Sociality, Rationality, and the Ecology of Choice

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ABSTRACT

This paper discusses the influence of human sociality on choice behavior, through association with social networks and the influence of these networks on constraints, perceptions, preferences, and decision-making processes. The paper discusses ways to incorporate these factors into choice models, while retaining the aspects of the theory of individual rationality that are predictive. Finally, the paper outlines an econometric method for solving the "reflection problem" of determining whether social affiliations follow preferences, or preferences follow social affiliations, by distinguishing opportunity-based and preference-based motivations for association with social networks.

1. Introduction.

A defining feature of the neoclassical economic theory of choice is that consumers meet in the marketplace, but are individualistic and egocentric in their tastes and beliefs. They are indifferent to the welfare of others, with sovereign preferences that are immune to the influence of their peers. Jostling in the market, haggling over prices, and influences that are not effectively priced such as congestion, induce interdependence between consumers that may be intense. Consumers use these interactions to acquire facts and update their rational expectations, but in the classical theory, a consumer never lets social interactions get under her skin and directly touch her perceptions or preferences. Rivalry in markets may be up-close, but if it becomes personal, then one has to take it outside (of classical economics).

This paper considers the alternative proposition that *sociality,* the influence of direct interpersonal interaction on human behavior, must be taken into account in modeling choice behavior. Humans are social animals, and even when self-interest is paramount, one's self is defined through the reaction and approval of others. Models that fail to account for sociality will not predict well in

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circumstances where consumers use their social networks to define their beliefs and preferences. This paper examines ways to model behavior that incorporate sociality while keeping the core aspects of rationality that are predictive for choice.

Sociality is usually defined as the tendency to associate in or form social groups and networks, such as families, friends, neighbors, co-workers, teams, religious sects, tribal and ethnic groups, political parties, and other affinity and interest groups. I will term all of these alliances social networks. Membership in some social networks is involuntary – you do not get to choose your family or your nationality. However, many social network affiliations are voluntary, and are often dynamic, involving recruitment, commitment in varying degrees, and the possibility of expulsions, quits, and break-aways. There are four (non-exclusive) primary motivations for voluntary affiliation with social networks:

– Mutual support, protection, and status
– Efficiencies in collection and sharing of information
– Opportunity-Based Homophily: Joint production and division of effort, and risk-sharing
– Preference-Based Homophily: Decision-making economies, and approval

All of these motivations stem from the evolution of humans as social animals who are comfortable operating in groups, but the last three are also economic, reducing the likelihood of regret from unsatisfactory choices.

Two significant features of the social behavior of humans are *reciprocity*, exchanges of benefits that are not necessarily synchronous or bilateral, and *altruism*, conveying of benefits to others without an expectation of a reciprocal benefit. Reciprocity is often explained by enlightened self-interest, the instrument for establishing reputation and trust that facilitates mutually advantageous commerce. Norms for reciprocity and fairness may evolve in social networks through accountability, approval, and sanctions of network members; e.g., a person who fails to conform to norms for sharing may be punished. Networks also establish reciprocity and fairness norms through recruitment and expulsion of members, recruiting those who appear to accept the network norms and expelling those who fail to conform. Finally, to the extent that these norms make social networks more rewarding for

members, there is likely to be group selection, in which networks with more effective norms are more attractive, and consequently more likely to survive.

Altruism enters behavior when the preferences of individuals depend on the satisfactions achieved by other network members. One way to recast classical consumer theory to encompass altruism is to postulate that consumers have individualistic felicities, and personal welfare functions that depend on their own felicity and the felicities of others. An immediate question with this formulation is how a consumer can know or judge how satisfied other network members are. One possibility is that consumers depend on the self-reported satisfactions of others, but such reports are not necessarily reliable; e.g., the aphorism "Learn to complain without suffering." Another, proposed by Browning and Chiappori (1998), is that satisfaction of others is judged by observed features of their consumption; e.g., the size of their house or the brand of their wristwatch. There are several broad regularities of altruism that provide some insight into its nature. First, altruism is weaker toward people who when placed in a situation similar to oneself behave differently than oneself; see Luttmer (2001). Second, altruism is stronger toward people who demonstrate altruism to other network members, and this reinforces norms for multilateral reciprocity; see Tagiuri and Kogan (1957). Together, these patterns suggest that consumers may evaluate the felicities of others using their own tastes, and what they can observe or infer about others' circumstances. Such behavior would be consistent with the psychological observation that while people may be empathetic to others, they find it difficult to "put themselves in the other person's shoes", so that the other person's pleasure, pain, and emotion are attenuated and interpreted through one's own experiences. Behavior that does not seem sensible when viewed using one's own preferences and expectations will tend to be interpreted as destructive or improper.

A behavioral aspect of individualistic preferences is that people seem to be on a *hedonic treadmill*, with quick adjustment to homeostasis, and pleasure and pain experienced relative to the status quo, with losses looming larger than comparable gains. The hedonic treadmill may also operate interpersonally, with personal welfare adapting quickly to status quo privilege and status in networks, but highly sensitive to gains and losses in position in the network. Thus, "keeping up with the Joneses" is less about one's historical status and more about the "fairness" of changes in relative status, and individuals are likely to be particularly adverse to unfavorable innovations that they view as unfair or undeserved.

Both altruism and reciprocity can be interpreted as the result of evolution, mechanisms for satisfactory solution of repeated games or resource allocation within networks that have survival value, and have become internalized through the success of individuals and networks with higher propensities to conform to the associated behaviors.

This paper develops the implications of sociality for choice behavior, and discusses ways in which social network effects on choice can be modeled. Section 2 gives a very selective review of the large literature on sociality and behavior, and classifies the ways in which sociality may enter the decision-making process. Section 3 gives a more detailed discussion of the channels through social network effects influence choice, and ways to build these channels into econometric models of choice. Section 4 examines more closely the econometric issue of simultaneity in the determination of individual choices and aggregate network behavior.

2. How Sociality Influences Economic Behavior

Economist and other social scientists have long been aware that behavior is influenced by the social networks in which individuals operate. The early economists emphasized the importance of family in economic decisions. Adam Smith (1759) said “"Every man feels [after himself, the pleasures and pains] of the members of his own family.” Edgeworth (1881) said "... efforts and sacrifices ... are often incurred for the sake of one’s family rather than oneself.” Veblen (1899) emphasized the competitive aspects of sociality, stating that the “human instincts of emulation, predation, workmanship, parental bent, and idle curiosity [dictate consumption behavior]”. These aspects of consumer behavior were omitted from the neoclassical formalization of consumer theory by Hicks and Samuelson, but not from the concerns of economists. Dusenberry (1949) and Schelling (1969, 1971) emphasized the comparative aspects of consumption. Manski (1993), Banerjee (1992), and Samuelson (2004) emphasized the role of information obtained from social networks regarding the attributes and desirability of choice alternatives; e.g., Banerjee says “We often decide on what stores and restaurants to patronize or what schools to attend on the basis of how popular they seem to be.”

There have been attempts to model network effects on choice. Brock and Durlouf (2001, 2002) construct a model in which “[t]he utility or payoff an individual receives from a given action depends directly on the choices of others in that individual's reference group [a field effect], as opposed to the

sort of dependence which occurs through the intermediation of markets." Manski (1995, Chap. 7) shows that field effects cannot be identified from equilibrium observations except through functional restrictions. Dugundi and Walker (2004) estimate a model in which "interdependencies [across decision-makers] are captured [through] choices of others [and] correlation of disturbances," an informative analysis that does not, however, overcome Manski's identification problem.

An aspect of sociality that has received relatively little attention from econometricians is the endogeneity of network effects when network affiliation is voluntary. A simple and fundamental question is whether individuals join networks to gain information that will improve their choices, or to gain approval that will reinforce their choices. A few experimental studies indicate that network affiliation is at some level a "disposable" aspect of behavior that is acquired or dropped at the individual's convenience, and does not loom large in preferences; see Myagkov et al (2007). However, this seems at odds with the rather strong reciprocity and altruism effects that are observed even in relatively transient social networks.

Today, interest in sociality ranges across the scientific spectrum, from neurological and cognitive science, through evolutionary biology, to studies of cultural and social norms in anthropology and sociology, and to demand for positional goods in marketing. However, while sociality has been widely recognized as critical to understanding human behavior, the mechanisms underlying its influence on choice have been obscure, and there is no simple formalization of socially-driven choice behavior that is comparable to that for neoclassical consumer theory. A useful starting point is to recognize that sociality can influence the choice process at four stages: constraints that define available choice alternatives, information about and perceptions of alternatives, preferences, and the processes used to reach decisions. The following section discusses each of these channels in some detail, and cites selected evidence on their nature and importance.

3. Modeling the Effects of Sociality

3.1. Constraints. Constraints are the limits on choice imposed by the actions of others. These may be mediated by the market, as in the price of gasoline a commuter faces as a result of the driving behavior of others, or bridge tolls imposed by highway authorities. They may also come from outside of markets, as in the effect of travel decisions by other household members on the modes available

to a commuter, or the effect of driving decisions of others on the traffic congestion a commuter faces. For example, the choice environment faced by a driver in congested conditions is largely determined by the constraints imposed by surrounding traffic. The classical theory of rational behavior is designed to handle these sort of constraints. Its primary focus is on the consumer's budget constraint operating through market prices and income, but non-market externalities (e.g., congestion, social network field effects) can be accounted for in neoclassical characterizations of alternatives, individualistic preferences can take these effects into account, and one does not have to introduce new features of consumer theory to accommodate them. In judging whether rational models are adequate for predicting choice behavior, it will be important that these models be fed realistic and fully articulated constraints. In particular, instrumental activities such as travel that are part of household and network production of personal benefits can be accommodated within the neoclassical model, although when the constraints on the individual are determined by bargaining in the social network, it may not be appropriate to treat them as exogenous. For example, two-stage budgeting at the family level, negotiation over who gets the family car, and allocation of household production tasks, require a formulation of the consumer problem that goes beyond individualistic felicities. In some circumstances, individuals may subject themselves voluntarily to constraints as part of their resource allocation problem within their social networks, so these constraints are endogenous.

3.2 Perceptions. Perceptions are formed in the rational consumer model through observing events and processing facts in a systematic way consistent with the laws of probability. In general, the classical theory permits consumers to have innate subjective priors that are updated over time through experience and observation, with the market reconciling the beliefs of different individuals through myriad wagers; a phenomenon we do not observe. There is much stronger empirical support for the behavioral alternative that memory is imperfect, with selective memory for first, last, and extreme occurrences, and coincidences, and the personal probability calculus is inconsistent, with small probabilities either over-estimated or ignored. Analogies and exemplars, often drawn from associates in social networks, are used in place of carefully calculated risk probabilities. Risk perceptions are modulated by inattention, and heavily influenced by the status quo.

One major problem that individuals have in forming accurate perceptions is *extension bias*, a cognitive failure to consistently integrate experience along dimensions that are relevant for

determining satisfactory choices. A classical experiment of Kahneman et al (1993) shows that individuals remember an episode that extends over time primarily in terms of the extreme and final levels of experienced pleasure or pain, rather than an integral of the instantaneous sensations. This can lead to choices based on remembered felicity that is inconsistent with optimization of experience. A convincing example of how extension bias can harm decision-makers is the common perception that when driving, one tends to frequently get stuck in a slow lane, compelling a lane change. Redelmeier and Tibshirani (1999) conducted an experiment in which they "videotaped traffic sequences by mounting a camera in a moving vehicle and filming the side-view perspective of the next lane on a congested road. When a section of videotape showing a slightly slower average speed in the next lane was screened to driving students (n = 4120), 70% stated that the next lane was moving faster and 65% said they would change lane if possible." What causes this common perception? Psychophysical effects may play a role. An overtaken vehicle is quickly out of sight (and out of mind), while an overtaking vehicle is a visible source of irritation until it disappears ahead. Losses from the "status quo", being overtaken, outweigh gains, and are more memorable. Slowly moving drivers may be more attentive to adjacent lane activity. Finally, humans (and other animals) are more stressed by objects moving toward them in their visual periphery than objects moving away from them in their central vision. However, an extension bias is the most likely explanation of the misperception. Suppose two adjacent lanes have the same average speed, and over a long distance are equally fast, but vary in relative speed. If you count the number of cars passing your, or that you pass, or the proportion of the distance traveled during which you are being passed, you will conclude correctly that there is no advantages to switching lanes. However, if you take a time average of the events of passing or being passed, then you will conclude that you are being passed a majority of the time. Figure 1 shows the transit times of drivers in adjacent grey and black lanes when speeds vary sinusoidally, with a phase shift between the lanes. The black lane is initially faster, but eventually slower, and total transit time over a kilometer is the same for both lanes. In either lane, the event of being passed occurs 58 percent of the time, so that all drivers who time average will conclude that they are stuck in the slower lane. Redelmeier and Tibshirani find a similar pattern in a more realistic simulation with random arrival times in the two lanes and various levels of congestion.

The point of this example is that perceptions, even those based on personal observation, are not necessarily accurate enough to exclude bad choices. Then, the reported perceptions and experiences of network members, and their observed behavior, may provide a stabilizing guide to the individual decision-maker. An important role of social networks is to collect and disseminate information on attributes of choice alternatives. Active information transfers occur when "early adaptors" convey their experiences with new products to other network members; e.g., friend's ratings of new movies, books, and restaurants. Passive information transfers occur when individuals "learn by observing" behavior patterns of network members; e.g., perceiving that a brand of mobile phone is desirable because many network members have acquired one. The dynamics of either type of information flows are described by contagion models, in which the share of early-adopters in a network, and the level of reliability and trust in the network, determine the speed of transmission and the ultimate penetration of the information. For example, transmission will be more complete in voluntary networks characterized by preference-based homophily, as the shared tastes in such networks raise the likelihood that alternative attributes that appeal to others in the network will also appeal to you. A feature of contagion processes is that they can lead to distinct non-unique equilibria, perhaps triggered by systematic features of a network, but also perhaps generated by chance. Kohler (1997) gives an example of the dissemination of information on contraceptive techniques among women in rural villages in Korea, where different methods are dominant in different villages due to chance first adoptions and contagion within, but not between, villages. An important econometric consequence of equilibrium in contagion models is that it will often be impossible to identify from observations on equilibrium the structural parameters of the process, and separate the effect of initial propensities of a network from the effect of contagion; see Manski (1993). To overcome this problem, it is necessary to observe the dynamics of the process. Further discussion of the field effects of information on perceptions and induced preferences can be found in Banerjee (1992), Aoki (1996), and Brock and Durlauf (2001, 2002).

A strong behavioral effect is ambiguity aversion – people will choose an alternative with known risk characteristics over one with unknown risk characteristics, even in circumstances where there can be no objective difference in risk. Figure 2 shows two bowls, each containing ten balls that are either white or black. You are asked to choose a bowl, then draw a ball. If you draw a black ball, you win a prize. Bowl A contains five black balls, so the probability of winning if you choose A is

50 percent. The number of black balls in bowl B is completely unknown, with no prior information that would lead you to believe than one configuration is more likely than another. Then, your probability of winning if you choose B is also 50 percent. However, experimental subjects overwhelmingly choose bowl A. More generally, when consumers are faced with choice among unfamiliar alternatives, ambiguity is a critical element. People will then be strongly motivated to turn to their social networks for information that removes ambiguity, strengthening field effects and herd behavior. Gilboa and Schmeidler (1989) and Fosgerau and de Borger (2008) show that this behavior is "rational" when consumers use least-favorable Bayesian priors to resolve ambiguity. Ambiguity aversion has a number of behavioral consequences. First, it will induce strong "status quo" effects – "the devil you know is better than the devil you don't." Second, neglect of private information and adoption of protective heuristics (e.g., "Don't gamble.", or "Never a borrower nor a lender be.") will often induce inefficient resource allocation, even if effective in avoiding major risks. Third, while emulating network behavior will induce stable response to small shocks, as decision-makers discount private information relative to observed field response of the network, it may induce chaotic response to large shocks when contagion flips the network to a new equilibrium.

3.3. Preferences. The neoclassical consumer model is based on the proposition that consumers have predetermined, sovereign, individualistic preferences, and as a consequence are indifferent to the welfare of others, and immune to influence from their social networks. The existence of social networks belies this premise – the attraction of social networks and the glue that permits their operation must be rooted in interpersonal sources of satisfaction. Approval by others, and accountability to network social norms and the threat of sanctions, may shape preferences and be internalized. One model for these interpersonal connections is that individuals have personal welfare functions of the individualistic felicities of themselves and of others in their network, with altruism explaining the dependence. Other interpersonal traits may also enter this characterization of preferences, such as competition for status, predation, and altruistic punishment of network members who breach social norms. In practice, individuals will not know all details of the consumption of others, or their idiosyncratic felicities. This can be modeled by postulating that individuals form expectations regarding the felicities of others using their own experiences and tastes, and what they observe about the behavior and stated satisfactions of others. A strong but plausible hypothesis is

that when judging the satisfaction of others, individuals use their own felicity tastes, and are substantially less willing to accept statements of satisfaction that are inconsistent with their own tastes.

Strong empirical evidence for altruistic preferences comes from experimental play of the trust game. This is a one-shot game with anonymous players who are not allowed to engage in side conversation. The experimenter gives 100 monetary units to the first player, called the investor. This player can then transfer a proportion X of this endowment to the second player, called the trustee. The experimenter augments this transfer with an additional 2X monetary units, so the trustee has 3X in total. The trustee than transfers an amount Y between zero and 3X back to the investor, and keeps the remainder. This is a dictator sub-game for the trustee, and a rational response for a selfish trustee is to return $Y = 0$. Then, it is rational for the first player to invest $X = 0$. It is found in many trust game experiments that the players are not neoclassically rational, and instead both the amounts invested and the amounts returned are positive. For example, Berg, Dickhaut, and McCabe (1995) find that for knowledgeable players, the average investment is 56.1 monetary units or percent of the endowment, and the average return by the trustee is 67.6 monetary units, which is 40.2 percent of the augmented investment the trustee receives. The question then is what the motivations of the players could be.

One possible explanation for trust game behavior is that each player has an individualistic felicity for herself, and imputed felicity for the other player, and seeks to maximize a personal welfare function that gives a positive altruistic weight to the other player's imputed felicity. Another is that social norms for reciprocity are sufficiently strong, and sufficiently internalized, so that some trustees will over-ride utility considerations and return to the investor a "fair" portion of the augmented investment received. For example, an investor may believe that there are three types of trustees, (1) selfish/rational players who will return nothing, (2) reciprocators who will return half the augmented investment, 3X/2, and (3) utility maximizers who are somewhat altruistic and will maximize a personal welfare function that is symmetric with the investor's personal welfare function. The likelihood the investor attaches to these types will then determine the level of investment that maximizes expected personal welfare. A construction illustrates how this might work. Suppose each player has a CARA felicity function, $u(c) = (1 - \exp(-\delta c))/\delta$, where δ is a risk aversion parameter which will be assumed to be one in this example. Suppose that the investor anticipates, in this case

correctly, that the trustee's felicity function is the same her own, and assume that her personal welfare function is

$$u = E_y \{(1 - \exp(-\delta(1-x+y)))/\delta + \lambda(1 - \exp(-\delta(3x - y)))/\delta\},$$

where λ parameterizes the extent of altruism, and the expectation is with respect to the investor's beliefs on trustee behavior, given by a probability α that the trustee is of the selfish type and a probability β that she is of the welfare-maximizing type.[2] Values of α, β, and λ that result in X and Y matching the McCabe data are $\alpha = 17.8\%$, $\beta = 1.8\%$, and $\lambda = 0.05$. Note that these values are not unique; we are fitting three parameters to two data points, and furthermore, the characterization of reciprocators is unwarrentedly specific. However, the nonlinearity of maximized expected welfare in the parameters restricts solutions to a range where the proportion of reciprocators is relatively high and proportion of welfare maximizers is relatively low. The fit illustrates that a mix of selfishly rational, norm-driven, and altruistic behaviors may explain outcomes in the trust game and similar games.

Fehr and Fischbacher (2004), and Baumgartner et al (2008) conduct trust game experiments in which players are subject to treatments in which they are administered the "trust" peptide oxytocin, or a placebo, prior to play. They find that investors who received the oxytocin choose substantially higher investments than those administered the placebo. On the other hand, trustee play is not affected by the treatment. These experiments show that perceptions and/or preferences can be altered chemically. This is an acid test that shows that preferences cannot be sovereign and immutable, and must be considered functions of the context in which the individual is placed.

3.4. Process. The decision-making process is simple in the neoclassical model – maximize expected utility, with rational expectations. The behavioral alternative is that individualistic utility maximization may be supplemented or replaced by processes that use analogies, exemplars, and heuristics influenced by information obtained from social networks, internalized social norms, and approval of network members. A very broad characterization of social experiments and observations

[2] A welfare-maximizing trustee will maximize $u = \lambda(1 - \exp(-\delta(1-x+y)))/\delta + (1 - \exp(-\delta(3x - y)))/\delta$ in y subject to $0 \le y \le 3x$; this is achieved at $y = \max\{0,\min\{3x,2x - \frac{1}{2} + \frac{1}{2} \ln \lambda\}\}$.

is that consumers behave consistently with individualistic rationality when stakes are high, but show influence of sociality when stakes are modest, particularly in situations where alternatives are unfamiliar and ambiguous. This decision-making pattern is consistent with a model of decision-making inside social networks in which the individual follows the herd in circumstances where the effort required to complete individualistic optimization is high, and the potential regret from follower behavior is less than the potential regret from a decision that does not rely on network support. If decision-making is costly, and regret painful, then it may be an efficient strategy to affiliate with a social network, accept the limits on choices imposed by network social norms, and follow the herd. This is, for example, the behavior of riders in a bicycle race, who form pellatons in which riders follow a rotating leader. By doing so, they save energy and avoid wasteful and unproductive excursions. However, "break-aways" also occur in this example, and in the broader context of decision-making, this would correspond to abandonment of an old social network affiliation, and formation of a new network that more closely matches the individual's perceptions and tastes.

How heuristics and procedures other than welfare optimization develop and survive is an important question. It is possible that some procedures are initially motivated by welfare maximization, and live on as heuristics in analogous situations because they are available and have proved satisfactory in the past. It is also possible that trial heuristics arise more or less at random, and the successful ones are selected and reused. The observation that behavior is close to optimum (judged by neoclassical standards, such as revealed preference) when stakes are high suggests that individuals facing a choice may first engage in a meta-choice of decision-making protocol. When the stakes are low and the possibilities for regret are small, readily-available, easily deployed heuristics are likely to be adopted, particularly easy rules that rely on network field effects. When the possibilities for regret are more substantial, then more attention is allocated to the decision problem, and solutions that test for consistency with self-interest are more likely to be employed. When attention is limited and decision-making effort costly, this may be a choice strategy that in an over-arching sense is nearly optimal.

4. Econometric Analysis of the Effects of Sociality on Choice

This paper has outlined some of the ways in which sociality can influence decision-making. The channels of influence through constraints, perceptions, preferences, and process are not necessarily

mutually exclusive and distinct, but there are differences in observable implications for the different channels, and with experiments it will be possible in most cases to identify the separate effects. However, the econometric task of identifying these effects in natural choice settings is difficult. To be specific, consider the question of the identification of field and group (homophily) effects, the problem studied by Manski (1993), Aoki (1996), and Brock and Durlauf (2001, 2002), in which individual preferences and/or perceptions are influenced by the field effects from network choices. An empirical study by Dugundji and Walker (2004) considers this problem for mode choice in Amsterdam, and considers the influence of neighborhood and social strata networks. The authors consider homophily effects, which appear as unobserved factors common to all network members, and field effects, which appear as factors in individual utility functions. In their setup, there is no separation of opportunity-based and preference-based homophily effects, or distinction between field effects that arise from common supply-side or opportunity-based factors, and those that arise because of contagion in transmission of information on the available alternatives. The authors do not resolve Manski's reflection problem, or deal with possible endogeneity. Subject to these limitations, the authors find that network field effects are significant, and that unobserved group or homophily effects do not add significant explanation once field effects are taken into account.

A natural question is whether further econometric analysis could untangle the homophily, field, and equilibrium effects, or whether in the absence of observations on the dynamics of mode choice, point identification of these effects is impossible. Several features of the networks the authors consider may aid identification. Both neighborhood or social strata networks are arguably predetermined, so that network affiliation can be treated as exogenous.[3] Neighborhood network effects are likely to come from supply-side constraints and opportunity-based homophily, such as availability and convenience of public transit or bicycle lanes. Social stratum network effects are more likely to come from preference-based homophily and from economic constraints; e.g., high income people are likely to have similarly high values of time, and to have budgets that permit consideration of all alternative modes.

Field and supply-side effects act on individuals through market equilibrium, and this will tend to make them endogenous when they are entered as explanatory factors in choice models.

[3]Of course, if individuals engage in life-cycle optimization, then the choice of where to live, and choice of job that determines income and social status, may be influenced by the same latent factors as later decisions such as mode choice, so that networks defined by neighborhood and socioeconomic status are not genuinely predetermined.

Specifically, if there are unobserved group or homophily effects, then they will have a non-negligible impact on market equilibrium, inducing dependence between unobservables in the individual choice and market-level field effects. This is precisely the reflection problem considered by Manski in the context of linear models.

To analyze this problem further, consider a model of social network effects in which there are K networks, indexed k = 1,...,K, and j = 1,...,N_k individuals in network k. Suppose for simplicity that each individual belongs to exactly one network, and faces a binomial transportation mode choice. Suppose the relative utility of alternative 1 is $u = X_{jk}\beta + Y_k\gamma + \alpha_k + \varepsilon_{jk}$, where X_{jk} is a vector of observed relative mode attributes, possibly interacted with observed individual characteristics, Y_k is a network equilibrium (field) effect, α_k is an unobserved random group (e.g., preference-based-homophily) effect, ε_{jk} is an individual disturbance that will be assumed to be independent of α_k and Y_k and to have a logistic distribution, and β, γ are parameters. Think of Y_k as a measure of relative congestion, crowding, or travel time that is determined as a result of the equilibrium of supply and demand for transportation modes. Then, observed choices satisfy

$$d_{jk} = \mathbf{1}(X_{jk}\beta + Y_k\gamma + \alpha_k + \varepsilon_{jk} > 0),$$

where d_{jk} is an indicator that is one when alternative 1 is chosen. Define the network share,

$$s_k = \sum_j d_{jk}/N_k.$$

The supply side of the market that determines network equilibrium is given by an equation

$$\zeta_k = g(s_k, Z_k, Y_k),$$

where Z_k are observed exogenous factors that influence supply, but are excluded from the utility model that determines individual choice, and the ζ_k are disturbances that for the current discussion will be assumed independent of the demand side disturbances. In this supply-side system, Z_k is assumed to include factors that influence market equilibrium; this is necessary to escape Manski's reflection problem. Examples in the mode choice application would be variations in public transit

operating characteristics, such as schedule frequency and line density, and variations in out-of-network demand.

With this setup, it may be possible to identify and estimate group and field effects using a simple version of the Berry-Levinsohn-Pakes (1995) estimator. The choice probability can be written

$$P_{jk} = \mathbf{E}_{\alpha|Y} L(X_{jk}\beta + Y_k\gamma + \alpha_k),$$

where L denotes the logistic function; the problem with working directly with this model is the dependence of Y and α. However, one can estimate a model with a network fixed effect that absorbs all the impact of Y and α,

$$P_{jk} = L(X_{jk}\beta + \alpha^*_k).$$

This step provides consistent estimates of β, but note that the effect of any component of X_{jk} that does not vary within the network will be swept into the fixed effect and cannot be separately identified. Redefine $\alpha_k = \mu + \eta_k$ to isolate an overall mean, and estimate the linear model

$$\alpha^*_k = Y_k\gamma + \mu + \eta_k,$$

where the left-hand-side variable is the fitted network fixed effect, using instrumental variables with functions of the Z_k as instruments. If the conditions for instrumental variables are met, then this procedure will identify γ and the empirical distribution of the random group effects. The substantive question for the application is whether the field variable considered, s_k, is in fact determined in an equilibrium influenced by exogenous supply-side factors that do not appear in the individual choice criterion.

If one has observations on the dynamics of choice, it is natural to consider models in which an individual's choice today depends on her and other network members' choices yesterday. This removes the reflection problem, but leaves an initial values problem due to dependence of group effects and the first observed market equilibrium. This may in turn be resolved if the network is observed from the first time a choice becomes available, or handled in a sufficiently long panel by

using semiparametric setups that estimate the initial distributions of group effects conditioned on the initial market state.

5. Conclusions

The purpose of this paper has been to show that sociality matters for understanding and predicting choice behavior. Social network effects influence economic choice behavior through constraints, perceptions, preferences, and the decision-making process, and their omission makes choice models incomplete and misleading. The rational choice model can be expanded to encompass field, opportunity-based homophily, and preference-based homophily effects, and altruism, but econometric analysis must then account for equilibrium, endogeneity of field effects, and in a problem that does not so far appear to have been analyzed, the endogeneity of network affiliations. Identification of field and group effects will usually be aided by study of the dynamics of network field effects, with a remaining initial value problem in the specification of the distributions of unobserved group effects.

Reconciliation of rational choice models with reciprocity and other social norms that make sense in the context of repeated games, reputation, and evolution will require deeper analysis of the dynamics of preferences. It may be possible in the future to explain the evolution of social norms as solutions to repeated games.

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FIGURES

Figure 1. Travel Times in Adjacent Lanes

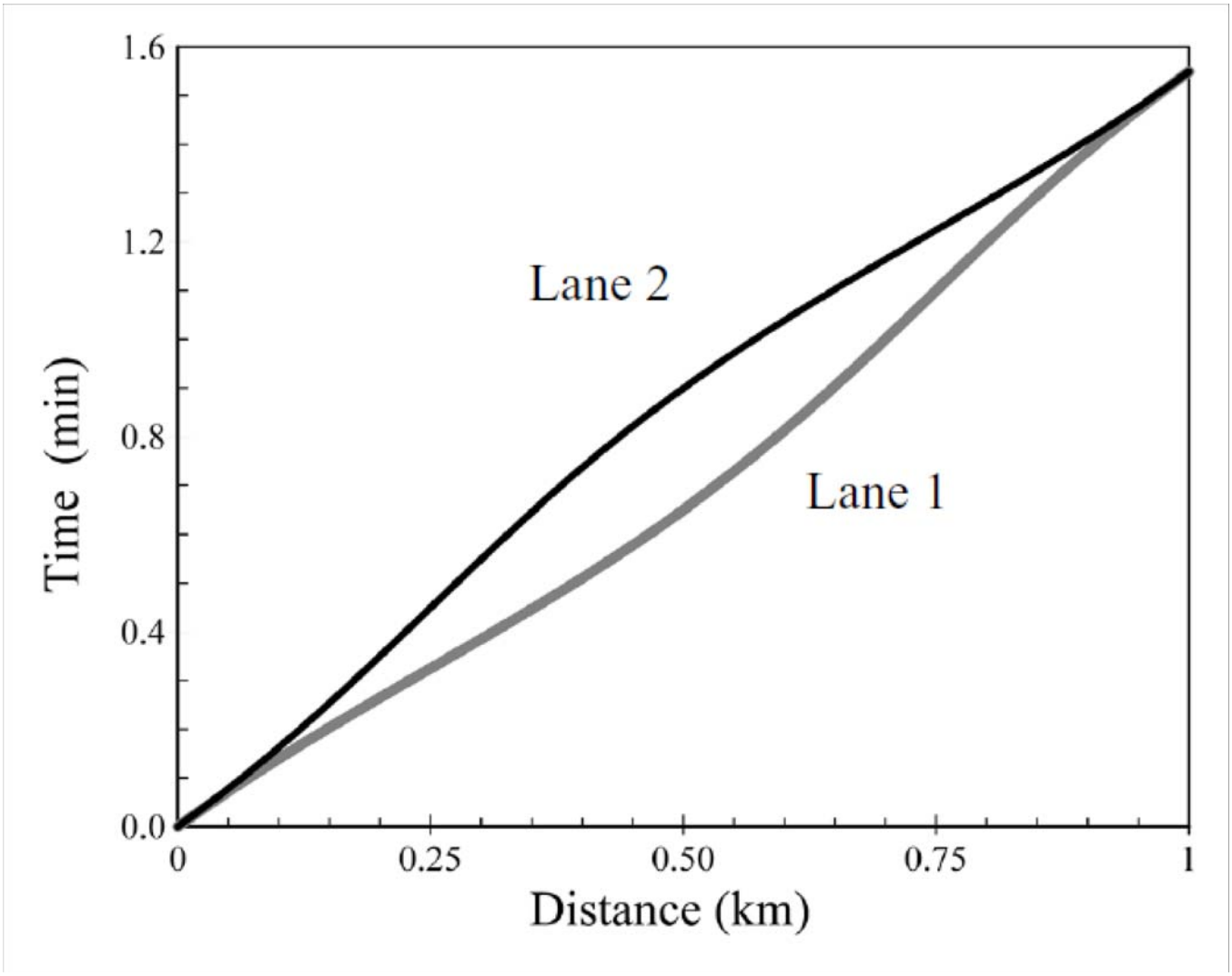

Figure 2. Ambiguity Aversion