POINT AND LINE VULNERABILITY AS BASES FOR PREDICTING THE DISTRIBUTION OF POWER IN EXCHANGE NETWORKS: REPLY TO WILLER[1]

David Willer's comment on our 1983 *AJS* article provides us with a useful opportunity to describe the progress that we have made in refining the measure of vulnerability introduced in that article. To place Willer's commentary in perspective, the primary purpose of our article was to present the results of an experiment and of computer simulations on network centrality and its relation to power in exchange networks. Willer's comment does not deal with these findings. At the very end of the article, we proposed—as a preliminary notion—the idea that vulnerability might be a useful theoretical concept (see p. 299), and we suggested point vulnerability as one potential technique or measurement tool for determining points of minimum dependence in networks. Such points would thus be the most powerful network locations according to power-dependence theory.

Willer's main criticism is that our measure of vulnerability, Reduction in Maximum Flow (RMF), is not generalizable across all types of networks. On this point he is quite correct. In fact, we clearly noted this limitation (see p. 301, n. 21). We introduced the RMF measure merely as an illustration of the theoretical potential of the notion of vulnerability, not as a refined procedure for use in empirical research. We thought that we had made this clear. For example, on page 299 we stated, "Our *first step* toward a theoretical solution . . . was prompted by the . . . concept of 'vulnerability' " (emphasis added).

Although Willer takes us to task for not developing a better measure, he does not propose an alternative. Subsequent to publication of our experimental results, we continued to work on this measurement problem and to explore the limitations of our preliminary measure. In this work we explored the use of both point and line vulnerability as the basis for a more general measure. The task that we set for ourselves was to develop a more comprehensive measure. We will briefly describe our proposed solution (more details are available from us in a technical report).

The simplest network in which our original RMF measure of vulnerability fails to predict the distribution of power is the four-person network shown in figure 1. In this network, all points are predicted by the RMF measure to be of equal power. However, simulation results show that A is

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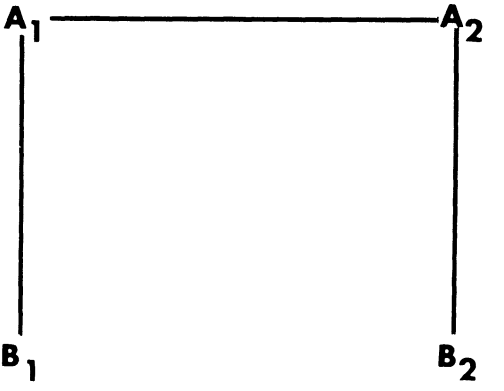

FIG. 1.—Four-person exchange network

more powerful than B (A's average profit was 65% of the total available profit). To overcome this limitation in the original measure, we introduced the notion of the cost of exercising power. The RMF measure proposed in the 1983 article is based on the graph-theoretic notion of point vulnerability, the notion that the complete removal of an actor from a network can result in a certain loss or reduction in the level of resource exchange throughout the entire network. An actor can impose a resource loss on the network by isolating himself or herself from the network, but this act is quite costly to the actor. If the actor can produce the same amount of resource loss without isolating himself completely from the network (and thus keeping open opportunities to exchange with some actors), the cost of exercising power is greatly reduced for that actor. This can be accomplished by an actor's closing off some exchange opportunities rather than removing himself from the network. For example, A_1 in figure 1 can reduce the maximum flow of resources to 24 units simply by closing off the opportunity to exchange with B_1 while keeping open the opportunity to exchange with A_2. In contrast, B_1 must isolate himself completely from the network in order to reduce the maximum flow of resources to 24 units.

This type of reasoning led us to the graph-theoretic notion of line vulnerability (see Cook, Gillmore, and Yamagishi 1984). A network is vulnerable at a line if removal of that line (or exchange relation) reduces resource flow throughout the network. Point vulnerability determines the absolute maximum power potential for each position in a network, and line vulnerability determines the cost of exercising structural power. The cost may be defined as a reduction in the potential for gaining profit owing to the removal of lines (or exchange opportunities) in order to

exercise power at its potential. As a first approximation of the cost measure, we devised a measure that we refer to as CRMF:

$$\text{CRMF}_i = \frac{\text{No. of lines that need to be removed to exercise power at its potential}}{\text{Total no. of lines connected to point i}}$$

We know that this is not a very good approximation, since lines that represent exchange opportunities differ in importance. Some exchange opportunities are more important than others and are thus used more often. Ultimately, we would like to weight the lines by their importance in calculating the CRMF measure. However, even this approximation is sufficient to solve the problem raised by Willer. In the network in figure 1, CRMF for A is one-half, and for B it is one. This measure is relevant only when RMF is not zero. Thus we arrived at a new measure of network-wide dependence, D_{Ni}, based on the concepts of point and line vulnerability:

$$D_{Ni} = \text{RMF}_i \times (1 - \text{CRMF}_i).$$

This measure of D_{Ni} should not be interpreted as an exact formulation of network-wide dependence in exchange networks; rather, it simply indicates the direction in which our work on this issue is heading.

According to this measure, B_2 in Willer's figure 2 is predicted to be most powerful, followed by B_1, and finally by A_1, A_2, and A_3. It will be easy for the reader to apply this measure to derive predictions of differential power among A, B, and C in Willer's figure 3. We examined, through a series of computer simulations, a number of networks in which the original RMF measure was not successful in predicting the distribution of power (some of which are similar to the cases identified by Willer), and the simulation results repeatedly supported the predictions based on the revised measure. Thus it appears to be a measure superior to the one we introduced in 1983.

Willer also claims in several places that our measure leads us to "logically impossible" inferences. While we are not defending our preliminary measure, it is important to understand the underlying theoretical point. Willer claims, for example, that "if A is exercising power over B, then B *cannot* be exercising power over A" (emphasis added). This is simply wrong from a power-dependence perspective. Emerson first discussed this issue in his 1962 article: "The notion of reciprocity in power-dependence relations raises the question of equality or inequality of power in the relation. If the power of A over B . . . is confronted by equal opposing power of B over A, is power then neutralized or cancelled out? We suggest that in such a balanced condition, power is in no way removed from the relationship" (1962, pp. 33–34). If a social relationship

exists because each actor is more or less dependent on the other, then each has some power in that relationship no matter how unequal it may be.

We hope that this response clears up any misunderstanding about our intentions in presenting the RMF measure in its early and unrefined stage. Clearly more empirical work is needed on this and other measures currently being developed. Bonacich (1985), for example, has recently proposed a measure that appears quite promising. Perhaps our "exchange" with Willer will serve as a stimulus to more work on this question.

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