop small ethnic groups from the sample. In Panel B, columns (2) and (3), we use the logarithm of the number of co-workers of the own and other type as explanatory variables. Column (2) assigns -1 to minority workers who have no co-worker from the same ethnic group, while we drop these observations in column (3). Results in column (4) correspond to the baseline specification, but we add squared terms of the share variables. All regressions include fixed worker and fixed firm effects.
Coefficients with * are statistically significant at the 5 percent level, those with ** at the 1 percent level.
Source : Social Security Data, Munich, 1990 to 2001.

Table 8: Who Benefits Most from Networks?

Panel A: Results by Incumbency, Age and Education	**Incumbency**		**Age**	
	(1)	(2)	(3)	(4)
	Entrants	Incumbents	≤30	>30
Own Share	0.064	0.004	0.068	-0.010
	(0.003)**	(0.003)	(0.005)**	(0.003)**
Panel B: Results by Tenure	(1)		(2)	
	Fixed Firm Effects		Fixed Firm and Worker Effects	
	Coeff	StdE	Coeff	StdE
Own Share at Start	0.089	(0.003)**	0.045	(0.006)**
Own Share at Start * Tenure	-0.027	(0.001)**	-0.027	(0.001)**
Panel C: The Quality of Networks	(1)		(2)	
	Fixed Firm Effects		Fixed Firm and Worker Effects	
	Coeff	StdE	Coeff	StdE
Own Share	0.049	(0.003)**	0.036	(0.003)**
Own Share * Quality Own	0.017	(0.001)**	0.006	(0.001)**
Own Share * Quality German	0.003	(0.000)**	0.002	(0.000)**

Note: The table investigates whether the benefits of networks are heterogeneous. In Panel A, we allow the impact of the share of co-workers from the own and other ethnic groups to vary by whether the worker has just entered the firm (entrants) or whether he was employed for the firm in the previous period (incumbents) and by age. Regressions include both fixed worker and fixed firm effects. In the education regression in columns (5) and (6), we set the education level to the one with which the worker enters the labor market. In Panel B, we report the impact of the share of minorities of the own type and of other types at the start of the employment relationship affects starting wages and wage growth by tenure. In Panel C, we allow the impact of the share of co-workers from the own and from other ethnic groups to vary with the quality of co-workers, measured as the average years of education. The coefficients on the share variables refer to the case when co-workers are of average quality of minority workers. In Panel B and C, we first report results that include fixed firm effects only, and then add fixed worker effects.
Coefficients with * are statistically significant at the 5 percent level, those with ** at the 1 percent level.
Source : Social Security Data, Munich, 1990-2001.

Appendix: Baseline Results for Other Cities

Table A.1: Baseline Results for the Four Largest West German Cities

	(1) Munich	(2) Frankfurt	(3) Cologne	(4) Hamburg
Panel A: Ethnic Segregation in the Workplace				
Effective Index of Dissimilarity	28.8	29.2	29.0	31.1
Effective Index of Co-Worker Segregation	16.4	17.1	14.7	15.9
Panel B: The Impact of Networks on Wages				
Own Share	0.023	0.033	0.066	0.026
	(0.003)**	(0.004)**	(0.004)**	(0.005)**
Other Share	-0.022	0.010	0.023	-0.012
	(0.003)**	(0.003)**	(0.003)**	(0.003)**
Panel C: The Impact of Networks on Turnover				
Own Share	-0.045	-0.053	-0.029	-0.009
	(0.008)**	(0.007)**	(0.007)**	(0.012)
Other Share	0.018	0.013	0.024	0.019
	(0.006)**	(0.007)	(0.007)**	(0.009)*

Note: The table reports our baseline results for the four largest West German metropolitan areas. In Panel A, we report the effective index of dissimilarity and the effective index of co-worker segregation at the firm level, conditional on gender and education (see also Table 2, column (4)). In Panel B and C, we report the impact of the share of minority workers from the same and other ethnic groups in the firm on wages and turnover decisions of minority workers. Regressions control for observable worker and firm characteristics whose effect we allow to vary by minority status, year fixed effects, worker fixed effects, and firm fixed effects (see also Table 6, column (5)).

Coefficients with * are statistically significant at the 5 percent level, those with ** at the 1 percent level.

Source : Social Security Data, Munich, Frankfurt, Cologne, and Hamburg, 1990-2001.