IMPROVING THE PRECISION AND PARSIMONY OF NETWORK EXCHANGE THEORY: A COMPARISON OF THREE NETWORK EXCHANGE MODELS

Pamela Emanuelson
University of South Carolina

ABSTRACT

With the aim of improving network exchange theory's precision and parsimony, I test three alternative Network Exchange Models (GPI-R, GPI-RD and GPI-l*2) of identical scope. Previous analyses found GPI-RD's predictions the most precise, however, those analyses included only four networks. I analyze data for eight networks including old and new data for two previously studied networks, old data for one previously studied network, and new data for five previously unstudied networks. The first phase of the analysis assesses the support for GPI-RD's degree assumption. I determine whether degree inflates payoffs to advantaged positions in early exchanges. In addition, I determine whether, within one network, "higher degree advantaged positions" benefit significantly more than "lower degree advantaged positions". Both tests do not support GPI-RD's degree assumption. Therefore, in the second phase, I test the three models. Contrary to previous findings, the most parsimonious of the three models, GPI-R is the most precise predictor. Hence, network exchange theory can improve its precision and parsimony by abandoning GPI-RD and GPI-l*2 in favor of GPI-R.

Whereas parsimony and precision are generally considered essential for theory, (Kuhn 1970, Lakatos 1970, Popper 1994, Fararo and Kosaka 2003) network exchange theory (Willer and Anderson 1981, Markovsky et al. [1988] 1999; Patton and Willer 1990, Markovsky et al. 1993, Willer and Szmatka 1993, Lovaglia et al. [1995] 1999, Szmatka and Willer 1995, Thye et al. 1997, Willer et al. 1997, Willer and Skvoretz 1997a and 1997b, Lovaglia and Willer 1999, Simpson and Willer 1999, Corra and Willer 2002, Girard and Borsch 2003 and Willer 2003), one of several modern exchange theories, offers three distinct models (GPI-R, GPI-RD, and GPI-l*2) [1] of identical scope. Network exchange theory's parsimony can be improved by selecting the most precise of the three models; however, evidence from previous studies is insufficient to identify which model is most precise. Lovaglia et al. (1995) found the strongest support for GPI-RD, and Lovaglia and Willer (1999) found comparable support for GPI-RD and GPI-l*2 over GPI-R. At odds with Lovaglia et al. and Lovaglia and Willer, Burke (1997) found support for GPI-R over GPI-RD. It follows that the most precise model is not currently discernable.

GPI-R, GPI-RD, and GPI-l*2 are scope restricted to predicting weak power networks. According to Simpson and Willer (1999), weak power networks include all networks that are not strong or equal power. Therefore, to delineate the scope of GPI-R, GPI-RD, and GPI-l*2, exclude all networks that fit the definition of either a strong or equal power network. Simpson and Willer (1999) define strong power networks as, "networks that contain two and only two types of positions: one or more high power positions which are never excluded and two or more low power positions, at least one of which must be excluded; low power positions are only connected to high power positions." (271). Equal power networks are networks in which all positions have equal likelihoods of being included in exchange. (Simpson and Willer 1999: 271).

I seek to improve network exchange theory's parsimony by analyzing more extensive data in the hope of providing sufficient grounds for preferring one model. In the following, I explain the theoretical foundation for the three models. Next, I present each model and two hypotheses offered to test GPI-RD's unique assumption. Since two of three previous studies most strongly support GPI-RD's predictions, the first phase of the analysis tests the two hypotheses. In the second analysis phase, I compare the three models' predictions to observed mean payoffs. Each model's weighted average absolute deviation is examined to determine which model is the most precise.

THEORY

GPI-R, GPI-RD and GPI-l*2 integrate a position's likelihood of being included into resistance equations to make point predictions for positions' payoffs in weak power networks. GPI-R integrates likelihood and resistance using the fewest assumptions. Both GPI-l*2 and GPI-RD are different from GPI-R. GPI-l*2 squares the likelihood values. GPI-RD assumes that relative degree, the number of a position's connections relative to the total number of the exchange relation's connections, affects resource divisions. After explaining likelihood and resistance, I present the three models. While explaining GPI-RD, I offer two hypotheses to test whether GPI-RD's relative degree assumption is theoretically justified.

Likelihoods and the Resistance Model

Seek likelihoods, which represent each position's chance of being included in an exchange, are calculated by assuming that actors seek exchange with all partners equally (Markovsky 1992). "Each position's likelihood of being included in exchanges, *l* (or of being excluded, 1 - *l*) is calculated under the assumption that actors have no preferences among partners." (Lovaglia [1995] 1999: 162). For example, if actor A is connected to four Bs, A seeks each B .25 of the time. If each B is connected only to A, each B seeks A 1.0 of the time. The joint probability of any one A – B exchange is (1)(.25) = .25. Thus, B's likelihood of being included, *l*[B], is .25 while A's likelihood is *l*[A] = .25 + .25 + .25 + .25 = 1.0. Positions with higher likelihoods are more advantaged by structure than positions with lower likelihoods. I used a publicly available computer program designed by Dudley Girard and located at http://www.cla.sc.edu/SOCY/Faculty/WILLER/index.html to calculate the likelihoods.

According to NET, actors have mixed motives in exchange. Motives are complementary because exchange benefits both actors, but are in opposition because an increase in one actor's payoff decreases her/his partner's payoff. Resistance factors apply actors' mixed motives to predict resource divisions in exchange networks. More specifically, each resistance factor balances an actor's motive in gaining her/his *maximal payoff*, Pmax - P, with the actor's motive in avoiding the *payoff at disagreement*, P - Pcon. Where P[A]max is the best possible payoff for A, P[A]con is the payoff for A if exchange does not occur, and P[A] is the payoff for A,

$$[eq.1] R_A = \frac{P_A \max - P_A}{P_A - P_A con}$$

The Principle of Equiresistance determines payoffs by setting exchange partners' resistance factors equal to each other. Equiresistance asserts that, "agreements occur at the point of equal resistance for undifferentiated actors in a full information system." (Willer 1999:43). Therefore, to determine the payoffs to A and B in an A - B exchange dyad, set the resistance factors for A and B equal to each other,

$$[eq.2] R_A = \frac{P_A \max - P_A}{P_A - P_A con} = \frac{P_B \max - P_B}{P_B - P_B con} = R_B$$

For exchange relations embedded in networks, conditions, such as network type, affect actors' evaluations of Pmax and Pcon. For instance, in the networks studied here, the initial conditions of exchange, Pmax and Pcon, are affected by positions' likelihood values.

Integrating Resistance and Likelihood

Lovaglia et al. ([1995] 1999) integrated likelihood values and resistance to make models for predicting the distribution of benefit in weak power networks. They assert that, "more precise prediction requires that we extend network exchange theory to incorporate actors' profit expectations. We concentrate on possible sources of actors' expectations that might develop from initial network conditions and ongoing feedback that might result from them." (Lovaglia et al. [1995] 1999: 164). One source of actors' expectations is actors' likelihoods of being included. The Resistance-Likelihood Assumption asserts that, the higher the likelihood of being included, the higher the actor's Pcon and Pmax (Lovaglia et al. [1995] 1999: 169). [2]

GPI-R

For the three models, Lovaglia et al. ([1995] 1999: 169) limit the range of possible values for Pmax and Pcon. [3] Pcon represents actors' consideration of payoffs available in exclusive alternative exchange relations. In a network with V negotiable value, Pcon ranges between zero, the payoff at disagreement, and V/2, half the negotiable value. Pmax represents the actor's best hope. It ranges between V, reflecting maximal payoff, and V/2. NET asserts that, within those ranges, Pmax and Pcon are proportional to the likelihood value of each actor. Hence, for actor B where *l[B]* is the likelihood for B being included in exchange

[eq. 3] P[B]con = V/2 (*l[B]*)

And

[eq. 4a] P[B] max = V/2 (*l[B]*+1)

It immediately follows that Pmax is a function of Pcon:

[eq. 4b] P[B] max = P[B] con + V/2

Using equations 3 and 4b, GPI-R determines Pcon and Pmax values, and then solves for equiresistance. For example, in the B—A—A—B network where $V = 24$, B's likelihood of being included, *l[B]* = .75, and A's likelihood of being included, *l[A]* = 1. Solving equations 3 and 4a for A and B in the A - B exchange, P[B] con = 24/2 (.75) = 9, P[B] max = 24/2 (.75 + 1) = 21, P[A] con = 24/2 (1) = 12, and P[A] max = 24/2 (1 + 1) = 24.

$$[eq. 5] R_A = \frac{24 - P_A}{P_A - 12} = \frac{21 - P_B}{P_B - 9} = R_B$$

Solving P[B] = 10.5 and P[A] = 13.5. [4]

GPI-RD

GPI-RD adds relative degree to GPI-R. GPI-RD assumes that "the higher an actor's relative degree, the higher the actor's perceived conflict outcome." (172). Relative degree for actor A in exchange A - B is an index calculated by dividing the number of A's ties by the sum of the numbers of A's and B's ties. When t[B] represents the number of B's ties and t[A] represents the number of A's ties, the degree of B relative to A (d[BA]) is

[eq. 6] $d[BA] = t[B]/(t[B] + t[A])$

For example, in the B-A-A-B network, $d[BA] = 1/(1 + 2) = 1/3$ and $d[AB] = 2/(2 + 1) = 2/3$.

Combining resistance, likelihood and degree for P[B] con,

[eq. 7] $P[B]\ con = V/2\ (l[B])\ (d[BA])$

Applying equation 7 to determine the initial conditions of B's resistance factor in the A-B exchange of the 4-Line where $V = 24$, $P[B]\ con = 24/2\ (.75)(1/3) = 3$. Applying equation 4b determines $P[B]\ max = 3 + 24/2 = 15$. Applying equations 7 and 4b to determine the initial conditions for A's resistance factor, $P[A]\ con = 8$ and $P[A]\ max = 20$. Plugging the values into a resistance equation,

$$[eq. 8]\ R_A = \frac{20 - P_A}{P_A - 8} = \frac{15 - P_B}{P_B - 3} = R_B$$

Solving $P[B] = 9.5$ and $P[A] = 14.5$.

I offer and test two hypotheses from the relative degree assumption. First, as just seen, GPI-RD inflates payoffs of positions with high relative degree beyond payoffs predicted by likelihoods. It follows that for any two positions with identical l and in relations with identical V, positions with higher relative degree will earn more than positions with lower relative degree. For all exchange relations in networks studied here, $V = 24$. Therefore,

Hypothesis 1: Comparing positions for both of which $l = 1$, the position with the higher relative degree will have the greater payoff.

Network exchange theory suggests that the effect of degree is greatest initially and then will decline. As shown by earlier experiments (Brennan 1981) and as Lovaglia and Willer (1999) assert, "Degree is not a structural condition producing power in weak power networks." (Lovaglia and Willer 1999: 186). However, Lovaglia et al. ([1995] 1999) assert, "Assuming that human actors cannot fully evaluate the ramifications of their location in a network structure-especially when lacking systemwide information-it is reasonable to presume that information of a more localized nature becomes especially salient. The number of direct ties is just such a piece of information." (Lovaglia et al. ([1995] 1999:171). The two statements together suggest that degree's effect should decay such that the best fitting predictions for actors' payoffs in earlier exchanges are GPI-RD's and in later exchanges are GPI-R's. Stated differently, payoffs to structurally advantaged positions with high degree will peak in early exchanges. Actors in the networks studied here had full information, so with each additional exchange, the actors could evaluate with greater accuracy the structure's impact on their negotiations. I examine the data to see if a peak exists. If a peak exists, then I will test for a pattern of decline.

Hypothesis 2: The payoffs to high power positions with high degree will peak in early exchanges.

GPI-l*2

Lovaglia and Willer (1999) presented GPI-l*2, as an alternative to GPI-R and GPI-RD. The Lovaglia et al. ([1995] 1999) data indicated that GPI-R's predictions for structurally advantaged actors were lower than observed mean payoffs, so Lovaglia and Willer suggested that the effect of likelihood was not necessarily linear. The equations used by Lovaglia and Willer (1999) are identical to those used by GPI-R but for the squaring of likelihoods. Using GPI-l*2, in the B - A -A - B network where V = 24, P[B]con = 24/2 (.75)2 = 6.75 and P[B]max = 6.75 + 24/2 = 18.75. Using the same equations P[A] con = 12 and P[A] max = 24. Solving the resistance equation, P[A] = 9.4 and P[B] = 14.6.

METHOD AND EXPERIMENTAL NETWORKS

I obtained both published and unpublished experimental data gathered over the previous decade and stored at the University of South Carolina to test GPI-R, GPI-RD, and GPI-l*2. Published data includes the Lovaglia et al. (1995) data on the 4-Line, the Stem, and the Dbranch2. The analysis here includes the Lovaglia et al. (1995) data, additional data gathered for the 4-Line and the Stem, and data gathered for five previously unpublished networks. All of the data for the DBranch2 was not available so the observed mean includes only 30 of the original 63 data points used by Lovaglia et al. (1995) [5].

Subjects were undergraduate volunteers paid according to their earnings in the experiments. Experiments were conducted using ExNet, a PC based system that allows subjects seated in separate rooms to interact using their PCs. ExNet allows participants to send, receive, and confirm offers, and make exchanges using mouse control. ExNet provides participants with full information by displaying the network and the payoffs to all subjects on each subject's screen. Figure 1 displays the eight investigated networks.

Figure 1. Eight Weak Power Networks

A. 4-Line

A——— B——— B——— A

B. Stem

C. D-Box

D. Box-Stem

E. D-Branch

F. K-Stem

G. L5-Stem

H. Borg6
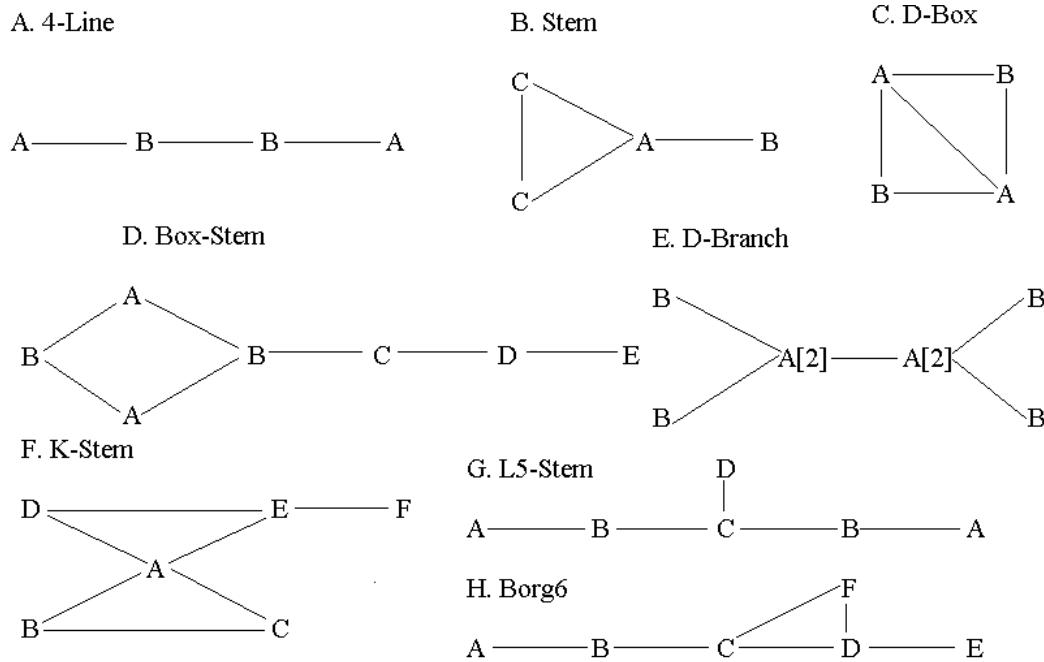
Periods comprise sessions and rounds comprise periods. The number of a session's periods equals the number of the investigated network's positions with the exception of the BoxStem, which has six positions and only four periods. After a period's conclusion, subjects rotated to a new position until each subject had occupied all network positions, structurally advantaged and disadvantaged. Rotation controlled for confounding psychological factors and allowed subjects similar opportunities for overall profit.

Subjects divided a 24-point resource pool, a set of resources placed between each connected pair, and were restricted to maximally a single exchange per round. As the subscripts in the Figure indicate, the DBranch2 was an exception in which the As could exchange maximally twice and the Bs once. A time limit for negotiating resource divisions constrains rounds. Subjects who did not reach an agreement before the time limit expired, received nothing. Subjects saw their earnings for a round at each round's conclusion than clicked to begin the next round. The BoxStem experiments ran ten rounds while all other network experiments ran four.

Experiments began with a tutorial that was followed by a practice session. Practice sessions allowed subjects to send, receive, and confirm offers in networks other then the network under investigation. After the practice rounds, subjects began negotiating in one of the eight networks in the Figure.

I conduct two phases of analysis to test GPI-R, GPI-RD, and GPI-l*2 using data for three previously examined and five new networks. Phase one examines GPI-RD, the model most strongly supported by previous investigations. (Lovaglia et al. [1995] 1999, Lovaglia and Willer 1999). The first phase includes examining two hypotheses offered to test GPI-RD's relative degree assumption. I test Hypothesis 1 by making intra-network comparisons between structurally advantaged positions with different relative degrees. For example, in network X, A is structurally advantaged in the A-i exchange and B is structurally advantaged in the B-j exchange. I compare A's payoff to B's payoff when 1) l[A] = l[B] = 1 and 2) d[Ai] > d[Bj] or d[Ai] < d[Bj]. For Hypothesis 2, I conduct a comparison of means to determine if payoffs peak in early exchanges. In phase two, I compare models for precision. The predictions are compared to observed means using *t*-tests and the models are compared relative to their weighted average absolute "deviation scores" (See Below) (Burke 1997).

RESULTS

Degree as a Biasing Factor in GPI-RD

Tables 1 and 2 display the first phase of the analysis, the testing of GPI-RD's relative degree assumption. Table 1 shows intra-network comparisons between the payoffs to positions that have likelihoods equal to one and relative degrees that are not equal. Table 2 uses *t*-tests to determine if payoffs peak in early exchange rounds.

Table 1 displays a test of Hypothesis 1. In Table 1, I compare payoffs to structurally advantaged positions with different relative degrees. For the purposes of testing, structurally advantaged positions are positions for which: 1) l =1 and 2) there is at least one connection for which l < 1. For instance, in the L5Stem, l[B] = l[C] = 1.0 and l[B] > l[A] and l[C] > l[D]. So, in the L5Stem, B is structural advantaged over A and C is structural advantaged over D. However, B's degree value relative to A, .67, is less than C's degree value relative to D, .75; d[BA] < d[CD]. Hypothesis 1 predicts that C's payoff will be inflated more than B's payoff.

Before testing Hypothesis 1, I ask whether it is testable, given the variance observed. That is to say, is the predicted payoff to position C in the L5Stem large enough to test *significantly greater than* the predicted payoff to lower degree position B. In the {} of Table 1, fourth row, I compare GPI-RD's predicted P[B] = 14.4 to GPI-RD's predicted P[C] = 15.6 using a pooled estimate generated from the data. Results indicate that predicted P[C] would be significantly greater than predicted P[B] at <. 005. Similar comparisons of predictions for the remaining two relations in Table 1 indicate that the payoffs to positions with higher degree would test significantly higher than the payoffs to their lower degree partners. Therefore, the test is feasible.

Table 1: Comparing Payoffs to Advantaged Positions with Differing Degrees within Exchange Networks

Structure	Relation		Pooled Estimate	*t*	*p*
	Lower Degree	Higher Degree			
L5Stem	P[B] (A/B)	P[C] (C-D)			
	12.91 {14.4}	13.72 {15.6}	0.385	2.10 {3.11}	<.025 {<.005}
Borg6	P[B] (A/B)	P[D] (C-D)			
	14.02 {14.5}	14.52 {15.6}	0.644	0.776 {1.71}	NS {<.05}
BoxStem	P[B] (A/B)	P[C] (A-C)			
	12.71 {12.3}	12.82 {13.5}	0.661	0.166 {1.81}	NS {<.05}

Note: Ns and standard deviations are available in Table 3. The GPI-RD predictions and *t*-values comparing predictions are in {}.

In Table 1, the observed variance is sufficient between the predicted payoffs to P[B] and P[C] of the L5Stem, P[B] and P[D] of the Borg6 and P[B] and P[C] of the BoxStem to test Hypothesis 1. For two compared positions $l = 1$, but one position has higher degree. In the second column of Table 1 are the positions with lower degree while the positions with higher degree are in the fourth column.

Evidence does not support the hypothesis that, when comparing positions for both of which $l = 1$, the position with the higher relative degree will have the greater payoff. The hypothesized effect of relative degree is found in only one of the three comparisons shown in Table 1. Only in the L5Stem did the position with higher relative degree earn significantly more than the position with lower relative degree, while in the Borg6 and the Box Stem no significant difference was found in the payoffs. Thus, on the whole the results do not support Hypothesis 1.

Table 2 displays a test of Hypothesis 2. In the third column is a position's highest observed mean payoff as taken from one of the first two periods and in the fourth column is the same position's lowest observed mean payoff as taken from the last two periods. To test if payoffs peak early in the session, the observed mean payoffs in the early periods are compared to the observed mean payoffs in the later periods. Only certain exchange relations are examined for the following reason.

Table 2: Tracking the Development of Power Across Periods using Payoffs to Advantaged Positions

Structure	Position/Relation	Early Per.	Late Per.	P. Est.	*t*	p
4Line[a]	P[B] (A-B)	13.65	13.50	.871	0.172	NS
Stem[b]	P[A] (A-B)	14.98	14.04	1.45	0.648	NS
Dbox[c]	P[A] (A-B)	13.73	12.11	1.11	1.46	NS
BoxStem[d]	P[C] (A-C)	13.67	12.07	2.13	0.751	NS
DBranch2[e]	P[A] (A-B)	16.20	15.05	1.45	0.793	NS
KStem[f]	P[E] (E-F)	14.19	12.83	1.01	1.35	NS
L5Stem[g]	P[C] (C-D)	14.67	13.00	1.68	0.994	NS
Borg6[h]	P[D] (D-E)	16.14	14.43	2.04	0.838	NS

a. Eight sessions with four periods were run. A datum point for each period in each session was obtained by averaging the Bs' payoffs in the specified relations from the last three rounds. The observed mean for each period in a network was obtained by averaging the data points for periods across sessions.

b. Eleven sessions with four periods were run. A datum point for each period in each session was obtained by averaging A's payoff in the specified relation from the last three rounds. The observed mean for each period in a network was obtained by averaging the data points for periods across sessions.

c. Seven sessions with four periods were run. A datum point for each period in each session was obtained by averaging the As' payoffs in the specified relations from the last three rounds. The observed mean for each period in a network was obtained by averaging the data points for periods across sessions.

d. Five sessions with four periods were run. A datum point for each period in each session was obtained by averaging C's payoff in the specified relation from the last six rounds. The observed mean for each period in a network was obtained by averaging the data points for periods across sessions.

e. Five sessions with six periods were run. A datum point for each period in each session was obtained by averaging the A's payoffs in the specified relations from the last three rounds. The observed mean for each period in a network was obtained by averaging the data points for periods across sessions.

f. Seven sessions with six periods were run. A datum point for each period in each session was obtained by averaging E's payoff in the specified relation from the last three rounds. The observed mean for each period in a network was obtained by averaging the data points for periods across sessions.

g. Eight sessions with six periods were run. A datum point for each period in each session was obtained by averaging C's payoff in the specified relation from the last three rounds. The observed mean for each period in a network was obtained by averaging the data points for periods across sessions.

h. Seven sessions with six periods were run. A datum point for each period in each session was obtained by averaging C's payoff from the last three rounds. The observed mean for each period in a network was obtained by averaging the data points for periods across sessions.

Relative degree is sometimes open to contrary interpretations in full-information networks such as the ones studied here. Ambiguity arises because distance effects are possible. For instance, in the Borg6, A can have two different interpretations of B's power. Relative degree reflects A's expectations that, because B has a larger degree than A, B is more powerful. However, since A has full-information concerning the network, A knows that B's alternative exchange partner, C, has higher degree than B. As a consequence, A might expect B's power over A to be canceled or weakened. GPI-RD will not reflect these expectations. Controlling for possible distance effects, the exchange relations of Table 2 were selected such that GPI-RD would capture unambiguous expectations flowing from degree. For example, the 4Line is included because B's alternative to A has a degree no higher than B's (i.e. 2). More generally, the structurally advantaged position in the listed exchange relations has at least one alternative with degree equal to or lower than its own.

Though GPI-RD suggests that payoffs to structurally advantaged positions will be inflated by relative degree beyond what is predicted by GPI-R, that inflation should only occur in early exchanges when the impact of a position's chance of being included or excluded is not yet salient to the actor. Examination of data in Table 2 shows no peak in the payoffs to actors in structurally advantaged positions. In none of the eight exchange relations did an actor in a structurally advantaged position receive a significantly higher payoff in the higher of her/his first two exchanges than in the lower of her/his last two exchanges. Since payoffs do not peak in early exchanges, there can be no significant decline. The evidence provides no support for Hypothesis 2. Taken together, Tables 1 and 2 do not support the relative degree assumption.

A remaining defense of GPI-RD addresses the possibility that exchange ratios did not reach equilibrium. If the number of rounds were insufficient for exchange ratios to reach equilibrium, a peak would be undetectable and expectations stemming from relative degree should inflate observed means throughout the observations. In that case GPI-RD should be a better predictor of observed means than GPI-R or GPI-l*2. To test that possibility, the three models are tested against each other using *t*-tests and a "deviation score," a method employed by Burke (1997). A deviation score is the average absolute deviation between the prediction and the available data, weighted by the expected number of exchanges between the indicated positions as determined using likelihood values.

Comparing Predictions

For the first three networks in column 1 of Table 3, Lovaglia et al. ([1995] 1999) and Lovaglia and Willer (1999) presented data supporting GPI-RD and GPI-l*2 over GPI-R. In the two networks for which there was additional data, evidence reverses the previous findings. GPI-R is the only model with predictions that are not significantly different from observed means in the 4Line and the Stem. Furthermore, in the afore-mentioned networks, the GPI-RD and GPI-l*2 models' *t* values are at least ten times, and in some cases a hundred times, larger than GPI-R's *t* values.

Table 3: Predictions and Outcomes for Specified Position (*t-* tests in Brackets)

Structure	Relation	Observed Mean	Standard Deviation	GPI-R	GPI-RD	GPI-1*2
4Line{a} n = 32	P[A] (A/B)	13.58	1.787	13.5 [0.249]	14.5*** [2.87]	14.6*** [3.18]
Stem{b} n = 44		14.41	2.740	14.4 [2.85]	15.6*** [2.85]	15.8*** [3.33]
DBranch2{c} n = 30		15.29	2.254	13.3*** [4.75]	16.3* [2.41]	14.4* [2.13]
DBox{d} n = 26		12.80	1.600	12.9 [0.312]	13.6** [2.50]	13.7*** [2.81]
KStem{e} n = 40	P[E] (E/F)	13.69	2.165	14.5* [2.34]	15.1*** [4.07]	15.9*** [6.37]
BoxStem{f} n = 20	P[B] (A/B)	12.71	1.824	12.6 [0.263]	12.3 [0.980]]	13.2 [1.17]
	P[C] (A/C)	12.82	2.233	12.6 [0.429]	13.5 [1.33]	13.2 [0.742]
	P[D] (D/E)	12.69	1.099	13.3* [2.42]	14.4*** [6.78]	14.3*** [6.39]
Borg6{g} n = 42	P[B] (A/B)	14.02	2.953	13.5 [1.13]	14.5 [1.04]	14.6 [1.26]
	P[D] (D/E)	14.52	2.877	14.4 [0.267]	15.6* [2.40]	15.9*** [3.07]
L5Stem{h} n = 47	P[B] (A/B)	12.91	1.459	13.2 [1.35]	14.4*** [6.93]	14.1*** [5.53]
	P[C] (C/D)	13.72	2.162	14.3* [1.82]	15.6*** [5.90]	15.8*** [6.52]
Deviation score 1				0.491	1.11	1.19

a. Eight sessions were run each consisting of four periods containing four rounds. At the end of Each period, subjects were rotated to a new position. Data points were calculated for each period by taking the average value obtained in the last three rounds. Round one was never used.
b. Eleven sessions were run each consisting of four periods containing four rounds. At the end of each period, subjects were rotated to a new position. Data points were calculated for each period by taking the average value obtained in the last three rounds. Round one was never used.
c. Five sessions were run each consisting of six periods containing four rounds. At the end of each period, subjects were rotated to a new position. Data points were calculated for each period by taking the average value obtained in the last three rounds. Round one was never used.
d. Seven sessions were run each consisting of four periods containing four rounds. At the end of each period, subjects were rotated to a new position. Data points were calculated for each period by taking the average value obtained in the last three rounds. Round one was never used. In two periods of one of the sessions, no agreement was reached.
e. Seven sessions were run each containing six periods consisting of four rounds each. At the end of each period, subjects were rotated to a new position. Data points were calculated for each period by taking the average value obtained in the last three rounds. Round one was never used. In two periods agreements were not reached.

f. Five sessions were run each containing four periods consisting of ten rounds each. At the end of each period subjects were rotated to a new position. Data points were calculated for each period by taking the average value obtained in the last six rounds. Rounds one through four were never used.

g. Seven sessions were run each containing six periods consisting of four rounds. At the end of each period, subjects were rotated to a new position. Data points were calculated for each period by taking the average value obtained in the last three rounds. Round one was never used.

h. Eight sessions were run each containing six periods consisting of four rounds. At the end of each period, subjects were rotated to a new position. Data points were calculated for each period by taking the average value obtained in the last three rounds. Round one was never used. In one period agreement was not reached in two of the last four rounds and the datum point was not used.

Note: All predictions without a star are not significantly different from the observed means.
* Significant at <. 05
**Significant at <. 01
***Significant at <. 005

The only network of Table 3 in which GPI-R did not receive unilateral support is the DBranch2, a network that can break into two networks that fall outside the three models' scope. In the DBranch2, the As have two exchanges. If the As exchange first with each other, the network breaks at the A − A connection forming two independent strong power networks so that in each A's second exchange, A is high power relative to it's remaining connections. As such, the DBranch2 may not provide a good test for comparing the predictive precision of the three models. Although GPI-R is the worst predictor for the DBranch2, its *t* value relative to the *t* values of the other models suggests that its predictions are closer to being accurate for the DBranch2 than the other models are to being accurate for the 4-Line and the Stem.

The test of the three models continues with data from five previously unstudied networks. The observed mean payoff to the higher power position in the Dbox, in one relation in the KStem, in three distinct relations in the BoxStem, and in two distinct relations in the Borg6 and the L5Stem each are compared to the predictions made by the three models. Again, the predictions made by GPI-R find the strongest support. In two of three relations in the BoxStem, all three models made accurate predictions, however, in both cases, GPI-R's predictions were the closest to observed means. Similarly, for the payoff to B in the A/B exchange of the Borg6, all three models make predictions that are not significantly different from the observed means. The predictions by GPI-R and GPI-RD for P[B] in the Borg6 are comparable in that they are approximately the same distance away from the observed mean.

The payoffs to D in the D/E relation of the BoxStem and to E in the E/F relation of the KStem are significantly different from all predictions, however, the predictions made by GPI-R are closer than those of the other models. The *t* values for the GPI-RD and GPI-l*2 models are two to three times larger than the *t* values for the GPI-R model. GPI-R's predictions are closer to the observed means and are at a lower level of significance. In the D/E relation of the Borg6, P[D] is only accurately predicted by GPI-R. Overall, GPI-R is the most accurate predictor for payoffs to higher power actors in the Borg6.

For the L5Stem, GPI-R's predictions are more accurate than predictions made by the other models. GPI-R's prediction for P[B] in the A/B relation of the L5Stem is the only prediction that does not significantly differ from the observed mean. Though significantly different from the observed P[C] mean, GPI-R's prediction for the C/D relation is substantially more accurate than predictions from the other two models. The evidence again supports the use of GPI-R.

Finally, comparing the weighted average absolute deviation scores indicates that GPI-R is a superior predictor. In previous tests of eight exchange models including GPI-R and GPI-RD, Burke (1997) found that GPI-R's deviation score, 1.6, was less than GPI-RD's deviation score, 2.1. Similarly, I find that GPI-R has the smallest deviation score. Furthermore, GPI-R's deviation score (0.491) is less than half of GPI-RD's (1.11) or GPI-l*2's (1.19) deviation score.

The tests indicate that the most parsimonious model, GPI-R, is also the most precise. The first two tests do not support the possibility that there is an effect of expectations that declines after early sessions and neither the *t*-tests nor the deviation scores support the possibility that the observed means above are inflated by an enduring effect of expectations. Finally, both *t*-tests and deviation scores strongly support GPI-R over GPI-RD and GPI-l*2.

CONCLUSION

This research improves network exchange theory's precision and parsimony by providing grounds for the selection of one of three models all of which have the same scope - GPI-R over GPI-RD and GPI-l*2. Previous tests comparing the three models examined fewer data points, fewer networks, and across studies did not find consistent support for any one model (Lovaglia et al. [1995] 1999, Lovaglia and Willer 1999, Burke 1997). In hope of providing sufficient evidence for the selection of one model, I conducted the analysis in two phases. The first phase examined the theoretical justification for GPI-RD's relative degree assumption. Evidence, despite previous findings strongly supporting GPI-RD, is consistent with tests conducted by Brennen (1981), which show that degree is not a condition affecting the distribution of benefit. In light of the lack of support for the relative degree assumption and, hence, GPI-RD, I conducted a second phase of analysis comparing the three models for precision. Results from comparing observed mean payoffs to advantaged actors to predicted payoffs for the same actors strongly support GPI-R. GPI-R has the smallest average absolute deviation between predicted and observed means. Evidence provided here suggests that both the precision and the parsimony of network exchange theory will be significantly improved by retaining only GPI-R. Beyond its greater precision, GPI-R is the most parsimonious of the three models.

Future research could further improve the parsimony and, perhaps, the scope of GPI-R by finding a simpler method for calculating likelihood values. Although GPI-R is simple, the calculations for likelihood values must take into consideration all the possible combinations of exchanges and all the possible sequences in which those combinations can occur. As such, each additional node in a network increases the difficulty of calculation exponentially. Since it is impractical to calculate likelihood values by hand, computer programs must be used which restrict applications to small networks - ones with 15 or fewer nodes - and inhibit accessibility of the method.

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ENDNOTES

[1] Superscripts are indicated by * and subscripts by [ ].

[2] As noted by Lovaglia et al. [1995] 1999, the assumption that likelihood of being included affects the rank ordering of power positions in weak power networks is supported by Markovsky et al. 1993.

[3] In Lovaglia et al. [1995] 1999, Pmax is M, Pcon is C, and P is *V*. The terminology here was adjusted to show how likelihood was integrated into resistance equations. *V* was used instead of P to eliminate confusion between P, the pool of value available for negotiation and P, the payoff to an actor.

[4] The equations used in this paper are consistent with ones used by Lovaglia et al. ([1995] 1999). Here the goal is to show, as simply as possible, how resistance and likelihood are integrated. The equation used by Lovaglia et al. ([1995] 1999) P[A] = (P + C[A] - C[B])/ 2, is mathematically equivalent. (For changes in terminology, refer to footnote 5). Therefore, P[A] = (24 + 12 - 9)/2 = 13.5. Again P[A] + P[B] = P so P – P[A] = P[B]. P[B] = 24 - 13.5 = 10.5.

[5] In this study, more data points were available for the analysis of the 4Line and Stem networks. Slight differences in observed means can be attributed to the use of more data points and the possibility that included more or less rounds in the calculation of observed means. For instance, in the 4Line network, each datum point was gained by averaging the payoffs to a position in the last three out of four rounds of exchange. Neither Lovaglia et al. ([1995] 1999) nor Simpson and Willer (1999) specify how they calculated their observed means.

AUTHOR'S NOTE

AUTHOR BIOGRAPHY

Pamela Emanuelson is a current graduate student at the University of South Carolina. Direct all correspondence to Pamela Emanuelson Department of Sociology, University of South Carolina, Columbia, SC 29208, pamelaemanuelson@juno.com.