Identification, screening and stereotyping in labor market discrimination

Identification, screening and stereotyping in labor market discrimination

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Abstract:

Social-psychological research reveals two opposite ways in which a person can respond to increased feelings of uncertainty in decision-making. First, he (or she) may try to reduce his uncertainty by searching for more specific information. This leads to less stereotyping and discrimination. Second, he may identify more strongly with a salient social group he belongs to (his ingroup, e.g. men). This induces him to rely more on stereotypic perceptions and prejudices, and hence to discriminate more against an outgroup (e.g. women). This paper develops a microeconomic model that integrates both responses in the context of hiring and pay decisions by an employer. The model determines simultaneous equilibrium levels of expenditures on screening of job applicants and ingroup identification. Increasing competition in the product market makes the employer feel more uncertain about his profits, but also raises the opportunity cost of screening expenditures. The latter rise elicits substitution of ingroup identification for screening expenditures, and hence enhances discrimination. Affirmative action has the opposite effect by raising the marginal benefits of screening expenditures. Some experimental and empirical evidence is briefly discussed.

Theme: Discrimination, Personnel economics

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I. Introduction

In the last fifty years a rich literature on discrimination has developed in social psychology (see Fiske, 1998; Zanna, 1994; Hewstone, 2002, for overviews). Some basic concepts in this literature, like prejudice and stereotyping, have been adopted in economics as well (see, e.g., Becker, [1957], 1971; Antonji and Blank, 1999). However, a sizable reservoir of potentially interesting findings for economics have remained untapped so far. One particular combination of such findings is the following. When a person feels uncertain about things that are important for him (or her), such as being able to make a living, he is, under certain circumstances, inclined to identify himself more strongly with a salient social group he belongs to (his ingroup, e.g. men, natives; see, e.g., Mullin & Hogg, 1998). In its turn, this induces him to rely more on stereotypic perceptions and prejudices, which can lead to more discrimination against members of an outgroup (e.g. women, foreigners).

A striking development in the Western world in which this psychological mechanism may have played an important role is that the upsurge of fear of terrorism after September 11, 2001, seems to have led to more stereotyping and probably more discrimination against Muslims in the labor market ("we against them").[1] As quite a different example, agents may feel uncertain when they have to survive in an environment of fierce market competition. This seems especially relevant for people in former communist countries in their transition towards a market economy. The psychological prediction of increasing stereotyping and discrimination then is consistent with indications that, e.g. in Russia, the old stereotype that men should have a job and women should stay at home has revived, while at the same time labor market discrimination against women has increased (Hunt, 1997). Such a phenomenon may in particular play a role in relation to competition in the labor market: In regions within European countries where unemployment is higher, stereotypic perceptions about the roles of men and women tend to be stronger, leading to a larger gender gap in unemployment (Azmat et al., 2003). Boone et al. (2003) describe a comparable process in the newspaper-publisher industry, where powerful top-management teams become more homogeneous with respect to demographic characteristics when competition in the product market strengthens – by hiring demographically similar and firing dissimilar team members.

[1] For example, in the Netherlands the unemployment among Moroccans rose from 10.1% in 2001 to 22.3 in 2004, i.e. much more strongly than the unemployment among immigrants in general (from 6.5% in 2001 to 11.9 in 2004; www.cbs.statline.nl). This may be partially due to dislike of Muslims. See also the Human Rights Watch World Report 2002 on hate crime against Muslims in the US.

However, social-psychological research also suggests quite a different kind of response to increased feelings of uncertainty. Tiedens and Linton (2001) conducted an experimental-psychological study on individual decision-making focusing on the effects of uncertainty-related emotions on information processing and stereotyping. They find that stronger uncertainty-related emotions lead to a more thorough look at the individual information at hand and less reliance on stereotypes. This is the rational type of response that an economist could expect.

Thus, two opposite responses to increased feelings of uncertainty seem possible. This raises the question under which conditions one or the other response will occur or dominate. To answer this question, this paper builds a microeconomic model that explains both the psychological identification mechanism and the ‘economic’ response, and integrates them. It is formulated in terms of a simultaneous utility maximization with respect to ingroup identification on the one hand and a conventional economic variable on the other hand. The model addresses the way in which a risk-averse employer forms his expectation of the relative productivities of a number of equally qualified candidates for a position. He may base this expectation on individual information from job interviews, hiring tests, etc., but he may also use stereotypic information on the average productivities of groups candidates belong to (men/women, white/black, etc.). We then consider situations in which the employer starts to feel more uncertain about the level of his profits. This is assumed to make the employer more (absolutely) risk averse with respect to the uncertainty in his productivity estimates, which raises his utility loss due to this uncertainty. This evokes two kinds of response to reduce this utility loss.

First, the employer may spend more money, time and cognitive energy on collecting individual information on candidates (cf. Tiedens and Linton). This rise in screening expenditure (cf. Altonji and Blank, 1999, p. 3190) raises the perceived reliability of the individual information, and hence induces the employer to give a higher weight to this individual information in his productivity estimates (cf. Phelps, 1972; Aigner and Cain, 1977). As a result, the uncertainty in the productivity estimates, and hence the ensuing utility loss drops, and less use is made of stereotypic information. However, screening is costly, and this may induce the employer to respond to his increased feelings of uncertainty by identifying himself more strongly with his ingroup. This creates an “illusion of certainty” with respect to perceptions of group characteristics, which makes the employer perceive his stereotypic information on the average productivities of the ingroup and the outgroup as more reliable. As a result, the perceived uncertainty in the productivity estimates, and hence the ensuing utility loss again drops, but now *more* use is made of stereotypic information.

Thus, screening expenditure and ingroup identification are substitute means to reduce the perceived uncertainty in the productivity estimates of applicants, and hence the ensuing utility loss. The degrees to which screening expenditure or ingroup identification are used by the employer to reduce the uncertainty determines whether the use of stereotypic information in the productivity estimates will fall or rise. To investigate under which conditions one or the other will happen, we derive expressions for simultaneous equilibrium levels of screening expenditure and ingroup identification dependent on certain variables. Since social identification is more salient in group situations, we assume that the employer is the residual claimant in a production team (as in the classic entrepreneurial firm of Alchian and Demsetz, 1972) most members of which belong to the ingroup of the employer. In such a context the employer will easily identify with his ingroup, and hence use this identification to reduce uncertainty. This marginal benefit of ingroup identification is assumed to be balanced by a marginal cost from less personal identity ("depersonalization"; e.g. Turner, 1984). The implied endogenization of ingroup identification represents a novelty of the model.[2]

A surprising implication of our model is that when the employer becomes more uncertain about his profits, and hence more risk averse, screening expenditure unambiguously rises, but ingroup identification may rise or fall depending on whether the marginal efficiency of screening expenditure in raising the reliability of the individual information is diminishing or increasing. In particular, this effect occurs when increasing competition on the supply side of the product market lowers profits, and hence raises the risk of bankruptcy. However, lower profits also imply a tighter budget for expenditures, and hence raise the opportunity cost of screening expenditures. This elicits substitution of ingroup identification for these expenditures as a means to reduce uncertainty. For a common power specification of the employer's utility function of profit, the resulting rise in identification is shown to dominate the counteracting 'economic' effects in leading to a higher use of the stereotypic perception for 'most' profit levels. Moreover, in the case where there is group discrimination, the discrimination coefficient of the employer rises as competition strengthens at sufficiently low profit levels. Competition in the product market then raises group discrimination even when there are no differences in real productivity distribution and in reliability of individual information between the ingroup and the outgroup, so even when discrimination is not rational from a profit-maximizing point of view. The counteracting 'economic' effects work in the same direction as the long-run selection mechanism in Becker's ([1957], 1971) theory

[2] Akerlof and Kranton (2000) give an interesting general analysis of the impact of social identity on economic outcomes. However, they treat identity as an exogenous variable.

of employer discrimination, according to which employers with a zero discrimination coefficient drive employers with a non-zero discrimination coefficient out of the competitive product market. However, the psychological effect of competition may work in such a way that under competitive pressure even employers with zero discrimination coefficient develop a non-zero one over time. This would then imply that not all teams with non-zero discrimination coefficient would be driven out of the market.

Other economic models (e.g., of employee and customer discrimination, search costs, statistical discrimination, imperfect competition, self-fulfilling prophecies, gender differences in efficiency-wage effects, wage bargaining; see, e.g., Altonji and Blank, 1999; Coate and Loury, 1993; Haagsma, 1993; Rosén, 2003) are able to explain that discrimination can be persistent under strengthening competition in the product market, but only few of them predict that discrimination which is not based on differences in real productivity distribution or reliability of individual information between groups may even *increase* under competitive pressure.[3] More importantly, (almost) all economic models seem to assume that the extents to which employers rely on stereotypic perceptions and prejudice do not change when competition in the product market increases. Both social-psychological research and the empirical evidence mentioned above suggest that reliance on stereotypes and prejudices may become stronger when competition intensifies, leading to an increase in discrimination (cf. Shleifer, 2004). Therefore, this paper endogenizes reliance on stereotypes and prejudices in a microeconomic model integrating social-psychological findings. Also, at the end of the paper we review some experimental and empirical evidence[4] and consider the impact of affirmative action.

The organization of the paper is as follows. Section II develops the model, which simultaneously determines the screening expenditure on a job applicant and identification with the ingroup. Section III analyses the implied effects of competition on discrimination. Section IV reports some evidence, and Section V makes concluding remarks.

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[3] When there is a difference in variance of the productivity distribution or reliability of individual information between the ingroup and the outgroup, rising risk aversion as a result of increasing competitive pressure will raise discrimination against the outgroup (see Aigner and Cain, 1977; Hendricks et al., 2003; see also Cornell and Welch, 1996). However, this is not the kind of mechanism that we model in this paper.

[4] We then also shortly explain how increasing labor supply competition can raise discrimination. The focus of this paper is on the effects of product supply competition since for this kind of competition it is much less obvious that it may raise discrimination than for labor supply competition..

II. The model

A. Basic assumptions and relations

Consider a representative firm that produces one homogeneous good and sells it in a competitive market. The number of competitors in this market is large so that the firm is a price taker, but profits are still positive due to entry barriers. The internal structure of the firm is that of a production team one member of which takes decisions on, among other things, hiring and pay of new team members (Alchian and Demsetz, 1972). This employer receives the firm's residual income, i.e. the profit, while the other team members earn fixed wages. Most team members belong to a certain ingroup of equally qualified individuals of the employer (e.g. men, natives), but new team members can be hired from the ingroup as well as the equally qualified outgroup (e.g. women, foreigners). Within these groups marginal team productivities q_i, i.e. marginal contributions of new team members i to the prevailing team production, vary, but between the groups no real differences in the distribution of q_i exist except for a possible difference in average $\overline{q}$.

The employer has imperfect information about the q_i's in the ingroup and the outgroup (but perfect information about other variables). Therefore, he has to form subjective expectations $\hat{q}_i$ of the q_i of individual candidate team members from the ingroup and the outgroup. On the one hand, to save on search for information on individual productivities, he bases this expectation on stereotypic perceptions $\overline{q}^S$ of the average marginal team productivities $\overline{q}$ of the two groups. The perception $\overline{q}^{SO}$ of the outgroup differs from the perception $\overline{q}^{SI}$ of the ingroup. To fix ideas, we assume $\overline{q}^{SO} < \overline{q}^{SI}$, but the model also allows for the possibility that $\overline{q}^{SO} > \overline{q}^{SI}$ (see Sec. III.C). These perceptions may be correct or not (see Sec. D for more on this). On the other hand, to reduce the uncertainty in his estimates of individual productivities, the employer also spends some money, time and cognitive energy on collecting information on individual candidates, e.g. by means of hiring tests. Assume that, in the perception of the employer, this individual information yields unbiased, but imperfectly reliable estimates q_i^T of individual q_i's. More specifically, $q_i^T = q_i + u_i$, where u_i is a normally distributed error term, independent of q_i, with zero mean and constant variance $V(u)$. Furthermore, for ingroup as well as outgroup members q_i has a prior subjective probability distribution, which is normal as well, with mean equal to the stereotypic perception $\overline{q}^S$ (different for ingroup and outgroup members) and constant variance $V(q)$ (equal for ingroup and outgroup members). The posterior (subjective) expected value of q_i, given the individual test estimate q_i^T , then is:

$$\hat{q}_i \equiv E(q_i \mid q_i^T) = S\overline{q}^S + (1-S)q_i^T , \tag{1}$$

where

$$S = \frac{V(u)}{V(q)+V(u)} \tag{2}$$

(Phelps, 1972; Aigner and Cain, 1977).[5] The coefficient $S \in [0,1]$ represents the extent to which the team members use their stereotypic perception $\overline{q}^S$ in the formation of $\hat{q}_i$. Since $V(u)$ and $V(q)$ are assumed to be the same for the ingroup and the outgroup, S is the same for ingroup and outgroup members.

The feature of the individual $\hat{q}_i$'s being partially based on perceived group averages implies *individual* statistical discrimination in hiring and pay. Assuming that the individual test estimates q_i^T are unbiased not only in the perception of the employer, but also in reality (see Sec. III.C about a relaxation of this assumption), taking objective expectations conditional on q_i in eq. (1) yields

$$E^o(\hat{q}_i \mid q_i) = S\overline{q}^S + (1-S)q_i = S(\overline{q}^S - q_i) + q_i\,. \tag{3}$$

Interpreting deviation $E^o(\hat{q}_i \mid q_i) - q_i$ as a measure of positive/negative individual (i.e. within-group) discrimination, eq. (3) implies that this measure equals $S(\overline{q}^S - q_i)$. Thus, in absolute value it is linearly increasing in the extent of stereotyping S.

Eq. (3) also implies that outgroup members with the same q_i as ingroup members will on average have a lower estimated $\hat{q}_i$ since $\overline{q}^{SO} < \overline{q}^{SI}$ (Aigner and Cain). Nevertheless, if these stereotypic perceptions are correct, i.e. if $\overline{q}^{SI} = \overline{q}^I$ and $\overline{q}^{SO} = \overline{q}^O$, there is no (between-)group discrimination since on average for the ingroup as well as the outgroup the individual discrimination measure equals $S(\overline{q}^S - \overline{q}) = 0$. On the other hand, if at least one of the stereotypic perceptions is incorrect, e.g. if $\overline{q}^{SO} < \overline{q}^O$ and $\overline{q}^{SI} = \overline{q}^I$, we have $S(\overline{q}^{SO} - \overline{q}^O) < 0$, while $S(\overline{q}^{SI} - \overline{q}^I) = 0$, indicating negative group discrimination against the outgroup. This group discrimination is then linearly increasing in S as well. Such cases will be made plausible and elaborated in Sec. D.

Product price p times the marginal productivity estimates $\hat{q}_i$ determine the labor demands for ingroup and outgroup members in a complex way. To keep the model sufficiently simple and since we want to link it to Becker's (1957) model of employer discrimination in Secs. II.D and III, we make the following simplifying assumptions with respect to the labor markets for ingroup and outgroup members. All firms that compete in the product market have the same two job levels with two different wages, which are given to and identical across the firms. Ingroup members are employed on the higher job level and outgroup members on the lower one. The labor markets for the two job levels are competitive

[5] Note that S corresponds to the coefficient $1-\gamma$ of average productivity α in eq. (2) of Aigner and Cain (1977).

and in market-clearing equilibrium.[6] When the employer wants to hire a new employee, he hires the candidate with the highest $p\hat{q}_i - w^g$, $g = I, O$, where w^g denotes the market wage prevailing for ingroup, respectively outgroup members.[7]

For further use we define the perceived reliability R^T of the individual information q_i^T as $1/V(u)$ and the perceived reliability R^S of the stereotypic information $\overline{q}^S$ as an indicator of q_i as $1/V(q)$. The latter R^S has in fact two components: (i) the reliability of $\overline{q}^S$ as an indicator of the average productivity of ingroup/outgroup members $\overline{q}$ and (ii) the reliability of $\overline{q}$ as an indicator of individual productivity q_i. This corresponds with a decomposition of the prior subjective probability distribution of q_i around $\overline{q}^S$ into a first-order distribution of q_i around the stochastic $\overline{q}$ and a second-order distribution of $\overline{q}$ around $\overline{q}^S$ (Camerer and Weber, 1992). Assuming that these two distributions are mutually independent, it follows then easily by substitution of $\overline{q} = \overline{q}^S + w$ into $q_i = \overline{q} + v_i$ that the total variance $V(q)$ equals the first-order variance $V(v)$ (assumed independent of *i*) plus the second-order variance $V(w)$. Variance $V(v)$ can be said to represent first-order risk, while $V(w)$ indicates second-order risk or ambiguity.

Rewriting eq. (2) in terms of the perceived reliabilities R^S and R^T yields the intuitively appealing expression

$$S = \frac{R^S}{R^S + R^T}, \tag{4}$$

i.e., the extent to which the team members use their stereotypic perceptions in the formation of their productivity expectations equals the perceived reliability of this stereotypic information relative to the sum of the reliabilities of the two types of information. The following sections will show how R^T and R^S, and hence *S*, can change as a result of changes in financial-economic and psychological choice variables.

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[6] The two equilibrium wages are determined by equality of downward-sloping labor demands and upward-sloping labor supplies for ingroup and outgroup members. The labor demands are based in a complex way on the distributions of *p* times $\hat{q}_i$ for ingroup and outgroup members. We do not elaborate this here since it is not central to the present paper.

[7] Thus, because of its unreliability, the individual test information on job applicants is only used for selection in hiring, but not as a basis for individual variation in wages. Furthermore, there is no difference in risk premium for ingroup vs. outgroup members since we assume equal perceived variances of $\hat{q}_i$ for ingroup and outgroup members.

B. Screening expenditure

The perceived reliability of individual information R^T is determined by the amounts of money, time and cognitive energy that are spent on collecting information on the q_i of an individual candidate (e.g., by means of a hiring test). We can express all these expenditures in terms of one monetary measure by noting that time and cognitive energy have monetary opportunity costs given by the revenues from spending time and cognitive energy on the most profitable alternative activities. The expenditures of time and cognitive energy can then be measured by these monetary opportunity costs and added to the expenditures of money. The resulting total expenditures for candidate i are referred to as screening expenditure X (assumed to be the same for each candidate; cf. Altonji and Blank, 1999, p. 3190). This X represents an endogenous choice variable of the employer. By raising X the employer can make the individual information more reliable, i.e. lower $V(u)$, and hence raise R^T. In its turn, this lowers the use of stereotypic information S by virtue of eq. (4).

How is X determined by the employer? It is chosen at the level at which the expected marginal benefit B_X of X for the employer is equal to its expected marginal cost C_X. These B_X and C_X are implied by a general one-period utility function of the employer

$$U(X,I) = E^a[E^p(U^\Pi(\Pi))](X,I) + U^I(I) . \tag{5}$$

Here I is identification of the employer with his ingroup. The first term on the right-hand side denotes the ex ante (i.e. before screening) expected value of the ex post (i.e after screening) expected utility of profit Π in the extended team, i.e. including a new team member. Profit Π is stochastic due to the uncertainty in the q_i of a new team member[8], and in addition its ex post expected value is stochastic ex ante since the individual test estimate q_i^T has yet to be made. Subutility function U^Π has positive and diminishing marginal utility, implying risk aversion (in line with Aigner and Cain, 1977; Hendricks et al., 2003). This assumption may be justified by presuming that capital markets work imperfectly and/or that the employer does not like the firm to go bankrupt since he is committed to the firm or fears loss of reputation in the market of employers from bankruptcy.[9] The second term $U^I(I)$ indicates the utility of general benefits and costs of I (see next section).[10]

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[8] The productivity of the existing team is assumed to be perfectly predictable because of the knowledge of production levels of the existing team in the past (neglecting fluctuations).

[9] Alternatively, risk aversion may be due to a negative dependence of profits on unpredictable variation in the q_i of team members (cf. Aigner and Cain, 1977, p. 181).

[10] This utility should not be confused with the disutility due to prejudice in Becker's (1957) theory of employer discrimination. See Sec. D for that.

Profit Π in the extended team depends negatively on screening expenditure X as this is part of the total costs of the team. The 'new' profit Π is related to X and the (perfectly predicted) profit of the existing team Π_0 as $\Pi = \Pi_0 + pq_n - w^I + \Delta w \delta_O - mX - k$, where q_n is the q_i of the new hire, $\Delta w \equiv w^I - w^O$, δ_O is a dummy equal to 1 when an outgroup member is hired and 0 otherwise, m is the number of candidates who are screened, and k is marginal capital and other costs. We assume that m is exogenously determined by a limited supply of equally best-qualified candidates. Besides its cost, X also has the benefit of lowering $V(u)$ (see above), and hence of reducing the posterior variance $V(q \mid q^T) \equiv Var(q_i \mid q_i^T)$ (assumed to be independent of i).[11] To make this variance visible, we make a second-order Taylor expansion of $U^\Pi(\Pi)$ around the ex post (i.e. posterior) expected value $\hat{\Pi}$ of Π (as usual in risk analysis; see, e.g., Nicholson, 1998, p. 223).[12] This implies

$$E^p[U^\Pi(\Pi)] \cong U^\Pi(\hat{\Pi}) + \tfrac{1}{2} U^{\Pi}{''}(\hat{\Pi}) p^2 V(q \mid q^T)\,. \tag{6}$$

Considering the ante expected value of this expression, we can approximate $E^a[U^\Pi(\hat{\Pi})]$ by $U^\Pi(\hat{\Pi}^S)]$ and $E^a[U^{\Pi}{''}(\hat{\Pi})]$ by $U^{\Pi}{''}(\hat{\Pi}^S)]$, where $\hat{\Pi}^S \equiv E^a(\hat{\Pi})$, which is obtained by replacing $\hat{q}_n$ by its prior expectation $\overline{q}^S$ in the expression for $\hat{\Pi}$ as implied by the equation for Π above eq. (6).[13] The prior $\overline{q}^S$, and hence $\hat{\Pi}^S$, is different for a new team member from the ingroup versus the outgroup, but the employer also has an ex ante expectation whether he will hire a candidate from the ingroup or the outgroup, dependent on whether $p\overline{q}^{SI} - w^I$ or $p\overline{q}^{SO} - w^O$ is higher. It then follows that

$$E^a[E^p(U^\Pi(\Pi))] \cong U^\Pi(\hat{\Pi}^S) + \tfrac{1}{2} U^{\Pi}{''}(\hat{\Pi}^S) p^2 V(q \mid q^T)\,. \tag{7}$$

Further, making the plausible assumption that total screening expenditures mX are low relative to $\hat{\Pi}^S$, we can approximate $U^\Pi(\hat{\Pi}^S)$ by its first-order Taylor expansion with

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[11] Of course, also some expenditure has to be made to select the set of (more or less) equally best-qualified candidates. This, however, is not included in X.

[12] This is not equivalent to assuming a quadratic specification of $U^\Pi(\Pi)$ since this Taylor expansion is only used as a local approximation of $U^\Pi(\Pi)$ for Π near $\hat{\Pi}$, and hence is still consistent with a general utility function $U^\Pi(\hat{\Pi})$. Mutatis mutandis, this holds for the following approximations in this section as well.

[13] These approximations imply that we neglect terms in $V(\hat{q})$. This variance indicates the ex ante uncertainty in the posterior estimates $\hat{q}_i$ since the test estimates q_i^T have yet to be made. Using eqs. (1) and (2) and $q_i^T = q_i + u_i = \overline{q}^S + w + v_i + u_i$ ex ante, $V(\hat{q})$ can easily be shown to equal $V(q)$. In the present context of utility maximizing with respect to X, the second-order Taylor-expansion term in $V(\hat{q})$ of $E^a[U^\Pi(\hat{\Pi})]$ can be omitted since it does not depend on X (see the next section for the case of I).

respect to mX around $\hat{\Pi}_0^S \equiv (\hat{\Pi}^S \mid mX = 0)$, and approximate $U^{\Pi}''(\hat{\Pi}^S)$ by $U^{\Pi}''(\hat{\Pi}_0^S)$, yielding

$$E^a\left[E^p(U^{\Pi}(\Pi))\right] \cong U^{\Pi}(\hat{\Pi}_0^S) - U^{\Pi}'(\hat{\Pi}_0^S)mX + \tfrac{1}{2}U^{\Pi}''(\hat{\Pi}_0^S)p^2V(q \mid q^T). \qquad (8)$$

Since subutility $U^I(I)$ in eq. (5) does not depend on *X*, eq. (8) gives an expression for maximand $U(X)$. The second term of this expression represents the expected opportunity cost of the total screening expenditures mX for the employer in terms of utility. The last term indicates the ex ante expected utility loss $E^a(\Delta U)$ due to the perceived risk of making mistakes in the individual productivity estimates $\hat{q}_i$. As indicator of this perceived risk serves the posterior conditional variance $V(q \mid q^T)$, which is related to the prior unconditional variance $V(q)$ as $V(q \mid q^T) = SV(q)$ (Aigner and Cain, 1977, p. 180). Substituting eq. (4) and $V(q) \equiv 1/R^S$ into this relation, it follows that

$$V(q \mid q^T) = (R^S + R^T)^{-1}. \qquad (9)$$

Substituting this expression into the formula for the expected utility loss $E^a(\Delta U)$ in eq. (8), differentiating utility function (8) to *X*, and rearranging terms yields the first-order condition for an interior utility-maximizing level of screening expenditure *X**

$$\tfrac{1}{2}\,|U^{\Pi}''(\hat{\Pi}_0^S)|\,p^2(R^S + R^T(X^*))^{-2}R^T{}'(X^*) = U^{\Pi}'(\hat{\Pi}_0^S)m, \qquad (10)$$

where R^T is a function $R^T(X)$ with $R^T{}'(X) > 0$. The left-hand side of this condition represents the expected marginal benefit B_X at *X** for the employer of higher screening expenditures per candidate *X*. It is given by the ex ante expected reduction of the utility loss ΔU. The right-hand side of condition (10) shows the expected marginal cost C_X at *X** of a higher *X* as the expected marginal disutility of screening expenditures mX. As a result of the first-order Taylor expansion (8) for $mX << \hat{\Pi}_0^S$, C_X is constant. The second-order condition for an interior *X** then implies that B_X must be falling at *X**. This holds if and only if $R^T{}''(X^*) < 2R^T{}'(X^*)^2(R^S + R^T(X^*))^{-1}$ (see App. A), i.e. $R^T{}''(X^*)$ should not be too positive. Note that positive as well as negative values of $R^T{}''(X^*)$ are consistent with diminishing marginal reduction in variance $V(u)$ as X rises.[14] Making the plausible assumption that there is a unique interior *X** that fulfils the first- and second-order conditions, it follows that changes in exogenous variables *Z* that raise/lower B_X ceteris paribus lead to a higher/lower *X**, while changes that raise/lower C_X ceteris paribus lead to a lower/higher *X**. This implies:

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[14] Consider, e.g., $V(u)(X) = X^{-\varepsilon}$ with $\varepsilon > 0$. This implies $V(u)''(X) = \varepsilon(\varepsilon+1)X^{-\varepsilon-2} > 0$ and $R^T(X) = 1/V(u)(X) = X^{\varepsilon}$ with $R^T{}''(X) = \varepsilon(\varepsilon-1)X^{\varepsilon-2}$, which is negative if $\varepsilon < 1$, but positive if $\varepsilon > 1$.

Proposition 1. *Assume a unique interior X*. Then*

$$X_Z^* > 0 \; for \; Z = |U^{\Pi}{}''(\hat{\Pi}_0^S)|, \; r(\hat{\Pi}_0^S), \; p, \; R^T{}'(X^*)^{15},$$
$$X_Z^* < 0 \; for \; Z = R^S, \; R^T(X^*), \; U^{\Pi}{}'(\hat{\Pi}_0^S), \; m. \tag{11}$$

Here $r(\hat{\Pi}_0^S) \equiv |U^{\Pi}{}''(\hat{\Pi}_0^S)| / U^{\Pi}{}'(\hat{\Pi}_0^S)$, i.e. Pratt's measure of absolute risk aversion. Its positive effect on X^* can be seen from dividing both sides of eq. (10) by $U^{\Pi}{}'(\hat{\Pi}_0^S)$. While $r(\hat{\Pi}_0^S)$ is a determinant of risk premia in terms of money, $|U^{\Pi}{}''(\hat{\Pi}_0^S)|$ is a determinant of the utility loss due to risk, and can therefore be considered as a measure of absolute risk aversion in terms of utility. Thus, X^* depends positively on $|U^{\Pi}{}''(\hat{\Pi}_0^S)|$, $r(\hat{\Pi}_0^S)$, product price p, marginal efficiency $R^T{}'(X^*)$ of X at X^* in raising $R^T(X)$, and negatively on perceived reliability of the stereotypic information R^S, $R^T(X^*)$, marginal utility of profit $U^{\Pi}{}'(\hat{\Pi}_0^S)$, and number of screened candidates *m*. The next subsection will show how R^S can vary as a result of a change in ingroup identification *I**. By virtue of ineq. (11) this will then also affect *X**.

C. Identification and stereotyping

An interesting finding in social psychology that we want to incorporate into the model is that when someone experiences *self-relevant uncertainty* in the terminology of (one interpretation of) social-identity theory (e.g., Mullin & Hogg, 1998), he is inclined to identify himself with a salient ingroup (e.g. men). Experiencing self-relevant uncertainty (*SRUC)* means that someone feels uncertain about things that are important in his life and for his self-definition, such as having a job or being able to make a living. This situation is aversive, and therefore people in some situations react by creating a kind of "certainty illusion" by identifying themselves with their ingroup, i.e., they depersonalize themselves and perceive themselves more as group members and less as individuals. Turner (1984, p. 528) describes the process and effect of depersonalization as follows: a "cognitive redefinition of the self – from unique attributes and individual differences to shared social category memberships and associated stereotypes". A certainty illusion exists in such a situation because group membership provides individuals with perceptions of right and wrong and standards of behaviour etc. This illusion diminishes their *SRUC* and, at the same time, induces them to rely more on stereotypes and prejudice in their decisions, because they now act as "group members" and not as "individuals".

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[15] This refers to the partial derivative of *X** with respect to changes in $R^T{}'(X^*)$ *at given (old) X**.

How do these social-psychological processes fit into our model? The basic problem is a suitable interpretation of the concept of *SRUC* in the context of the model. Let us start with some observations. First, *SRUC* is a perception accompanied by a negative emotion. Second, *SRUC* can increase in two ways: (i) the subjective uncertainty (*UC)* about important things may increase, (ii) the self-relevancy (*SR)*, i.e. subjective importance, of the things one is uncertain about increases. This observation suggests to operationalize the concept of *SRUC* as a product of self-relevancy *SR* and uncertainty *UC*. Moreover, we can interpret the *SR* as the subjective importance of *UC* for the (overall) subjective well-being of a person. Multiplying this *SR* with *UC* then yields the perceived loss or gain in well-being due to the uncertainty, where the loss holds for risk-averse persons and the gain for risk-loving persons.[16] In the context of our model, the *UC* is given by the perceived-risk indicator $V(q\,|\,q^T)$ (or $V(\Pi\,|\,q^T)$), and the corresponding *SRUC* is the ensuing ex ante expected utility loss $E^a(\Delta U)$ as given by the last term of utility function (8).[17] This *UC* can be considered as self-relevant since it implies, for sufficiently low levels of profits, a substantial risk of negative profits, and hence bankruptcy. Accordingly, for higher level of profits the *SR* would be low. The expression for $E^a(\Delta U)$ in eq. (8) implies that the *SR* of $V(q\,|\,q^T)$ is equal to $\frac{1}{2}|U^{\Pi}{}''(\hat{\Pi}_0^S)|\,p^2$, and so proportional to absolute risk aversion $|U^{\Pi}{}''(\hat{\Pi}_0^S)|$ and product price squared p^2 (see Sec. III.A for more on this).

The previous section has shown that one way in which the employer can reduce $V(q\,|\,q^T)$, and hence his *SRUC*, is raising his screening expenditure *X*. However, this is costly, and in the given social context an alternative, possibly less costly means to reduce *SRUC* is raising one's identification with the ingroup *I*. The resulting stronger "certainty illusion" can be interpreted as leading to a higher perceived reliability R^S of the stereotypic information, and hence by virtue of eq. (9) to a lower perceived risk $V(q\,|\,q^T)$, and so a lower *SRUC*. The stronger identification *I* can raise R^S in two ways: (i) by a stronger focus on

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[16] Strictly speaking, the psychological concept of *SRUC* only applies to risk-averse persons since it involves a negative emotion. However, by allowing the emotion to be positive it can be extended to risk-loving persons as well.

[17] The approximations in the previous sections imply that we neglect terms in $V(\hat{q}) = V(q)$ (see footnote 12), although this variance is reduced by increases in *I* (see below). However, since this ex ante uncertainty in the posterior estimates $\hat{q}_i$ is resolved when the test estimates q_i^T have been made, it does not really seem self-relevant and aversive, and hence will not induce the employer to create a certainty illusion by stronger identification with his ingroup. However, uncertainties in other variables that are here neglected as well will contribute to the employer's *SRUC* about his profit, and are therefore considered in Sec. IIIC.

stereotypes (see above) it leads to a higher perceived reliability of the stereotypic perceptions $\bar{q}^S$ as indicators of average productivity $\bar{q}$ for ingroup as well as outgroup members (see the decomposition of R^S in Sec. C), and (ii) it raises the perceived reliability of $\bar{q}$ as an indicator of individual productivity q_i for ingroup as well as outgroup members (so both the ingroup and outgroup are perceived as more homogeneous with respect to marginal team productivity).[18] Thus, a higher *I* can reduce both the perceived first-order risk $V(v)$ and the perceived second-order risk $V(w)$.

Just as in the case of screening expenditure *X*, we ask how the level of ingroup identification *I* is determined. To answer this question, we assume, in line with social-identity theory, that people have a personal identity and one or more ingroup identities. In some situations the personal identity, in others a specific ingroup identity is more salient. Accordingly, we define *I* more precisely as the degree to which a specific ingroup identity is salient as compared to the personal identity.[19] Hence, *I* is (analogously to *S*) continuously variable between *0* (zero weight of ingroup identity) and *1* (100% weight of ingroup identity and zero weight of personal identity). Moreover, we assume that it is not generally optimal in terms of individual well-being to identify fully with an ingroup at the expense of a zero weight of personal identity (*I = 1*). It seems more plausible to suppose that for a certain *I** between *0* and *1* there is an optimal balance between ingroup identity with weight *I** and personal identity with weight *1-I**. Important determinants of this optimal balance are the needs for reduction of self-relevant uncertainty and enhancement of self-esteem and distinctiveness, which are seen as additional motives for identification with an ingroup in social psychology (Hewstone, 2002; Mullin & Hogg, 1998). In particular, the *SRUC* due to $V(q\,|\,q^T)$ is reduced as *I* rises. In addition, *SRUC* due to other, profit and not-profit-related uncertainties is diminished as well by increasing *I*. On the other hand, there are marginal costs from “depersonalization”, i.e., less personal identity, for which a psychological need exists as well. This leads to a balance of marginal benefits and costs of *I*, which is interrelated with the equality of marginal benefits and costs of screening expenditure *X*. This is modeled as the maximization of the employer’s utility function (5) with respect to *I* and *X*. Again using

[18] See, for example, De Cremer (2001), who gives an overview of the social-psychological literature on ingroup and outgroup-homogeneity effects.

[19] For the sake of simplicity, we assume that there is only one ingroup with which team members identify. This is a reasonable assumption at a certain point in time, in a certain setting, where one particular categorization is salient.

Taylor expansion (8), omitting the constant $U^{\Pi}(\hat{\Pi}_0^S)$ and rearranging terms, maximand $U(X,I)$ is then given by

$$U(X,I) \cong U^I(I) + \tfrac{1}{2}U^{\Pi}{}''(\hat{\Pi}_0^S)p^2(R^S(I)+R^T(X))^{-1} - U^{\Pi}{}'(\hat{\Pi}_0^S)mX\,. \qquad (12)$$

Here $U^I(I)$ represents the utility of all benefits and costs of *I* apart from the benefit of reduction of *SRUC* due to $V(q\,|\,q^T)$. It is strictly concave (so $U^I{}''(I) < 0$) with positive marginal utility for $I < I_0$, a satiation point at $I = I_0$, and negative marginal utility for $I > I_0$. Thus, if there were no uncertainty $V(q\,|\,q^T)$, the employer would reach a psychological equilibrium at I_0, at which his utility $U^I(I)$ is maximal with respect to *I*. However, the employer also likes to reduce his *SRUC* due to $V(q\,|\,q^T)$, which is indicated by the ex ante expected utility loss term in eq. (12) next to $U^I(I)$. By raising *I* beyond its "base level" I_0 each team member can increase $R^S(I)$, and hence lower the utility loss. The utility loss can also be reduced by increasing screening expenditures *X*, and hence $R^T(X)$, but this has costs that are indicated by the last term in eq. (12).

The first-order condition for maximization of utility function (12) with respect to *I* at given *X* can be written as

$$\tfrac{1}{2}|U^{\Pi}{}''(\hat{\Pi}_0^S)|\,p^2(R^S(I^*)+R^T(X))^{-2}R^S{}'(I^*) = -U^I{}'(I^*)\,, \qquad (13)$$

where the left-hand side represents the marginal benefit B_I of *I* at *I** and the right-hand side the marginal cost C_I at *I** of raising *I* above its "base level" I_0. Since $U^I{}''(I) < 0$, C_I is rising as a function of $I > I_0$. The second-order condition for an interior *I**, conditional on *X*, then implies that B_I must be falling or rising less than C_I as a function of *I* at *I**. Making a second-order Taylor approximation $U^I(I) \cong U^I(I_0) + U^I{}''(I_0)(I - I_0)^2$, this second-order condition is easily shown to be always fulfilled (see App. A). Plausibly assuming that there is a unique interior *I**, we then obtain, analogously to Proposition 1:

Proposition 2. *Assume a unique interior I*, conditional on X. Then*

$$\begin{aligned} &I_Z^* > 0 \textit{ for } Z = |U^{\Pi}{}''(\hat{\Pi}_0^S)|,\ r(\hat{\Pi}_0^S),\ p,\ R^S{}'(I^*),\\ &I_Z^* < 0 \textit{ for } Z = R^S(I^*),\ R^T(X),\ |U^I{}'(I^*)|. \end{aligned} \qquad (14)$$

The partial derivative with respect to $r(\hat{\Pi}_0^S)$ now holds at constant marginal cost $|U^I{}'(I^*)|/U^{\Pi}{}'(\hat{\Pi}_0^S)$ of *I** in terms of money.

To derive the simultaneous interior *X** and *I** we should combine eqs. (10) and (13). The expressions for B_X and B_I on the left-hand sides of these equations are similar: in fact $B_X / R^T{}'(X) = B_I / R^S{}'(I) = B_R$, where B_R is the marginal benefit of raising either R^S or R^T by one unit. Using this symmetry, Appendix A proves:

Proposition 3. *Assume a unique interior equilibrium (X*,I*). Then*

$$X_Z^* > 0 \text{ for } Z = |U^{\Pi}''(\hat{\Pi}_0^S)|,\ r(\hat{\Pi}_0^S),\ p,\ R^T{}'(X^*),\ |U^I{}'(I^*)|,$$
$$X_Z^* < 0 \text{ for } Z = R^S(I^*),\ R^T(X^*),\ U^{\Pi}{}'(\hat{\Pi}_0^S),\ m,\ R^S{}'(I^*), \tag{15a}$$

$$I_Z^* \gtreqless 0 \text{ for } Z = |U^{\Pi}''(\hat{\Pi}_0^S)|,\ r(\hat{\Pi}_0^S),\ p, \text{ and } I_Z^* \lesseqgtr 0 \text{ for } Z = R^S(I^*),\ R^T(X^*) \text{ if and only if } R^T''(X^*) \lesseqgtr 0,$$
$$I_Z^* > 0 \text{ for } Z = R^S{}'(I^*),\ U^{\Pi}{}'(\hat{\Pi}_0^S), \text{ and } I_Z^* < 0 \text{ for } Z = |U^I{}'(I^*)|,\ R^T{}'(X^*). \tag{15b}$$

Inequalities (15b) indicate that I_Z^* is positive for $Z = |U^{\Pi}''(\hat{\Pi}_0^S)|$, $r(\hat{\Pi}_0^S)$, p if $R^T''(X^*) < 0$, zero if $R^T''(X^*) = 0$, and negative if $R^T''(X^*) > 0$, and analogous relations for the other partial derivatives on the first line of (15b). Thus, if absolute risk aversion as measured by $|U^{\Pi}''(\hat{\Pi}_0^S)|$ or $r(\hat{\Pi}_0^S)$ rises, *ceteris paribus*, self-relevant uncertainty *SRUC* as given by minus the second term of utility function (12) and the expected marginal benefits B_X and B_I (eqs. (10) and (13)) rise as well. This leads to an increase in *X** conditional on *I* (Prop. 1) as well as simultaneous with *I** (Prop. 3), and to an increase in *I** conditional on *X* (Prop. 2), which is consistent with the findings in social psychology (e.g., Mullin and Hogg, 1998). However, it only leads to an increase in *I** simultaneous with *X** if $R^T''(X^*) < 0$, i.e. if the marginal efficiency $R^T{}'(X)$ of *X* in raising $R^T(X)$ falls with increasing *X* at *X**. If $R^T''(X^*) > 0$, *I** even decreases as risk aversion rises. This is due to the accommodating rise in screening expenditure *X**, raising the perceived reliability of individual information R^{T*}, and hence lowering the perceived posterior uncertainty $V(q\,|\,q^T)$ of the q_i of a new team member (eq. (9)). This lowers B_I (eq. (13)), and hence leads to a lower *I**. Since the C_X curve is horizontal by approximation, the rise in *X** is considerable, and will, when its marginal efficiency $R^T{}'(X^*)$ rises as well (raising B_X^*), even be so strong as to push *I** back below its original level. Thus, the rise in *X** more than fully substitutes for the initial rise in *I** in reducing *SRUC*. This possibility of full substitution of *X* for *I*, but not the reverse, is due to our approximation of a constant C_X. However, this is a plausible approximation (see the previous section), and in combination with the case where $R^T''(X^*) \geq 0$, it may be considered as a 'worst-case' scenario with respect to the effect of rising risk aversion on *I**. This will serve to strengthen the robustness of our result of a positive effect of increasing competition on *I** in Sec. III.

The interpretation of the other inequalities in Proposition 3 is straightforward. In comparison to the conditional effects in Propositions 1 and 2, there are now also positive cross-substitution effects $\partial X^*/\partial |U^{I}{}'(\hat{\Pi}_0^S)|$ and $\partial I^*/\partial U^{\Pi}{}'(\hat{\Pi}_0^S)$ of rises in the marginal costs of I^* and X^* on each other's level, and negative cross-effects $\partial X^*/\partial R^S{}'(I^*)$ and $\partial I^*/\partial R^T{}'(X^*)$ of rises in the marginal efficiencies of I^* and X^* on each other's level.

What are the consequences of all this for the equilibrium value S^* of the extent of using stereotypic perceptions? According to eq. (4) $S^* = R^{S^*}/(R^{S^*} + R^{T^*})$. Hence, the equilibrium value S^* is, via R^{S^*} and R^{T^*}, determined by the simultaneous equilibrium values I^* and X^*. A rise in X^* raises R^{T^*}, and hence lowers S^*, whereas a rise in I^* raises R^{S^*}, and hence raises S^*. So, when in the case where $R^T{}''(X^*) \geq 0$ risk aversion $|U^{\Pi}{}''(\hat{\Pi}_0^S)|$ (or $r(\hat{\Pi}_0^S)$) rises, leading to a rise in X^* and a fall in I^* (Prop. 3), S^* unambiguously falls. On the other hand, when $R^T{}''(X^*) < 0$ holds and risk aversion rises, the resulting rises in X^* and I^* counteract each other in their effects on S^*, making the sign of the net effect on S^* ambiguous. Rewriting eq. (4) as $S^* = (1 + R^{T^*}/R^{S^*})^{-1}$, it follows that S^* rises/falls if the relative (i.e. percentual) rise in R^{S^*} is higher/lower than the relative rise in R^{T^*}. Using this property, Appendix A derives:

Proposition 4. *Assume a unique interior equilibrium (X*,I*). Then*

$$S_Z^* \gtreqless 0 \text{ for } Z = |U^{\Pi}{}''(\hat{\Pi}_0^S)|,\ r(\hat{\Pi}_0^S),\ p, \text{ and } S_Z^* \lesseqgtr 0 \text{ for } Z = R^S(I^*),\ R^T(X^*), \text{ if and only if } R^T{}''(X^*) \lesseqgtr -\frac{R^S{}'(I_0)}{R^S{}'(I^*)}\frac{R^S(I^*)}{R^S(I^*) - R^S(I_0)}\frac{R^T{}'(X^*)^2}{R^T(X^*)},$$

$$S_Z^* < 0 \text{ for } Z = R^T{}'(X^*),\ |U^I{}'(I^*)|, \text{ and } S_Z^* > 0 \text{ for } Z = R^S{}'(I^*),\ U^{\Pi}{}'(\hat{\Pi}_0^S). \quad (16)$$

Note that the right-hand side of the inequality for $R^T{}''(X^*)$ is negative. Thus, only when $R^T{}''(X^*)$ is more negative than this expression[20], a rise in risk aversion leads to a sufficiently weak increase in X^* and a sufficiently strong increase in I^* so as to cause a rise in stereotyping S^*. The interpretation of the other inequalities in Proposition 4 is straightforward. The inequalities have interesting implications for the effects of competition on discrimination, which will be examined in Section III.

D. Rationalization of discriminatory taste and group discrimination

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[20] If $V(u)(X) = X^{-\varepsilon}$ with $\varepsilon > 0$ (see footnote 13), it can be shown that ε, i.e. the absolute magnitude of the elasticity of $V(u)$ with respect to X, should then be smaller than ½ if the absolute magnitude of the elasticity of $V(u)$ with respect to I is not too much greater than 1.

As we saw in Section A, a rise in stereotyping S^* leads to a proportional increase in individual statistical discrimination, but it can only imply an increase in *group* discrimination if at least one of the stereotypic perceptions $\bar{q}^{SI}$ and $\bar{q}^{SO}$ of the average marginal productivities in the ingroup and outgroup is incorrect. In the economic literature on discrimination (see, e.g., Aigner and Cain, p. 177) it has been argued that such incorrect perceptions are unlikely to persist in competitive markets since they lead to a competitive disadvantage vis-à-vis competitors with correct or less incorrect perceptions. Hence, either the incorrect perceptions will be corrected by learning about real productivities or employers with such perceptions will, in the long run, be competed away. However, the psychological literature on discrimination shows that even when real differences in $\bar{q}$ between two groups have disappeared, incorrect stereotypic perceptions of such differences tend to be quite persistent and widespread due to several psychological processes.

First, this stereotypic perception may be deeply ingrained in the mind of employers as a result of socialization and influencing by the media. Imagine, for example, the standard picture of the role of women versus men in the media. Relatedly, the stereotypic perception may serve as justification and rationalization of an emotional prejudice and the ensuing discriminatory behavior against the outgroup (e.g., Snyder and Miene, 1994). This can be explained from the psychological inclination of a person to reduce cognitive dissonance between, on the one hand, his self-image (as someone who does not discriminate without a good reason) and, on the other hand, his discriminatory prejudice and behavior (Festinger, 1957; Arrow, 1973, p. 26). As these processes largely work unconsciously, the resulting emotions and cognitions will not easily change. Quite a different kind of reason for the persistence of wrong stereotypic perceptions is implied by the social-psychological BIAS model of Fiedler (1996). This model explains many so-called "biases" in differential perception of in and outgroups from the fact that ingroup samples are usually bigger than outgroup samples (e.g. the sample a male CEO makes of male versus female CEOs, but also the sample an economist makes of fellow economists versus social psychologists). Even when there are no real differences in distribution of the productivities q_i between the ingroup and the outgroup, the ingroup is then perceived as having a higher $\bar{q}$ than the outgroup since the pattern of productivity-relevant attributes of the bigger ingroup sample correlates more strongly with the ideal pattern than the pattern of productivity-relevant attributes of the smaller outgroup sample does.[21] This represents boundedly rational information processing by

[21] It would lead too far to explain the model in detail here, but see Fiedler (1996, 2000). See Fryer and Jackson (2003) for a somewhat related approach in the context of economics.

agents who do not know how to make correct inferences from real-world samples about the underlying populations, and is a persistent phenomenon of human cognition.

Let us therefore consider such a case of incorrect stereotypic perceptions in more detail. We assume that employers have incorrect perceptions of a too low $\overline{q}^{SO} < \overline{q}^{O}$ of outgroup members, but correct perceptions $\overline{q}^{SI} = \overline{q}^{I}$ of ingroup members. Since in many real-life situations cognitive stereotypes and emotional prejudices go together (Kinder & Sears, 1981), we further presume that the incorrect perceptions $\overline{q}^{SO}$ are partially due to rationalization of prejudices and the ensuing discriminatory tastes of the employers against the outgroup. However, the associated discrimination coefficients d^{O} of the employers (Becker, 1957) are supposed to be fully rationalized into the (generally heterogeneous) $\overline{q}^{SO}$, leaving no separate contribution of d^{O} to the group discrimination in addition to that of $\overline{q}^{SO}$. The incorrect $\overline{q}^{SO}$ lead to stereotypic overestimations $\Delta\overline{q}^{S} \equiv \overline{q}^{SI} - \overline{q}^{SO}$ of the real difference in average productivity $\Delta\overline{q} \equiv \overline{q}^{I} - \overline{q}^{O}$ between the ingroup and the outgroup, and hence to group discrimination against the outgroup in favour of the ingroup. This group discrimination can be measured by the discrimination coefficients of the employers, i.e by the objective expectations of the amounts of money the employers are willing to pay on average for hiring an ingroup instead of an outgroup member in addition to what is implied by the real productivity difference $\Delta\overline{q}$. These discrimination coefficients are fully based on productivity estimates. We normalize them by product price p since what matters most are the discrimination coefficients relative to the part $p\Delta\overline{q}$ of the wage difference $\Delta w \equiv w^{I} - w^{O}$ between the ingroup and the outgroup that is due to the real $\Delta\overline{q}$. If $\Delta\overline{q} = 0$, the discrimination coefficient relative to w^{I} is relevant, where w^{I} positively depends on p, and is even proportional to p when the labor supply of ingroup members is inelastic. The common factor in both cases is p, and hence discrimination coefficient D is defined as

$$D \equiv E^{o}(p\overline{\Delta\hat{q}_{jl}} - p\Delta\overline{q} \mid \{\Delta q_{jl}\}) / p = \overline{E^{o}(\Delta\hat{q}_{jl} \mid \Delta q_{jl})} - \Delta\overline{q}\ , \tag{17}$$

where $\overline{\Delta\hat{q}_{jl}}$ is the average of $\Delta\hat{q}_{jl} \equiv \hat{q}_{j} - \hat{q}_{l}$ over all possible candidates j from the ingroup and l from the outgroup. Taking the first difference of eq. (3), it is easily seen that

$$D = S(\Delta\overline{q}^{S} - \Delta\overline{q})\ . \tag{18}$$

In this expression not only the extent of using stereotypic perceptions S, but also the size of the stereotypic overestimation $\Delta\overline{q}^{S} - \Delta\overline{q}$ should be considered as endogenous since social-psychological research (e.g, Lepore & Brown, 1999) suggests that not only S, but also prejudice, and hence via rationalization $\Delta\overline{q}^{S} - \Delta\overline{q}$, increases with ingroup identification I. To find an expression for $\Delta\overline{q}^{S} - \Delta\overline{q}$, we first suppose $\Delta\overline{q}^{S} - \Delta\overline{q} = \Delta\overline{q}_{0}^{S} + \gamma d^{O}$, where $\Delta\overline{q}_{0}^{S}$ is the part of $\Delta\overline{q}^{S} - \Delta\overline{q}$ due to cognitive biases in the interpretation of information (see above) and γd^O is the rationalization part with positive parameter γ.[22] Next, note that the prejudice gives rise to a disutility $U^O(O)$ of having O outgroup members in the team (assumed to be separable from utility function (5) "before rationalization"; cf. Arrow, 1973, p. 6). This implies a disutility $U^O{}'(O)$ of hiring an outgroup member (assumed to be diminishing in *O*), translating into the discrimination coefficient d^O, which is the amount of profit an employer is willing to sacrifice to avoid the disutility $U^O{}'(O)$. Hence, the disutility of d^O, in linear approximation given by $U^{\Pi}{}'(\hat{\Pi}_0^S)d^O$, equals $U^O{}'(O)$, and so $d^O = U^O{}'(O)/U^{\Pi}{}'(\hat{\Pi}_0^S)$.[23]

Furthermore, we assume that disutility $U^O{}'(O)$ due to prejudice increases with ingroup identification *I* as $U^O{}'(O) = f(I)g(O)$, where $f(I) > 0$ and $f'(I) > 0$ for *I* higher than a critical threshold value $I_c \geq 0$, $f(I) = 0$ for $I \leq I_c$, $g(O) > 0$, and $g'(O) < 0$.[24] The underlying presumption is that only when I exceeds a certain minimum level I_c, a discriminatory taste will develop, and then grow with *I*. Both I_c and the level of $g(O)$ may vary among employers (see also Sec. III.B). Substituting the expression for $U^O{}'(O)$ into that for d^O and the resulting expression into $\Delta\bar{q}^S - \Delta\bar{q} = \Delta\bar{q}_0^S + \gamma d^O$ yields

$$\Delta\bar{q}^S - \Delta\bar{q} = \Delta\bar{q}_0^S + \gamma f(I)g(O)/U^{\Pi}{}'(\hat{\Pi}_0^S). \tag{19}$$

Thus, a higher equilibrium value *I** of ingroup identification implies not only a higher *S**, but, for $I^* > I_c$, also a larger $\Delta\bar{q}^{S^*} - \Delta\bar{q}$, and hence a higher team discrimination coefficient *D** via $\Delta\bar{q}^{S^*} - \Delta\bar{q}$ as well as *S** by virtue of eq. (18).

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[22] Eq. (18) then corresponds to the taste for discrimination as conceived by Becker (1971, pp. 16-17) when he says that it incorporates both prejudice and ignorance about the true economic efficiency of the discriminated group. However, a difference is that whereas Becker states that ignorance that is not based on prejudice may be quickly eliminated by the spread of knowledge, we assume, in line with social-psychological insights of Fiedler (1996), that such ignorance can persist due to systematic cognitive mistakes in the interpretation of information.

[23] This is the negative of the marginal rate of substitution of profit for outgroup members (cf. Arrow, 1973, p. 7).

[24] An important component of this 'discriminatory taste' could be the disutility of a loss in ingroup identity of an ingroup member when he has to work with an outgroup member (see Akerlof and Kranton, 2000, p. 732). It is plausible that this component increases when the identification with the ingroup *I* rises. In the case where the ingroup consists of men and the outgroup of women, a related component of the discriminatory taste may be the disutility due to violation of the social norm that when jobs are scarce, men should have more right to a job than women (as measured in Eurobarometer surveys, see Azmat et al., 2003, p. 22; see also Vendrik, 2003).

III. Effects of competition

A. Effects on I and X**

What happens with ingroup identification I^* and screening expenditure X^* when competition on the supply side of the product market intensifies? Such an increase in competition is conceived as a rise in upward-sloping supply relative to downward-sloping demand in the product market near the equilibrium price p. This may be due to either an increase in the number of competing teams or a fall in demand. As a result, p, and hence expected profit $\hat{\Pi}_0^S$ (at given I and O [25]) will fall. This has several effects.

At given variance in profits $V(\Pi \mid q^T)$, the fall in $\hat{\Pi}_0^S$ will raise the risk of negative profits, i.e. of going bankrupt, for the employers. Intuition suggests that this will raise the self-relevant uncertainty *SRUC* of employers. According to our interpretation in Section II.C of *SRUC* as the ex ante expected utility loss $E^a(\Delta U)$ due to the uncertainty $UC = V(q \mid q^T)$ in the q_i of a new team member, self-relevancy $SR = \frac{1}{2}| U^{\Pi}{}''(\hat{\Pi}_0^S) | \, p^2$ should then increase. For many specifications of utility function $U^{\Pi}(\Pi)$ absolute risk aversion measure $| U^{\Pi}{}''(\hat{\Pi}_0^S) |$ rises when $\hat{\Pi}_0^S$ falls, but not for all (e.g. for the additive quadratic specification $| U^{\Pi}{}''(\hat{\Pi}_0^S) |$ remains constant). Moreover, the fall in product price p suppresses *SR* via the factor p^2. This effect appears since the fall in p directly lowers the uncertainty $V(pq_i \mid q_i^T) = p^2 V(q \mid q^T)$ in revenue from a new team member, i.e. less is at stake in absolute money terms. For the intuitively expected net rise in *SR*, and hence in *SRUC*, to occur, the relative (i.e. in terms of percentage) rise in risk aversion $| U^{\Pi}{}''(\hat{\Pi}_0^S) |$ should be greater than the relative fall in p^2. To see when this may hold, we approximate utility function $U^{\Pi}(\Pi)$ by the common power function

$$U^{\Pi}(\Pi) = \Pi^{\rho} / \rho \,, \qquad \rho < 1,\ \rho \neq 0 \,,$$
$$U^{\Pi}(\Pi) = \ln \Pi \,, \qquad \rho = 0 \,. \tag{20}$$

This implies $| U^{\Pi}{}''(\hat{\Pi}_0^S) | = (1-\rho)\hat{\Pi}_0^{S^{-2+\rho}}$. Empirical evidence is generally consistent with values of ρ in the range of -3 to -1 (Nicholson, 1998, p. 226), and since the relative fall in $\hat{\Pi}_0^S$ is greater than the relative fall in p, it easily follows that for $\rho \leq 0$ the relative rise in $| U^{\Pi}{}''(\hat{\Pi}_0^S) |$ is greater than the relative fall in p^2 (see App. B for the derivation). Thus, if employers are not much less risk averse than generally measured, $SR = \frac{1}{2}| U^{\Pi}{}''(\hat{\Pi}_0^S) | \, p^2$, and hence *SRUC*, rises as competition increases. By the same token, the expected marginal benefits B_X and B_I of X and I in reducing *SRUC*, as given by the left-hand sides of eqs. (10) and (13), will rise as well. This arouses incentives to spend more resources on screening of candidate team members as well as to identify more strongly with the ingroup.

[25] Note that $X=0$ in $\hat{\Pi}_0^S$.

However, Proposition 3 implies that these incentives are only sufficient to lead to a rise in the equilibrium I^* simultaneous with X^* when $R^{T}''(X^*) < 0$. On the other hand, another determinant of I^* changes as well, viz. the marginal utility of profit $U^{\Pi}'(\hat{\Pi}_0^S)$. This rises as competition increases, and hence profits drop. Consequently, C_X as given by the right-hand side of eq. (10) rises. This means that employers expect a higher opportunity cost of their screening expenditures when their expected profits are lower since the expenditures will then weigh more heavily on their budgets. (This implies an income effect of lower profits on X^*.) As a result, the equilibrium X^*, conditional on I, will only increase if B_X^* rises more than C_X^*. This holds if and only if $|U^{\Pi}''(\hat{\Pi}_0^S)|\, p^2 / U^{\Pi}'(\hat{\Pi}_0^S) \equiv r(\hat{\Pi}_0^S) p^2$ rises as competition increases. Intuition suggests that absolute risk aversion measure $r(\hat{\Pi}_0^S)$ will rise as profits fall, but again this holds only for certain specifications of $U^{\Pi}(\Pi)$ like power function (20) (Nicholson, 1998, pp. 224-225). For this function $r(\hat{\Pi}_0^S) = (1-\rho)\hat{\Pi}_0^{S^{-1}}$, implying that the relative rise in $r(\hat{\Pi}_0^S)$ is even greater than the relative fall in p, but not necessarily greater than the relative fall in p^2. Appendix B shows that for $\hat{\Pi}_0^S$ greater than total production costs C the relative rise in $r(\hat{\Pi}_0^S)$ is actually smaller than the relative fall in p^2, whereas for lower $\hat{\Pi}_0^S$ the reverse holds. Hence, for $\hat{\Pi}_0^S > C$ C_X^* rises more than B_X^*, resulting in falling conditional screening expenditure X^* as competition increases. On the other hand, as $\hat{\Pi}_0^S$ has fallen below C, B_X^* starts to rise more than C_X^*, resulting in rising X^* as competition increases.

In contrast to C_X , the expected marginal cost C_I of ingroup identification, which is given by the right-hand side of eq. (13), does not change as competition increases since it is non-monetary. This implies that the equilibrium I^*, conditional on X, unambiguously rises as competition increases. Moreover, it can be shown that I^*, simultaneous with X^*, unambiguously rises as well if and only if $R^{T}''(X^*)$ is smaller than a positive expression which varies with $\hat{\Pi}_0^S$ in a very complex way. Because of this complexity we do not specify it here.[26] This result is due to the rise in C_X^*, which leads to substitution of screening expenditure X by ingroup identification I in reducing self-relevant uncertainty *SRUC*. This substitution works as follows: the fall or less strong rise in X^* due to the rise in C_X^* lowers the reliability of individual information R^{T*}, which raises uncertainty $V(q \mid q^T)$ (eq. (9)). This raises B_I^* (eq. (13)), and hence leads to a higher I^*. In its turn, this raises R^{S*}, which lowers $V(q \mid q^T)$, and hence B_X^*, leading to a lower X^*, etc., until X^* and I^* stabilize on a new simultaneous equilibrium.

[26] An extensive derivation is available from the authors on request.

The negative feedback of a rising I^* on X^* adds to the direct negative effect of a higher $C_X{}^*$, and both effects counteract the positive effect of a higher $B_X{}^*$ due to the higher risk aversion $|U^{\Pi}{}''(\hat{\Pi}_0^S)|$. To derive which effects may be stronger under which conditions and since a general derivation is untractable, we now make linear approximations $R^T(X) = \alpha X$ and $R^S(I) = \beta I$, implying $R^T{}''(X^*) = 0$ and $R^S{}''(I^*) = 0$, and $V(u) = \alpha^{-1} X^{-1}$ and $V(q) = \beta^{-1} I^{-1}$ with elasticities *-1*, which represent intermediate cases (see Prop. 3 and footnote 14). Appendix B shows that then, in the case of power function (20) with $\rho < 1/2$, the negative feedback effect of a higher initial I^* dominates for sufficiently low $\hat{\Pi}_0^S$, implying falling X^* simultaneous with I^*, when competition increases.[27] For $\hat{\Pi}_0^S > C$ the negative effect of a higher $C_X{}^*$ dominates (see above), and there may be an intermediate range of $\hat{\Pi}_0^S < C$ where the positive effect of a higher $B_X{}^*$ dominates, implying rising simultaneous X^* as competition intensifies. However, the latter effect is not strong enough to prevent I^* from rising (cf. Prop. 3). Since a lower value of $R^T{}''(X^*)$ can be shown to imply a stronger rise in I^*, and hence in R^{S*}, as competition increases[26], we then have a stronger negative feedback on X^*. Hence, the above result of a predominantly falling X^* as competition increases a fortiori holds when $R^T{}''(X^*) < 0$.

B. Effects on S^*, $\Delta\bar{q}^{S*} - \Delta\bar{q}$, and D^*

The rise in the simultaneous I^* leads to an increase in R^{S*}, and hence in the extent of stereotyping $S^* = R^{S*}/(R^{S*} + R^{T*})$. This rise in S^* is reinforced when the simultaneous X^* falls, lowering R^{T*}. On the other hand, when X^* rises as competition increases, the direction of change in S^* is ambiguous. Accordingly, in the case of power function (20) with $\rho < 1/2$ and the linear approximations made above, there may be an intermediate range of $\hat{\Pi}_0^S < C$ for which S^* falls as competition increases, while for all other levels of $\hat{\Pi}_0^S$ S^* rises (until it reaches value *1* for very low $\hat{\Pi}_0^S \leq \breve{\Pi}_0^S$ [28]; see App. B for this and following results). Since a lower value of $R^T{}''(X^*)$ implies a stronger rise in R^{S*}, but does not affect X^*, and hence R^{T*},

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[27] At an assumedly very low level $\breve{\Pi}_0^S$ of $\hat{\Pi}_0^S$, X^* becomes zero, and remains zero when $\hat{\Pi}_0^S$ further falls. This is due to the particular implication of power function (20) that the marginal utility of profit $U^{\Pi}{}'(\hat{\Pi}_0^S)$ goes to infinity when $\hat{\Pi}_0^S$ approaches zero. Since this implication seems too extreme, power function (20) may not be a good approximation of $U^{\Pi}(\hat{\Pi}_0^S)$ for very low levels of $\hat{\Pi}_0^S$.

[28] This occurs when X^*, and hence $R^{T*} = \alpha X^*$, becomes zero (eq. (4)). Estimates of the individual productivities of candidate team members are then purely based on stereotypic perceptions (eq. (1)). Since this case of zero screening expenditure, and hence, e.g., no job interviews, seems rather unrealistic (see also the previous footnote), we will pay little attention to it in the following.

as competition increases[26], this result of a predominantly rising S^* a fortiori holds when $R^{T}{}''(X^*) < 0$.

The rise in the simultaneous I^* for "not too positive $R^{T}{}''(X^*)$" (see above) also leads to a rise in the stereotypic overestimation $\Delta\bar{q}^{S^*} - \Delta\bar{q}$ of the average-productivity difference between the ingroup and outgroup for $I^* > I_c$ (eq. (19)). On the other hand, the rise in the marginal utility of profit $U^{\Pi}{}'(\hat{\Pi}_0^S)$ directly lowers $\Delta\bar{q}^{S^*} - \Delta\bar{q}$ via the "discriminatory taste coefficient" d^{O^*}. This represents an income effect of falling profits (Comanor, 1973), according to which falling profits make it relatively more expensive to indulge one's discriminatory taste, and hence suppress the amount of money one is willing to spend on it. As a result, employers will be more cautious in their stereotypic perceptions. App. B shows that, for the linear approximations made above and approximating $f(I)$ for $I > I_c$ linearly as $I - I_c$ in eq. (19), this negative income effect on $\Delta\bar{q}^{S^*} - \Delta\bar{q}$ dominates the positive effect of stronger ingroup identification if $I_c < I_0$, but is dominated by it if $I_c > I_0$.

Thus, for employers with $I_c < I_0$ $\Delta\bar{q}^{S^*} - \Delta\bar{q}$ falls as competition strengthens, for $\hat{\Pi}_0^S > \breve{\Pi}_0^S$ (see above).[29] This counteracts rises in S^* in the discrimination coefficient $D^* = S^*(\Delta\bar{q}^{S^*} - \Delta\bar{q})$. However, for the case of power function (20) with $\rho < 1/2$, the positive effect on D^* of a rising S^* can still be shown to dominate the negative effects on D^* for sufficiently low $\hat{\Pi}_0^S$ [30], whereas for sufficiently high $\hat{\Pi}_0^S$ the negative income effect dominates. Furthermore, there may be an intermediate range of $\hat{\Pi}_0^S$ (including $\hat{\Pi}_0^S = C$) where D^* first rises as competition increases and then falls (due to a rising X^*). Thus, for $I_c < I_0$, D^* as a function of $\hat{\Pi}_0^S$ has, for $\hat{\Pi}_0^S \geq \breve{\Pi}_0^S$, a U-shape with a possible "hump" in the middle part.[31] For employers with $I_c > I_0$ the rise in $\Delta\bar{q}^{S^*} - \Delta\bar{q}$ reinforces the positive effect on D^* of a rising S^* such that D^* rises as well as competition increases with possibly an intermediate range of $\hat{\Pi}_0^S$ where D^* falls, but now with a lower "probability". Note that for $I^* \leq I_c$ (which can only occur for sufficiently low $\hat{\Pi}_0^S$ when $I_c > I_0$), $\Delta\bar{q}^{S^*} - \Delta\bar{q} = \Delta\bar{q}_0^S > 0$ implies proportionality of D^* to S^*. A negative instead of zero value of $R^{T}{}''(X^*)$ reinforces rises in D^* via S^* and $\Delta\bar{q}^{S^*} - \Delta\bar{q}$ as competition increases, but for $I_c < I_0$ it is not clear whether it may eliminate the U-shape of D^* as a function of $\hat{\Pi}_0^S$ for sufficiently negative $R^{T}{}''(X^*)$.

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[29] For $\hat{\Pi}_0^S \leq \breve{\Pi}_0^S$ $\Delta\bar{q}^{S^*} - \Delta\bar{q}$ can be shown to "probably" rise as competition increases.

[30] These $\hat{\Pi}_0^S$ are assumed to be still higher than $\breve{\Pi}_0^S$ (see footnotes 27 and 28).

[31] For $\hat{\Pi}_0^S < \breve{\Pi}_0^S$ (and so $S^* = 1$) D^* "probably" rises as competition increases due to the rise in $\Delta\bar{q}^{S^*} - \Delta\bar{q}$ (see footnote 29).

The effects of competition that have been identified in this section can be summarized as

Proposition 5. *Consider power function (20). When competition on the supply side of the product market increases,*

a. *if $\rho \le 0$, self-relevant uncertainty SRUC initially rises;*

b. *if and only if $\rho \le 0$ and $R^T{}''(X^*)$ is "not too positive", simultaneous ingroup identification I^* rises;*

c. *if $\rho < 1/2$, $R^T{}''(X^*) \le 0$ and $R^S{}''(I^*) = 0$, simultaneous screening expenditure X* falls except for a possible intermediate range of $\hat{\Pi}_0^S < C$, where X* rises, and except for assumedly very small $\hat{\Pi}_0^S \le \breve{\Pi}_0^S$, where $X^* = 0$;*

d. *if $\rho < 1/2$, $R^T{}''(X^*) \le 0$ and $R^S{}''(I^*) = 0$, stereotype use S* rises except for a possible intermediate range of $\hat{\Pi}_0^S < C$, where S* falls, and except for very small $\hat{\Pi}_0^S \le \breve{\Pi}_0^S$, where $S^* = 1$;*

e. *if $R^T{}''(X^*) = 0$, $R^S{}''(I^*) = 0$, and $f(I) = I - I_c$* for *$I > I_c$, stereotypic overestimation $\Delta\overline{q}^{S*} - \Delta\overline{q}$ falls for $\hat{\Pi}_0^S > \breve{\Pi}_0^S$ when $I_c < I_0$, and rises for $\hat{\Pi}_0^S > \breve{\Pi}_0^S$ such that $I^* > I_c$ when $I_c > I_0$;*

f. *if $\rho < 1/2$, $R^T{}''(X^*) = 0$, $R^S{}''(I^*) = 0$, and $f(I) = I - I_c$* for *$I > I_c$, discrimination coefficient D*, when $I_c < I_0$, falls for sufficiently high $\hat{\Pi}_0^S$ and rises for sufficiently low $\hat{\Pi}_0^S \ge \breve{\Pi}_0^S$ except for a possible intermediate range of $\hat{\Pi}_0^S$ (including C), where D* first rises and then falls; when $I_c > I_0$, D* rises except for a possible intermediate range of $\hat{\Pi}_0^S$, where D* falls.*

The results under (d)-(f) are particularly interesting in relation to the long-run selection mechanism in Becker's theory of employer discrimination. According to this mechanism employers with lower *D** drive employers with higher *D** out of the product market as $\hat{\Pi}_0^S$ approaches zero. In particular, if some employers have zero *D**, these are the only teams to survive in the market, thus eliminating discrimination. However, our psychological model casts doubts on the assumption that some employers have zero *D**. It is a very general human inclination to identify with one's ingroup, and in many cases stronger identification with one's ingroup will raise the probability of developing a preference for the ingroup or a discriminatory taste against the outgroup. Even employers who initially (say at $I = I_0$) have a zero discriminatory taste ($d^{O*} = 0$) may develop a non-zero one ($d^{O*} > 0$) under competitive pressure as this makes them identify more strongly with their ingroup. In our model their *I** then passes their (person-specific) critical threshold value $I_c > I_0$. Further, to justify their discriminatory taste, they can rationalize it into a stereotypic overestimation $\Delta\bar{q}^{S*} - \Delta\bar{q}$ of the average-productivity difference between the ingroup and outgroup. The discrimination coefficients $D*$ would then rise above zero (if they are not already positive due to the cognitive bias $\Delta\bar{q}_0^S$) and further rise as $\hat{\Pi}_0^S$ falls, by increasing use $S*$ of $\Delta\bar{q}^{S*}$ as well as rising $\Delta\bar{q}^{S*} - \Delta\bar{q}$ (see Prop. 5.d-f). In the end, even the discrimination coefficient of the surviving teams with the lowest $D*$ in the market would still be substantially positive.[32]

Thus, our psychological model offers arguments why increasing competitive pressure may not diminish and may even raise employer discrimination. This points to the importance of policy measures like affirmative action to alleviate this problem. Holzer and Neumark (2000) provide evidence for the U.S.A. that affirmative action has increased the number of recruitment and screening practices used by employers and has raised employers' willingness to hire stigmatized applicants. In the context of our model, the former increase can be interpreted as a rise in screening expenditure *X** (cf. Antonji and Blank, 1999, p. 3190) as a result of an additional marginal benefit of *X**. This extra benefit can be subtracted from marginal cost C_X as given by the right-hand side of eq. (10)), and so has the effect of making *X** less costly relative to ingroup identification *I**. Consequently, *X** rises and *I** falls, which both lead to a lower use of stereotypes *S**, and hence less discrimination. Thus, affirmative action not only raises screening expenditures, but also diminishes the need for identification with the ingroup.

C. Robustness

A limitation of Proposition 5 is that only the result under (e) (and (b) for $R^{T}{}''(X^*) = 0$) holds for any specification of utility function $U^{\Pi}(\Pi)$ with positive and diminishing marginal utility. To get an impression of the sensitiveness of the results to the specification of $U^{\Pi}(\Pi)$, consider the additive quadratic specification, which has quite different implications from those of the power function. When competition increases, risk aversion measure $|U^{\Pi}{}''(\hat{\Pi}_0^S)|$ then remains constant, and hence, contrary to psychological intuition, *SRUC* falls due to

[32] This argument should be modified when some teams in the market consist in majority of outgroup members (e.g. women) from the perspective of the dominant ingroup in other teams (e.g. men). Under competitive pressure these 'outgroup' members may identify with their own ingroup, and hence not develop a discriminatory taste against their own ingroup. On the other hand, feelings of inferiority or small-sample biases according to the BIAS model of Fiedler (1996; see Sec. II.D) may still lead to a stereotypic perception of a lower average productivity of their own ingroup as compared to the dominant group (see Schwieren, 2004). These teams would then develop a rising discrimination coefficient against their own ingroup.

falling p. By the same token, marginal benefits B_X and B_I then fall as well, while marginal cost C_X rises. This implies falling screening expenditure X^* and, for "not too positive $R^{T}{''}(X^*)$", rising ingroup identification I^* for all $\hat{\Pi}_0^S$. As a result, stereotype use S^* then rises for all $\hat{\Pi}_0^S$. Furthermore, for employers with $I_c < I_0$ the falling $\Delta\overline{q}^{S*} - \Delta\overline{q}$ again results in a U-shape of D^* as a function of $\hat{\Pi}_0^S$. Thus, the outcomes are similar to those in the power-function case. On the other hand, the results in Proposition 5 are sensitive to relaxing the linear approximations made. For example, for a sufficiently (but perhaps implausibly) high positive value of $R^{T}{''}(X^*)$, all else equal, increasing competition leads to a falling I^* and a rising X^*, and hence a falling S^* and D^*.

A rather strong assumption in the basic model made in Section II.A is that there is only uncertainty about the marginal team productivity q_i of a new team member. This assumption can be relaxed by allowing uncertainty in other variables like product price p and the productivities of incumbent team members as well. Assuming independence of variances of p and productivities and taking a second-order Taylor expansion of $U^{\Pi}(\Pi)$ around $\hat{\Pi}$ (see Sec. II.B), additional utility losses due to variances then emerge in eqs. (6)-(8) and (12). Just like the utility loss due to $V(q \mid q^T)$, these utility losses are reduced by the certainty illusion of ingroup identification I, implying additional marginal benefits of I in eq. (13). By raising risk aversion, competitive pressure augments these marginal benefits as well, thus reinforcing the rises in I^*, and hence in S^* and D^*, according to Proposition 3.[33]

Another extension of the model is allowing hiring tests to be biased against outgroup members (see Sec. II.A). This complication can be shown to imply similar effects as found in the basic model. Finally, our model allows for the possibility that the outgroup is stereotypically perceived as having a higher, rather than lower, average productivity $\overline{q}$ than the ingroup. This may, for instance, occur when a group of women perceives a group of men as having a higher average productivity (see Schwieren, 2004, and footnote 32). Increasing ingroup identification may raise use and strength of such outgroup-biased stereotypic perceptions as well, by reinforcing certainty illusions and feelings of inferiority, respectively.

IV. Experimental and empirical evidence

Evidence that is consistent with the model in Sec. II is (of course) given by the social-psychological findings that we wanted to incorporate in our model (see Sec. I). In particular, the experimental findings of higher self-relevant uncertainty leading to stronger ingroup

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[33] On the other hand, these additional uncertainties may also lead to search for information to reduce them, which would diminish the reinforcement of the rises in I^*, S^* and D^*.

identification, and hence to more stereotyping, prejudices and discrimination (see Secs. II.C and D), correspond to the case of zero or at least constant X in our model. An exogenous increase in *SRUC* (interpreted as the pertinent term in eq. (12)) at given I^* and X implies a rise in marginal benefit $B_I = SRUC.R^{S}{}'(I^*)/(R^S(I^*) + R^T(X))$ (see eq. (13)), which can be associated with a rise in risk aversion $|U^{\Pi}{}''(\hat{\Pi}_0^S)|$. It is therefore predicted to lead to a higher I^* at given X (see Prop. 2), and hence higher S^*, $\Delta\overline{q}^{S*} - \Delta\overline{q}$, and D^*.

On the other hand, Tiedens and Linton (2001) find in their experimental study of individual decision-making that stronger uncertainty-related emotions lead to a more thorough look at the individual information at hand and less reliance on stereotypes.[34] In the context of our model this corresponds to higher screening expenditure X^* and a lower use of stereotypes S^*. Stronger uncertainty-related emotions are likely to lead to a higher risk aversion $|U^{\Pi}{}''(\hat{\Pi}_0^S)|$ or a lower perceived reliability of the individual information $R^T(X^*)$ at given X^*. Both changes imply a higher *SRUC* (eq. (12)) and are predicted to lead to a higher X^* at given I (Prop. 1). As far as I may have played a role in the experiments of Tiedens and Linton (the context of individualized decision-making made ingroup identification less probable), Proposition 3 predicts that I^* will rise or fall depending on the sign of $R^T{}''(X^*)$ and that X^* will unambiguously rise. As a result, use of stereotypes S^* will indeed fall when $R^T{}''(X^*)$ is "not too negative" (Prop. 4).

To test the predictions of the model with respect to competition (Sec. III) an experimental study was conducted by Schwieren et al. (2004) for the case where $X = 0$. Equilibrium identification I^* then rises as competition strengthens (Prop. 2). The experiments used artificial groups, i.e., "blue" and "red", following the minimal-group paradigm in social psychology (Tajfel et al., 1971), and tried to generate a stereotypic perception $\Delta\overline{q}^S$ along the lines of Fiedler's (1996) BIAS model (see Sec. II.D). The rise in I^* was then supposed to raise the use S^* of this stereotype vis-à-vis the use of indications that there was no real difference in average productivity between the ingroup and the outgroup. The experiments found weakly significantly higher discrimination coefficients D^* as competition was stronger, but they tended to be in favor of the outgroup. The latter result is probably related to the artificial nature of the group categories, leading to less ingroup identification than can be expected for real-life categories. Nevertheless, the effect of a rising S^* on D^* apparently dominated a possible negative income effect via $\Delta\overline{q}^{S*} - \Delta\overline{q}$ (see Prop. 5.e-f).

A study by Schwieren and Glunk (2004) extends the experimental testing to a more complex situation, using a business-simulation game, where categories used are real, namely

[34] See Tiedens and Linton (2001) also for related social-psychological literature on this subject.

different nationalities (Dutch and German). In this case the stereotype that German students performed better than Dutch students was realistic, but it was dominated by a strong discriminatory taste of Dutch against German students when competition was perceived to be strong. Moreover, perceived competition correlated significantly positive with ingroup identification. This suggests that ingroup identification can indeed play a major role in raising discrimination when competition increases (see Sec. II.D).

In an extensive empirical study Boone et al. (2003) find that top executive management teams in the newspaper-publisher industry tended to hire more 'similar' team members and fire more 'dissimilar' team members when they had more power vis-à-vis the board of directors and competition from alternative media (particularly television) was strong (interaction effect). Similarity in their study is not related to sex or race, but rather to other demographic characteristics, namely age, career path, industry experience and academic status. A major force underlying this "homosocial reproduction" effect of competition may be identification of the members of a powerful team with their ingroup ("closing ranks" as Boone et al. call it). This may have led to (more) discrimination against the outgroup.

Azmat et al. (2003) investigate the possible sources of gender gaps in unemployment in OECD countries. Most of their hypotheses find little support in the data, but they find a significantly positive interregional correlation of the gender gap with attitudes on whether men are more deserving of work than women. Hence, discrimination against women may explain part of the large gender gap in the Mediterranean countries. Moreover, there turns out to be a weakly significant positive relationship between discriminatory attitude or prejudice and overall unemployment rate across regions within European countries.[35] This suggests that stronger competition on the supply side of the labor market (higher unemployment) may raise prejudice as a result of the higher uncertainty it entails and ensuing identification with the ingroup (cf. Sec. II.D). In particular, managers who take hiring and pay decisions may be affected by this, inducing them to discriminate (more) against women.

More indirect indications that psychological identification effects of competition on discrimination might be important are given by empirical studies which find no (clear) evidence of a suppressing effect of competition in the product market on employer discrimination (as predicted by Becker, [1957], 1971). For example, Shepherd & Levin

[35] For the data of Azmat et al. we linearly regressed prejudice on unemployment rate in 1996 across 143 regions, correcting for country-fixed effects. This yielded a weakly significant positive regression coefficient (p value 0.065). We are indebted to Maia Güell for kindly informing us about the data sources of Azmat et al. and for help with the estimations.

(1973) and Oster (1975) do not find market power in the product market to influence discrimination, and Baldwin & Johnson (1996) find evidence for discriminatory hiring even if it is obviously inefficient (in the presence of competition in the product market). Furthermore, Szymanski (2000) and Preston & Szymanski (2000) find evidence in the increasingly competitive English soccer league that there was employer discrimination against black players despite of clear performance criteria.

V. Conclusions

This paper has developed a model that integrates two opposite responses to increased feelings of uncertainty in hiring and pay decisions, as suggested by social-psychological research. Employers may raise their screening expenditures on job applicants, but they may also identify more strongly with their ingroup. A simultaneous-equilibrium analysis showed that under certain plausible conditions the former response dominates the latter response, leading to less stereotyping and discrimination. As an application, the effects of increasing competition on the supply side of the product market were analysed. Strengthening competition makes the employers feel more uncertain about their profits, but it also has the effect of raising the opportunity cost of screening expenditures. This elicits substitution of ingroup identification for screening expenditures, and so enhances use of stereotypes, and hence discrimination. On a policy-making level, this calls for affirmative action to raise screening expenditures, and thus to diminish the need for ingroup identification among employers.

The main predictions of the model are reasonably robust to different specifications and extensions. There is experimental and empirical evidence that supports the implications and relevance of the model, but more research should be done to test the predictions. Perhaps, the main contribution of this paper is that it integrates an important psychological mechanism into a microeconomic discrimination model and shows how this mechanism can dominate the familiar economic forces. More specifically, social identification and stereotyping are endogenized within a microeconomic model, and this may be of relevance for all domains of economic life where these phenomena play an important role.

Appendix A. Comparative statics of *X**, *I** and *S**

The second-order condition for an interior X^*, $U_{XX}(X^*) < 0$, implies $B_{XX}^* \equiv B_{XX}(X^*) < 0$. Since $B_X^* = B_R^* R^{T}{}'^*$, where B_R^* is the marginal benefit of raising R^T by one unit at R^{T*}, it follows that $B_{XX}^* = B_{RR}^* R^{T}{}'^{*2} + B_R^* R^{T}{}''^* < 0$. Substituting eq. (10) into eq. (9) and differentiating this utility function with respect to R^T yields

$B_R{*} = \frac{1}{2} | U^{\Pi}{''}(\hat{\Pi}_0^S) | p^2 (R^S + R^{T*})^{-2}$, and hence $B_{RR}{*} = -2B_R{*}(R^S + R^{T*})^{-1}$. Substituting these expressions into the second-order condition then implies $R^T{''}{*} < 2R^T{'}{*}^2 (R^S + R^{T*})^{-1}$.

The second-order condition for an interior $I*$, $U_{II}(I*) < 0$, implies $B_{II}{*} - C_{II}{*} =$ $= B_{RR}{*} R^S{'}{*}^2 + B_R{*} R^S{''}{*} - | U^I{''}{*} | = -(2R^S{'}{*}^2 (R^{S*} + R^{T*})^{-1} - R^S{''}{*}) B_R{*} - | U^I{''}{*} | < 0.$ The first-order condition $B_I{*} = C_I{*}$ implies $B_R{*} = B_I{*} / R^S{'}{*} = C_I{*} / R^S{'}{*} = | U^I{''}{*} | / R^S{'}{*} \cong$ $\cong | U^I{''}{*} | (I - I_0) / R^S{'}$, and substituting this in the second-order condition yields $R^S{''}{*}(I - I_0) < R^S{'}{*} + 2R^S{'}{*}^2 (R^{S*} + R^{T*})^{-1}(I - I_0)$. Since $R^S{''}{*}(I - I_0) \cong R^S{'}{*} - R^S{'}(I_0) <$ $R^S{'}{*}$, This inequality is always fulfilled.

Differentiating first-order conditions $U_X = 0$ and $U_I = 0$ (omitting *) with respect to any exogenous variable Z yields $U_{XZ} + U_{XX} X_Z + U_{XI} I_Z = 0$ and $U_{IZ} + U_{IX} X_Z + U_{II} I_Z = 0$. Writing this system of two equations into Hessian-matrix form and solving it for X_Z and I_Z by inverting the matrix, we get $X_Z = h^{-1}(-U_{II} U_{XZ} + U_{XI} U_{IZ})$ and $I_Z = h^{-1}(U_{IX} U_{XZ} - U_{XX} U_{IZ})$, where h is the determinant of the Hessian matrix, which is assumed to be positive by virtue of the second-order conditions. Hence, the signs of X_Z and I_Z equal the signs of $-U_{II} U_{XZ} + U_{XI} U_{IZ}$ and $U_{IX} U_{XZ} - U_{XX} U_{IZ}$, respectively.

Elaborating these expressions for Z that raise/lower B_R, ceteris paribus, viz. $| U^{\Pi}{''}(\hat{\Pi}_0^S) |$, p, R^S and R^T, yields $-U_{II} U_{XZ} + U_{XI} U_{IZ} = -(B_{II} - C_{II}) B_{XZ} + B_{XI} B_{IZ} =$ $= -(B_{RR} R^S{'}^2 + B_R R^S{''} - | U^I{''} |) B_{RZ} R^T{'} + B_{RR} R^T{'} R^S{'} B_{RZ} R^S{'} = (-B_R R^S{''} + | U^I{''} |) B_{RZ} R^T{'}$. Since $| U^I{''} | - B_R R^S{''} \cong | U^I{''} | - | U^I{''} | (I - I_0) R^S{''} / R^S{'} = | U^I{''} | (R^S{'} - R^S{'} + R^S{'}(I_0)) / R^S{'} =$ $= | U^I{''} | R^S{'}(I_0) / R^S{'} > 0$ (see above) and $R^T{'} > 0$, the sign of $-U_{II} U_{XZ} + U_{XI} U_{IZ}$, and hence of X_Z, equals the sign of B_{RZ}. Similarly, $U_{IX} U_{XZ} - U_{XX} U_{IZ} = B_{IX} B_{XZ} - B_{XX} B_{IZ} =$ $B_{RR} R^T{'} R^S{'} B_{RZ} R^T{'} - (B_{RR} R^T{'}^2 + B_R R^T{''}) B_{RZ} R^S{'} = -B_R R^T{''} B_{RZ} R^S{'}$. Since $B_R > 0$ and $R^S{'} > 0$, the sign of $U_{IX} U_{XZ} + U_{XX} U_{IZ}$, and hence of I_Z, equals the sign of $-R^T{''} B_{RZ}$. Thus, if $B_{RZ} > 0$, $I_Z \gtrless 0$ if and only $R^T{''} \lesseqgtr 0$. Analogously, if $B_{RZ} < 0$, $I_Z \lesseqgtr 0$ if and only $R^T{''} \lesseqgtr 0$.

For $Z = R^T{'}$, that raises B_X, but not B_I, ceteris paribus, it follows that $-U_{II} U_{XZ} + U_{XI} U_{IZ} = -U_{II} B_{XR^{T'}} > 0$ and $U_{IX} U_{XZ} - U_{XX} U_{IZ} = B_{IX} B_{XR^{T'}} < 0$, and hence $X_{R^{T'}} > 0$ and $I_{R^{T'}} < 0$. Analogously, $I_{R^{S'}} > 0$ and $X_{R^{S'}} < 0$. For Z that raise C_X, ceteris paribus, viz. $U^{\Pi}{'}(\hat{\Pi}_0^S)$ and m, $-U_{II} U_{XZ} + U_{XI} U_{IZ} = U_{II} C_{XZ} < 0$ and $U_{IX} U_{XZ} - U_{XX} U_{IZ} = -B_{IX} C_{XZ} > 0$, and so $X_Z < 0$ and $I_Z > 0$. Analogously, for $Z = | U^I{''} |$, that raises C_I, ceteris paribus, we get $I_{|U^I{''}|} < 0$ and $X_{|U^I{''}|} > 0$.

Second-order condition $h > 0$ can be shown to be equivalent to $R^T{''} < 2R^T{'}^2 \left[R^S + R^T + 2(R^S{'} / R^S{'}(I_0))(R^S - R^S(I_0)) \right]^{-1}$, which is somewhat stronger than the condition for $R^T{''}$ implied by $U_{XX} < 0$ (see above), but still allows positive values of $R^T{''}$.

Stereotyping $S = (1 + R^T / R^S)^{-1}$ rises/falls at an increase in Z if and only if $R^S{}_Z / R^S \gtrless R^T{}_Z / R^T$, or $R^S{}' I_Z / R^S \gtrless R^T{}' X_Z / R^T$. For Z that raise/lower B_R, ceteris paribus, $I_Z = -h^{-1} B_R R^T{}'' B_{RZ} R^S{}' = -h^{-1} | U^I{}'' | (I - I_0) R^T{}'' B_{RZ}$ and $X_Z = h^{-1}(| U^I{}'' | - B_R R^S{}'') B_{RZ} R^T{}' = h^{-1} | U^I{}'' | (R^S{}'(I_0) / R^S{}') B_{RZ} R^T{}'$ (see above). Factoring out common factors, the condition for $S_Z \gtrless 0$ then becomes $-R^S{}'(I - I_0) R^T{}'' / R^S \gtrless R^T{}'(R^S{}'(I_0) / R^S{}') R^T{}' / R^T$ for $B_{RZ} > 0$ and the reverse for $B_{RZ} < 0$. The former condition can be rewritten as. $R^T{}'' \gtrless -\frac{R^S}{R^S{}'(I - I_0)} \frac{R^S{}'(I_0)}{R^S{}'} \frac{R^T{}'^2}{R^T} \cong -\frac{R^S{}'(I_0)}{R^S{}'} \frac{R^S}{R^S - R^S(I_0)} \frac{R^T{}'^2}{R^T}$, q.e.d. The signs of S_Z for the other Z are straightforward.

Appendix B. Effects of competition

For power function (20) with $\rho \leq 0$, a fall in p and the ensuing fall in $\hat{\Pi}_0^S$ together lead to a net rise in self-relevance $\frac{1}{2} | U^{\Pi}{}''(\hat{\Pi}_0^S | p^2$ of the uncertainty in q_i. This follows from $\frac{1}{2} | U^{\Pi}{}''(\hat{\Pi}_0^S) | p^2 = (1-\rho) \hat{\Pi}_0^{S\,-2+\rho} p^2 = (1-\rho)(\hat{\Pi}_0^S / p)^{-2} (\hat{\Pi}_0^S)^{\rho}$, which rises when p falls since $\hat{\Pi}_0^S / p = (p\hat{Q} - C) / p = \hat{Q} - C / p$, where $\hat{Q}$ is expected output quantity and C is production costs[36], then falls (neglecting minor changes in $\hat{Q}$ due to changes in $\hat{q}_i$).

For power function (20) $r(\hat{\Pi}_0^S) = (1-\rho) \hat{\Pi}_0^{S\,-1}$. Writing $p = (C + \hat{\Pi}_0^S) / \hat{Q}$, it then follows that $r(\hat{\Pi}_0^S) p^2$ is positively proportional to $\hat{\Pi}_0^{S\,-1} (C + \hat{\Pi}_0^S)^2 = C^2 \hat{\Pi}_0^{S\,-1} + 2C + \hat{\Pi}_0^S$. This function of $\hat{\Pi}_0^S$ is easily seen to have a U-shape with minimum point $\hat{\Pi}_0^S = C$. The effects of competition on X^* simultaneous with I^* are also determined by the feedback from I^* on X^*. Approximating $R^T(X)$ linearly as $R^T(X) = \alpha X$, eq. (10) is easily solved for X^* conditional on I, yielding

$$X^* = p\sqrt{r(\hat{\Pi}_0^S)/(2m\alpha)} - R^S(I)/\alpha \geq 0 \qquad \text{(B.1)}$$

or $X^* = 0$ if the expression in eq. (B.1) is negative. Next, linear approximation $R^S(I) = \beta I$ allows solving I^* simultaneous with X^* from eq. $C_I^* / R^S{}'(I^*) = C_X^* / R^T{}'(X^*)$ (implied by $B_I / R^S{}'(I) = B_X / R^T{}'(X) = B_R$) as

$$I^* = I_0 + \beta m U^{\Pi}{}'(\hat{\Pi}_0^S) / (\alpha | U^I{}''(I_0) |). \qquad \text{(B.2)}$$

When I^* is so high as to make the expression for X^* in eq. (B.1) negative, eq. (B.2) no longer holds and I^* becomes conditional on $X^* = 0$. Substituting eq. (B.2) into $R^S(I^*) = \beta I^*$, and the resulting expression into eq. (B.1), yields the formula for the simultaneous $X^* \geq 0$. In the case of power function (20) the expression for $R^S(I^*)/\alpha$ then varies as $c_2 \hat{\Pi}_0^{S\,-1+\rho}$, where $c_2 = \beta^2 m / (\alpha^2 | U^I{}''(I_0) |) > 0$. Combining this with the first term $c_1(C\hat{\Pi}_0^{S\,-1/2} + \hat{\Pi}_0^{S\,1/2})$ in

[36] These are given by wage costs $w^I N - \Delta w O$ plus non-wage costs K.

eq. (B.1), where $c_1 = \sqrt{(1-\rho)/(2m\alpha)}/\hat{Q} > 0$, it is easily derived that $\partial X^*/\partial \hat{\Pi}_0^S$ is positive (negative) if and only if $\hat{\Pi}_0^S - C$ is greater (smaller) than $-2(1-\rho)(c_2/c_1)\hat{\Pi}_0^{S-1/2+\rho}$. A graph of these functions then shows that for $\rho < 1/2$ the "greater-than" inequality, implying falling X^* as competition increases, may hold for all values of $\hat{\Pi}_0^S$, but there may also be an intermediate range of $\hat{\Pi}_0^S < C$ where the "smaller-than" inequality holds.

Substituting eq. (B.1) for X^* into $R^{T*} = \alpha X^*$, it easily follows that $R^{S*} + R^{T*} = p\sqrt{\alpha r(\hat{\Pi}_0^S)/(2m)}$. Substituting eq. (B.2) into $R^{S*} = \beta I^*$, and next substituting the expressions for R^{S*} and $R^{S*} + R^{T*}$ into $S^* = R^{S*}/(R^{S*} + R^{T*})$, yields

$$S^* = \beta\left[I_0 + \beta m\,|U^{\Pi}{}'(\hat{\Pi}_0^S)|/(\alpha\,|U^I{}''(I_0)|)\right]\sqrt{2m/(\alpha\, r(\hat{\Pi}_0^S))}/p \tag{B.3}$$

(if the inequality in eq. (B.1) holds). This expression implies that, for power function (20), S^* varies with competition in proportion to $(I_0 + (\alpha c_2/\beta)\hat{\Pi}_0^{S-1+\rho})\hat{\Pi}_0^{S1/2}/(C + \hat{\Pi}_0^S) = (I_0\hat{\Pi}_0^{S1/2} + (\alpha c_2/\beta)\hat{\Pi}_0^{S-1/2+\rho})/(C + \hat{\Pi}_0^S)$. Differentiating this expression to $\hat{\Pi}_0^S$ yields that $\partial S^*/\partial \hat{\Pi}_0^S$ is negative (positive) if and only if $\beta I_0(\hat{\Pi}_0^S - C)$ is greater (smaller) than $-(1-2\rho)\alpha c_2 C\hat{\Pi}_0^{S-1+\rho} - (3-2\rho)\alpha c_2\hat{\Pi}_0^{S\rho}$. A graph of these functions then shows that, for $\rho < 1/2$, the "greater-than" inequality, implying rising S^* as competition increases, may hold for all values of $\hat{\Pi}_0^S$, but there may also be an intermediate range of $\hat{\Pi}_0^S$ within the interval $(\tilde{\Pi}_0^S, C)$ where the "smaller-than" inequality holds.

In case rationalization makes $\Delta\bar{q}^S - \Delta\bar{q}$ linearly increasing in d^{O*}, substituting $f(I) = I - I_c$ and eq. (B.2) for I^* into eq. (19) for $\Delta\bar{q}^{S*} - \Delta\bar{q}$ yields

$$\Delta\bar{q}^{S*} - \Delta\bar{q} = \Delta\bar{q}_0^S + \gamma g(O)(I_0 - I_c)/U^{\Pi}{}'(\hat{\Pi}_0^S) + \gamma g(O)\beta m/(\alpha\,|U^I{}''(I_0)|) \tag{B.4}$$

for $I^* > I_c$ (such that the inequality in eq. (B.1) holds), while for $I^* \le I_c$ $\Delta\bar{q}^{S*} - \Delta\bar{q} = \Delta\bar{q}_0^S$. Eq. (B.4) implies that, for $I_c \ne I_0$, $\Delta\bar{q}^{S*} - \Delta\bar{q}$ varies with competition in proportion to $1/U^{\Pi}{}'(\hat{\Pi}_0^S)$, and hence for power function (20) in proportion to $\hat{\Pi}_0^{S1-\rho}$. By virtue of eq. (B.4) this contributes a factor of the form $1 + c_3\hat{\Pi}_0^{S1-\rho}$ to the variation of discrimination coefficient $D^* = S^*(\Delta\bar{q}^{S*} - \Delta\bar{q})$ with competition, where $c_3 > 0$ if $I_c < I_0$ and $c_3 < 0$ if $I_c > I_0$. Coefficient D^* then varies in proportion to $(I_0\hat{\Pi}_0^{S1/2} + (\alpha c_2/\beta)\hat{\Pi}_0^{S-1/2+\rho})(1 + c_3\hat{\Pi}_0^{S1-\rho})/(C + \hat{\Pi}_0^S)$. Writing out the numerator and differentiating to $\hat{\Pi}_0^S$ yields that $\partial D^*/\partial \hat{\Pi}_0^S$ is negative (positive) if and only if $(\beta I_0 + \alpha c_2 c_3)(\hat{\Pi}_0^S - C)$ is greater (smaller) than $-(1-2\rho)\alpha c_2 C\hat{\Pi}_0^{S-1+\rho} - (3-2\rho)\alpha c_2\hat{\Pi}_0^{S\rho} + (3-2\rho)\beta I_0 c_3 C\hat{\Pi}_0^{S1-\rho} + (1-2\rho)\beta I_0 c_3\hat{\Pi}_0^{S2-\rho}$. Graphs of these functions for $c_3 > 0$ and $c_3 < 0$ then show for $\rho < 1/2$: For $c_3 > 0$ the "greater-than" inequality, implying rising D^* as competition increases, holds for sufficiently low values of $\hat{\Pi}_0^S$, and the "smaller-than" inequality, implying falling D^*, holds for sufficiently high values of $\hat{\Pi}_0^S$, but there may also be an intermediate range of $\hat{\Pi}_0^S$, including $\hat{\Pi}_0^S = C$, where $D*$ first rises as competition increases and then falls. For $c_3 < 0$ we have the same result as for $S*$, but now the possible intermediate range of $\hat{\Pi}_0^S$ where $D*$ falls is less "probable".

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