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Social status in economic theory: a review

by

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DISCUSSION
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Social Status in Economic Theory: a Review

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Abstract

Social distinction or status is an important motivation of human behaviour. This paper provides a selective survey of recent advances in the economic analysis of the origins and consequences of social status. First, a selection of empirical research from a variety of scientific disciplines is discussed to underpin the further theoretical analysis. I then consider the origins and determinants of tastes for status, discuss the endogenous derivation of such a preferences for relative standing and assess the different formalisations these preferences. Subsequently, the consequences of preferences for status are studied for a variety of problems and settings. The last section discusses a number of implications of status concerns for normative economics and public policy.

1 Introduction

Distinction and status are among the stronger motivations of human behaviour. The importance of distinction as a fundamental biological dynamic was underlined by Darwin (1871), who introduced sexual selection as a second selection mechanism next to natural selection. To spread across the population, genes of sexual species not only need to survive in their natural and social environment, but also need to be or appear a more attractive mating partner than their same sex competitors.[1] In sociology, Bourdieu (1979) established social distinction as a crucial dynamic of culture and social life. Distinction was recognised as a powerful motivation for human conduct by the classical economists, but was increasingly marginalised (as being 'sociological' in nature) as the formalisation of economic theory proceeded, despite notorious exceptions such as Rae (1834), Veblen (1899), Pigou (1903) and Duesenberry (1949).[2] The development of game theory, the contemporary importance of consumerist culture, and a range of empirical anomalies (cfr. infra) have induced a rapid development of the economic analysis of social status in the past decades. This article provides a selective survey of the economic analysis of social status and its consequences. The first section discusses

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a selection of empirical evidence from various disciplines, motivating the formal models presented later in this article. The second section shows the endogenous derivation of status concerns from cooperation between heterogeneous partners with endogenous partner choice. The third section studies the positive consequences of relative concerns for real world economic problems and social phenomena. The last section concerns the implications of status concerns for welfare analysis and economic policy, in the form of taxation and welfare programs.

2 The Empirics of Social Status

Empirical evidence of the importance of social status comes from sociology and social psychology, biology, philosophy... In economics, the number of empirical attempts to trace the importance of status concerns for economic behaviour is more modest, but no less conclusive.

2.1 Happiness studies

This research was pioneered by Easterlin (1974,1995), who boldly answers the question whether raising the income of all will raise the happiness of all: "*It is 'no'*" (Easterlin, 1995). Evidence for this statement comes from many national and international happiness comparisons, for which respondents are asked to state their level of happiness or subjective wellbeing on an index scale. In the post-war United States (until '80), one finds no time trend in average happiness in spite of a (constant dollar) increase of median national family income of 40% (Duncan, 1975). Maddison (1991) confirms these results for the next decades. One finds a similar pattern in 1973-1989 data of nine European countries, where no happiness trend can be unravelled, in spite of a real GDP growth of 25% to 50%. In Japan, real per capita income rose to its fivefold in the 1958-1987 period but average happiness remained unchanged. As Easterlin (1995) and Easterlin and Crimmins (1991) note, people's understanding of what is essential for a 'good life'seems to grow at the same rate as GDP (Gallup, 1977). Finally, Easterlin (2001) shows that the lack of a trend in happiness is not due to a changing population: in a cohort analysis of stated happiness no increase in average happiness is noted in spite of the clear raise of average income throughout the cohort life cycle.

Interestingly, however, a strong correlation between income and stated happiness can be found in within country comparisons, as investigated by Easterlin (1995, 2001) for the United States, Oswald (2004) for the European Union, and Frey and Stutzer (2001) for Switzerland. Within a country, we see that higher income family groups report on average higher happiness than poorer families. The correlation between stated happiness and relative income is both relatively strong and very significant. Evidence for the relative income hypothesis may also be found on a micro-level. Luttmer (2005) finds that happiness depends negatively on neighbours' income.

Van Praag and Kapteyn employ a cardinal empirical utility function with a range between zero and one, named 'Individual Welfare Function of Income' (WFI), to study the impact of habit formation ('preference drift') and interpersonal comparison ('reference drift') on the subjective appreciation of income. The WFI is constructed from repondents' stated estimates of the net income needed to reach various levels of satisfaction. Van Praag, Kapteyn and co-authors use the WFI to test the relative income hypothesis (e.g. Wansbeek and Kapteyn,1985). Van de Stadt, Kapteyn and van de Geer (1985) show that utility has an important relative component. Various estimations suggest that own income, reference group mean income and past median income are important to explain the individual's WFI.

The relativity of utility is also observed for other qualities than income. Powdthaveee en Oswald (2007) find that respondents lose on average less happiness from obesity in an environment with many obese people. Clark (2003) finds that unemployment diminishes happiness less when general unemployment levels are high. Further results on the relative nature of stated happiness are surveyed by Clark (2007).

2.2 Stated preferences

Stated preference research puts respondents before a hypothetical choice problem and asks them to state their preference for the option they believe would maximise their utility. Solnick and Hemenway (1998) ask their respondents to choose for 12 different goods or characteristics (e.g. income, attractiveness, vacation time) between 2 states: a 'relative case' A, in which the respondent is worse off in absolute terms (compared to case B), but better off than the others and an 'absolute case' B, in which one is better off in absolute terms, but worse off then the others. For example:

- A: Your current yearly income is \$50,000; others earn \$25,000
- B: Your current yearly income is \$100,000; others earn \$200,000

(Prices are what they are currently and are the same in states A and B)

Solnick and Hemenway (1998) find that for some goods, up to 80% of the respondents prefer the relative case. The number of people choosing option A is highest for attractiveness and intelligence and lowest for workload and vacation time (still almost 20%), with income in the middle. A similar survey was undertaken by Tversky and Griffin (1991), who let respondents choose between a job at a magazine A, with own salary of \$35,000 and colleagues paid \$38,000 and a magazine B, where one earns \$33,000 and others \$30,000. Tversky and Griffin report that 85% of the respondents prefer magazine A, but that in a second group 64% believe to be happier at magazine B. Note also the difference in reference group: Solnick and Hemenway (1998) enclose all others, while Tversky and Griffin (1991) consider only colleagues. Johansson-Stenman, Carlsson and Daruvala (2002) let respondents choose between two states for their hypothetical grandchildren and fit a constant relative risk aversion utility function through the results. They also find that respondents are willing to pay considerably to improve the relative position of their hypothetical grandchildren. Alpizar, Carlsson and Johansson-Stenman (2005) use a similar survey to discriminate between different functional forms. They conclude that positionality matters far more for commodities as houses and cars than for vacation and insurance, but also that both absolute and relative consumption matter for each category.

2.3 Revealed preferences

Real life revealed preference techniques have the advantage that people have to live the consequences of their choices, cannot answer strategically and have the opportunity to learn. Unfortunately, real world behaviour typically fits many alternative interpretations. To minimize vulnerability to this identification problem (the 'Manski reflection problem', Manski (1993, 2000)), ingenious setups are required. Revealed preference work on status therefore trades off generality and robustness against alternative explanations, although this can be cured partially by more sophisticated data.

George Kosicki (1987) shows how the fact that, contrary to permanent income and life cycle models, saving rates rise with long run income can easily be rationalized and well predicted by a simple model with relative concerns. Stark and Taylor (1991) study international and intranational migration and find that if absolute income is controlled for, relative income (within the village) is important in explaining migration decisions. Glazer and Konrad (1996) argue that charity donations are also motivated by status motives, (probably) next to altruism. That some donators are also concerned with status is shown by donation records of institutions that report the names of donators in donation categories (e.g. \$150-500, \$501-\$1000, 1001-5000, ...). Glazer and Konrad observe that mean donations within each category are very close to the category lower bound, as predicted by a theory of donations as signals. Harbaugh (1998) fits a utility function through similar alumni donation data of law schools. He finds that status seems an important motivation for charity and that overall donations can be expected to decrease if not reported at all, and increase if fully reported. Neumark and Postlewaite (1998) incorporate preference interdependence in a female labour supply model. They study whether the labour decision of a woman depends on the choices of her sister-in-law, to avoid spurious regressions due to common social background. Neumark and Postlewaite find a positive effect of employment of the sister-in-law on a woman's labour decision and that if the sister-in-law is unemployed, a woman is significantly more likely to be employed if her husband earns less than her sister-in-law's husband.

2.4 Medical and biological evidence

A range of medical and biological evidence testifies that social status induces something real to happen in both the human and primate brain and body. Long et alii (1982) find that test persons show a higher heart rate and blood pressure when confronted with an experimenter who bears signs of a high status (suit, name tag, formal language). McGuire et al. investigate the relation between status and the neurotransmitter serotonin (McGuire et al. 1982). High serotonin concentrations are associated with feelings of happiness, whereas deficiencies in the serotonin metabolism are linked to depression, suicide attempts, mania and sleeping disorders. In groups of vervet monkeys, the dominant animal carries a much (on average 50%) higher concentration of the serotonin in his blood. By removing the leader, a new substitute leader-monkey sees its serotonin level rise, and decline again when the old leader is reintroduced (Frank, 1985b). Raleigh *et alii* (1986, 1994) found that serotonin also helps individuals to rise in the hierarchy: monkeys treated with a drug that boosts serotonin levels are significantly more likely to climb the hierarchy (Frank, 1999). The same team also found significant differences in serotonin levels in local human hierarchies, such as college fraternities and athletic teams (Frank, 1985a). In males, there also exists a relation between status and testosterone: reductions in social status are followed by a decrease in plasma testosterone concentrations and a rise in social hierarchy by an increase. Tennis players show higher testosterone concentrations after they won a match (Frank, 1999).

Medical studies find that the wealthier people in society tend to be healthier and longer lived. Wilkinson (1996) notes that increases in absolute wealth, though initially important, affect human health with sharply diminishing returns: once per capita income reaches about $ 5000 a year, additional income gains produce little health gains. However, within countries relative deprivation and health are correlated. But does health cause a higher income, or does relative income also affect health? The first causality is obvious, but research also confirms the inverse causality. Marmot et al. (1984,1991) investigate British civil servants, who are all well educated, well paid, have access to the National Health Service and have a clear local hierarchy. They found that mortality, after controlling for a range of causal factors, was inversely correlated with the ranking in the local hierarchy. Another indication comes from a population of 524 top scientists. Rablen and Oswald (2008) find that in a population of winners and nominees of the Science Nobel Prize, and after correcting for a variety of potential biases, effectively winning the prize lengthens lifetime on average between one and two years.

3 Modelling the Struggle for Social Status

Part of the evidence above suggests that we enjoy status for the sake of status itself. Social status can then be considered an ultimate motive for human action. However, when applying for a job, office or place in a sporting team, it is the relative the rather than the absolute level of capacities that is decisive. In social life, a general omnipresent social ranking criterion matters for the allocation of many goods: social status. Weber (1922) defined 'social status' as: "'*Status' shall mean an effective claim to social esteem in terms of positive or negative privileges*". The positions in the socially perceived ranking in a social group determine the allocation of a range of socially provided goods, such as (sexual) mates, friends, invitations, partnerships, esteem, sympathy, courtesy, help etc. (see also: Corneo and Jeanne (1998)). In turn, these mates, partners or friends often imply material advantages. Marrying a rich counterpart can be an effective way of raising disposable income, as historical upper class marriage customs demonstrate. The provision of several rationed or heterogeneous goods often functions similarly. This interpretation suggests that preferences should be defined over ordinary commodities and that a rank dependent social allocation mechanism should be modelled next to the market.

If there were no interdependence between status and consumption and labour decisions, status could go in the *ceteris paribus* clause and would only be of limited importance. However, social status is not independent of consumption or labour decisions and the introduction of social status changes the predictions of economic models considerably.

3.1 Constraint or preference interdependency?

People care about their relative standing for the sake of status itself and because high social status implies many material and non-material benefits. How should one then proceed in modelling the social interdependencies induced by social status? Manski (2000) distinguishes three categories of interdependencies by which social interactions can be channelled in the usual microeconomic model: constraint interactions, expectation interactions and preference interactions.

Constraint interactions include competitive markets: the demand and supply by all consumers and producers together determine the prices and incomes, and thereby set of feasible consumption bundles. Expectation interdependencies arise under uncertainty, when consumers form expectations based on (past) choices of themselves and others (e.g. statistical discrimination). Preference interactions mean that preference orderings depend on the choices of others, implying that the behaviour of others becomes a direct argument of the utility function (e.g. fashion).

Which way should one walk to model social status interdependencies? Part of the empirical evidence supports the instrumental interpretation of status, indicating a constraint interdependency, while the biological and medical evidence suggests that preferences are the right place to introduce status-interdependencies. Both ways of modelling are valuable and preferable in some contexts and, yet, there needs not to be a juxtaposition. The instrumental approach is more fundamental and rationalises the direct preference interpretation as a behavioural or emotional shortcut. Postlewaite (1998) argues that the preference interdependency and constraint interdependency approach are equivalent, because some utility functions with status directly as an argument can be understood as a reduced form formulation of a model in which relative position is instrumental.

If one chooses to enter the status interdependency directly in the preferences, then two major options stand out: the Duesenberry formulation and the Frank formulation. Duesenberry (1949) proposes a utility function of the form,

$$U_i = U_i\left(\frac{C_i}{\sum_j \alpha_{ij} C_j}\right) \tag{1}$$

with C_i the consumption of person i and α_{ij} the weight attached by person i to the consumption levels of person j.. This specification is the oldest and has the advantages that utility changes continuously in own and other consumers' consumption and that one can enter social structure through the reference weights. The major alternative is the formulation of Frank (1985b),

$$U\left(x, y, \Psi(y)\right)$$

in which utility increases with the consumption of two goods x and y and with the rank in the distribution of good y in the population $\Psi(y)$, with $\Psi(.)$ the distribution function of consumption of good y in the population. This formulation has the advantage that it is rationalised by the constraint interdependency approach (cfr. infra), but the disadvantage that utility is discontinuous in the consumption of others and for finite populations also in own consumption. Hopkins and Kornienko (2004b) developed this specification further into $U\left(x, y, S(y, \Psi(y))\right)$ with:

$$S(y) = \gamma\Psi(y) + (1-\gamma)\Psi^{-}(y) + S_0, \tag{2}$$

in which $\gamma \in [0,1[$ and $S_0 \in \mathbb{R}^+$ are constants and $\Psi^{-}(y) \equiv \lim_{\breve{y}\to y} \Psi(\breve{y})$ denotes the mass of individuals with consumption strictly less than y. This formulation solves the difficulty of ties in Frank's approach. The formulation of Frank (1985) suffers from the flaw that if all consumers buy the same amount of y, they all have the maximal status and no incentive to increase conspicuous consumption. This is not only counterintuitive, but it also tends to complicate analysis as it allows for infinitely many equilibria. The parameter γ represents the loss in utility from ties and ensures that the utility of being better than someone is strictly greater than the utility of sharing a rank with this person. The constant S_0 represents the harshness of status competition, as a minimum status level without any investment in status enhancing goods.

The major alternative to the preference interdependency models, the constraint interdependency approach, is matching models. These models are the most popular way of rationalising relative concerns since Cole, Mailath and Postlewaite (1992). They can be understood in the Lancaster-Becker tradition of endogenising marginal utility from consumption to allow for endogenous changes of the preferences over market commodities.

3.2 Finding the Right Match

Humanity's superiority as a species stems largely (next to e.g. cognitive capabilities) from the capacity to exploit the gains of specialisation and cooperation. If no two people are the same, choosing the best attainable partner to cooperate with is likely to be a crucial determinant of success. I restrict my attention on the following pages to the case in which each consumer can form a partnership with at most one other consumer: one-to-one matching. The many-to-one matching case produces similar but more extreme effects, as the rewards to outcompeting one's peers are higher. Each partner derives some benefits from cooperation through a jointly produced and shared good. Assume that the produced surplus is a good, such that the utility functions are increasing in this argument and that the capacities to produce joint surplus depend on some dimensions of the consumers' heterogeneity. Then consumers compete for the best match if partner choice is free. Let each match be a relation between members of two disjoint sets of consumers (typically male-female, employer-employee, principal-agent...). This is called 'two-sided-matching'. A two-sided-matching is called 'positively assortative' along some dimensions if consumers of equal ranking along these dimensions are matched together. For historic reasons, it is common to use the marriage market as described in Becker's 'Theory of Marriage' (1973) as the generic illustration of two-sided-matching models.

3.3 Basic Settings

Consider two disjoint sets of equal cardinality: a set $\mathcal{H} = \{h\}$, conveniently called 'males', and a set $\mathcal{F} = \{f\}$ of 'females', with $f, h = 1, ..., N$. Let all relevant individual quality be captured by a positive real number m. For males, $m(h) \in \mathcal{M}_H \subseteq \mathbb{R}_+$ is distributed according to $\Psi^H(m)$ and density function $\psi_H(m)$, and for females $m(f) \in \mathcal{M}_F \subseteq \mathbb{R}_+$ is distributed according to $\Psi^F(m)$, with density function $\psi_F(m)$. I employ the shorthand notation $m(h) \equiv m_h$ and $m(f) \equiv m_f$. Let f and h to be attributed from low to high m, such that $f < f' \Leftrightarrow m(f) < m(f')$ and $m(h) < m(h')$. These consumers may form a partnership with at most one member of the opposite set, such that the overall pattern of partnerships is characterised by a matching correspondence.

Definition 1 (Matching Correspondence) *A matching μ is a one-to-one correspondence from $\mathcal{H} \cup \mathcal{F}$ onto itself to the second order (i.e. $\mu(\mu(h)) = h$), such that $\mu(h) \in \mathcal{F} \cup \{\varnothing\}$ and $\mu(f) \in \mathcal{H} \cup \{\varnothing\}$.*

A 'blocking pair' for a matching μ is a pair of man and woman $(h, f) \in \mathcal{H} \times \mathcal{F}$ who are not matched together by μ, but who mutually prefer to be matched to eachother above their present match. A matching μ is 'individually rational' if no matched male or female prefers to remain unmatched above their partnership in matching μ. Using these pairwise and individual rationality requirements, one may qualify a matching equilibrium as a core-equilibrium:

Definition 2 (Stable Matching) *A matching μ is 'stable' if it is individually rational and if it is not blocked by any pair $(h, f) \in \mathcal{H} \times \mathcal{F}$.*

Gale and Shapley (1962) show that a stable matching always exists in one-to-one two-sided matching games. Assume for now, without much loss of generality, that all prefer any partner to remaining unmatched. Their algorithm to find (and prove the existence of) a stable matching consists of an iterative procedure in which each man proposes first to his most preferred woman. All women who receive proposals keep their most preferred choice on a string and reject the others. In the next round, the rejected men propose to their second choice, after which the women again keep their favourite choice (from the new proposals and the one they kept waiting) and send the rest off. After at most $N^2 - 2N + 2$ stages, each woman will have received at least one proposal and the 'courtship period' is over. Each woman accepts the one man she has waiting for her and a stable matching is implemented. This matching is stable, because if some man – say André – prefers another woman to his present wife, then he must have proposed to her before and she must necessarily have turned him down for a better man, Eric, who can only have been sent off for yet an even better man, and so on. Hence, there is no space for a mutual improvement. The problem is therefore not the existence, but the abundance of stable matchings. While the procedure above provides the best possible stable matching for males, indicated by μ^H, Roth and Sotomayor (1990) show that the procedure in which females propose results in a generally different matching profile, μ^F. The set of stable matchings consists in general of more matchings, with $\mu^M$and μ^F the most preferred by respectively males and females.

Assume that all consumers engage in a partnership to produce a joint surplus $\pi(m_h, m_f)$, which depends only on the levels of characteristics m_h and m_f in such a way that $\pi(m_h, m_f)$ is strictly increasing in both arguments. This joint surplus is divided among the two partners, in a share q_h for male h and a share q_f for female

f, which are both normalised to equal 0 for the share which equals their production without a partner. The total surplus $\pi(m_h, m_f)$ is divided among the partners by bargaining and in accordance to a particular 'consumption technology'. In the general case of non-transferable utility (NTU), the set of feasible divisions of a surplus $\pi(m_h, m_f)$ is characterised by a possibility frontier $\varphi(.)$ such that the male partner h can obtain at most $q_h = \varphi(m_h, m_f, q_f)$ out of a partnership with female f, who gets a share q_f and female f gets at most $q_f = \varphi(m_h, m_f, q_h)$ out of a partnership with a male h who gets q_h, with $q_h, q_f \in [0, \varphi(m_h, m_f, 0)]$ and $\varphi'_3(.) < 0$. One may distinguish two interesting special cases of this consumption technology formulation. In the transferable utility (TU) case, the whole surplus $\pi(m_h, m_f)$ can be divided among the partners along a linear possibility constraint such that $\pi(m_h, m_f) = q_h + q_f$. Alternatively, in perfect local public good case the possibility constraint is reduced to a point, such that $\pi(m_h, m_f) = q_h = q_f$.

Except for the perfect local public good, a matching equilibrium requires a specification of the partnerships (a stable matching) and a division of the surpluses among the partners which supports the stable matching.

Definition 3 (Matching Equilibrium) *A matching equilibrium specifies a matching correspondence μ and a surplus division q_h^* and q_f^* such that*

1. *for a given matching μ all pairs of surpluses of matched partners $\left(q_h^*, q_f^*\right)$ are feasible: $q_h^* \leq \varphi(m_h, m_f, q_f^*)$ for $h = \mu\left(f\right)$.*
2. *the matching μ is stable given the surplus division q_h^* and q_f^*: there do not exist any unmatched h and f and $\bar{q} > q_h^*$ such that $\varphi(m_h, m_f, \bar{q}) > q_f^*$.*

3.4 The baseline case

Can one predict a stable equilibrium of a matching game? Eeckhout (2000) shows conditions which reduce the set of stable matchings to a singleton $\{\mu^*\}$. One sufficient and intuitive condition requires all consumers to have the same ranking of potential partners. If all consumers prefer a partner with higher m above one with lower m, i.e.

$$\forall h \in \mathcal{H} : f \succ_h f' \Leftrightarrow f > f' \Leftrightarrow m_f > m_{f'}$$
$$\forall f \in \mathcal{F} : h \succ_f h \Leftrightarrow h > h' \Leftrightarrow m_h > m_{h'},$$

with $a \succ_x b$ denoting "x prefers a over b", then there exists a unique stable matching which is positively assortative along m_h and m_f, such that

$$\mathbb{N} \ni x \leq N : \mu^*(x) = x.$$

But when does this condition apply? In the case of the pure local public good, PAM is the unique stable matching whenever the surplus $\pi(.)$ is strictly monotonic in quality m. For transferable utility, conditions for PAM were first formulated by Becker (1973). Definitive sufficient conditions for PAM in the TU case are provided by Legros and

Newman (2002), and shown by Amir (2005) as a special case of the Topkis (1968) supermodularity result. A sufficient condition for PAM in the TU case is supermodularity of the surplus function, i.e.

$$\frac{\partial^2 \pi(.)}{\partial m_f \partial m_h} \geq 0.$$

This can for the discrete case be rewritten as:

$$\forall h > h', f > f' : \pi(m_h, m_f) - \pi(m_h, m_{f''}) \geq \pi(m_{h'}, m_f) - \pi(m_{h'}, m_{f'}),$$

which means that the incremental output of the better male switching to the better female exceeds the incremental output of the worse male switching to the better female, so that the better male can always (weakly) outbid the worse male to persuade the more attractive female. Legros and Newman (2007) have generalised this condition to the NTU case. A sufficient condition for PAM is then:

$$\begin{gathered} \forall h > h', f > f', \forall \bar{q}^{f'} \in [0, \varphi(m_{h'}, m_{f'}, 0)] : \\ \varphi(m_h, m_f, \varphi(m_h, m_{f'}, \bar{q}^{f'})) \geq \varphi(m_{h'}, m_f, \varphi(m_{h'}, m_{f'}, \bar{q}^{f'})). \end{gathered} \tag{3}$$

This condition may be read again as following: fix $\bar{q}^{f'}$ at some level as the share which the worst female receives. Then, at the left hand side $\varphi(m_h, m_{f'}, \bar{q}^{f'})$ denotes what female f should give male h to make him indifferent between matching f and f' and hence $\varphi(m_h, m_f, \varphi(m_h, m_{f'}, \bar{q}^{f'}))$ is what she may maximally get out of a match with h. Similarly, at the right hand side, $\varphi(m_{h'}, m_{f'}, \bar{q}^{f'})$ is what makes male h' indifferent between matching f and f' and therefore $\varphi(m_{h'}, m_f, \varphi(m_{h'}, m_{f'}, \bar{q}^{f'}))$ is what she can maximally get out of a match with h'.

These conditions for PAM are independent of the distribution functions Ψ^H and Ψ^F. The distributions do matter, however, for the size and division of the surplus. PAM implies that male h's partner quality is in equilibrium

$$m_f(\mu^*(h)) = \left(\Psi^F\right)^{-1} \left(\Psi^H(m_h)\right).$$

Hopkins (2005) studies the comparative statics of partner quality of a PAM with respect to the distributions Ψ^H and Ψ^F. Figure 1 illustrates PAM in two economies A and B, in which the distribution of m_f is identical but the distribution of male quality m_h differs. Distribution $\Psi^H_A(m)$ stochastically dominates distribution $\Psi^H_B(m)$ and this makes any male better off in society B. For a quality m male, the partner quality is b in society B and a in society A.

The females are better off in economy A compared to economy B. Clearly, the converse goes for two economies that differ only in the distribution of female qualities.

The distributions Ψ^H and Ψ^F also restrict the division of $\pi(.)$: by determining the surplus of the next best match of each of the partners, the matching process imposes a lower bound on the acceptable divisions of $\pi(.)$. Cole, Mailath and Postlewaite (2001) and Felli and Roberts (2002) apply this idea to the labour market and study the extent to which matching solves (or attenuates) the underinvestment of both parties as a consequence of the hold-up problem (investments, once acquired, are sunk costs and can therefore not be used in wage bargaining).

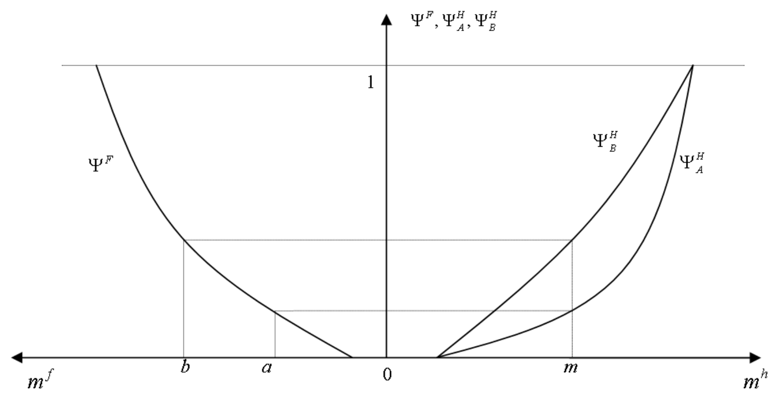

Figure 1: Positive Assortative Matching and Stochastic Dominance of $\Psi_A^H(m)$ over $\Psi_B^H(m)$ (after: Hopkins, 2005).

3.5 Matching along endogenous qualities

In the last paragraph, the utility of each consumer depended by assortative matching exogenously on her ranking among peers. In reality, the qualities along which matching occurs are mostly manipulable. This can be either because the true qualities are imperceptible, such that consumers distinguish themselves from lower types by costly signaling, or because the relevant qualities which determine the joint surplus are manipulable. In both cases, consumers invest in their observable quality to enhance their attractiveness as a partner. This implies a strategic investment decision: the returns to investment depend both on the own investment and on that of the competitors.

As a matter of taxonomy, one may - next to the TU-NTU distinction - distinguish six broad categories of matching along endogenous qualities games. A first categorisation concerns the sexes that signal:

1. *Both sexes invest.* The relevant matching qualities of both sexes are manipulable and hence both sexes inflate their attractiveness. This case tends to be analytically involved: both the costs of achieving a rank (the distribution of qualities of the own sex) and the returns to achieving that rank (the distribution of quality of the opposite sex) are endogenous for all consumers.

2. *One-sided investments.* The matching qualities of only one sex are manipulable. This is common in biological settings of sexual selection, but these are in fact mostly many-to-one matching models: since the best male can often perfectly inseminate all females, there is no incentive for the females to boost attractiveness. In one-to-one matching models, one-sided signaling is generally only assumed for analytical convenience.

A second important distinction is the functionality of the investment to partners:

1. *Costly signaling*: The classical signaling case, inspired by Spence (1974). The true quality of consumers is invisible to potential partners, and consumers invest

in a costly signal which is useless to the other sex (no argument of $\pi(.)$), but whose marginal costs are higher for worse types. Partners care about signaling as a reliable indicator of true quality. The signaling consumer may or may not derive direct utility from signaling.

2. *Premarital investment game*: The investment variable is the only reason for getting involved in the partnership. No other invisible characteristic matters for the joint surplus $\pi(.)$.

3. *Productive signaling*: The hybrid case, in which the signal itself is intrinsically valuable to the partner, but other exogenous characteristics matter as well. The surplus depends on a combination of endogenous investments and exogenous qualities.

A last important distinction in the matching along endogenous quality games concerns the size of the population. For very large populations, Peters and Siow (2002) and Peters (2006, 2007) show that the matching equilibrium bears strong resemblance to the hedonic pricing equilibrium of Rosen (1974).[3] In not so large populations, strategic interactions may become more intricate and attention is usually limited to particular symmetric equilibria.

The matching along endogenous qualities game is played in three stages:

1. Investment stage: consumers invest in observable qualities, denoted by $I \in \mathbb{R}_+$.

2. Matching stage: partners of the opposite sexes are matched along the relevant visible qualities.

3. Division of the surplus.

Consider the one sided signaling matching game with a pure local public good consumption technology, similar to that of Hopkins (2005). Assume two continua of consumers of equal measure distributed over the typespaces $\mathcal{M}_H$ and $\mathcal{M}_F$. Assume finally that males are the signaling sex and let (without too much loss of generality) m^h denote income. Female consumers choose a partner to maximise joint surplus. The male consumer divides income m^h on visible investments I and an aggregated rest consumption good. The prices of both goods are normalised to one. Visible investments serve the consumer in two ways: they generate utility directly and determine the surplus from cooperation, as I determines both the partner quality and own productivity. Let the preference ordering of all males be represented by an identical utility function which depends on income m^h, investments in visible good I and the quality of partner m^f:

$$V : \mathcal{M}_H \times \left[0, m_M^h\right] \times \mathcal{M}_F \to \mathbb{R}_+ : \left(m^h, I, m^f \left(\mu^* \left(I\right)\right)\right) \to \mathbb{R}_+.$$

Each male chooses I to maximise utility $V(.)$. Let $I : \mathcal{M}_H \to \left[0, m_M^h\right] : m^h \to I\left(m^h\right)$ represent the optimal investments of each type of male. If $I(.)$ is monotonically increasing in m^h and $\pi\left(.\right)$ still strictly increases in m^h and I, then the equilibrium matching is PAM in m^f and I and

$$m^f\left(\mu^*\left(I\left(m^h\right)\right)\right) = \left(\Psi_F\right)^{-1}\left(\Psi\left(I\left(m^h\right)\right)\right) = \left(\Psi_F\right)^{-1}\left(\Psi_H\left(I^{-1}\left(I\left(m^h\right)\right)\right)\right),$$

where $\Psi(I)$ represents the distribution function of I. Note that this implies that

$$\frac{\partial m^f(.)}{\partial I} = \frac{\psi\left(I\left(m^h\right)\right)}{\psi_F\left(\left(\Psi_F\right)^{-1}\left(\Psi\left(I\left(m^h\right)\right)\right)\right)} \text{ or } \frac{\partial m^f(.)}{\partial m^h} = \frac{\psi_H\left(m^h\right)}{\psi_F\left(\left(\Psi_F\right)^{-1}\left(\Psi_H\left(m^h\right)\right)\right)}$$

with ψ_H, ψ_F and ψ the density functions associated with, respectively, $\Psi_H(.)$, $\Psi_F(.)$ and $\Psi(.)$. In the fashion of Mailath (1987), one needs to impose a number of regularity conditions on $V(.)$ to guarantee a unique strictly increasing incentive compatible equilibrium (with $V_k'(.)$ and $V_{kj}''(.)$, respectively, the first and second order derivatives to the k$-$th argument and the k-th and j-th argument):

Condition 4 (Smoothness) *$V(.)$ is twice continuously differentiable.*

Condition 5 (Partner Monotonicity) *$V_3'(.) > 0$ on $\mathcal{M}_H \times \left[0, m_M^h\right] \times \mathcal{M}_F$.*

Condition 6 (Type Monotonicity) *$V_{12}''(.) > 0$ on $\mathcal{M}_H \times \left[0, m_M^h\right] \times \mathcal{M}_F$.*

Condition 7 (Strict Quasiconcavity) *$V_2'(.) = 0$ has a unique solution on $\mathcal{M}_H \times \left[0, m_M^h\right] \times \mathcal{M}_F$,which is denoted I^o (the 'intrinsic optimum'), where $V_{22}''(m^h, I^o, m^f) < 0$.*

Condition 8 (Boundedness) *There exist $\varepsilon, k > 0$ such that $|V_2'(.)| > k$ for $|I - I^o| > \varepsilon$ on $\mathcal{M}_H \times \left[0, m_M^h\right] \times \mathcal{M}_F$. There exists an $\varepsilon > 0$ such that $\psi_F(.) > \varepsilon$ on $\mathcal{M}_F$ and a $0 < K < \infty$ such that $\psi_F(.) < K$ on $\mathcal{M}_H$.*

Condition 9 (Initial Value) *$I(m_1^h) = I^o(m_1^h)$.*

Condition 10 (Single Crossing) *$\frac{V_3'\left(m^h, I, m^f\left(\mu^*(I)\right)\right)}{V_2'\left(m^h, I, m^f\left(\mu^*(I)\right)\right)} \frac{\partial m^f(.)}{\partial I}$ is strictly monotonically increasing in m^h over $\mathcal{M}_H$.*

Condition 5 encompasses the different types of investments and consumption technologies distinguished above, as it requires only that males prefer 'better' partners over worse. Condition 6 requires that the marginal utility cost of any level of investment is decreasing in income, i.e. it is always easier for higher income males to afford some level of investment than for lower income males. Condition 7 ensures that all males would have a unique optimal level of investments I in the absence of matching concerns. Condition 9 is in fact an optimality condition and requires that the poorest male, who will in equilibrium be matched with the poorest female anyway, will find it optimal to choose the investment he would make in the absence of matching concerns. Since there are no worse types to outcompete, he does not distort his behaviour because of matching. Condition 10 is the common single crossing condition for a continuum of types.

Under these conditions, it can be shown along the lines of Mailath (1987), that there is a unique equilibrium investment function $I(.)$, in which all males maximise their utility and PAM is stable. Moreover, the unique equilibrium investment function solves the initial value problem

$$\frac{\partial I}{\partial m^h} = -\frac{V_3'\left(m^h, I, m^f\left(\mu^*\left(I\right)\right)\right)}{V_2'\left(m^h, I, m^f\left(\mu^*\left(I\right)\right)\right)} \frac{\psi_H\left(m^h\right)}{\psi_F\left(\left(\Psi_F\right)^{-1}\left(\Psi_H\left(m^h\right)\right)\right)} \tag{4}$$
$$I(m_1^h) = I^o(m_1^h)$$

One intuition for the initial value problem in equation 4, suggested by Mailath (1987), is to allow all males to choose the male type $\hat{m}^h$ they want to be taken for by the females, given their true income m^h and the investment of such a type $I\left(\hat{m}^h\right)$. Males solve $\max_{\hat{m}^h} V\left(m^h, I\left(\hat{m}^h\right), m^f\left(\hat{m}^h\right)\right)$, whence the first order condition

$$V_2'\left(m^h, I\left(\hat{m}^h\right), m^f\left(\hat{m}^h\right)\right) \frac{\partial I}{\partial \hat{m}^h} + \tag{5}$$
$$V_3'\left(m^h, I\left(\hat{m}^h\right), m^f\left(\hat{m}^h\right)\right) \frac{\psi_H\left(\hat{m}^h\right)}{\psi_F\left(\left(\Psi_F\right)^{-1}\left(\Psi_H\left(\hat{m}^h\right)\right)\right)} = 0.$$

All consumers equate the marginal benefits of investing in I and getting a better partner (the second term) to the marginal utility costs of I (foregoing other consumption), net of possible direct utility benefits (both in the first term). If all consumers try to cheat in the same way, and if conditions 4 to 10 ensure that this optimum is strictly increasing in m^h, then this first order condition defines equilibrium investments $I\left(m^h\right)$, from which no male wants to deviate. Equation 5 can be rewritten to the differential equation in (4).

In equilibrium, all males invest just enough to discourage worse types from aspiring a better female and all males, but the worst, invest strictly more than what they would in the absence of matching. How much more depends on the utility function and the distributions of male and female exogenous qualities. Hopkins (2005) shows that the highest income males generically invest more if competition among high income types is fiercer (higher density of high types), but that more general statements require strong assumptions on $V(.)$ and the distribution functions. The comparative statics of partner quality, as demonstrated in the baseline case, remain of course valid. In the case of transferable utility the PAM outcome generally restricts the bargaining process considerably for a continuous typespace. The partners should get a sufficient share of the surplus in order not to prefer a lower partner type.

3.6 Indirect Preferences Revisited

Matching shows how under general conditions of cooperation among heterogeneous consumers with free partner choice, both the absolute and relative qualities of a consumer determine wellbeing. If the relevant qualities are manipulable, then the marginal utility of such a quality I depends through $\Psi(I)$ on the decisions of all other consumers. This generates an interpersonal interdependency in the consumer problem, which is not mediated by markets. The utility function with relative concerns entered directly in the style of Frank (1985b), a preference interdependency, is a reduced form of the consumer problem with matching along endogenous qualities (with the interdependency entered in the constraint):

$$V(m^h, I, m^f(\mu^*(I))) \approx U(m^h, I, \Psi(I))$$

If matching along endogenous qualities can be written in the Frank (1985) formulation, why then bother about matching? Postlewaite (1998) assesses the advantages of the direct (preference interdependence) and indirect (constraint interdependence) approach in three arguments. First, competition for partners explains why humans, as other mammals, seem to have hardwired preferences for status. Second, however, not entering ranking concerns directly has important methodological advantages over the direct approach. It allows to stick to the standard body of methods and its main virtues: parsimony and tractability. In line with the Lancaster-Becker paradigm, one defines stable 'deep' preferences over 'basic commodities' and social processes such as matching then allow rationalising and endogenising differences in preferences over market commodities. Third, the direct utility approach tends to explain virtually anything and hence nothing at all, as adding an immaterial variable as status weakens the predictive and explanatory power by increasing the arbitrariness of models. The indirect approach constrains the solution considerably and allows to make testable predictions of how social structure and formal and informal institutions map onto relative concerns through the matching process. Of course, the indirect approach also has drawbacks. First, although emotional behavioural shortcuts evolved to solve constraint or information interdependency problems, nothing guarantees that they always solve these optimally, such that an indirect approach may not predict actual behaviour correctly. Second, entering interdependencies through the constraint is more complicated, such that preference interdependencies are often preferred for viability. In the remainder of this article, I therefore often employ the preference interdependency approach as a reduced model.

4 Status and the Real World: Applications

4.1 Static Applications: A Consumption Bias

Relative concerns create a 'relativistic bias' in consumption choices: they push consumers away from the consumption pattern they would prefer in social isolation. Hirsch (1976) noted that interpersonal comparison is more important for some goods than for others. He named commodities as clothing, cars and housing, for which status pressures affect choices more, 'positional goods'. 'Nonpositional goods' have a relatively small social utility component and are typically goods like family time, insurance and workplace safety... One can easily formalize this relativistic bias in a static two goods model. Let m denote income, which a consumer can spend on a visible positional good I at price p_I (for 'status investment'), for which both absolute consumption and relative consumption $S(I)$ matters, and 'nonpositional' good c (for 'rest consumption') at price p_c. Social status $S(I)$ is defined as in (2). The consumption problem is:

$$Max \quad U(I, c, S(I)) \quad s.t. \quad p_I I + p_c c \leq m.$$

The first order condition dictates the equality of marginal utilities over prices,

$$\frac{1}{p_I}\frac{\partial U(.)}{\partial I} + \frac{1}{p_I}\frac{\partial U(.)}{\partial S}\psi(I) = \frac{1}{p_c}\frac{\partial U(.)}{\partial c}. \tag{6}$$

The marginal utility of I consists of two components: intrinsic marginal utility and social marginal utility $\frac{1}{p_I}\frac{\partial U(.)}{\partial S}\frac{\partial S(I)}{\partial I}$.[4] Relative concerns have traditionally been conceived as a wasteful, welfare reducing pressures. The reason is that status competition is zero-sum game in ranks, as Hirsch (1976) noted. When a consumer rises one place in the hierarchy, another necessarily goes down one place. If equilibrium investments $I(m)$ are strictly increasing in income, then all would achieve the same status by investing only a fraction of I or if m were visible (and the only relevant variable). The social marginal utility component of I is a 'spurious return' (Frank, 1985b). However, investing in I is typically the dominating strategy: if others abstain from investing, one may gain ranks by investing. And if all others invest, one has to invest to maintain the present rank. As a consequence, all are trapped in a n-person prisoners' dilemma. As Hirsch (1976) puts it: "*Consumers, taken together, did not get what they ordered.*" Frank (1985a, 1999) extensively illustrates this 'relativistic bias' for the case of overspending in conspicuous goods like cars, private airplanes, housing, exclusive wines and cigars and other luxury goods and underspending in nonpositional goods like leisure and family time, saving and insurance. Cole, Mailath and Postlewaite (1995) show how matching concerns make consumers work too much and enjoy suboptimally little leisure. Robson (1992) shows excessive risk taking as a consequence of status concerns.

4.2 Dynamic Applications

The 'relativistic' bias quite naturally extends to dynamic consumer problems. When social or institutional arrangements persistently bias consumption and investment decisions in the same direction, relative concerns can have important consequences for growth and development. Postlewaite (1998) suggests that matching concerns can be an essential building block in explicit models of how different social arrangements explain apparent differences in time preferences and the resulting differences in growth and development (see also Futagami and Shibata (1998)). A dynamic growth model with endogenous matching was the main ingredient of Cole et al. (1992), which initiated the literature of endogenous relative concerns.

Cole, Mailath and Postlewaite (1992) introduce an infinite horizon intergenerational model, in which generations of males, indexed h, have identical preferences different initial income m_h. Each male h cares at time t about his own consumption $c_{h,t}$ and the wellbeing of his son, which depends on the son's consumption $c_{h,t+1}$ and the quality of partner he attracts $m(\mu(h, t+1))$. Each generation lives for one period t and divides inherited wealth between consumption $c_{h,t}$ and investment in the family's capital stock $k_{h,t}$, by passing on $Ak_{h,t}$ as a bequest to the next generation (with $k_{h,0} = m_h$ and A the growth rate of capital). Consumption choice is therefore constrained by $c_{h,t} = Ak_{h,t-1} - k_{h,t}$. The dynamic optimisation problem for each lineage of males is:

$$\max_{k_{h,t}(t=1,\ldots,\infty)} \sum_{t=0}^{\infty} \beta^t \left[U(Ak_{h,t} - k_{h,t+1}) + m\left(\mu\left(h,t\right)\right)\right]$$
$$\text{s.t.} \quad k_{h,0} = m_h \text{ and } \; Ak_{h,t} \geq k_{h,t+1}$$

If the partner matching $\mu\left(h,t\right)$ is exogenous, optimal investments $k^*_{h,t+1}$ at time $t+1$ satisfy the usual first order condition

$$U'(Ak^*_{h,t} - k^*_{h,t+1}) = A\beta U'(Ak^*_{h,t+1} - k^*_{h,t+2}).$$

Matching may again occur along the total consumption, as in the pre-marital investment game, e.g. Cole et al. (1992), or along some positional good, as in the signaling game, e.g. Corneo and Jeanne (1998). If matching occurs positively assortative along inherited wealth $Ak_{h,t-1}$ and the exogenously distributed (along $\Psi_F(.)$) wealth of the female partner, then

$$m\left(\mu\left(h,t\right)\right) = \left(\Psi_F\right)^{-1}\left(\Psi\left(k_{h,t-1}\right)\right),$$

such that the first order condition of this optimal savings problem with endogenous matching is:

$$U'(Ak^*_t - k^*_{t+1}) = \beta\left[AU'(k^*_{t+1} - k^*_{t+2}) + \frac{\psi(k^*_{h,t+1})}{\psi_F\left(\left(\Psi_F\right)^{-1}\left(\Psi\left(k_{h,t+1}\right)\right)\right)}\right].$$

Cole et al. (1992) prove the existence of a symmetric equilibrium in this game and show that in this equilibrium optimal investments in capital are increasing in initial wealth m_h. More importantly, the fraction of wealth invested in capital is always weakly higher in the endogenous matching case than with exogenous matching (and generically strictly higher). Hence, this model suggests that matching arrangements can induce differences in capital accumulation among societies. However, the effects of status concerns on capital accumulation are generally not as straightforward as this simple model suggests. Corneo and Jeanne (1998) observe that even the sign of this bias in saving depends crucially on the timing of the matching stage in the consumers' lifetime. If matching concerns matter more during youth than during old age, then consumers face an extra marginal cost component of saving while young. In fact, the intergenerational transfers model with altruistic parents is one of the rare cases where the direction of the status concerns incentives on capital accumulation is beyond doubt.

Cole et alii (1992) then introduce a different matching rule, aristocratic matching, which serves as a self-enforcing institution to reduce the effects of matching concerns. Social status $\widetilde{s_h}$, depends in this matching also on the initial wealth ranking. In all later periods t, sons inherit the status of their fathers if they match a girl of their own standing, but lose their status $\widetilde{s_h} = 0$ if they deviate from their historical fate. Cole et alii (1992) disentangle the conditions under which aristocratic matching is sustainable, i.e. in which the costs of loosing the ancestral status outweigh the gains of marrying a richer partner of the 'wrong' lineage. However, low status lineages have little to loose and hence little incentive to stick to the equilibrium, such that the aristocratic equilibrium only holds when the distribution of initial wealth is sufficiently spread out. Cole et alii (1998) extend the idea of collective and self-enforcing attribution of status. The threshold which makes sticking to the aristocratic norm optimal, endogenously demarcates the border between two different social classes, with different modes of conduct. The importance of an underclass lies in the threat of ostracism to higher classes, so that despite the lack of direct interactions between the classes, the lower class sustains collective action within the upper class.

Aristocratic matching is a first example of how an utterly useless attribute can become valuable in a matching process. The only value of aristocratic status lies exactly in the fact that other consumers value it, again for the same reason. And because other consumers value it, status enhances the matching prospects of one's offspring and is therefore worth investing in. Mailath and Postlewaite (2006) develop this idea further to illustrate how qualities can be valued in a matching context which have no direct value to either partner and no correlation to intrinsically valuable characteristics. If society values some inheritable characteristic, then this quality is worthwhile to invest in. Mailath and Postlewaite (2006) allow for both genetic characteristics, such as hair or skin colour, which are inherited with probability $\rho = 0.5$ per parent with the attribute, and for epigenetic qualities such as accent or sophisticated manners, which can be inherited by socialisation with a probability $\rho \neq 0.5$. Mailath and Postlewaite show an infinite horizon endogenous matching process with two-period lived consumers, divided over disjoint sets of males and females of equal measure. Consumers differ in a binary way in two dimensions, such that the typespace for both sexes is $\Xi = \{(m_H, Y), (m_L, Y), (m_H, N), (m_L, N)\}$, with Y and N indicating whether a consumer has the attribute or not, and m_H and m_L indicating high and low income. Assume for simplicity $\rho = 0.5$ and that half of the males and females have the attribute. The attribute is 'unproductive' if consumers with and without the attribute have a high income with probability $\frac{1}{2}$ and 'productive' if consumers with and without the attribute have a high income with probabilities $\frac{1}{2} + k$ and $\frac{1}{2} - k$ respectively. In this matching game, PAM, which means assortion along income and then attribute, is always stable:

$$\begin{pmatrix} (m_H, Y) & (m_H, Y) \\ (m_H, N) & (m_H, N) \\ (m_L, Y) & (m_L, Y) \\ (m_L, N) & (m_L, N) \end{pmatrix},$$

with males, in the first column and females, in the second column, of the same row matched together. Define the discounted utility stream for this simple setting as

$$V = \sum_{t=1}^{\infty} \beta^{t-1}(1-\beta)\upsilon_t,$$

with $\beta \in [0, 1)$, such that the discounted value of an infinite sequence of constant flow utilities υ has a discounted value υ. One may then normalize the flow utility of a match of two high income partners to 1 and of two low income consumers to 0. Remark that in the PAM equilibrium, a lineage with the heritable attribute keeps it forever. Average discounted utility for a lineage with the attribute is $V_Y^A = \frac{1}{2} + k$ and without is $V_N^A = \frac{1}{2} - k$, such that the discounted value of the attribute is $V_Y^A - V_N^A = 2k$ and hence zero for an unproductive trait. Interestingly, there also exists a stable matching equilibrium which is mixed in income (the relevant argument) and implies that some high income lineages without the attribute give up part of their consumption to have a fraction ρ of their offspring with the heritable trait:

$$\begin{pmatrix} (m_H, Y) & (m_H, Y) \\ (m_L, Y) & (m_H, N) \\ (m_H, N) & (m_L, Y) \\ (m_L, N) & (m_L, N) \end{pmatrix}.$$

In this equilibrium, the discounted expected utility of a consumer lineage with the attribute can be written recursively as:

$$V_Y^M = \left(\frac{1}{2} + k\right) \left[(1-\beta)\, 1 + \beta V_Y^M\right] + \left(\frac{1}{2} - k\right) \left((1-\beta)\, u + \frac{\beta}{2} \left(V_Y^M + V_N^M\right)\right),$$

with u the flow utility of a match between a high and low income consumer. The first term is the discounted utility of having a high income (with certainty of a high income match and offspring with the attribute) multiplied by its probability, the second term is the discounted utility of having a low income (with a mixed match and uncertainty over the attribute of the offspring) multiplied by its probability. Similarly, the discounted expected utility of a consumer without the attribute is:

$$V_N^M = \left(\frac{1}{2} + k\right) \beta V_N^M + \left(\frac{1}{2} - k\right) \left((1-\beta)\, u + \frac{\beta}{2} \left(V_Y^M + V_N^M\right)\right).$$

The discounted value of the heritable trait may then be seen to equal: $V_Y^M - V_N^M = \frac{(1+2k)(1-\beta)}{2-\beta(1+2k)}$, which remains positive for unproductive traits ($k = 0$). Mailath and Postlewaite (2006) show that the mixed matching profile is stable if and only if $\frac{4-3\beta}{4-2\beta} \geq u$, such that investing in useless attributes can only be optimal if the future is sufficiently important compared to the foregone income to acquire the attribute. Hence, in this equilibrium, high income consumers without the attribute are willing to forego consumption to improve the matching prospects of their offspring, to whom the attribute is valuable again because it is valued by others. Mailath and Postlewaite (2006) also show that a sufficiently large increase of income can break the stability of mixed matching, as this raises the opportunity costs of obtaining the heritable trait, and they investigate endogenous investments in the cultural transmission of the attribute as an extension.

Corneo and Jeanne (1998, 1999) investigate the implications of social segmentation between two classes on status emulation and the accumulation of capital. The extreme cases of social segmentation may be a strongly segmented caste system, in which one meets almost only consumers of the same type and a fully mixed unsegmented society on the other hand, in which every consumer draws the type of a potential partner with the same probabilities. Corneo and Jeanne (1999) show that segmentation aggravates social competition and the relativistic bias in the full information context, as segmentation aggravates competition among likes, but reduces competition and the bias in an asymmetric information context, as segmentation functions there as a weak substitute for signaling, decreasing the incentives to distinguish oneself from worse types.

How does the relativistic bias depend on economic inequality? A first simple answer can already be found in the static expression in (6), where the social marginal utility component $\frac{1}{p_I}\frac{\partial U(.)}{\partial S}\psi(I)$ contains the density function $\psi(I)$. When incomes are more densely concentrated, one may gain more by marginally increasing status investments I, such that the resulting relativistic bias is higher. Hopkins and Kornienko (2006) develop this idea in a setting in which male consumers live for two periods and are endowed at birth at time t with an income m_h, drawn from a distribution $\Psi^H(m_h)$ over support $[m_1, m_M] \subseteq \mathbb{R}_+$ and with mean $\bar{\mu}$. Males spend this income on consumption in both periods. Only consumption when males are young is visible and determines their status, modelled as in (2). For simplification, consumers care only about status when young and only about consumption when old, such that they maximise

$$U_{h,t} = \log S\left(c_{h,t}, \Psi(c_{h,t})\right) + \beta \log c_{h,t+1}.$$

Let $k_{h,t}$represent investments in capital, which are constrained by $c_{h,t} + k_{h,t} \leq m_h$, $c_{h,t+1} \leq A_t\left(k_{h,t}\right)^{\alpha}$ and $c_{h,t}, c_{h,t+1} \geq 0$. Hopkins and Kornienko (2006) show[5] that the optimal of savings or capital, $k^*_{h,t}$, in this simple model may be stated as:

$$k^*_{h,t} = m_h - c^*_{h,t} = \frac{\int\limits_{m_1}^{m_h} \left(S_0 + \Psi^H(z)\right)^{\dfrac{1}{\alpha\beta}} dz + m_1\left(S_0\right)^{\dfrac{1}{\alpha\beta}}}{\left(S_0 + \Psi^H(m_h)\right)^{\dfrac{1}{\alpha\beta}}}.$$

If $S_0 = 0$, social competition is cut-throat, with total social exclusion for the worst male. The almost worst consumer then invests his whole income on status and saves nothing. Consider then the effect of inequality via a linear taxation scheme, with $\tau \in [0, 1[$ a linear income tax rate of which the revenues are distributed equally among all consumers, such that post tax income $\tilde{m}$ may be written

$$\widetilde{m} = (1-\tau)m + \tau\bar{\mu} \Leftrightarrow m = \frac{\widetilde{m}}{1-\tau} - \frac{\tau\bar{\mu}}{1-\tau}.$$

The pre tax distribution of incomes is a mean preserving spread of the post tax distribution $\check{\Psi}^H(\tilde{m})$. Status rankings are unaffected by this tax, but incentives to save have changed: the density at the mean $\bar{\mu}$ has risen from $\psi^H(\bar{\mu})$ to $\dfrac{\psi^H(\bar{\mu})}{1-\tau}$ and has decreased in the tails. If $S_0 = 0$, all but the poorest consumer (who saves zero) save less after taxation. If $S_0 > 0$, redistribution makes the consumers below the average better off in income terms. But as social competition increases directly under the mean, some consumers get more income after taxes but save less. Hence, after taxes all consumers with an income above the mean became poorer and save less, the poorest became richer and save more, but a fraction of the population right under the mean became richer, but still saves less because of increased social competition. Whether more equality improves economic growth is, from the viewpoint of status competition, questionable.

5 Welfare and Taxation: Policy

5.1 Welfare analysis

Status competition is essentially a zero sum game, and because of this wasteful and 'immoral' character, status concerns have themselves been a rather popular subject of welfare assessment. A first issue is then the choice of a point of reference to compare the relativistic equilibrium with. A first candidate is the exogenous assortative matching case. Since the quality of mate (and hence surplus π) is constant, only intrinsic utility matters in this comparison. Since the relativistic bias is a costly deviation away from the intrinsic utility maximum, relative concerns generate a welfare loss for all but the worst consumer. This exogenous status or matching scenario has been the most popular point of comparison, but is it also the most relevant? In a signaling or matching framework, the natural alternative to the separating and assortative equilibrium is a pooling equilibrium with random matching or average status (Rege, 2007). This comparison considers not only the costs of the relativistic competition, but also potential efficiency gains of endogenous assortative matching the distributional effects through the allocation of partners and status. The lowest quality consumer is always worse off in the separating or assortative equilibrium than in the pooling one, such that very inequality averse social planners always prefer the pooling equilibrium.

A second factor in the welfare assessment of relative concerns is the functionality of investment variable I. As long as I refers to wasteful signaling, the relativistic bias causes a welfare loss compared to the exogenous matching case. But for the premarital investment game, the intrinsic optimum is actually socially suboptimal, because it does not take the positive externality of I on the future partner into account. Relative concerns due to endogenous matching partly compensate this underinvestment. Peters and Siow (2002) show that a two-sided premarital investment game can, for very large markets, sometimes fully internalise the externality of I on the partner, although equilibrium investments tend to overshoot the externality for smaller populations. Peters (2005) shows for a more general setting that matching concerns typically make consumers over-invest in I, even in large markets. In the Cole, Mailath and Postlewaite (1992,1998), the higher saving levels due to matching concerns are considered inefficiently high, because they are higher than the intrinsic optimum. However, they show, in fact, a pre-marital investment game, with total consumption a pure local public good, such that the matching process may help to internalise the externality of saving on the future partner and therefore correct the inefficient saving of the intrinsic optimum.

In many cases, relativistic preferences are rather the appropriate framework to assess some other phenomenon. Hopkins and Kornienko (2004b) pioneer in expanding the traditional evaluation of income distributions to an interdependent preference framework in the style of Frank (1985b). They set out a particular multiplicative utility function to stress the similarity with first bid sealed price auctions. Utility is then the product of intrinsic utility and status:

$$V(I,c)S(I,\Psi(I)),$$

with $S(I,\Psi(I))$ defined as in (2). The price of the nonpositional good p_c is normalised to 1, such that the budget constraint is $pI+c\le m$. Assume that

$$\frac{\partial V(.)}{\partial I}>0, \frac{\partial V(.)}{\partial c}>0, \frac{\partial^2 V(.)}{\partial^2 I}\le 0, \frac{\partial^2 V(.)}{\partial^2 c}\le 0 \text{ and } \frac{\partial^2 V(.)}{\partial I\partial c}\ge 0.$$

For a strictly monotonic equilibrium investment function $I(m)$, the probability of having a strictly higher status than some random other consumer with income m', may be written as $F^-(I)=\Pr(I^{-1}(I(m))>m')=\Psi(m)$. The problem of consumer with income m is:

$$\max_I V(I,m-pI)(\Psi(I^{-1}(I)+S_0) \tag{7}$$

which results in the first order condition:

$$V_1'(I,m-pI)-pV_2'(I,m-pI)+V(I,m-pI)\frac{\psi(m)}{(\Psi(m)+S_0)\,\dfrac{\partial I(m)}{\partial m}}=0$$

in which the third term contains the part of utility which is socially interdependent through $\psi(m)$ and $\Psi(m)$. The optimal solution is again characterized by an initial value problem similar to (4):

$$\begin{gathered}\frac{\partial I(m)}{\partial m}=\frac{V(I,m-pI)}{pV_2'(I,m-pI)-V_1'(I,m-pI)}\frac{\psi(m)}{(\Psi(m)+S_0)} \\ I(m_1)=I^o(m_1)\end{gathered} \tag{8}$$

with $I^o(m_1)$ the intrinsic optimum solving $\dfrac{V_1'(I,m_1-pI)}{V_2'(I,m_1-pI)}=p$. One problem with multiplicative utility is that if $S_0=0$, the worst consumer always has zero utility, such that his optimal consumption remains undetermined. The initial value problem in (8) uniquely determines the optimal choice of all other consumers (under conditions similar to conditions 4 to 10) and all but the worst consumer invest strictly more than in the intrinsic optimum. Hopkins and Kornienko (2004b) consider the welfare effects of a shift in the income distribution for consumers who remain at a constant income level. Such a change in the income distribution affects the utility of consumers with fixed incomes in two ways: by decreasing their status $S(.)$ and by changing the optimal levels of investment in I.

Hopkins and Kornienko (2004b) show that if income distribution Ψ_A second order Lorenz dominates distribution Ψ_B and both distributions cross a limited number of times with first crossing at $\widetilde{a}$, then all consumers with income smaller than $\widetilde{a}$ are better off in distribution Ψ_B. More equality decreases the status of the poor whose income remains constant and their optimal level of I either increases or decreases. Note that even if the poor consume their intrinsic optimum, they are still worse off in the dominating distribution because of the lower status. In the case of first order stochastic dominance, all consumers (at constant income) are worse off in the dominating distribution. A higher minimal status level S_0 has an appeasing effect on social competition, such that the optimal level of status investments I decreases.

To obtain stronger welfare results, Hopkins and Kornienko (2004b) employ a ratio refinement of second order stochastic dominance: unimodal likelihood ratio ordering. Two distributions Ψ_A and Ψ_B satisfy *Unimodal Likelihood Ratio* ordering (denoted $\Psi_A \succ_{ULR} \Psi_B$) if $\bar{\mu}_A \geq \bar{\mu}_B$ and the ratio of their density functions $\dfrac{\psi^A(m)}{\psi^B(m)}$ is unimodal (with a mode at $\ddot{m}$), such that the ratio $\dfrac{\psi^A(m)}{\psi^B(m)}$ is strictly increasing for all $m < \ddot{m}$ and strictly decreasing for $m > \ddot{m}$. If $\Psi_A \succ_{ULR} \Psi_B$, then Hopkins and Kornienko (2004b) show that the ratio $\dfrac{S_0 + \Psi_A(m)}{S_0 + \Psi_B(m)}$ has at most two extremal points, a minimum $\overline{\overline{m}}^-$ and a maximum $\overline{\overline{m}}^+$, and one point $\tilde{m}$ where the ratio equals 1 (the unique crossing of $\Psi_A(m)$ and $\Psi_B(m)$), which are such that $m_1 \leq \overline{\overline{m}}^- < \tilde{m} < \overline{\overline{m}}^+$. If $S_0 = 0$, status investments are strictly higher for all consumers with (constant) income lower than $\overline{\overline{m}}^+$in the ULR dominating distribution and possibly for higher incomes too. If $S_0 > 0$, then status investments are lower in the dominating distribution for consumers with income lower than $\overline{\overline{m}}^-$, higher after some income level in the interval $]\overline{\overline{m}}^-, \tilde{m}]$ and possibly again lower after an income level higher than $\overline{\overline{m}}^+$.

The focus of Hopkins and Kornienko (2004b) on the welfare effects at a fixed income levels is fairly limiting. Hopkins and Kornienko (2004a) allow for changes in the income of all individuals (and hence the support of the income distribution). These income changes are limited to a linear income tax of which the revenues are divided equally. This implies that the pre tax income distribution is a mean preserving spread of the post tax distribution. It also means that income rankings are kept constant, while incomes and the distribution of incomes change. The poor all have a higher income now, but may or may not be worse off because of increased social competition, whereas the welfare effect of the tax on the rich is clearly negative. Despite having a higher income, the increase in social competition incited by the denser income distribution also obliges these consumers to spend more on status investments, such that they may after all have less income left to spend on consumption they intrinsically enjoy. Hopkins and Kornienko (2004a) claim that this ambiguous relation between equality and welfare may explain some of the empirical difficulties in establishing the correlation between equality and happiness, which traditional theory would expect positive. Earlier work by Corneo and Grüner (2000) develops this idea further to explain why middle class median voters may vote against redistribution, even if they would materially benefit from it.

5.2 Optimal Taxation & redistribution

Status investments impose a negative externality with zero sum game characteristics on other consumers. The case for welfare improving policy and taxation is therefore clear. A number of early papers noted that status concerns call for higher taxation on income or luxury commodities. Boskin and Sheshinski (1978) show a model in which utility depends negatively on the population's mean consumption, calculate the optimal income tax and show that this tax is higher for interdependent preferences. Oswald (1983) computes an optimal non-linear tax rule for interdependent preferences and shows that the results deviate substantially from the traditional results.

The externalities related to status consumption suggest Pigovian corrective taxes, which may implement the intrinsic optimum. A classical linear Pigovian tax on status consumption, raising private costs to the full social cost and thus implementing the intrinsic optimum, is investigated by e.g. Seidman (1988). If the tax authority has perfect discriminatory abilities, optimal Pigovian taxes will generally be nonlinear, e.g. because marginal social benefits of status consumption vary with its local density in the overall distribution. Denoting the optimal tax as a function of income by $\tau(m)$, $p_\tau \equiv p_I(1+\tau(m))$ and normalising the price of rest consumption to 1, Hopkins and Kornienko (2004b) try to find an income tax scheme which implements the intrinsic optimum. The problem of an income m consumer is

$$\max_I V(I, m - p_\tau I) S(I, \Psi(I)),$$

with $S(.)$ again as in (2). Proceeding as in (7), one finds the first order condition

$$\left[V_1'(I, m - p_\tau I) - p_\tau V_2'(I, m - p_\tau I)\right] \frac{\partial I(m)}{\partial m} + V(I, m - p_\tau I) \frac{\psi(m)}{(\Psi(m) + S_0)} = 0.$$

Hopkins and Kornienko (2004b) seek a nonlinear tax scheme $\tau(m)$ which implements the intrinsic optimum $I^o(.)$. Using

$$p_\tau = V_1'(I^o, m - p_\tau I^o) - p_\tau V_2'(I^o, m - p_\tau I^o) = 0,$$

the first order condition may be written into the initial value problem

$$\begin{aligned} \frac{\partial I(m)}{\partial m} &= \frac{V(I^o, m - p_\tau I^o)}{\tau(m) p_I V_2'(I^o, m - p_\tau I^o)} \frac{\psi(m)}{(\Psi(m) + S_0)} \\ I(m_1) &= I^o(m_1), \end{aligned}$$

such that the tax scheme can be written

$$\tau(m) = \frac{V(I^o, m - p_\tau I^o)}{p_I V_2'(I^o, m - p_\tau I^o) \frac{\partial I(m)}{\partial m}} \frac{\psi(m)}{(\Psi(m) + S_0)},$$

which has a unique continuous solution under similar conditions as imposed on the initial value problem in equation 4. Hopkins and Kornienko (2004b) show that for two distributions of which $\Psi_A \succ_{ULR} \Psi_B$ and with $\overline{\overline{m}}^-$ and $\overline{\overline{m}}^+$ defined as in the last section, then $\tau_A(m) < \tau_B(m)$ on $]m_1, \overline{\overline{m}}^-[$, $\tau_A(m) > \tau_B(m)$ on $]\overline{\overline{m}}^-, \overline{\overline{m}}^+[$ and $\tau_A(m) < \tau_B(m)$

in the interval $]\overline{\overline{m}}^{+}, m_M[$ (with τ_A obviously indicating the optimal tax scheme for Ψ_A and τ_B for Ψ_B). This result states that Pigovian taxes should higher where the social competition is higher, which is near the mode of the distribution.

Relative concerns may also explain factual redistribution. Corneo (2002) attempts to explain why income taxation tends to be highly redistributive in countries where the pre-tax income is already quite egalitarian. Corneo suggests that in the case of relative concerns, a redistributive tax improves the allocation efficiency of resources more in an economy with a more egalitarian pre-tax distribution of incomes, since the status externality distorts more in more equal income distributions. Corneo (2002) uses as utility function

$$\log c_h + \alpha_1 \log l_h + \alpha_2 \log(\Psi(m_h)),$$

with c_h consumption, l_h leisure time, $\Psi(m_h)$ the distribution function of pre-tax income m_h of consumer h and α_1 and α_2 constants. Leisure is specified as $l_h = \bar{L}_h - L_h$, with $\bar{L}_h$ total time endowment and L_h the labour supply of consumer h, such that $m_h = wL_h$. Tax schemes $\tau(m)$ may be described by $m_h - \tau(m_h) = \Lambda\,(m_h)^{\varsigma}$, with ς and Λ positive scalars. The parameter ς represents the elasticity of post-tax income with respect to pre-tax income and is called the residual progression. A tax schedule is called progressive if $\varsigma < 1$ and regressive if $\varsigma > 1$. A smaller ς indicates a more progressive tax schedule. Parameter Λ is a scalar to make taxes revenue neutral:

$$\Lambda = \frac{\sum_h m_h}{\sum_h (m_h)^{\varsigma}}.$$

Corneo (2002) shows that only if the Gini coefficient of the pre-tax income distribution is smaller than some threshold, introducing a small progressive income tax is a Pareto improvement. Secondly, it is shown that the tax schedule that implements the undistorted labour allocation is progressive, and that this degree of progressivity decreases with the Gini coefficient of the pre-tax income distribution.

These results on Pareto improving income taxation relate closely to work by Ireland on status signaling and taxation. Ireland (1994, 1998, 2001) understands status as an absolute rather than a relative phenomenon, defining status as the spectators' estimate of the total consumption (or utility) of a consumer. Utility is taken to depend on intrinsic utility $u(I, c)$ from status investments I and rest consumption c and on social status S. Status S is understood as the spectators' inference about the utility level of a consumer, $\widehat{u}(I, c)$. As c is not observable by assumption, $\widehat{u}(I, c)$ is an estimate of $u(.)$ based on visible good I. In practice c is substituted by an estimate of c from I, denoted by $d(I)$, such that the social status part in Ireland's (1994, 1998, 2001) specification becomes $S = \widehat{u}(I, d(I))$. The budget constraint is again $c + pI \leq m$, with 1 and p the prices of rest consumption and status investments. Ireland (1994, 1998) models utility as a convex combination of intrinsic and social utility, such that the consumer problem is:

$$\max_I U = (1-\alpha)(u(I, m_i - pI) + \alpha\widehat{u}(I, d(I)),$$

with constant $\alpha \in [0, 1[$ the relative importance of status. Ireland solves this problem following Mailath (1987a), deriving the familiar differential equation and no distortion at the bottom condition (as in e.g. (4)). Equilibrium consumption is biased towards conspicuous consumption good I, as consumers try to inflate public appearance. But since all predictably inflate their visible consumption, public inference will in equilibrium be correct. Ireland (1994) solves this general model for quasi-linear utility $u(I, c) = I + \log(1 + c)$, such that the consumer's problem becomes:

$$\max_{I} U = (1 - \alpha)\left[I + \log(1 + m - pI)\right] + \alpha\left[I + \log(1 + d(I))\right],$$

while assuming that $p > 1$, such that consumers never consume only I in the absence of status effects. In the independent preferences case $\alpha = 0$, all consume their intrinsic optimum $c = \min\left\{(p-1), m\right\}$ and $I = \max\left\{\dfrac{m - (p-1)}{p}, 0\right\}$. If $\alpha > 0$ and incomes are invisible, one easily derives[6] the familiar differential equation from the first order condition to this problem in the case that $I(.) > 0$

$$-\frac{\partial d\,(I)}{\partial I} = \frac{1 + d(I) - (1-\alpha)p}{\alpha},$$

such that

$$d(I) = D \exp\left(-\frac{I}{\alpha}\right) + ((1-\alpha)p - 1),$$

with D a constant of integration. If $m_1 \leq p - 1$ (so that the poorest invests $I = 0$ in the intrinsic optimum), then the poorest consumer with income m_1 gets utility $\log(1+m_1)$ without signaling. The second worst buys just enough of I to make imitation unprofitable for the poorest. After solving for D, one obtains

$$d(I) = (m_1 - ((1-\alpha)p - 1)) \exp\left(-\frac{I}{\alpha}\right) + ((1-\alpha)p - 1), \tag{9}$$

which also characterises equilibrium expenditures on I.

Within this framework, Ireland studies the possibility of a Pareto improving income tax and two other transfer policies. An income tax may in this framework increase welfare rather than impose a burden, by offsetting the status driven incentives to overwork. Ireland (1998) investigates under which circumstances an income tax may be a Pareto improvement and finds that income taxation can only benefit all as long as the range of pre-tax income is not too great.

Ireland (1994) also studies optimal transfers in the same framework. A first transfer policy is a uniform in-kind support of rest consumption, denoted $\bar{\bar{c}}$, to all consumers. Does it matter whether this support is in-kind or cash, i.e. whether $\bar{\bar{c}}$ can be exchanged for good I or not? If $m_1 + \bar{\bar{c}} < p(1-\alpha) - 1$ (the intercept in equation 9), all consumers spend at least $m_1 + \bar{\bar{c}}$ on c anyway, so whether the transfer is in-kind or cash does not matter. It does shift the income distribution, however, as $m_1 + \bar{\bar{c}}$ rather than m_1 is now the lowest income, and this makes the path of I slightly steeper. All consume more c, but this difference is less for higher incomes. If however $m_1 + \bar{\bar{c}} > p(1-\alpha)-1$, then non-exchangeable transfers may constrain the choice of some consumers if $\bar{\bar{c}} > p(1-\alpha)-1$. Otherwise, cash or in-kind makes no difference.

Another option are services to the poor only with optional take up. Give consumers with an income under $\underset{\sim}{m}$ who claim it an income supplement up to level $\underset{\sim}{m}$ (i.e. a transfer $\underset{\sim}{m}$-m). Take-up should then be complete, if it goes unnoticed. But when take-up becomes public knowledge, everyone knows the true income of a consumer after take up: $\underset{\sim}{m}$. As such, spectators infer their type as the average of those who take up the welfare benefit, denoted $\xi(\underset{\sim}{m})$. In this case, there is an interval of consumers who are entitled to the benefits but prefer not to take these up. This interval $[\widehat{m},\underset{\sim}{m}]$, where $\widehat{m}$ is the critical type who is indifferent between taking up the welfare benefit and being treated as the average 'poor', and alternatively not taking up and having as status higher than $\xi(\underset{\sim}{m})$. This interval increases as the importance of status increases. Take up is never 100%, as an upper part of the interval of intended poor prefer to live poorer, but seem richer. The stigma which keeps many poor from claiming the welfare benefits they are entitled to get, a phenomenon of considerable empirical importance, is thus understood as a fear of being pooled with worse types.

6 Conclusions

Although considerable progress has been made in the past decades, the economics of status still remains for a large part *terra incognita*. Empirically, the relevance and importance of status for economic theory has been well established, but the actual functioning of status is still largely unknown. Better data, experimental research and a further integration of the human sciences will most likely reveal more. As for the theoretical understanding of the economics of status, many issues are unsolved. I mention some. First, the common status dependent utility function formulations of Duesenberry (1949) and Frank (1985b) capture only a fraction of the complexity and dynamics of relativistic preferences. Second, only the relatively simple cases have been solved in the matching literature, and a lot is to be discovered about multidimensional matching, many-to-many matching and matching along endogenous qualities. Developments in these will certainly trigger new insights in known applications of social status in economic theory. Third, contemporary consumerist culture is so rich and complex that many interesting new applications are impatiently waiting to be studied. Fourth, the implications of status emulation for welfare analysis are another poorly understood topic. And finally, the interaction between preferences for conformity and distinction are still almost uninvestigated and only by combining both dynamics the richness of the real world will be revealed.

Notes

[1]See Miller (2000) and Cronin (1993) for excellent surveys on sexual selection theories.

[2]See Mason (1998) for a survey of the history of the economic analysis of status concerns.

[3]Peters (2005) shows under which conditions the premarital investment game, played as a bilateral matching game with endogenous qualities of buyers and sellers, converges to the hedonic pricing equilibrium. The premarital investment game may thus provide a non-cooperative foundation for the hedonic pricing equilibrium.

[4]Note that for smooth distributions, $\frac{\partial S(I)}{\partial I}$ reduces to $\psi(I)$.

[5]From

$$\max_{c_{h,t}} \log\left(\Psi\left(c_{h,t}^{-1}(c_{h,t})\right) + S_0\right) + \beta \log\left(A_t (m_h - c_{h,t})^{\alpha}\right),$$

the first order condition is

$$\frac{1}{S_0 + \Psi\left(c_{h,t}^{-1}(c_{h,t})\right)} \frac{\psi\left(c_{h,t}^{-1}(c_{h,t})\right)}{c'_{h,t}\left(c_{h,t}^{-1}(c_{h,t})\right)} - \beta \frac{\alpha A_t (m_h - c_{h,t})^{\alpha-1}}{A_t (m_h - c_{h,t})^{\alpha}} = 0$$

but $c_{h,t}^{-1}(c_{h,t}) = m_h$, such that this first order condition defines together with initial condition $c_{1,t}(m_1) = 0$ the initial value problem

$$c'_{h,t}(m_h) = \frac{\psi(m_h)}{S_0 + \Psi(m_h)} \frac{(m_h - c_{h,t}(m_h))}{\alpha\beta}$$
$$c_{1,t}(m_1) = 0$$

The differential equation may be written

$$(S_0 + \Psi(m_h))^{\frac{1}{\alpha\beta}-1} \frac{\psi(m_h)\, m_h}{\alpha\beta} = c'_{h,t}(m_h)\,(S_0 + \Psi(m_h))^{\frac{1}{\alpha\beta}} + (S_0 + \Psi(m_h))^{\frac{1}{\alpha\beta}-1} \frac{\psi(m_h)\, c_{h,t}(m_h)}{\alpha\beta}$$

This differential equation is a well-known problem in the theory of first price auctions (see e.g. Jehle and Reny, 2001, pp. 376-377). Integrating both sides and using the intial condition, one obtains the equation above.

[6]From the first order condition

$$1 - \frac{(1-\alpha)\,p}{1 + m - pI} + \frac{\alpha}{1 + d(I)} \frac{\partial d(I)}{\partial I} = 0,$$

and using that in equilibrium $m = pI + d(I)$.

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