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Abstract

We examine the impact of discrimination on labour market performance when workers are subject to a risk of losing skills during the experience of unemployment. Within a search and matching model, we show that all natives and immigrants are affected by discrimination. Discrimination in one sector has positive spillovers, inducing employment increases in the other sector. Discrimination may induce immigrants to train more or less than natives, depending on the sector where it is present. Welfare tends to be most negatively affected by discrimination among high-productivity workers.

Keywords: discrimination, unemployment, search and matching, wages.

JEL classifications: J15, J31, J61, J64, J71

1 Introduction

According to the *OECD Employment Outlook 2008*, labour market discrimination – i.e. the unequal treatment of equally productive individuals only because

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they belong to a specific group – is still a crucial factor inflating disparities in employment and the quality of job opportunities in many countries. Evidence presented in that study suggests that workers from ethnic minorities have to search 40% to 50% longer than individuals with the same characteristics but belonging to majority groups before they receive a job offer, which renders them much more vulnerable to the risk of long-term unemployment.

The purpose of this paper is to study the effects of the discrimination of immigrants on labour market performance taking into account that workers risk losing skills during an unemployment spell causing long-term unemployment.[1] The novelty of the paper is to consider a double effect of discrimination: it affects the skills of immigrants through skill loss and the decision to train.

Several studies have found that the terrorist attacks of September 11, 2001 had effects on the USA labour market outcomes of individuals with country of origin profiles similar to those of the terrorists.[2] Zussman (2010) finds that ethnic bias in judicial decision-making in Israel depends on the number of fatalities from recent attacks in the vicinity of the court but not in other places. Discrimination can be a reaction to external events where none of the parts are involved. We model discrimination as a capricious rejection of immigrant applicants. Negative events, such as unexpected violent political developments, trigger these rejections. An immigrant worker does not get a job offer after a trigger event, while a native worker does.

The impact of discrimination is amplified if workers are subject to the risk of losing skills during the experience of unemployment. Discrimination may not only result in natives and immigrants getting different pay for the same work, but also in workers with similar skill levels ending up in different occupations. Unemployed workers who lose their skills can only search for jobs in the low-productivity sector.[3] Low-skilled workers may regain their skills by accumulating work experience or by training when unemployed. This issue has previously been neglected in the theoretical literature.

Empirical evidence supports the fact that employment below an individual's qualifications and loss of skill are important issues to consider. First, Arai et al (2000) show that the probability of getting a qualified job is 70% lower for immigrants to Sweden born in Eastern Europe, Asia or Africa and 50%

[1] Larsen (2001) has a similar set-up, but does not distinguish by origin.

[2] Davila and Mora (2005), Kaushal, Kaestner, and Reimers (2007), Rabby (2009) etc.

[3] For simplicity, we disregard self-employment.

lower for those born in Latin America, than for similar natives. Immigrants are overrepresented in only three out of 29 occupations, all of which require no education or training. Second, Reitz (2001) shows that the under-utilization of immigrant skills is significant in Canada. Finally, Nielsen et al (2004) show that a large fraction of the wage gap between immigrants and natives in Denmark would disappear if only immigrants could accumulate work experience.

The model is along the lines of Pissarides (2000) combined with an endogenous skill choice. Acemoglu (2001) and Albrecht and Vroman (2002) model the choice of skill requirements by firms, while we consider the decision taken by workers. In Burdett and Smith (2002) and Aricó (2009), workers with heterogeneous training costs take an investment decision in skill-acquisition before entering the job market, while we allow for training every time a worker loses skills. None of these papers study the issue of discrimination.

First, we present a model, where the training decision is optimally taken by the workers. We then abandon endogenous training in order to allow for on-the-job training, so that skills which have been lost while being unemployed can be regained while working.

When training is endogenous we obtain the following results. Because of discrimination, immigrants suffer higher unemployment rates, despite receiving lower wages. By being unemployed more often, skilled immigrants are subject to a higher risk of losing skills and, consequently, more often end up in low-productivity jobs. The effect is strongest for the affected immigrants, but other workers are also affected. Discrimination in the high skilled sector furthermore implies that fewer low skilled workers train. This negative impact on training is higher for immigrants than for natives as the latter group is not directly negatively affected by discrimination. This impact, together with the reduced vacancy supply directed towards high skilled workers, implies that the proportion of skilled workers in the economy falls. The negative impact is again stronger for immigrants than for natives. When discrimination is instead facing low skilled workers, they train more. The effect is stronger for immigrants than for natives due to the direct effect from discrimination. The proportion of skilled immigrants is then higher than the proportion of skilled natives, despite the fact that more immigrants tend to become low skilled workers, that is, more of them loses skills. This is the case as immigrants train to counteract the negative impact through discrimination.

The model with exogenous training and on-the-job training delivers similar results. Discrimination in one sector reduces wages of all workers and increases the unemployment rate of natives in the same sector, but it actually improves employment perspectives in the other sector. When low-productivity immigrants are discriminated against, all skilled workers accept lower wages to increase their employment chances and avoid the risk of losing skills through the experience of unemployment, thus reducing the rate of unemployment in the sector.

Considering welfare, the reduction in vacancy supply induced by discrimination has a negative effect on welfare and we tend to see the strongest negative effect when discrimination is prevalent in the high-productivity sector.

The paper is organized as follows. The model with endogenous training is set up in Section 2. Section 3 shows the effect of an increase in discrimination when training is endogenous. Section 4 presents the model where training is exogenous. Section 5 considers the effect of an increase in discrimination in this alternative model. Section 6 considers welfare and Section 7 concludes the paper.

2 Endogenous training

We develop a model with two types of agents, workers and firms. Both workers and firms are risk-neutral and infinitely-lived and have a common discount rate. Workers are either employed, unemployed or training. The economy is populated by native and immigrant workers. The share of native workers, n, is exogenously given. The labour force is normalized to one.

To hire a worker, a firm maintains an open vacancy at flow cost k. Free entry drives the discounted profits of creating a vacancy to zero. The economy is divided into two sectors. Firms in sector h require skilled workers with high productivity, y_h, while firms in sector l employ low-skilled workers with productivity $y_l < y_h$. The skills of workers is assumed to be observable.

We model discrimination as a capricious rejection of immigrant applicants. If a negative external event, such as media picturing immigrants in a negative manner, occurs after a vacancy was opened but previous to a match with an immigrant worker, the immigrant is not offered a job. Discrimination then implies that immigrants face a lower probability of getting a job than natives.

This occurs in a match with probability d_s $(s = h, l)$.[4]

For simplicity, we assume that all workers enter the labour market as skilled workers.[5] When unemployed, skilled workers lose their skills with probability λ. If workers choose to engage in a training program, they regain their skills once this program ceases.

2.1 Matching

Unemployed workers search for jobs in sector h or l, depending on their productivity level. Productivity is sector specific. We assume that the value of skilled unemployment is higher than the value of unskilled employment, implying it is not optimal for high-skilled workers to search for low-skilled jobs.[6] The matching function for sector s is assumed to have the functional form $(v_s)^{\alpha}(u_s)^{1-\alpha}$, where v_s is the sectorial vacancy rate and u_s is the unemployment rate in sector $s = h, l$ and $0 < \alpha < 1$.

The transition rate into employment for a native worker with productivity s is given by $f_s^N = f(\theta_s) = \theta_s^{\alpha}$, $s = h, l$, where $\theta_s = v_s/u_s$ captures sectorial labour market tightness. As discrimination may disrupt a match, the immigrant worker's transition rates into employment are reduced relative to those of natives to $f_s^I = f(\theta_s)(1 - d_s) = \theta_s^{\alpha}(1 - d_s)$, $s = h, l$. The flow arrival rate at which vacant jobs become filled is $q_s = q(1/\theta_s) = \theta_s^{\alpha-1}$, $s = h, l$.

2.2 Workers

The present discounted value, PDV, of the unemployed skilled worker i of origin $J = N, I$ (natives or immigrants) is given by

$$\rho U_{ih}^J = f_h^J \left(W_{ih}^J - U_{ih}^J\right) + \lambda \left(U_{il}^J - U_{ih}^J\right), \qquad J = N, I. \tag{1}$$

At the flow arrival rate f_h^J, the worker gets a job in the high-productivity

[4] An alternative is to model discrimination on exit, where an immigrant worker is either fired or forced to resign with a higher probability than a native worker. This alternative set up delivers results similar to those in our model.

[5] Letting a proportion of natives and immigrants be low skilled to begin with does not substantially modify the results.

[6] A sufficient condition requires that the difference in productivities is sufficiently large $y_h > \frac{(\rho+\lambda)}{4.5\sigma} y_l$, **the** risk of losing skills is not too low $\left(4.5 > \frac{(\rho+\lambda)(\rho+\sigma)}{\sigma(\lambda-\rho)}\right)$ and the unemployment rate of high-skilled workers is not too high ($u_h < 0.10$). See Appendix 1a for details. These conditions are satisfied in the simulations below as long as d_s is not too high (close to 0.5).

sector and receives the value W_{ih}^{J} and at the rate λ, the worker loses skills and becomes a low-skilled unemployed with the value of U_{il}^{J} :

$$\rho U_{il}^{J}=f_{il}^{J}\left(W_{il}^{J}-U_{il}^{J}\right), \qquad J=N,I. \tag{2}$$

The low-skilled unemployed worker i gets a job in the low-productivity sector with probability per unit of time f_{l}^{J}. All parameters in the model are common knowledge.

The present discounted value for the employed worker $i, W_{is}^{J}, s=h,l$ satisfies

$$\rho W_{ih}^{J} = w_{h}^{J}+\sigma\left(U_{ih}^{J}-W_{ih}^{J}\right), \qquad J=N,I, \tag{3}$$

$$\rho W_{il}^{J} = w_{l}^{J}+\sigma\left(U_{il}^{J}-W_{il}^{J}\right), \qquad J=N,I, \tag{4}$$

where w_{s}^{J} is the wage in sector s and σ is the rate of job separation, assumed to be exogenous, identical for natives and immigrants and in both sectors.

A low skilled unemployed worker can choose to search for a job in the low skilled sector or engage in a training process. We assume that the labour force is heterogenous in the sense that some workers have higher cost of training than others. To become high skilled both unemployed natives and immigrants pay a *per period* cost $c\sim U[0;C]$ which is specific to that opportunity. The effort needed by a worker to retrain in a particular opportunity depends on the location and time where this training is provided, whether she is healthy or sick, the family situation at that moment, etc. These factors vary over time. Therefore, the fact that a worker chooses to train in one opportunity does not imply that the worker also train next time her or she loses skills.

The worker compares the present discounted value of training, $U_{it}^{J}(c)$, to the value of being an unemployed *high* skilled worker. The value of training is given by

$$\rho U_{it}^{J}(c)=\gamma\left(U_{ih}^{J}-U_{it}^{J}(c)\right)-c, \qquad J=N,I,$$

where γ is the exogenous rate by which the training programme ceases. When this happens, the worker returns to the labour force as a skilled worker. The marginal worker, with cost $\widehat{c}^{J}, J=N,I,$ is indifferent between training and remaining low skilled. The marginal worker thus satisfies the condition

$$\rho U_{il}^{J}=\rho U_{it}^{J}\left(\widehat{c}^{J}\right), \qquad j=N,I. \tag{5}$$

Workers with cost of training $c<\widehat{c}^{J}$ train, whereas workers with higher cost do not.

2.3 Firms

The present discounted value of a new vacancy in sector s is

$$\rho V_s = q_s \left(\phi_s \left(X_s^N - V_s\right) + (1-\phi_s)(1-d_s)\left(X_s^I - V_s\right)\right) - k, \qquad s = h, l. \quad (6)$$

ϕ_s is the proportion of natives among the unemployed workers of productivity s and k is the per period cost of maintaining an open vacancy. With the probability per unit of time, $q_s\phi_s$, the vacancy is filled by a native and provides a value X_s^N to the firm, while the probability per unit of time of filling it with an immigrant is $q_s(1-\phi_s)(1-d_s)$ creating the value X_s^I.

The PDV of a job occupied by a worker of origin J, X_s^J satisfies

$$\rho X_s^J = y_s - w_s^J + \sigma\left(V_s - X_s^J\right), \qquad s = h, l \text{ and } J = N, I. \quad (7)$$

Using (6), (7), the matching function and assuming free entry, $V_s = 0$, we obtain two equations to determine labour market tightness, $\theta_s \quad s = h, l$:

$$g_s = k\theta_s^{1-\alpha}(\rho+\sigma) - \phi_s\left[y_s - w_s^N\right] - (1-\phi_s)(1-d_s)\left[y_s - w_s^I\right] = 0. \quad (8)$$

Discrimination causes, for given wages, a firm's surplus to deteriorate when there are many unemployed immigrants, that is, when ϕ_s is small.

2.4 Equilibrium

Wages are determined by Nash Bargaining with a bargaining power equal to one half, so that they are set to equalize the parties' surplus, $W_s^J - U_s^J = X_s^J$.

After substituting for eq. (2)-(7), this equalization implies

$$w_h^J = \frac{1}{2}\left[y_h + f_h^J\left(W_{ih}^J - U_{ih}^J\right) + \lambda\left(U_{il}^J - U_{ih}^J\right)\right], \qquad J = N, I, \quad (9)$$

$$w_l^J = \frac{1}{2}\left[y_l + f_l^J\left(W_{il}^J - U_{il}^J\right)\right], \qquad J = N, I. \quad (10)$$

By inserting the PDVs from eq. (1)-(4) in eq. (9) and (10), we obtain:

$$w_h^J = \frac{\left((\rho+\sigma)(\rho+\lambda) + \rho f_h^J\right) y_h + \frac{\lambda f_l^J(\rho+\sigma)}{2(\rho+\sigma)+f_l^J} y_l}{\left(2(\rho+\sigma)(\rho+\lambda) + \rho f_h^J\right)}, \qquad J = N, I, \quad (11)$$

$$w_l^J = \frac{\rho+\sigma+f_l^J}{2(\rho+\sigma)+f_l^J} y_l, \qquad J = N, I. \quad (12)$$

Skilled workers receive higher wages than low-skilled workers, $w_h^J > w_l^J,\ J = N, I$ as $y_h > y_l$. Wages received by skilled workers are affected by the conditions in the low productivity sector as the risk of losing skills implies that the low productivity sector is one possible outside option. Wages received by skilled immigrants are then directly affected by discrimination in both the high and low productivity sectors. Wages received by low skilled immigrants are only directly affected by discrimination in the low productivity sector. Skilled natives receive higher wages than skilled immigrants as they have a higher transition rate out of unemployment than skilled immigrants and thereby a better bargaining position.

Steady-state unemployment rates are derived by equalizing the flows into and out of employment and the fact that $e_l^N + e_h^N + \upsilon_h^N + \upsilon_l^N = n$ and $e_l^I + e_h^I + \upsilon_h^I + \upsilon_l^I = 1 - n$, where $e_s^J\left(\upsilon_s^J\right)$ denotes employment (unemployment). We obtain the following unemployment rates for immigrants and natives:

$$u_s^J = \upsilon_s^J / \left(e_s^J + \upsilon_s^J\right) = \sigma / \left(\sigma + f_s^J\right), \quad s = h, l, \quad J = N, I. \tag{13}$$

Due to discrimination, immigrants face higher unemployment than natives in both sectors, that is $u_h^I / u_h^N > 1$ and $u_l^I / u_l^N > 1$.

Replacing wages from equations (11) and (12), labour market tightness becomes

$$\begin{aligned} g_h &= k\theta_h^{1-\alpha}(\rho+\sigma) - \phi_h \Omega_h^N - (1-\phi_h)(1-d_h)\Omega_h^I = 0, \\ g_l &= k\theta_l^{1-\alpha}(\rho+\sigma) - \phi_l \frac{(\rho+\sigma)}{2(\rho+\sigma)+f_l} y_l - (1-\phi_l)\frac{(1-d_l)(\rho+\sigma)}{(\rho+\sigma)2 + f_l(1-d_l)} y_l = 0, \end{aligned}$$

where $\Omega_h^j = (\rho+\sigma)\frac{(\rho+\lambda)y_h - \frac{\lambda f_l^J y_l}{2(\rho+\sigma)+f_l^J}}{2(\rho+\lambda)(\rho+\sigma)+\rho f_h^J}$. In order to determine the relative size of labour market tightness in the high and low productivity sector, respectively, we need to the determine the relative size of ϕ_h and ϕ_l.

Inserting equation (1) into the training equation (5) we obtain, after substituting for values and then wages, the equation determining the marginal worker who trains, $\widehat{c}^J,\ J = N, I$:

$$\widehat{c}^J = \frac{\gamma f_h^J y_h - \left((\gamma+\rho) f_h^J + 2(\rho+\sigma)(\gamma+\rho+\lambda)\right)\frac{f_l^J}{2(\rho+\sigma)+f_l^J} y_l}{\left(2(\rho+\lambda)(\rho+\sigma) + \rho f_h^J\right)}, \quad J = N, I. \tag{14}$$

A necessary condition for workers to train is that the right hand side is positive. For this to be the case, retraining progammes need to be short (implying a high rate by which a programme ceases, high γ), the probability of getting a high skilled job $\left(f_h^J\right)$ needs to be relatively high and so does the difference in productivity achieved by training $(y_h - y_l)$. The direct impact of discrimination facing high skilled workers on training is negative. When discrimination is present in the low skilled sector, training becomes relatively more attractive and $\widehat{c}^J$ increases. We furthermore note that any positive impact on the workers' transition rate in the high productivity sector, increases the attractiveness of regaining skills through training, whereas the opposite holds for increases in labour market tightness in the low productivity sector. The relative size of the training fraction of natives versus immigrants depend on whether discrimination is present among the high productivity workers or among the low productivity workers.

The proportion of natives among the unemployment workers of productivity s changes to

$$\phi_h = \frac{\nu_h^N}{\nu_h^N + \nu_h^I} = \frac{1}{1 + \kappa \frac{(1-n)}{n} \frac{\widehat{c}^I}{\widehat{c}^N}}, \tag{15}$$

$$\phi_l = \frac{1}{1 + \kappa \frac{(1-n)}{n}}, \tag{16}$$

where $\kappa = \frac{\widehat{c}^N[\gamma f_h + \sigma(\lambda+\gamma)] + \lambda\gamma(\sigma + f_l)}{\widehat{c}^I[\gamma f_h(1-d_h) + \sigma(\lambda+\gamma)] + \lambda\gamma(\sigma + f_l(1-d_l))}$ and hence the proportion of natives among the skilled unemployed will be higher than the proportion of natives among the low skilled unemployed if natives choose to train to a higher extent than immigrants, that is, $\phi_h > \phi_l$ if $\widehat{c}^N > \widehat{c}^I$.[7]

The proportion of skilled workers in the economy is:

$$\frac{\nu_h^J + e_h^J}{n^J} = \frac{\widehat{c}^J \left(\sigma + f_h^J\right)\gamma}{\left(\widehat{c}^J \left(\gamma f_h^J + \sigma\left(\lambda + \gamma\right)\right) + \lambda\gamma\left(\sigma + f_l^J\right)\right)}, \quad J = N, I,$$

where $n^N = n$ and $n^I = 1 - n$. We cannot immediately determine whether the proportion of skilled workers is higher among natives than among immigrants. Discrimination is going to affect the proportion of skilled workers both directly as well as indirectly through its impact on labour market tightness and training.

3 Higher Discrimination - Endogenous training

Any change in the labour market conditions affects the bargaining positions in the match. A weakening of the worker's position results in acceptance of a

[7] See Appendix 2 for derivation.

lower wage. This is the direct effect of any change. There is a further indirect effect on all workers in the same sector. Firms offer fewer vacancies if the chance of filling them falls, which reduces labour market tightness and thus, the employment probability of a worker in the sector. The risk of losing skills and the probability of regaining skills, implies that a change in one sector potentially affects the bargaining position of the workers in the other sector. The proofs of the propositions follow from differentiation of the appropriate expression(s). We assume discrimination to be present in one sector at a time to improve the transparency of the intuition. This is equivalent to assuming that negative events trigger rejection in one sector, but not in the other.

3.1 Discrimination of high-skilled workers

When only high skilled workers are discriminated against, $d_h > 0, d_l = 0$, wages received by natives and immigrants with low productivity will be identical, $w_l^N = w_l^I = y_l \frac{\rho+\sigma+f_l}{(\rho+\sigma)2+f_l}$, labour market tightness in the low productivity sector is determined by $k\theta_l^{1-\alpha} = y_l / \left(2\left(\rho+\sigma\right)+f_l\left(\theta_l\right)\right)$. The labour market tightness condition for the high productivity sector is

$$g_h = k\theta_h^{1-\alpha} - \phi_h \frac{\left(\rho+\lambda\right) y_h - \frac{\lambda f_l y_l}{2(\rho+\sigma)+f_l}}{2\left(\rho+\sigma\right)\left(\rho+\lambda\right)+\rho f_h} - \left(1-\phi_h\right) \frac{\left(1-d_h\right)\left(\left(\rho+\lambda\right) y_h - \frac{\lambda f_l y_l}{2(\rho+\sigma)+f_l}\right)}{2\left(\rho+\sigma\right)\left(\rho+\lambda\right)+\rho f_h\left(1-d_h\right)} = 0, \tag{17}$$

where $\phi_h = \frac{1}{1+\kappa\frac{(1-n)}{n}\frac{\widehat{c}^I}{\widehat{c}^N}}$. Discrimination of high skilled workers has a direct negative impact on the labour market tightness for firms hiring skilled workers and an indirect effect via the training decision and the share of natives among the unemployed workers. The negative impact on training for immigrants increases the relative number of skilled natives in the economy, and therefore indirectly increases labour market tightness. We differentiate equation (17) and (14) for immigrants when $d_l = 0$, whereby we obtain the following results around $d_h = d_l = 0$.

Proposition 1 *When training is endogenously determined and discrimination in the high skilled sector increases, d_h increases, then fewer unemployed low skilled workers train, $d\widehat{c}^I/dd_h < 0$, $d\widehat{c}^N/dd_h < 0$, and the impact on labour market tightness facing the high skilled workers is negative, $d\theta_h/dd_h < 0$. Consequently, the high skilled workers' wages fall and their unemployment rate increases. Labour market tightness and thereby the unemployment rates facing low* *skilled workers, which is identical for immigrants and natives, are unaffected.*

Higher discrimination facing high skilled workers has a direct negative impact on labour market tightness for high skilled workers. Similarly, discrimination in the high skilled sector decreases the attractiveness of training such that fewer immigrant workers train. The decrease in the fraction of trained immigrants will increase the fraction of natives among the skilled workers, which tends to increase labour market tightness in the high skilled sector and therefore all skilled workers' transition rates. Around $d_h = d_l = 0$, the latter impact vanishes and the total impact on labour market tightness in the high skilled sector is negative. This, in turn, implies that also native low skilled workers train less, $d\widehat{c}^N/dd_h < 0$, but as they are not affected directly by discrimination, the negative impact on training is smaller for natives than for immigrants.

The reduction in labour market tightness facing skilled workers implies that their wages fall. As immigrants are also directly negatively affected, the negative impact is stronger for immigrants than for natives.

High skilled immigrant workers' unemployment rate is directly increased by discrimination and indirectly affected through the reduction in labour market tightness for high skilled workers. Native high skilled workers experience a smaller increase in unemployment as their unemployment rate is only affected by the reduced labour market tightness.

The proportion of skilled workers decreases for both natives and immigrants. The impact is stronger for immigrants than for natives. This is the case, both because natives' employment chances are reduced less than those of the immigrants and thereby the risk of losing skills and because the negative impact on training is lower for natives than for immigrants.

3.2 Discrimination of low-skilled workers

Even if discrimination is only present in the low productivity sector, $d_h = 0$, $d_l > 0$, wages received by skilled natives and immigrants will differ, $w_h^J = \frac{y_h((\rho+\lambda)(\rho+\sigma)+f_h\rho)+\lambda f_l^J \frac{y_l(\rho+\sigma)}{(\rho+\sigma)2+f_l^J}}{(2(\rho+\lambda)(\rho+\sigma)+f_h\rho)}$, $J = N, I$. This is due to the fact that the risk of losing skills reduces the immigrant workers' bargaining power further when discrimination among low skilled workers is present. Hence, when considering the impact on labour market tightness and training, we differentiate the equations (14), $J = N, I$, and (8), $s = h, l$, when $d_h = 0$ and $d_l > 0$ to obtain **results** around $d_h = d_l = 0$.

Proposition 2 *When training is endogenously determined and discrimination in the low skilled sector increases, d_l increases, then more low skilled unemployed immigrants train, $d\widehat{c}^I/dd_l > 0$, and the impact on labour market tightness in the low skilled sector is negative, $d\theta_l/dd_l < 0$, whereas it is positive in the high skilled sector, $d\theta_h/dd_l > 0$. Low skilled workers' wages fall and their unemployment rate increases. High skilled workers wages and unemployment rate fall and the impact on the number of training unemployed natives is positive, $d\widehat{c}^N/dd_l > 0$.*

Discrimination among low skilled workers has a direct positive impact on workers' training and a direct negative impact on labour market tightness for low skilled workers. It furthermore reduces wages facing high skilled workers, because of the implied reduction of their bargaining power through the risk of losing skills. This wage reduction, on the other hand, makes vacancy supply more attractive for high skilled firms which increases labour market tightness and thus high skilled workers' transition rate. Consequently, skilled natives' and immigrants' unemployment rates fall.

Low skilled workers' unemployment rate increases. For native low skilled workers the reason is the fall in labour market tightness, whereas immigrant workers furthermore experience a direct increase in unemployment from discrimination.

Natives also train more as the improved employment chances of high skilled workers and the worsened employment chances of low skilled employed, tend to increase the number of low skilled natives training. The impact is modified by the reduced wages. Immigrants being most negatively affected by the increase in discrimination, experience a larger increase in training than natives, $\left|d\widehat{c}^I/dd_l\right| > \left|d\widehat{c}^N/dd_l\right|$.

The proportion of skilled workers increases. The impact is larger for immigrants than for natives. This is the case because the reduction in employment chances as low skilled workers is smaller for natives than for immigrants and also because the positive impact on training is larger for immigrants than for natives.

One factor we have left out of our model is the fact that workers may regain their skills while working in the low productivity sector. We incorporate this possibility in the model by assuming exogenous training and on-the-job training. We consider this in an alternative setting of the model after examining simulations.

3.3 Simulations

In order to illustrate the results, we perform simulations. The following parameter values are used (annual values) in the solutions: the discount rate is set to $\rho = 0.08$; the separation rate is set to $\sigma = 0.1$ (see Millard and Mortensen 1997); the match efficiency is assumed to be $\alpha = 0.5$ (Pissarides 1995); y_l is normalized to one; y_h is set equal to 1.3 to obtain a relatively large difference between productivity levels in the two sectors. The fraction of natives was around $n = 0.85$ in Sweden in 2011 (www.scb.se). Hiring costs are assumed to be $k = 0.7$ (70% of an annual low-skilled productivity). $\lambda = 0.27$ is set to approximately match unemployment in Sweden in 2011, $u = 0.076$ (www.oecd.org), the fact that the unemployment of natives was 37% of the unemployment of immigrants (www.scb.se) and that the fraction of long-term unemployed (more than 12 months) was 16.6% in 2010 (www.oecd.org). In our model, the long-term unemployed workers correspond to the workers that have lost their skills.

In Appendix 3, we show the effect of an increase in the level of discrimination in one sector at a time, with training being endogenously determined at the optimal level. In the first(second) set of simulations, d_h (d_l) increases from 0 to 0.5, while d_l (d_h) is constant at 0.25. We simulate the effects on wages, rates of unemployment, skill shares and proportion of training workers, for the four groups of workers: high-skilled natives (Nh), high-skilled immigrants (Ih), low-skilled natives (Nl) and low-skilled immigrants (Il).

Increasing discrimination in the high-productivity sector mainly affects skilled immigrants: they receive lower wages and face higher unemployment. As a consequence, the probability that a low-skilled immigrant chooses to train decreases as does the share of skilled immigrants. When d_h rises, the value of skills decreases for all workers, so less of them choose to train. When discrimination increases, the risk that a vacancy is not filled rises, resulting in creation of fewer vacancies in the high-productivity sector, until discrimination reaches a certain level, see below. This means that skilled natives face changes in wages and unemployment (leading to changes in skills and probability of training) in the same direction as skilled immigrants, but of a much smaller magnitude. Instead of training, low-skilled workers choose to work, accepting slightly lower wages, which tend to increase the vacancy supply.

The proportion of skilled workers among natives increases after $d_h = 0.35$, see graphs 3. This is the case as there a now so few immigrants among high skilled workers, that the positive impact on vacancy supply through an increase in ϕ_h is dominating and vacancy supply increases in the high skilled sector. Therefore skilled natives also faces lower unemployment after this discrimination level and higher wages.

We then consider the second set of graphs. When discrimination increases in the low-productivity sector, the effect is stronger for low-skilled immigrants who suffer lower wages and higher unemployment. They have a strong incentive to leave this sector and will do so by training more, increasing the probability that an immigrant trains and the share of skilled immigrants. Low-skilled natives also face lower wages and higher unemployment, but the impact is much weaker for them, and so is the positive effect on training and skills. Skilled workers acknowledging that the conditions in the low-skilled sector have deteriorated, accept lower wages in order to face lower unemployment and reduce the risk of losing skills. The discrimination of low-skilled workers improves the employment perspectives of all skilled workers.

The simulations show that when $d_l = 0$ and $d_h = 0.25$, immigrants choose to train to a lower extent than natives. As d_l increases, the value of skills increases for all workers, but the effect is much stronger for immigrants who choose to train to an even larger extent.

In the simulations, if one fourth (one half) of the matches is affected by negative events, $d_h = d_l = 0.25$ ($d_h = d_l = 0.5$), immigrants obtain a wage reduction of more than 3% (7%), while they suffer more than 30% (90%) larger unemployment than natives. In Sweden, immigrants have 11% lower wages[8] and 128% higher unemployment[9] than natives. In the USA, immigrants have slightly lower unemployment than natives, but when considering discrimination, this may be the wrong comparison. In the last quarter of 2007, Blacks or African Americans had more than 20% lower median weekly earnings and more than 100% higher unemployment than whites.[10] We do acknowledge that these

[8] In 2006, according to "Wages and Immigrant Occupational Composition in Sweden" by Hansen, Wahlberg, Faisal, IZA DP No. 4823.

[9] In 2007 according to the *OECD Factbook 2009: Economic, Environmental and Social Statistics.*

[10] According to the Bureau of Labor Statistics in http://www.bls.gov/cps/.

differences can be explained by many other factors than discrimination which are absent in the present model.

4 Exogenous Training

We maintain the assumptions from section 2, except that workers may regain skills in two different ways: i) they get a low-productivity job and regain their skills at the exogenous rate a or ii) they train while unemployed and regain their skills at the exogenous rate γ. The exogenous probabilities a and γ are common knowledge and identical for natives and immigrants. The matching process is as above.

4.1 Workers

The present discounted value, PDV, of the unemployed skilled worker i of origin $J = N, I$ (natives or immigrants) is given by eq (1), while the PDV of the unemployed low skilled worker is now given by

$$\rho U_{il}^J = f_{il}^J \left(W_{il}^J - U_{il}^J\right) + \gamma \left(U_{ih}^J - U_{il}^J\right), \qquad J = N, I. \tag{18}$$

The worker i gets a job in the low-productivity sector with probability per unit of time f_l^J, and regains skills by training while unemployed at the rate γ. All parameters are common knowledge.

The present discounted value for the employed worker $i, W_{is}^J, s = h, l$ satisfies equation (3) in the high productivity sector, while in the low productivity sector it is given by:

$$\rho W_{il}^J = w_l^J + \sigma \left(aU_{ih}^J + (1-a)\, U_{il}^J - W_{il}^J\right), \tag{19}$$

We assume that a proportion a of the workers regains skills and joins the pool of skilled unemployed. For simplicity, we assume that regaining skills and job separation take place at the same time.[11][12]

4.2 Firms

The present discounted value of a new vacancy in sector s is given by eq (6), the PDV of a job occupied by a worker of origin J, X_s^J satisfies eq (7) and labour market tightness, $\theta_s \quad s = h, l$ is determined by eq (8) as in section 2.

4.3 Equilibrium

Wages are determined by Nash Bargaining with a bargaining power equal to one half, so that they are set to equalize the parties' surplus, $W_s^J - U_s^J = X_s^J$. After substituting, this equalization implies :

$$w_h^J = \frac{1}{2}\left(y_h + \rho U_{ih}^J\right), \qquad J = N, I, \tag{20}$$

$$w_l^J = \frac{1}{2}\left[y_l + f_l^J\left(W_{il}^J - U_{il}^J\right) + (\gamma - \sigma a)\left(U_{ih}^J - U_{il}^J\right)\right]. \tag{21}$$

The wage of a low-skilled worker decreases with a, the proportion by which he or she regains skills with on-the-job training. This possibility makes employment more attractive, so the worker accepts a lower wage in the bargaining process. We assume that the exogenous rates at which all workers regain skills by training while unemployed is equal to the rate by which they regain skills while working, $\gamma = \sigma a$. This simplifying assumption implies that the wages of low-skill workers are independent of the transition rates in the high-productivity sector and allow us to obtain analytical results.[13]

[11] This same assumption is present in Larsen (2001). As job separation is exogenous, it does not need to be optimal to quit. However, workers would always quit when they regain their skills if the value of being a high-productivity unemployed worker is higher than the value of being an employed low-skilled worker. A sufficient condition requires that the difference in productivities is sufficiently large $\left(y_h \geq \frac{(\rho+5.5\sigma)}{4.5\sigma} y_l\right)$, and the risk of losing skills is not too high $(\rho + (2-a)\sigma + 0.75 \cdot \sigma \geq \lambda)$ and the unemployment rate of high-skilled workers is not too high ($u_h < 0.10$). See Appendix 1b for details. These conditions are satisfied in the simulations below as long as d_s is not too high (close to 0.5).

[12] As a robustness test, we also examined the possibility that workers may search on the job. In the model extended with search on the job for low-skilled workers (it would never be optimal for high-skilled workers to search on the job as they cannot receive higher wages), wages received by low-skilled workers will be further reduced, as low-skilled workers become even more eager to obtain a job, due to the fact that the potential gain increases. Details are available upon request.

[13] We describe the consequences of relaxing this assumption below.

Unemployment rates for the four groups of workers are still given by (13) whereas the proportion of native workers among the unemployed is changes to $\phi_h = \frac{1}{1+\frac{(1-n)}{n}\kappa}$, $\phi_l = \frac{1}{1+\frac{(1-n)}{n}\frac{(\sigma+f_l)}{(\sigma+f_l(1-d_l))}\kappa}$, where $\kappa = \frac{\lambda+a(f_h+\sigma)}{\lambda+a(f_h(1-d_h)+\sigma)} > 1$. As above, the additional negative impact of discrimination on low-skilled immigrant workers results in relatively more natives among the skilled unemployed, $\phi_h > \phi_l$.

By inserting the PDV from eq. (1)-(19) in eq. (20) and (21), we obtain:

$$w_l^J = \frac{\rho+\sigma+f_l^J}{2(\rho+\sigma)+f_l^J} y_l \qquad J = N, I, \tag{22}$$

$$w_h^J = \frac{\left[(\rho+\sigma)(\rho+\lambda+\gamma)+(\rho+\gamma) f_h^J\right] y_h + \lambda f_l^J \frac{\rho+\sigma}{2(\rho+\sigma)+f_l^J} y_l}{2(\rho+\sigma)(\rho+\lambda+\gamma)+(\rho+\gamma) f_h^J}. \tag{23}$$

Native workers receive higher wages than immigrants in both sectors, $w_s^N > w_s^I$, $s = h, l$ as $f_s^N > f_s^I$. Skilled natives receive higher wages than skilled immigrants as they have a higher transition rate out of unemployment than skilled immigrants and thereby a better bargaining position. And finally, skilled workers receive higher wages than low-skilled workers, $w_h^J > w_l^J$, $J = N, I$ if $f_h > f_l$.

Equations (22) and (23), together with equation (8), determine labour market tightness for the two sectors. The labour market tightness facing skilled workers is higher than that facing low-skilled workers, $\theta_h > \theta_l$, if the productivity difference is sufficiently large or if there is more discrimination in the low-productivity sector, $d_h \leq d_l$. This implies that it is easier for a skilled worker than for a low-skilled worker to find a job, $f_h > f_l$. If we relax the simplifying assumption so that $\gamma > \sigma a$, the low-skilled workers' outside option improves raising their wages, as the probability of regaining skills is higher while unemployed. The opposite holds if $\gamma < \sigma a$.

Proposition 3 *Due to discrimination in sector h, the proportion of low-skilled immigrants is higher than the proportion of low-skilled natives in the economy.*

Proof. The proportion of high skilled workers is, respectively,

$$\frac{\upsilon_h^I + e_h^I}{1-n} = \frac{a(\sigma + f_h(1-d_h))}{\lambda + a(f_h(1-d_h)+\sigma)}, \quad \frac{\upsilon_h^N + e_h^N}{n} = \frac{a(\sigma+f_h)}{(\lambda + a(f_h+\sigma))},$$

where we observe that

$$\left(\upsilon_h^I + e_h^I\right)/(1-n) < \left(\upsilon_h^N + e_h^N\right)/n, \quad \left(\upsilon_l^I + e_l^I\right)/(1-n) > \left(\upsilon_l^N + e_l^N\right)/n. \quad \blacksquare$$

Natives and immigrants enter the economy with the same distribution of skills, but immigrants become less skilled due to discrimination in sector h.[14]

5 Higher Discrimination - Exogenous training

We assume again discrimination to be present in one sector at a time to improve the transparency of the intuition.

5.1 Discrimination of high-skilled workers

Due to the simplifying assumption $(\gamma = \sigma a)$, discrimination in the high-productivity sector has no effect on wages in the low-productivity sector. Furthermore, the proportion of natives among the unemployed is the same for skilled and non-skilled workers, that is, $\phi_h = \phi_l$, as low-skilled immigrants are only indirectly affected by discrimination in sector h. We assume that productivity differences are sufficiently large to insure that $f_h (1 - d_h) > f_l$.

Proposition 4 *All wages in the high-productivity sector decrease whenever d_h increases. The wages of low-skilled workers are unaffected.*

Higher discrimination directly reduces skilled immigrants' wages as their bargaining position deteriorates. Higher discrimination indirectly reduces the transition rate faced by all skilled workers, even natives, and thereby their wages.

Proposition 5 *The unemployment of all skilled workers goes up when d_h increases. Unemployment of low-skilled workers is unaffected.*

The direct effect of higher discrimination is that more skilled immigrants become unemployed and risk losing their skills. Furthermore, higher discrimination increases the expected duration of a vacancy and thereby causes a reduction in vacancy supply. This is the indirect effect of discrimination. Higher discrimination therefore lowers the transition rates into employment for all skilled workers whereby unemployment increases. Discrimination implies that natives are overrepresented among skilled workers and more affected by the negative indirect effect. [15]

[14] This result is independent of whether we have discrimination of low-skilled workers because of the simplifying assumption $\gamma = \sigma a$.

[15] The model may resemble Bergmann's model on occupational crowding (Bergmann 1971), as a larger segment of immigrants than natives are "crowded" into the lower tier of the

5.2 Discrimination of low-skilled workers

All workers are affected both in terms of wages and unemployment.

Proposition 6 *All wages fall whenever d_l increases.*

Proposition 7 *When d_l increases, unemployment of skilled workers falls and unemployment of low-skilled workers increases.*

Low-skilled immigrants suffer from both the direct and the indirect effect of discrimination, while low-skilled natives only suffer from the indirect effect. Hence, all low-skilled workers face lower wages and higher unemployment.

The fall in low-skilled workers' wages and transition rates worsens the outside option for all skilled workers, due to the risk of losing skills. Skilled workers' bargaining position is then damaged and they accept lower wages. This makes skilled workers more attractive and therefore, more vacancies are opened in this sector, thus reducing unemployment. Wages rise due to more vacancies, but this effect is smaller than the original wage reduction. Hence, the existence of discrimination in the low-productivity sector provides a positive employment externality on the high-productivity sector; it actually improves the employment perspectives of all skilled workers.

5.3 More Immigrants

In this subsection we consider the impact on labour market performance from an increase in the share of immigrants in the economy. We let the share of immigrants increase with the total work force still being normalized to one and let discrimination be present in one sector at a time.

Proposition 8 *When the share of immigrants, $1-n$, increases, in an economy where only skilled immigrants are discriminated against, all skilled wages fall. Wages received by low-skilled workers remain unchanged.*

Proposition 9 *When the share of immigrants increases in an economy where $d_h > 0$ and $d_l = 0$, the unemployment rate of all skilled workers increases. The*

labour market. On the other hand, in our set-up, not only immigrants but all workers in the economy are affected by discrimination. This result is also obtained in papers like Ortega (2000). However, he does not consider the direct negative impact on firms' vacancy supply from discrimination.

unemployment rate of skilled natives increases relatively more than that of skilled immigrants. The unemployment of low-skilled workers remains unchanged.

When there is an increase in the share of immigrants, a high-productivity firm is more likely to match with an immigrant. This increases the expected duration of a vacancy, as discrimination implies that more immigrants is associated with a lower matching frequency. The attractiveness of opening a vacancy falls. All high skilled workers' wages fall as their bargaining position is weakened. This reduction in wages increases the transition rates for skilled workers, modifying the wage reduction. Low-skilled wages are unaffected due to the assumption that $\gamma = \sigma a$.

Unemployment increases following the reduced vacancy supply. Skilled natives work in the sector to a larger extent, whereby their unemployment rate increases more than that of skilled immigrants, that is, $\left(u_h^I / u_h^N\right)$ decreases.

Proposition 10 *In an economy where only low-skilled immigrants are discriminated against, a higher* $(1-n)$ *reduces the wages received by all low-skilled workers.*

Proposition 11 *When the share of immigrants,* $(1-n)$, *increases in an economy with* $d_h = 0$ *and* $d_l > 0$, *the unemployment rates of all low-skilled workers increase, while the unemployment rates of all skilled workers fall. The unemployment of low-skilled natives increases more than that of low-skilled immigrants.*

An increase in the share of immigrants makes opening a vacancy in the low-productivity sector less attractive, and the resulting fall in the transition rates of low-skilled workers deteriorates their bargaining position, which causes them to accept lower wages. Even skilled workers are induced to accept lower wages to avoid unemployment and the risk of losing skills, but the lower wages themselves lead to an increase in the transition rate that once more raises wages. The total effect on skilled workers' wages is indeterminate.

Fewer vacancies increase unemployment of all low-skilled workers. As low-skilled natives are employed to a higher extent, they suffer a higher increase in unemployment, whereby the relative unemployment rate for immigrant vs native low-skilled workers $\left(u_l^I / u_l^N\right)$ decreases.

5.4 Simulations

In the simulations in Appendix 4, we let the parameters have the same values as in Appendix 3. Furthermore, we assume that the probability that a worker regains skills by training is exogenously given at $\gamma^I = \gamma^N = \sigma a = 0.08$ so that we let $a = 0.8$ to approximately match unemployment in Sweden in 2010. We then consider the impact on the endogenous variables from higher discrimination in one sector at a time, when discrimination in the other sector is larger than zero and given by $d_s = 0.25$. Finally, we increase the share of immigrants in a model with a fixed level of discrimination at $d_h = d_l = 0.25$. Our numerical solutions show that the effect of an increase in the share of immigrants has a much smaller order of magnitude than the effect of an increase in discrimination. In both cases, that is when training is exogenous and when it is endogenous, all variables move in the direction indicated in section 5.3, but the changes are very small.[16]

6 Welfare

We consider the model with exogenous training. We have shown that discrimination has a different impact on labour market performance depending on the sector where it exists and in this section we consider how welfare is affected.

We use a utilitarian welfare function, which is obtained by adding all individuals' and firms' steady state flow values of welfare in both the high- and the low-productivity sector. To disregard congestion externalities, we assume that $\alpha = 1/2$, that is we impose the traditional Hosios condition (Hosios 1990) where the elasticity of the expected duration of a vacancy is equal to the bargaining power of workers in a symmetric Nash bargaining situation. Using the asset equations for workers and firms in the two sectors, imposing the flow equilibrium conditions and considering the case of no discounting, i.e., $\rho \to 0$,[17] we can write the welfare function as production minus vacancy costs,

[16] In our example, an extreme increase in the share of immigrants, from 10% to 90%, means that wages decrease by less than 1%, while the unemployment rates increase by less than 3% (less than 0.01 percentage points) for all workers.

[17] We ignore discounting in order to compare different steady states without needing to consider the adjustment process. This is common in the literature; see, for example, Engström et al (2005).

$W = e_h y_h + e_l y_l - \upsilon_h \theta_h k - \upsilon_l \theta_l k$ which is equal to

$$W = \sum_{s=h,l} \left(\left(e_s^N + e_s^I \right) y_s - \sigma \left(e_s^N + \frac{e_s^I}{1-d_s} \right) f_s k \right). \tag{24}$$

Assuming risk neutral individuals, we ignore distributional issues and hence, wages will not feature in the welfare function.

We now consider the impact on welfare resulting from an increase in d_h as compared to an increase in d_l around $d_h = d_l = 0$ and obtain:

$$\begin{aligned}
\frac{\partial W}{\partial d_h} &= \frac{de_h}{dd_h} y_h + \frac{de_l}{dd_h} y_l - \sigma \left(\frac{de_h}{dd_h} + e_h^I \right) f_h k - \frac{\sigma e_h}{2 f_h} \frac{d\theta_h}{dd_h} - \sigma \frac{de_l}{dd_h} f_l k, \\
\frac{\partial W}{\partial d_l} &= \frac{de_h}{dd_l} y_h + \frac{de_l}{dd_l} y_l - \sigma \frac{de_h}{dd_l} f_h k - \frac{\sigma e_h}{2 f_h} \frac{d\theta_h}{dd_l} - \sigma \left(\frac{de_l}{dd_l} + e_l^I \right) f_l k - \frac{\sigma e_l}{2 f_l} \frac{d\theta_l}{dd_l}.
\end{aligned}$$

Discrimination in the high-productivity sector unambiguously reduces employment in sector h, which decreases welfare in that sector, even if reduced hiring costs mitigate this effect. In the low-productivity sector, the reduction in labour market tightness tends to reduce employment of natives and immigrants.

When discrimination is present in the low-productivity sector, more divergent effects emerge. As labour market tightness in the high- productivity sector increases, there is a general increase in employment, raising welfare in sector h (once more slightly mitigated by increased hiring costs). The increased transition rate in sector h reduces the number of low-skilled workers, but the reduced transition rate in sector l tends to decrease the number of employed low-skilled natives and immigrants. Furthermore, discrimination of low-skilled immigrants causes a direct negative impact on them. Once more, reduced hiring costs have a smaller impact on welfare than the impact through employment.

Substituting for employment changes, wages and using labour market tightness equations when $\rho = 0$ and $d_h = d_l = 0$ give

$$\frac{\partial W}{\partial d_h} = -\frac{e_h^N}{n} \frac{2(1-n)\sigma}{(\sigma(\lambda+\gamma) 2 + \gamma f_h)} \left(y_h (\lambda + \gamma) - \lambda \frac{f_l}{2\sigma + f_l} y_l \right) < 0, \tag{25}$$

$$\frac{\partial W}{\partial d_l} = -\frac{e_l^N}{n} \frac{2(1-n)}{2\sigma + f_l} \sigma y_l < 0. \tag{26}$$

Even though higher discrimination in the high-productivity sector directly increases employment in the low-productivity sector, this impact is smaller than the direct reduction in employment facing high-skilled workers. Discrimination unambiguously reduces welfare. We can show the following:

Proposition 12 *The negative impact on welfare is more severe if discrimination is present in the high-productivity sector than if it is present in the low-productivity sector, given the sufficient condition* $\frac{2}{3}y_h > \frac{\lambda}{\lambda+\gamma}y_l$.

Proof. We substitute for employment and use the fact that for employment to be larger than unemployment we need $f_l > \sigma$, and the result follows. ∎

The sufficient condition for discrimination to harm welfare more when present in sector h is satisfied when productivity differences are sufficiently large and/or the probability that the worker loses skills, λ, is relatively small compared to the rate at which a worker becomes skilled by training during unemployment, γ. The parameter values used in the simulations fulfill this condition.

The intuition is the following. As productivity is higher in sector h than in sector l, any negative impact on employment will cause a larger direct reduction in welfare in the high-productivity sector than in the low-productivity sector. However, as discrimination in sector h has a positive effect on employment in the low-productivity sector, the rate at which workers turn into low-skilled workers, λ, must also be small relative to the rate at which workers regain skills through training, γ. Otherwise, the pool of low-skilled workers may become so large that discrimination harms welfare more in the low-productivity sector.

We compare the changes in welfare produced by an increase in discrimination in one sector at a time in the simulation of Section 4.2, initially having $d_h = d_l = 0$. When we increase d_h to 0.30, welfare is reduced by 0.6 percent. Increasing d_l to 0.30 hardly reduces welfare (it is only reduced by 0.07 percent). Hence, the welfare reduction is much larger when discrimination increases in the high-productivity sector. Allowing training to be endogenous, hurts welfare further in the case where discrimination prevails in the high-productivity sector, as the skills of immigrants deteriorate even more. The opposite is true for discrimination in the low-productivity sector.

7 Conclusion

We formulated a model of discrimination triggered by negative events within a search and wage-bargaining setting, where workers are subject to the risk of losing skills during an unemployment spell. We allowed low-skilled workers to regain skills both through employment and by training while unemployed. We endogenized skill-acquisition and considered a double effect of discrimination, in the sense that it affects the skills of immigrants both through skill loss and its repercussion on the decision to train. We analyzed how the economy responds to higher discrimination facing high- and low-skilled workers and more immigrants.

We show that, due to discrimination, immigrants suffer higher unemployment rates, despite receiving lower wages. Even when discrimination exists only in one sector of the economy, its negative effects will spread to all workers. Discrimination in one sector reduces the wages of all workers and increases the unemployment rate of natives in the same sector, but it actually improves the employment perspectives in the other sector when discrimination is present in the low productivity sector.

Endogenous training delivers a further impact on labour market performance. Discrimination in the high skilled sector reduces the incentives to train for low skilled workers, where the effect is stronger for immigrants than for natives. The vacancy supply in the high skilled sector falls, resulting in a further reduction in the proportion of skilled workers in the economy. The negative impact is more pronounced for immigrants than for natives.

Discrimination facing low skilled workers drives them to train more. Immigrants are affected both by the direct effect of discrimination and by the reduced vacancy supply in the low skilled sector, while natives are only affected through the latter impact. As immigrants are more influenced than natives, more low skilled immigrants train in order to counteract the negative impact from discrimination. We here obtain the result that discrimination of low skilled workers implies a higher proportion of skilled immigrants than proportion of skilled natives, even though more immigrants lose skills.

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Appendix 1a: Condition for values with endogenous training

In this appendix we derive a condition for when $rU_h > rW_l$, that is, the value of being a high skilled unemployed worker is higher than the value of being a low skilled employed worker when training is endogenous. The value equations are given by equations (1)-(4) which here are rewritten

$$
\begin{aligned}
\left(\rho + f_h^J + \lambda\right) U_{ih}^J - f_h^J W_{ih}^J - \lambda U_{il}^J &= 0, \qquad J = N, I, \\
\left(\rho + f_{il}^J\right) U_{il}^J - f_{il}^J W_{il}^J &= 0, \qquad J = N, I, \\
\left(\rho + \sigma\right) W_{ih}^J - \sigma U_{ih}^J &= w_h^J, \qquad J = N, I, \\
\left(\rho + \sigma\right) W_{il}^J - \sigma U_{il}^J &= w_l^J, \qquad J = N, I,
\end{aligned}
$$

Giving the solution,

$$
\begin{aligned}
\rho U_h &= \frac{\rho\left(\rho + \sigma + f_l^J\right) f_h^J w_h + \lambda\left(\sigma + \rho\right) f_l^J w_l}{D} \\
\rho W_l &= \frac{\left(\rho + f_l^J\right)\left(\left(\sigma + \rho\right)\lambda + \rho\left(\sigma + f_h^J + \rho\right)\right) w_l}{D}
\end{aligned}
$$

where

$$
D = \left(\sigma + \rho + f_l^J\right)\left(\left(\sigma + \rho\right)\lambda + \rho\left(\sigma + f_h^J + \rho\right)\right)
$$

Hence the value of being high skilled unemployed is higher than the value of being low skilled employed if

$$
\begin{aligned}
&\rho\left(\rho + \sigma + f_l^J\right) f_h^J w_h + \lambda\left(\sigma + \rho\right) f_l^J w_l \\
> \; &\left(\rho + f_l^J\right)\left(\left(\sigma + \rho\right)\lambda + \rho\left(\sigma + f_h^J + \rho\right)\right) w_l
\end{aligned}
$$

which is equal to

$$
\begin{aligned}
&\left(\rho + \sigma + f_l^J\right) f_h^J w_h \\
> \; &f_l^J\left(\sigma + f_h^J + \rho\right) w_l + \left(\left(\sigma + \rho\right)\lambda + \rho\left(\sigma + f_h^J + \rho\right)\right) w_l
\end{aligned}
$$

We insert wages to obtain

$$
\begin{aligned}
& f_h^J \frac{y_h \left((\rho+\lambda)(\rho+\sigma) + f_h^J \rho \right)}{\left(2(\rho+\lambda)(\rho+\sigma) + f_h^J \rho \right)} + f_h^J \frac{\lambda f_l^J \frac{y_l(\rho+\sigma)}{(\rho+\sigma)2+f_l}}{\left(2(\rho+\lambda)(\rho+\sigma) + f_h^J \rho \right)} \\
> & \\
& \frac{\left((\sigma+\rho)(\lambda+\rho) + \rho f_h^J \right) y_l}{2(\rho+\sigma)+f_l} + \frac{(\sigma+\rho) f_l^J y_l}{2(\rho+\sigma)+f_l^J}
\end{aligned}
$$

which give two sufficient conditions

1)

$$
\begin{aligned}
f_h \frac{\left(2(\rho+\sigma) + f_l^J \right)}{2(\rho+\lambda)(\rho+\sigma) + f_h^J \rho} y_h &> y_l \Longleftrightarrow \\
f_h \rho (y_h - y_l) + f_h \rho y_h + f_h (2\sigma + f_l) y_h &> y_l 2 (\rho+\lambda)(\rho+\sigma)
\end{aligned}
$$

In case unemployment for the high productivity workers are below 10 percent we have: $\sigma / \left(\sigma + f_h^J \right) < \frac{1}{10} \Longleftrightarrow 9\sigma < f_h^J$ and noting that $\frac{(\rho+\sigma)}{(2\sigma+f_l)} < 1$ for unemployment smaller than employment, we obtain the sufficient condition $\frac{y_h}{y_l} > \frac{(\rho+\lambda)}{4.5\sigma}$.

2) The second sufficient condition is

$$
\begin{aligned}
\frac{f_h^J \lambda}{\left(2(\rho+\lambda)(\rho+\sigma) + f_h^J \rho \right)} &> 1 \Longleftrightarrow \\
4.5\sigma &> \frac{2(\rho+\lambda)(\rho+\sigma)}{(\lambda-\rho)},
\end{aligned}
$$

were we also have used that $9\sigma < f_h^J$.

Appendix 1b: Condition for values with exogenous training

Now, we derive a condition for that value of being a high skilled unemployed worker is higher than the value of being a low skilled employed worker when training is exogenous. The value equations are given by equations (1),(18), and (19), which here are rewritten as

$$
\begin{aligned}
\left(\rho + f_h^J + \lambda \right) U_{ih}^J - f_h^J W_{ih}^J - \lambda U_{il}^J &= 0, \qquad J = N, I, \\
\left(\rho + f_{il}^J + \gamma_i^J \right) U_{il}^J - f_{il}^J W_{il}^J - \gamma_i^J U_{ih}^J &= 0, \qquad J = N, I, \\
(\rho+\sigma) W_{ih}^J - \sigma U_{ih}^J &= w_h^J, \qquad J = N, I, \\
(\rho+\sigma) W_{il}^J - \sigma a U_{ih}^J - \sigma (1-a) U_{il}^J &= w_l^J, \qquad J = N, I,
\end{aligned}
$$

Giving the solution, using $\gamma = \sigma a$

$$\rho U_h = \frac{\left(\left(\rho+\gamma+f_l^J\right)\rho+(\rho+\gamma)\sigma+\gamma f_l\right) f_h^J w_h+(\rho+\sigma)\lambda f_l w_l}{D}$$
$$\rho W_l = \frac{\left(\sigma+\rho+f_l^J\right)\gamma f_h w_h+\left(\left(\rho+f_l^J\right)\left((\rho+\lambda)(\sigma+\rho)+f_h^J\rho\right)+\gamma\rho\left(\sigma+\rho+f_h^J\right)\right) w_l}{D}$$

where

$$D = \left[\left(\rho+f_l^J\right)\left((\sigma+\rho)(\lambda+\rho+\gamma)+(\rho+\gamma)f_h^J\right)+\sigma\left((\rho+\gamma)\left(\rho+f_h^J+\sigma\right)+\lambda(\rho+\sigma)\right)\right]$$

Hence, the value of being high skilled unemployed is higher than the value of being low skilled employed if $rU_h > rW_l$ which is equal to

$$\left(\rho+\sigma+f_l^J\right) f_h^J w_h > \left(\left(\rho+\gamma+f_l^J+\lambda\right)(\sigma+\rho)+\left(\rho+\gamma+f_l^J\right)f_h^J\right) w_l$$

We insert wages to obtain

$$\begin{aligned} & \left[\left(2(\rho+\sigma)+f_l^J\right) f_h^J (y_h-y_l)-(\rho+\sigma)(2(\rho+\lambda+\gamma))y_l-(\rho+\sigma)f_l^J y_l\right] \\ & +(\rho+\sigma)\left(f_h^J-f_l^J\right)y_l+f_h^J\sigma(1-a)y_l \\ > & \; 0 \end{aligned}$$

From that equation we obtain the sufficient condition:

$$\frac{\left(2(\rho+\sigma)+f_l^J\right)}{\left(2(\rho+\gamma+\lambda)+f_l^J\right)} f_h^J (y_h-y_l) > (\rho+\sigma)y_l$$

In case unemployment for the high productivity workers are below 10 percent we have $\sigma/\left(\sigma+f_h^J\right) < \frac{1}{10} \iff 9\sigma < f_h^J$ and for low productivity workers to have unemployment below 40 percent gives $\sigma/\left(\sigma+f_l^J\right) < 0.4 \iff \sigma 1.5 < f_l^J$. Hence, the sufficient conditions can be reduced to: $a)$ $\rho+(2-a)\sigma+0.5\cdot 1.5\cdot\sigma \geq \lambda$ and $b)$ $0.5 f_h^J (y_h-y_l) \geq (\rho+\sigma)y_l$ using that for the unemployment rate below 10 percent we have $f_h^J > 9\sigma$ we have

$$y_h \geq \frac{(\rho+5\sigma)}{4.5\sigma} y_l.$$

Appendix 2: Endogenous Training: Proportion of natives

In equilibrium, inflows are equal to outflows, The equilibrium flows characterizing the labour market for workers determining unemployment, employment and training workers, ν_h^N, ν_h^I, ν_l^N, ν_l^I e_l^N ,e_h^N and e_t^J and are given by:

$$\begin{aligned}
\left(\lambda + f_h^J\right)\nu_h^J &= \sigma e_h^J + \gamma' e_t^J,\ \ \left(f_l^J + \left(1-\hat{t}^J\right)\right)\nu_l^J = \lambda\nu_h^J + \sigma e_l^J,\quad J = N, I \\
\nu_l^J\left(1-\hat{t}^J\right) &= \gamma e_t^J,\ \sigma e_h^J = f_h^J \nu_h^J,\ J = N, I \\
\sigma e_l^J &= f_l^J \nu_l^J, J = N, I \\
e_l^N + e_h^N + \nu_h^N + \nu_l^N + e_t^N &= n,\ e_l^I + e_h^I + \nu_h^I + \nu_l^I + e_t^I = 1 - n,
\end{aligned}$$

which gives

$$\begin{aligned}
\nu_h^N &= \frac{\hat{c}^J \sigma\gamma n}{\left(\hat{c}^J\left(\gamma' f_h^J + \sigma\left(\lambda+\gamma'\right)\right) + \lambda\gamma'\left(\sigma + f_l^J\right)\right)},\quad J = N, I, \\
\nu_l^N &= \frac{\sigma\lambda\gamma n}{\left(\hat{c}^J\left(\gamma' f_h^J + \sigma\left(\lambda+\gamma'\right)\right) + \lambda\gamma'\left(\sigma + f_l^J\right)\right)},\quad J = N, I,
\end{aligned}$$

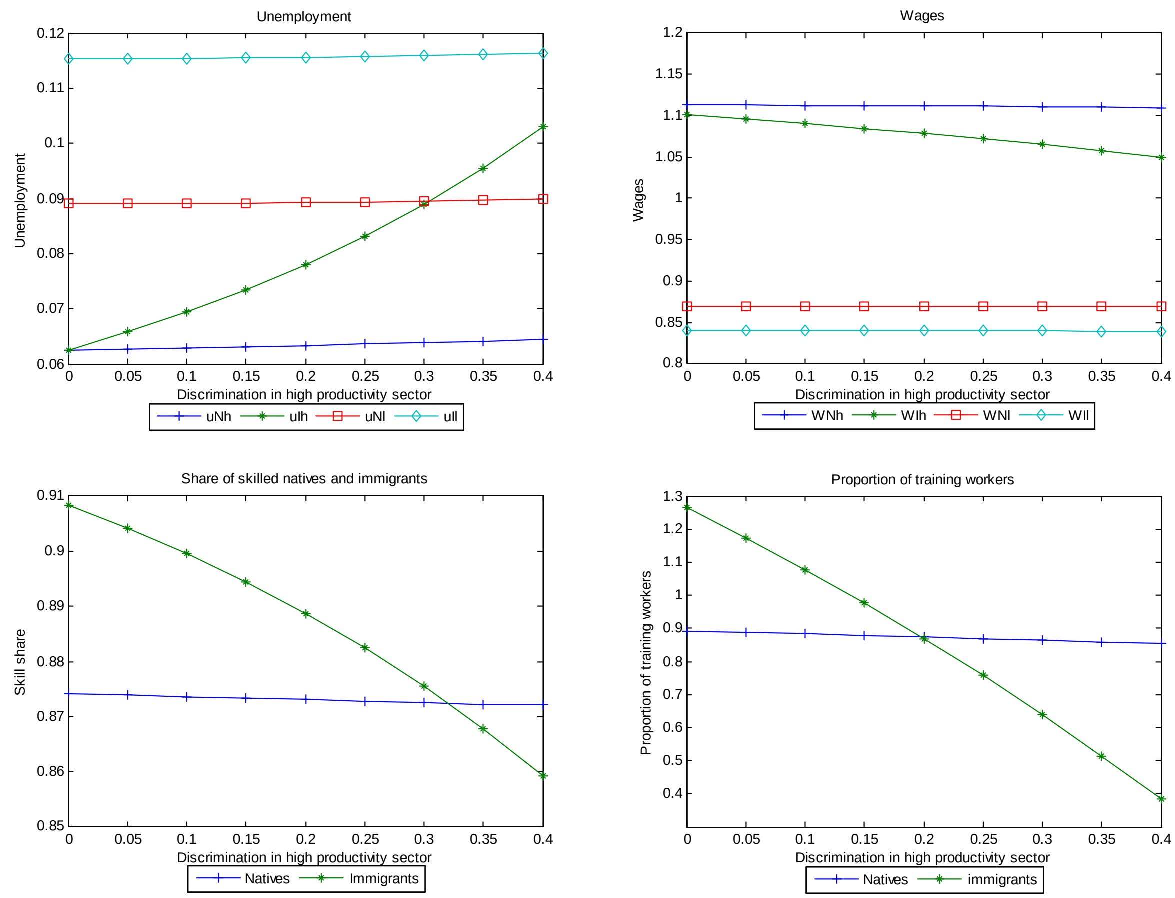
which gives the unemployment rates in equation (13) and the proportion of natives among unemployed high skilled and low skilled are, respectively:

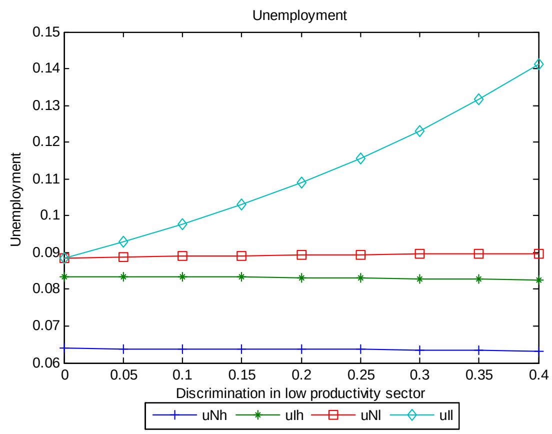
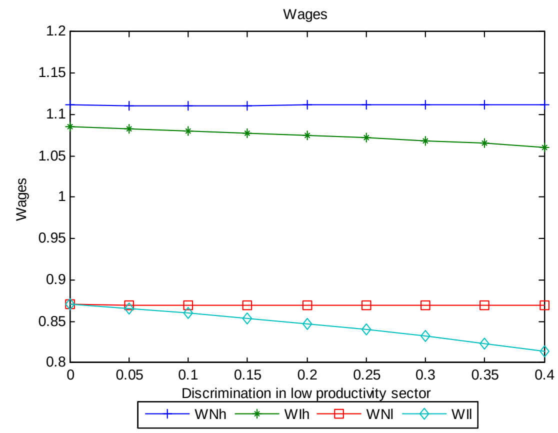
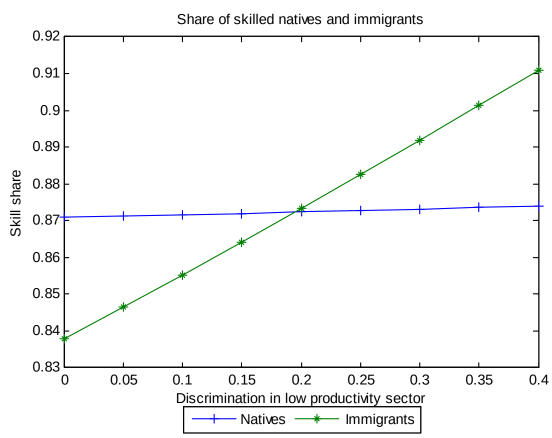
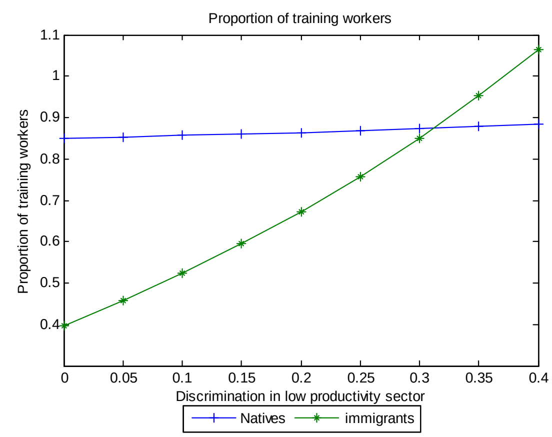
$$\begin{aligned}
\phi_h &= \frac{1}{1 + \frac{1-n}{n}\frac{\hat{c}^I}{\hat{c}^N}\kappa} \\
\phi_l &= \frac{1}{1 + \frac{1-n}{n}\kappa} \\
&\quad \textit{hence} \\
\phi_h &> \phi_l \text{ if } \frac{1-n}{n}\frac{\hat{c}^I}{\hat{c}^N} < 1
\end{aligned}$$

where $\kappa = \frac{\left(\hat{c}^N\left(\gamma' f_h + \sigma(\lambda+\gamma)\right) + \lambda\gamma'(\sigma + f_l)\right)}{\left(\hat{c}^I(\gamma' f_h(1-d_h) + \sigma(\lambda+\gamma)) + \lambda\gamma'(\sigma + f_l(1-d_l))\right)}$.

Appendix 3: Endogenous training

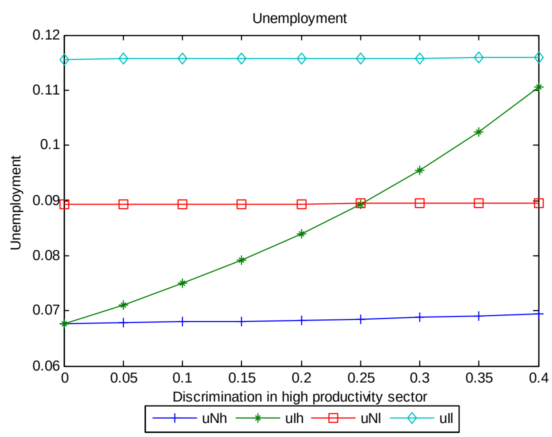
Effect of an ↑ in d_h and d_l in an economy with endogenous training. The parameters assumed are: $\gamma = 0.7, y_h = 1.30$, $y_l = 1.00$, $k = 0.70$, $\sigma = 0.10$, $\rho = 0.08$, $n = 0.85$, $\lambda = 0.27$ and $d_s = 0.25$ when constant.

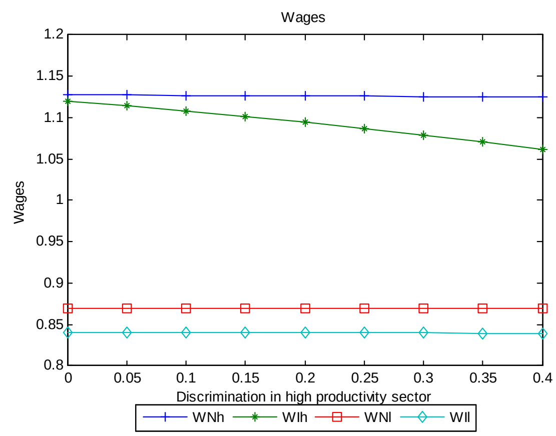


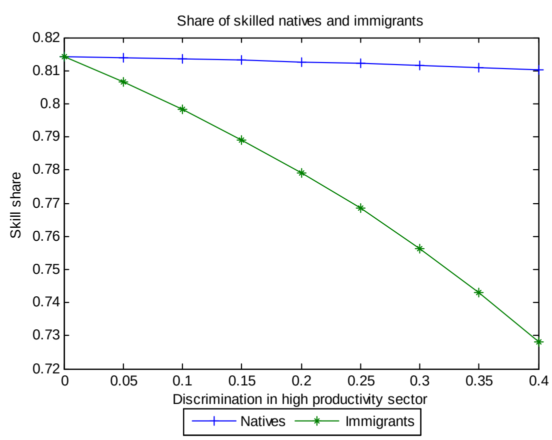

Unemployment
Unemployment
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
Discrimination in low productivity sector
uNh
uIh
uNl
uIl

Wages
Wages
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
Discrimination in low productivity sector
WNh
WIh
WNl
WIl

Share of skilled natives and immigrants
Skill share
0.92
0.91
0.9
0.89
0.88
0.87
0.86
0.85
0.84
0.83
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
Discrimination in low productivity sector
Natives
Immigrants

Proportion of training workers
Proportion of training workers
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
Discrimination in low productivity sector
Natives
immigrants

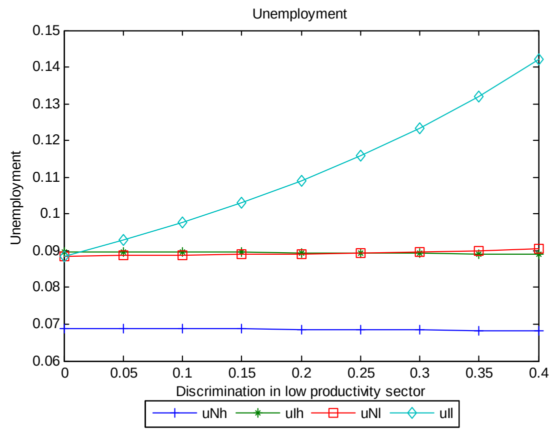
Appendix 4: Exogenous training

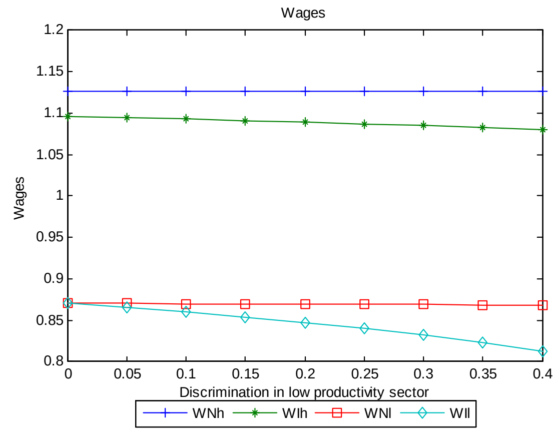
The effect of an increase in d_h (left) and d_l (right) are shown in an economy with exogenous training. The parameters assumed are: $y_h = 1.30$, $y_l = 1.00$, $k = 0.70$, $\sigma = 0.10$, $\rho = 0.08$, $n = 0.85$, $\lambda = 0.27$, $\gamma = 0.08$, $a = 0.80$.and $d_s = 0.25$ in the sector where it is constant.

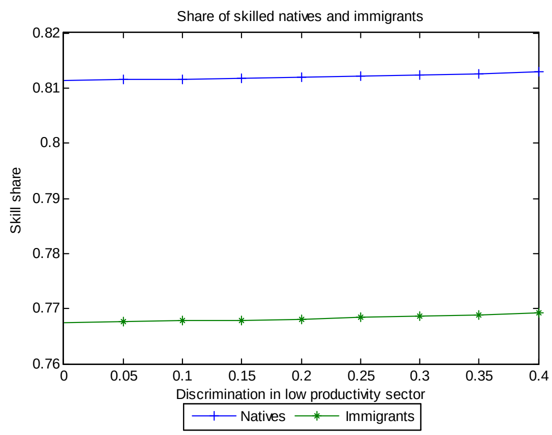







Unemployment
Unemployment
Discrimination in low productivity sector
uNh
uIh
uNl
uIl


Wages
Wages
Discrimination in low productivity sector
WNh
WIh
WNl
WIl


Share of skilled natives and immigrants
Skill share
Discrimination in low productivity sector
Natives
Immigrants