COMMENT: MODELING SOCIAL INTERDEPENDENCE: IS IT IN THE STRUCTURE OR IN OUR HEARTS?

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1. INTRODUCTION

We want to congratulate Steven Durlauf on a most interesting and provocative paper. He reminds us that modeling the social interaction among and the social interdependence of individuals is a challenging task that is at the core of social science theory. As James Coleman (1990) has argued, understanding the link between the micro and the macro is one of the keys to the development of social science theory. The social interaction model proposed by Durlauf is certainly a welcomed effort in this direction.

In this comment we will focus on one specific question: Why are individuals' behaviors interdependent in Durlauf's model. We examine two possibilities: (1) the external structure of the choice problem people face induces externalities; or (2) individuals' "intrinsic" utilities are a function of choices made by other individuals. We also briefly discuss statistical estimation issues in Durlauf's model.

2. TYPES OF INTERDEPENDENCE

In the conventional economic and rational choice analysis, individuals are "egoists"—i.e., they do not care "intrinsically" about the actions or welfare of others and as such the behaviors or payoffs of others do not enter into their utility functions directly. Individuals become interdependent only when they interact under certain social conditions that result in each player's behaviors having consequences for others. People's buying and selling behavior in a market is one such example. The well-known

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Prisoner's Dilemma game is another. In both cases, the same action by an individual will bring different payoffs if others behave differently.

In the standard model, individuals' "intrinsic" utility functions are egoistic (e.g., people care only about their own monetary returns), but *after* the social context is taken into account, their payoff functions become potentially interdependent. We call this type of social interdependence "structurally induced." In this scenario, how people's choices interrelate depends on the specific social context (i.e., the social or game structure) in which the individuals interact. For example, the same egoistic players will cooperate in a coordination game (e.g., the Battle of the Sexes game) but be noncooperative in a Prisoner's Dilemma game. The structure of the game is critical in predicting how people interact.

The second type of interdependence is what we call "intrinsic interdependence." This refers to situations where individuals have some "intrinsic" interests in the actions and payoffs of others. Their concerns about others may include altruism (caring about the improvement of others' welfare), status competition (evaluating one's own payoff by comparing it with that of others), reciprocity (an inclination to reproduce the benevolent or malicious behaviors of others), or conformity (tendency to follow the majority). In these cases, the utility functions of the individuals include components of others' actions prior to the specification of the social structure in which they will interact.

A third logical possibility is where both "intrinsic" and "structurally induced" interdependence occur. An interesting example would be two individuals who are endowed with a "reciprocity" tendency playing the Prisoner's Dilemma (see Rabin 1993). Or imagine people who are ready to conform to the social roles of husband and wife playing the Battle of Sexes game.

The distinction between "structurally induced" and "intrinsic" interdependence is not trivial. In the case of structurally induced interdependence, it may be possible to change behavior by changing the structure in which individuals are embedded. For example, suppose we observe that people not only care about their own absolute income but also the relative rank order of their income. If such payoff interdependence is "structurally induced"—for instance, assuming people care about the rank order of their incomes because there are certain goods such as medical care that can only be obtained on a rank order basis—then changing the structure to make those goods available to everyone on a different basis may eliminate concerns over one's relative status. If, however, status concerns are inherently part of human nature—that is, psychological—then changes in the structural context may have no effect on the nature of the interdependence.

Durlauf's model is ambiguous as to why the social interdependence arises. At the heart of the paper is the following equation, which we will call the Durlauf equation:[1]

$$S_i = -\sum_j \frac{J_{i,j}}{2} (\omega_i - E_i(\omega_j | F_i))^2,$$

where ω_i and ω_j are choices of the individuals i and j, respectively. $J_{i,j}$ measures the tendency of i to "conform" to or to "deviate" from the expected action of j which is $E(\omega_j | F_i)$.

It is unclear whether the interdependence represented here is an inherent part of an individual's utility function that exists *prior* to any game structure, or a payoff function that is a product of given social context and structures. Note that under this specification an individual's payoff is not a function of other peoples' payoffs, but only their choices.

3. THE DURLAUF EQUATION AS A MODEL OF "STRUCTURALLY INDUCED" INTERDEPENDENCE

In reading the article we have the impression that the Durlauf equation is intended to be a generic "structurally induced" payoff function. The author moves from the equation directly to equilibrium analysis, which is legitimate only when the game structures within which the players interact are already captured by the equation. Game theory teaches us that the functional forms of payoff functions are highly dependent on the specific structure of a game—i.e., on the social context within which the interactions take place. The issue arises as to what extent the Durlauf equation can serve as a general payoff function characterizing social interdependence

[1]There are two reasons for us to focus on equation (13). First, other functional forms, such as equations (1) or (12) in his paper are not different from the generic payoff functions commonly seen in conventional game theory with perhaps the exception of the stochastic component in equation (12). The innovation in Durlauf's paper is equation (13). Second, the analytical results in the paper are all obtained with that specific functional form.

among social actors. If it is not general, then it is imperative to specify to what types of social situations it is applicable.

We show that the Durlauf equation is not a generally applicable payoff function by looking at some elementary games as examples. Consider the widely discussed Prisoner's Dilemma game.

		Player *j*	
		Cooperate	Defect
Player *i*	Cooperate	5, 5	−10, 10
	Defect	10, −10	0, 0

The first number in each cell is player *i*'s payoff, the second is player *j*'s.

Now consider a simplified version of the Durlauf equation (we leave out the stochastic component and the expected value function to simplify the presentation):

$$V_i = u_i(\omega_i) - \sum_j \frac{J_{i,j}}{2}(\omega_i - \omega_j)^2,$$

where ω_i and ω_j are choices of the individual i and j, respectively. $J_{i,j}$ measures the tendency of i to "conform" to or to "deviate" from the action of j which is ω_j. $u_i(\omega_i)$ is the constant utility one receives when playing ω_i. Let 1 represent the choice of "cooperate" and -1 represent "defect," the payoff function of player i should then satisfy:

$$\begin{cases} u(1) - (J/2)(1-1)^2 = 5 \\ u(1) - (J/2)(1+1)^2 = -10 \\ u(-1) - (J/2)(-1-1)^2 = 10 \\ u(-1) - (J/2)(-1+1)^2 = 0 \end{cases} \rightarrow \begin{cases} u(1) - u(-1) = 5 \\ u(1) - u(-1) = -20 \end{cases}$$

Obviously, there is no $u(1)$ and $u(-1)$ that can satisfy the above system of equations.

There are many other games whose structurally induced interdependence among the players cannot be represented by the Durlauf equation with suitable parameter values. Interested readers can verify that this is true of the Chicken game.

Of course, there are games that the Durlauf model describes well. For example, take a standard "Battle of the Sexes" game:

		Player j Football	Player j Opera
Player i	Football	5, 4	1, 1
	Opera	0, 0	4, 5

Let 1 represent the choice of going to "football" and -1 represent the choice of going to "opera." The payoff function of player i should satisfy

$$\begin{cases} u(1) - (J/2)(1-1)^2 = 5 \\ u(1) - (J/2)(1+1)^2 = 1 \\ u(-1) - (J/2)(-1-1)^2 = 0 \\ u(-1) - (J/2)(-1+1)^2 = 4 \end{cases}$$

If we let $u(1) = 5$, $u(-1) = 4$, and $J = 2$, they satisfy the above equations. That means the payoff function can indeed be represented by a Durlauf equation with suitable parameter values.

But note that the applicability of the Durlauf equation is highly sensitive to the payoff structure of a game. If we change the above payoff matrix slightly, even though the game still belongs to the Battle of the Sexes genre, no suitable parameter values for the Durlauf equation can be found. For instance, consider the following variant:

		Player j Football	Player j Opera
Player i	Football	5, 4	0, 0
	Opera	0, 0	4, 5

It can be verified that this payoff matrix can not be represented by the Durlauf equations, since it implies that $u(1) - u(-1) = 1$ and $u(1) - u(-1) = 0$ at the same time.

The above examples illustrate that social interdependence under structural constraints can take highly diverse forms and can be very sensitive to the specifics of the structure of a game. They show that the Durlauf equation is not a generally applicable functional form for describing the social interdependencies induced by various game structures. This raises the question of what types of situations can be modeled using the Durlauf equation and what types cannot, which should be answered by explicitly analyzing how the equation's form is derived from the underlying game structure.

Being explicit about the derivation of the model also provides insight into the relationship between the model's form and the structure it models. Two games can have similar payoff functions for different structural reasons. For example, people may "conform" both in a stock market and on a factory floor. In the former setting, it might be the presence of imperfect information that promotes individuals to imitate one another's behavior. In the latter, it could be the social sanctions attached to a norm that creates the incentive for workers to conform. Although the individuals' payoff function may in both situations be of the Durlauf functional form, the values of J (measuring people's tendency to conform) in those two situations may be determined by very different factors. The introduction of private information, for example, may weaken the incentive to conform (i.e., the J value) in the stock market but may have little effect among the norm-conforming factory workers. Conversely, a decrease in the opportunity for repeated interactions could have a large impact on the tendency to conform (the J value) among the workers since it weakens the foundation of the sanctioning mechanism, but may have little effect on behavior in the stock market.

4. THE DURLAUF EQUATION AS A MODEL OF "INTRINSIC" INTERDEPENDENCE

The Durlauf equation can also be viewed as a general representation of an individual utility function prior to any game structure. This would be an even more radical step from the conventional economic and rational choice models, though not unprecedented.

Traditional economic models seem to be incapable of explaining some robust experimental evidence. For example, individuals frequently cooperate in the one shot Prisoner's Dilemma game or the public goods provision game. During repeated plays, cooperative behavior declines over time but never vanishes as predicted by standard game theory. In the Ultimatum Game or the Dictator Game, people seem to be willing to share the wealth they can take as their own. In many games, some actors take actions to punish those who do not cooperate or have behaved "unfairly" at their own personal costs, contradicting the prediction of conventional models (Kagel and Roth 1995; Rabin 1998; Ostrom 2000).

One response to this evidence has been to rethink the traditional assumption that individuals are essentially "egoists."[2] Various researchers have proposed novel ways of modeling the individual's inherent utility functions and explored their consequences. Rabin (1993), for example, has developed utility functions where individuals value reciprocity—i.e., being kind to those who are kind to them and hurting those who hurt them. Rabin shows how his modified utility function can change the equilibria set of games. For instance, it allows the {cooperate, cooperate} strategy as well as the {defect, defect} strategy to be equilibria in the Prisoner's Dilemma game. More generally, it implies that under suitable parameter values, equilibria will only be either "mutual-min" (the players are mutually mean to each other) or "mutual-max" (the players are kind to each other).

Another example is Akerlof and Kranton's (2000) model of identity in which they adopt the assumption that individuals have inherent utilities attached to their identities. Behaviors of their own or of others that deviate from those prescribed by the identity cause utility loss and create the possibility of retaliation. They show that when it is costly for members of a subgroup to adopt the mainstream identity (e.g., for blacks as a result of the discrimination), equilibria can exist in which some or all members of the subgroup will choose an opposition identity and engage in activities economically detrimental to themselves (e.g., not aggressively seeking educational or work opportunities).

It would be most interesting to investigate whether the Durlauf equation can be adopted as a novel specification of an individual level utility function and to analyze the degree to which it can be used to represent different psychological and sociological models of individual choice. Altruism, for instance, as the inclination for improving others' welfare, cannot

[2]This is, of course, not the only response. Roth (1996), for example, proposes a model that only modifies the assumption of forward-looking rationality but keeps the assumption of self-interested actors.

be directly represented by the Durlauf equation since it is a function only of the actions, not the payoffs, of other players. For the same reason, status competition, defined as the tendency to evaluate one's own payoff by comparing it with those of others, cannot be directly represented by the model either. However reciprocity—i.e., the tendency to return the actions of others—can be represented by the Durlauf functional form. This is similarly true of conformity.

The consequences of adopting such a novel utility function also needs to be explored in both general terms and for specific games and social contexts. Some simple examples illustrate. Suppose we are applying the Durlauf utility function to any two-person symmetric game in the following way: We augment the payoff of each individual in a given cell of the payoff matrix by adding the Durlauf component $S = J(\omega_i - \omega_j)^2$ to his or her original payoff in that cell. We can generally conclude that any equilibrium that occurs on the diagonal of the payoff matrix before the augmenting will be preserved after the augmenting (under the assumption that $J > 0$, of course), since moving away from a diagonal cell will be further penalized after the augmenting. Therefore, {defect, defect} will still be an equilibrium in the Prisoner's Dilemma when individuals are endowed with this particular utility function. Also the equilibria set for the Battle of the Sexes game will be unchanged. Furthermore, any diagonal cell that was not an equilibrium can become one if J is sufficiently large as to offset the loss from moving away from an off diagonal equilibrium. This implies that a cooperative equilibrium can exist in a Prisoner's Dilemma under suitable values of J.

5. STATISTICAL IMPLEMENTATION

We applaud Durlauf's effort to provide a statistical implementation for his model. Too often theoretical models in economics remain just that—theoretical models that are never tested empirically. We are concerned, however, about the robustness of the parameter estimates to different assumptions about functional form. Durlauf points out that his model can be identified based on nonlinearities alone. The implication, however, is that assumptions about the nature of that nonlinearity are likely to lead to potentially quite different parameter estimates. This is something that should be explored through simulation studies. Alternatively, nonparametric estimators for the model should be developed. Obviously, the later course is quite ambitious.

6. CONCLUSION

Durlauf's paper should stimulate sociologists and economists alike to think seriously about the modeling of social interdependence of individual agents. Sociologists may find the notion of modeling the micro-process explicitly prior to carrying out empirical analyses productive. It allows for both better theoretical understanding of the relationship among the variables and of their potential effects on behavior. Economists may find the introduction of sociological perspectives and premises helpful in developing models that can both explain the mounting evidence that evades the conventional models and be applied to a much larger set of social interactions. Innovation along the boundary of sociology and economics is beneficial to both disciplines, and is critical to the development of a "social theory" envisioned by James Coleman (1990), or of a "socioeconomic" theory, as Durlauf calls it.

We have pointed out that Durlauf's model is not explicit about what produces its functional form (social structure or human psychology), and ambiguous about the level at which it positions itself (prior or post to the game structure). Although these ambiguities hinder attempts to justify, test, and apply the model, we see the issue as one of incompleteness rather than of inherent defects in the model. As always, there is more work to be done.

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