The effects of externalities on partner choice and payoffs in exchange networks
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Transferring goods or splitting a resource pool: testing consequences of the violation of a basic assumption in exchange research*

* This chapter is co-authored with Marcel van Assen and is currently under review at *Social Psychology Quarterly.*
Abstract

Exchange is typically referred to as pure exchange (PE). We investigated the consequences for exchange outcomes of the violation of the assumption underlying the majority of sociological and social psychological research on exchange, that bilateral exchange can be represented as two actors splitting a resource pool (SRP). Five experimental conditions were designed to determine differences in bargaining behavior in PE and SRP. We conclude that the validity of research using the SRP approach for exchange is questionable, since much more variance and more inefficient agreements were observed in PE than in an SRP. Moreover, although theories accurately predicted outcomes of SRP, they could not predict outcomes of PE. Possible implications of our findings for exchange and research on exchange are discussed.
2.1 Introduction

A large amount of research in the social sciences has been undertaken in the field of exchange. The goal of the present paper is to investigate a major assumption underlying much of the research on negotiated exchange. This is the assumption that negotiated exchange can be validly represented as two exchange partners splitting a fixed pool of resources or ‘profit points’.

An exchange situation is a social situation in which two actors (either individuals or corporate actors) can collaborate with each other, to the benefit of both. This collaboration can take several forms, such as exchanging goods or services, but also performing favors or transmitting information (e.g., Blau, 1964; Homans, 1958; Lawler and Ford, 1995; Molm, 1997; Thibaut and Kelley, 1959), rendering exchange research important for a variety of disciplines in the social sciences, such as economics, sociology and (social) psychology.

Homans’ (1958) definition of social behavior as an exchange of goods implies pure exchange (PE), also called direct exchange by sociologists. In PE, partners are endowed with bundles of commodities that they can exchange with each other, and have different preferences over these commodities (Coleman, 1990; Edgeworth, 1881; Emerson, 1976). Most of the examples that we commonly think of as exchange are direct or pure exchanges (Molm 1997), such as exchanges of help or advice for approval, but also most economic exchanges or trades. Consider a simple PE situation with two actors, A and B, and two goods, X and Y. Assume that A holds 18 units of X, B holds 30 units of Y, A is equally interested in a unit of both goods, and B is five times more interested in a unit of good X than Y. In this PE situation A and B can make a mutually profitable exchange if the exchange rate is in the range of 1 to 5 units of Y for 1 unit of X.

Most of the research on exchange in sociology, and also the present paper, is on negotiated exchange, i.e., exchange involving a joint decision process to determine the terms of exchange (Molm, 1997). In the literature on negotiated exchange in sociology and social psychology an abstraction of PE gradually arose, in which exchange was conceptualized as the opportunity of two actors to split a resource pool (SRP). The first studies on exchange in sociology that introduced the SRP were Cook and Emerson (1978) and Stolte and Emerson (1977). After formulating pure exchange in their theory section they used transaction tables in their experiment to transform a PE situation into an SRP task: ‘This task is formally equivalent to exchange formulated as an Edgeworth box problem (Edgeworth, 1881). In Edgeworth's formulation, both actors can improve on their "initial" endowment by exchanging until some point on the "contract curve" is reached. (...) in the present task [pool split] (...) any agreement that gives a larger share to one person necessarily gives a smaller share to the other, as do exchanges along the contract curve of the Edgeworth box’ (Cook and Emerson, 1978: 729).
Thus Cook and Emerson made an explicit connection between PE and an SRP. However, the majority of subsequent studies on network exchange only used the SRP in both the theory and in possible experiments (e.g., see the special issues of Social Networks June 1992 and Rationality and Society January 1997). Accordingly, the SRP representation nowadays is by far the dominant representation in sociological and social-psychological exchange research (see van Assen, 2003, for an extensive list of references), and it is also being used in economics and behavioral game theory (e.g., see Camerer, 2003; Roth, 1995). PE is used in a minority of the exchange experiments in sociology and social-psychology (e.g., Michener, Cohen, and Sorensen, 1975, 1977; Molm, 1997; Willer, 1999).

A few variants of the SRP approach exist. In some studies using an SRP, as in Cook and Emerson (1978), subjects had restricted information; subjects did not know that they were splitting a common resource pool and did not know their partner’s payoff after exchanging (e.g., Lawler and Yoon, 1998; Molm, Peterson, and Takahashi, 1999). However, in the typical SRP experiment, utilized in dozens of studies, subjects had full information on the task and the others’ payoffs. All studies utilizing the SRP have the other characteristics of the SRP in common. Subjects negotiate over the split of a pool of points, typically of size 24, that has the same value to both of them. If two subjects manage to agree on a division of the pool, the points are divided according to the agreement. If they fail to reach agreement neither subject gets any points. The entire pool of points must be divided, provided agreement is reached. In our experiment we utilized this typical SRP approach, i.e., with full information to the subjects.

The conceptualization of PE as an SRP evokes two questions. First, are these conceptualizations equivalent with respect to payoff possibilities? Bonacich (1992: 22) has raised his doubts on the SRP as a conceptualization of exchange, by commenting on SRP experiments that ‘nothing is actually exchanged in these experiments.’ However, the dominant and often implicit assumption is that the SRP approach is equivalent to PE. Skvoretz and Willer (1993: 803, footnote 3) for instance argue that ‘this task [splitting a pool of points] is formally equivalent to exchange formulated as an Edgeworth box problem (...).’ However, van Assen (2001) has proved that PE and the SRP approach are not equivalent with respect to the payoff possibilities: only under some special, well-defined conditions exchanging resources (PE) can be represented by splitting a pool of points (SRP).

The second question is particularly compelling because of the violation of the basic assumption of the equivalence of SRP and PE underlying most work in negotiated exchange research: to what extent can results and conclusions of studies on exchange using the SRP approach be generalized to real exchange, i.e., PE? To answer this fundamental question one needs to compare bargaining outcomes in SRP and PE situations. If bargaining outcomes differ greatly in the two situations, then one should
have doubts concerning the validity of research using the SRP for exchange. The aim of
the present study is to investigate the consequences on exchange outcomes and research
on exchange of the violation of this basic equivalence assumption, by experimentally
comparing bargaining behavior in SRP and PE situations.

Figure 1a: Payoff space of conditions 1 (SRP) and 2

Figure 1b: Payoff space of condition 3
The inequivalence of the SRP approach and PE is visualized by comparing Figure 1a to Figure 1d. Figure 1 depicts the payoff space or payoff possibilities in four distinct bilateral PE situations. The payoffs of actors A and B are registered on the horizontal and vertical axes, respectively. The lines drawn in the figures show the sets of Pareto efficient agreements available to the pair of actors. A Pareto efficient agreement is an agreement such that no actor can improve his payoff without decreasing the payoff of the other actor. The area to the upper right of this Pareto frontier is the set of infeasible agreements. The area to the lower left of the frontier depicts feasible agreements if and only if this area is shaded in the figure. The shaded area depicts the agreements that are not Pareto efficient. The numbers at the intersections of the Pareto frontier and the axes indicate the
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actors’ maximum gains in the set of feasible agreements. If an actor earns his maximum his partner gains nothing.

Figure 1a depicts a PE situation that can be represented by an SRP of 72 points. Note that the only feasible agreements are Pareto efficient, both actors’ maxima are 72, and the sum of the actors’ payoffs is 72 for all agreements. If the actors do not agree, neither obtains any points. Figure 1d depicts the payoff possibilities that arise in a typical PE situation. Four differences exist between the PE situation depicted in Figure 1d and the SRP situation. These differences are:

(i) The task; in PE actors exchange resources, whereas in the SRP approach actors split a fixed pool of points.

(ii) Pareto efficiency; in the SRP approach Pareto efficiency is enforced by the requirement that the entire pool of points be divided, whereas Pareto efficiency is not guaranteed in PE, as indicated by the shaded area in Figure 1d.

(iii) Constant-sum; the sum of points that actors earn is always constant in the SRP approach, which is not generally true in PE. If the Pareto frontier is kinked, such as in Figure 1d, this sum of points cannot be constant.

(iv) Equal maximum; in the SRP approach the maximum number of points actors can earn is always equal for both subjects, which is not generally true in PE, as indicated in Figure 1d.

Table 1: Summary of the five experiment conditions and their characteristics

<table>
<thead>
<tr>
<th>Condition</th>
<th>(i) Splitting a fixed pool of points</th>
<th>(ii) Pareto efficiency enforced</th>
<th>(iii) Constant sum across Pareto efficient agreements</th>
<th>(iv) Identical maxima</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (SRP; Fig.1a)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2 (Fig.1a)</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3 (Fig.1b)</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>4 (Fig.1c)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>5 (typical PE; Fig.1d)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

The effects of each of these four differences on the bargaining outcomes of PE compared to SRP will be investigated by pair-wise comparisons of five experimental
conditions. These comparisons allow us to determine which characteristic of the typical PE, embodied in condition 5 below, is responsible for the differences in bargaining outcomes between SRP and PE, if such differences exist. The five experimental conditions and their characteristics are presented in Table 1. Condition 1, which is the standard SRP, has all characteristics (i) to (iv) and corresponds to Figure 1a, while condition 5, embodying the typical PE situation and corresponding to Figure 1d, has none of them. Compared to condition 1 (SRP), condition 2 only differs in (i) task, SRP vs. SRP, and thus also corresponds to Figure 1a. Condition 3 in addition also differs in (ii) Pareto efficiency, corresponding to Figure 1b, that has a shaded area indicating Pareto inefficient agreements are feasible. Condition 4 additionally differs in (iii) constant-sum, because of the kinked Pareto frontier, as depicted in the corresponding Figure 1c.

Several dimensions of outcomes of bargaining situations can be distinguished that might be effected by the differences between PE and SRP. The five experimental conditions are analyzed and compared with respect to the following five bargaining outcomes:

1. the average payoffs of the actors;
2. the probability of subjects reaching agreement, \( p(\text{agreement}) \);
3. the conditional probability that agreements are Pareto efficient given that agreements are reached, \( p(\text{Pareto}\mid\text{agreement}) \);
4. the conditional probability that actors’ payoffs are equal given that agreements are reached, \( p(\text{equal}\mid\text{agreement}) \), and
5. the variance in the actors’ payoffs.

With respect to the average payoffs, we make use of three formal bargaining theories that make exact predictions concerning actors’ payoffs. These theories are the Nash bargaining solution (Nash 1950), the Raiffa-Kalai-Smorodinsky (RKS) solution (Kalai and Smorodinsky 1975) and the Kernel solution (Friedman 1986; Shubik 1982). An important implication of the SRP approach in condition 1 is that these three theories all make the same prediction: they all predict actors A and B to split the pool evenly (see Figure 1a). In typical PE however, predictions of the three theories generally differ (see Figure 1d, corresponding to condition 5), indicating that different bargaining behavior can be expected in SRP and PE. Consequently, from the perspective of bargaining theories, the SRP approach abstracts away interesting aspects of PE that cause the theories’ predictions to be different, and thus yields uninteresting bargaining situations.

In the next section we will discuss the bargaining theories and formulate hypotheses concerning the comparisons of the different experimental conditions on the five bargaining outcomes. The subsequent section discusses the design and procedure of our
experiment. The results of these experiments are presented in the section after that, and the paper is concluded with a discussion.

2.2  Theory and hypotheses

Most of the hypotheses are derived from predictions of bargaining and exchange theories. In the first subsection these theories are briefly discussed. To test the basic assumption of exchange research, that SRP validly represents exchange, hypotheses are formulated in the second subsection concerning the expected differences in bargaining outcomes of conditions 1 (SRP), and 5 (typical PE). Finally, hypotheses concerning differences between subsequent experimental conditions are derived in the last subsection.

2.2.1 Bargaining theories

There are a number of reasons for choosing the three bargaining theories discussed in this section. The Nash bargaining solution from cooperative game theory is arguably the best-known solution to the bilateral bargaining problem. Its most famous rival in cooperative game theory is the RKS solution (Kalai and Smorodinsky 1975; Raiffa 1953). A basic principle of one of the most well-known and often used theory of exchange in sociology, called Network Exchange Theory, is based on the RKS solution (Willer 1999). This principle, called equiresistance (ER), yields predictions of bilateral exchange that are identical to predictions of the RKS solution (Heckathorn 1983a; Patton and Willer 1990). Finally, a natural and obvious other prediction of bilateral exchange is that both exchange partners share their gains of exchange equally. This prediction also results from a solution from cooperative game theory, called the Kernel (cf., Friedman 1986; Shubik 1982). Moreover, it also follows from a principle of the oldest theory of exchange in sociology, called Power-Dependence Theory (e.g., Cook and Emerson 1978). This principle is called equidependence (ED). The three solutions will be referred to be by Nash, ER, and ED.

All three solutions from cooperative game theory are axiomatized solutions. These solution concepts, and hence implicitly also their counterparts in sociology, prescribe certain requirements that the outcome of the bargaining situation should meet. Pareto efficiency is an outcome requirement in all three solutions. Moreover, the solutions assume agreement always occurs.

The Nash solution is that Pareto efficient agreement between the two players, for which the product of their utility gains is at a maximum. The ER solution is given by a Pareto efficient agreement between the two players, such that the players’ utility gains are proportional to their maximally attainable utilities. The ED solution is given by a Pareto
efficient agreement where the utility gains of the players are equal. All solutions are indicated in figures 1a through 1d.

2.2.2 Comparing condition 1 (SRP) to condition 5 (typical PE)

The three solutions predict the following payoffs of A and B (denoted $\pi_A$ and $\pi_B$, respectively), formulated as hypotheses:

Hypothesis 1a: In condition 1 (SRP) $\pi_A = \pi_B = 36$ (Nash/ER/ED).
Hypothesis 1b: In condition 5 (typical PE) i) $\pi_A = 12$ and $\pi_B = 60$ (Nash), ii) $\pi_A = 15$ and $\pi_B = 45$ (ER), iii) $\pi_A = 20$ and $\pi_B = 20$ (ED).

Hypotheses 1a and 1b reveal that the three solutions do not agree in typical PE situations such as condition 5, but do in SRP situations such as condition 1. That is, three solutions that are based upon reasonable characteristics that an outcome should have (maximum product of gains, equal relative gain, equal absolute gain) are in conflict in a typical PE situation but not in an SRP situation. We expect this conflict in solutions also to result in a higher probability of conflict between exchange partners, and more uncertainty concerning what a ‘good’ or ‘fair’ outcome of the exchange in a typical PE situation should be. Postponing a detailed account of the derivation of our hypotheses to the subsequent subsection, we expect the following differences with SRP concerning the four other bargaining outcomes. Formulated in hypotheses:

Hypothesis 2: $p(\text{agreement})$ is lower in condition 5 (typical PE) than in condition 1 (SRP).
Hypothesis 3: Pareto inefficient agreements are observed in condition 5 (typical PE): $p(\text{Pareto|agreement}) < 1$.
Hypothesis 4: $p(\text{equal|agreement})$ is lower in condition 5 (typical PE) than in condition 1 (SRP).
Hypothesis 5: The variance in the payoffs is higher in condition 5 (typical PE) than in condition 1 (SRP).
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Table 2: Hypotheses; an arrow in a cell indicates that the value of the corresponding dependent variable is expected to be lower or higher than in the preceding condition; corroborated hypotheses are underlined

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Payoffs</th>
<th>P(\text{agreement})</th>
<th>P(\text{Pareto agreement})</th>
<th>P(\text{equal agreement})</th>
<th>Variance payoff B</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>H1a</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
<td>H2a, H4a, H5a</td>
</tr>
<tr>
<td>3</td>
<td>H1a</td>
<td>↓</td>
<td></td>
<td></td>
<td>H3a</td>
</tr>
<tr>
<td>4</td>
<td>H1c</td>
<td>↓</td>
<td></td>
<td>↑</td>
<td>(H4b), H5b</td>
</tr>
<tr>
<td>5 (typical PE)</td>
<td>H1b</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
<td>H2, H2b, H3, H4, H4c, H5, H5c</td>
</tr>
</tbody>
</table>

2.2.3 Hypotheses concerning subsequent experimental conditions

Table 2 summarizes all hypotheses of this study. The last row presents hypotheses 1 to 5 comparing the condition 1 (SRP) to condition 5 (typical PE). Some cells of the table contain one arrow. A downward (upward) pointing arrow in a cell indicates we hypothesize that the corresponding dependent variable has a lower (higher) value in the corresponding condition, compared to its value in the condition preceding it. No arrow in a cell signifies that the dependent variable in this condition is expected to have the same value as in the preceding condition. For example, consider the dependent variable \( p(\text{equal agreement}) \). It follows from Table 2 that this probability is expected to be lower in condition 2 than in condition 1 (SRP), equal in conditions 3 and 2, lower in condition 4 than in condition 3, and lower in condition 5 (typical PE) than in condition 4. The hypotheses concerning subsequent experimental conditions are explained below for each dependent variable separately.

Since the Pareto frontiers of conditions 1 (SRP), 2 and 3 are identical (figures 1a and 1b), the theories make the same prediction concerning the average payoffs for the three conditions. Thus, Hypothesis 1a not only pertains to condition 1 (SRP), but also to
conditions 2 and 3. The kink in the Pareto frontier of condition 4, depicted in Figure 1c, causes the prediction of Nash to differ from the predictions of ER and ED, yielding Hypothesis 1c.

Hypothesis 1c: In condition 4 i) \( \pi_A = 36, \pi_B = 60 \) (Nash), ii) \( \pi_A = 45, \pi_B = 45 \) (ER/ED).

Note that ER and ED have identical predictions in condition 4, but different ones in condition 5 (typical PE), i.e., when both actors’ maxima are unequal. The two predictions are different in condition 4 (typical PE) because the ER solution is not affected by linear transformations of payoffs, but the ED solution is.

Two reasons underlie the expectation that \( p(\text{agreement}) \) is lower in condition 5 (typical PE) than in condition 1 (SRP). Firstly, moving from condition 1 (SRP) to condition 2 increases the complexity of the experimental task, since in condition 2 it involves the processing of more diverse types of information: how many units of what resource do I give up, how many units of which do I receive, how much is each resource worth to me and to the other subject, how much do I gain, etc? The task in condition 1 (SRP) is easier in this respect, since the size of the pool is known to the subjects, and no calculations with units of different resources have to be performed to determine one’s own gain from the (prospective) agreement. We expect that subjects will fail to reach agreement more often in the case of the more complex task (H2a in Table 2). Secondly, moving from condition 4 to condition 5 (typical PE) introduces a conflict between relative and absolute payoffs, or between the ER and ED solutions. In condition 4, the actors’ maximum payoffs are equal, as can be seen in Figure 1c, which implies that if the actors earn the same relative share off their maximum attainable payoffs, they earn the same absolute payoffs. In condition 5 (typical PE) however, this is no longer true, since A’s maximum is one third of the size of B’s maximum, as can be seen in Figure 1d. This means that a conflict results between a subject wanting relative payoffs to be equal and a subject that feels absolute payoffs should be equal. We expect this conflict to result in even fewer agreements in condition 5 (typical PE) than in condition 4 (H2b in Table 2).

Concerning \( p(\text{Pareto|agreement}) \), in condition 1 (SRP) and condition 2 Pareto inefficient agreements are not possible, contrary to the other three conditions. Although Pareto inefficient exchanges are possible in these three conditions, the three bargaining solutions presume that Pareto inefficient transactions do not occur. However, because of the task complexity or other reasons concerning the cognitive capacities of the subjects, some inefficient agreements in these conditions can be expected (H3 and H3a). Note that this expectation of inefficient agreements reflects our belief that subjects’ rationality is bounded.
We expect \( p(\text{equal|agreement}) \) to decrease as one goes from condition 1 (SRP) to condition 5 (typical PE). Firstly, we believe \( p(\text{equal|agreement}) \) in condition 2 is lower than in condition 1 (SRP) (H4a). In condition 1 (SRP) equally dividing the pool of points is a focal solution to the bargaining problem (Schelling 1960). In condition 2 this focal point is blurred, since there is no pool of points to be divided, even though the set of feasible agreements is identical. Secondly, we expect \( p(\text{equal|agreement}) \) to be even lower in condition 4 than in condition 3 (H4b). All three solutions point to equal gain for both actors in condition 3, but in condition 4, Nash points to an unequal gain, as can be seen by comparing figures 1b and 1c. If some subject’s or pair of subjects’ behavior is accurately described by the Nash solution, then fewer equal gain agreements will be observed in condition 4 than in condition 3. Finally, following a similar reasoning, even fewer equal gain agreements are expected to be observed in condition 5 (typical PE) (H4c); if some subjects’ behavior is accurately described by ER, then fewer equal gain agreements will be observed in condition 5 (typical PE) than in condition 4.

Hypotheses 5a to 5c on the variance of payoffs reflect those concerning \( p(\text{equal|agreement}) \). The variance is expected to be larger in condition 2 than in condition 1 (SRP) because the focal point is less prominent in the former than in the latter. And the variance is expected to be larger in condition 5 (typical PE) than in condition 4, in which it is in turn expected to be larger than in condition 3, because moving from condition 3 to condition 5 (typical PE), more solutions are conflicting in the subsequent condition.

2.3 Experimental conditions and design

In the experiment, half of the subjects were assigned the letter A, the other half were assigned the letter B, and each pair consisted of an A subject and a B subject.

2.3.1 Condition 1 (SRP)

In condition 1 (SRP), corresponding to Figure 1a, subjects A and B negotiate over the division of 72 points. They can divide these points in any way they wish, as long as they both agree to it.\(^2\) If they fail to reach agreement, neither gets any points. Provided subjects reach agreement, they must divide all of the 72 points. This implies any exchange is Pareto efficient.
Table 3: Endowments (E) and utilities (U) of goods X and Y for the PE conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Goods</th>
<th>Actors</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>X</td>
<td>Y</td>
<td>X</td>
</tr>
<tr>
<td>2 (Fig.1a)</td>
<td>E</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>U</td>
<td>18</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>3 (Fig.1b)</td>
<td>E</td>
<td>18</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>U</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>4 (Fig.1c)</td>
<td>E</td>
<td>18</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>U</td>
<td>3</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>5 (typical PE; Fig.1d)</td>
<td>E</td>
<td>18</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>U</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

2.3.2 Condition 2

In conditions 2 through 5 both subjects are given an endowment (E) of units of resources X and Y which they can exchange with each other, and for which they get points (U) in the experiment. Endowments and utilities in the four PE conditions are presented in Table 3. For instance, the first E-row in Table 3 shows that in condition 2, actor A has 1 unit of X and no units of Y, whereas actor B has no units of X and 90 units of Y. The first U-row indicates that in condition 2, a unit of X is 18 times more valuable to actor A than a unit of Y. The same row shows that in condition 2, a unit of X is 90 times more valuable to actor B than a unit of Y.

Since in condition 2, corresponding to Figure 1a, subject A has only 1 unit of X to transmit, any exchange that occurs is Pareto efficient. Since to A a unit of X is 18 times more valuable than a unit of Y, A will want at least 18 units of Y in return for it. In that case B will receive his maximum possible payoff gain equal to 72, and A will gain 0. Since to B, 1 unit of X is 90 times more valuable than a unit of Y, B is willing to maximally give up 90 units of Y in return for the unit of X. In that case A will receive his maximum possible payoff gain equal to 72, and B will gain 0. For all other exchange rates the gains also sum up to 72.
In the introduction it was stated that only if some special well-defined requirements are met, PE can be represented by SRP. Condition 2 satisfies all these requirements. These requirements are that (a) one actor can only transfer one unit of an indivisible good, implying Pareto efficiency, (b) the Pareto frontier is a straight line, and (c) both actors have the same maximum possible gain. Note that (b) and (c) are very restrictive assumptions on the actors’ preferences, implying that PE situations that can be represented as an SRP situation hardly occur in real-life. Requirement (a) is violated in conditions 3, 4 and 5 (typical PE), requirements (a) and (b) are violated in condition 4 and all three requirements are violated in condition 5 (typical PE).

2.3.3 Condition 3

As shown in Table 3, in condition 3 A has 18 units of X and is free to transmit any number of units of X in his possession. This way, Pareto inefficient exchanges become feasible, i.e., exchanges in which A transmits fewer than 18 units of X. The Pareto frontier of condition 3 however is identical to the Pareto frontier of conditions 1 (SRP) and 2, as shown in Figures 1a and 1b. Pareto inefficient exchanges in condition 3 are represented by points in the shaded area in Figure 1b.

2.3.4 Condition 4

In the previous PE conditions 2 and 3, A always transfers all his units of X to B in the set of Pareto efficient of exchanges. Condition 4, corresponding to Figure 1c is different since for an agreement to be Pareto efficient either the A subject must transfers all of his units of X to B, or the B subject must transfers all his units of Y to A, or both. This causes the sum of payoffs of the two subjects to vary across Pareto efficient agreements. The upper portion of the Pareto frontier in Figure 1c corresponds to exchanges in which subject A transfers all of his units of X. The lower portion corresponds to exchanges in which B transfers all of his units of Y. At the point where these portions intersect, i.e., at the ‘kink’ in Figure 1c, A and B both transfer all of their resources.

2.3.5 Condition 5 (typical PE)

In condition 5 (typical PE) the maximum for B is 72 and the maximum for A is 24, as is shown in Figure 1d. This is achieved by dividing the points of subject A by 3, relative to condition 4. This implies that the Pareto frontier of condition 5 (typical PE) is shifted inward, compared to the Pareto frontier of condition 4, as shown in Figure 1d.
2.3.6 Design and procedure

Subjects were students from several departments at the University of Groningen. We used a between-subjects design, meaning each individual subject bargained in only one of the five conditions. We recruited 124 subjects, who were paired randomly to form 62 pairs. Thirteen, 14, 9, 13, 13 pairs played conditions 1 (SRP) to 5 (typical PE), respectively. Each pair played a maximum of 6 rounds of 120 seconds each. Overall, 78, 78, 54, 75, 60 rounds were played for each of the conditions, respectively. A round ended whenever agreement was reached or time was up. When no agreement was reached, no points were scored.

In the PE conditions 2 through 5 (typical PE), both subjects were given a number of units of a resource and a payoff schedule that indicated how many points the resources were worth to the subject and his exchange partner, corresponding to Table 3. In condition 1 (SRP), subjects earned 1 point for any unit of the pool. In all the conditions, points scored in exchange were converted to money at a rate of 3 eurocents per point, which was paid out after the experiment, yielding an average of 5.80 Euro per subject across all conditions. In the PE conditions the value of the initial endowments were subtracted from subjects’ points, to ensure that no points were earned when no exchange had taken place. For instance, in condition 2, 18 points were subtracted from the points of subject A and 90 from the points of subject B. This way only points earned in exchange were counted, as is the case in condition 1 (SRP).

In much of the previous research using the SRP approach a full information design is employed. Since we intended to pitch this standard SRP approach against PE, we used the same full information design. Thus, subjects knew each other’s points in the game as well as gains in money. In 24 rounds of the first four conditions and in 12 rounds of condition 5 (typical PE) subjects were able to observe the ongoing negotiations of other pairs. Subjects were not told about the fact they could observe other pairs. Anyway, in the analyses below we control for the fact that some subjects had the possibility to observe other pairs, and others had not.

Experiments were conducted using the computer program ExNet 3.0, developed by Willer and co-workers at the University of South Carolina. Subjects were seated behind computer terminals, showing their own and their partner’s endowments, their own and their partner’s points for each unit of resource and the offers and counteroffers they and their partner made. Communication between subjects, other than making offers and counteroffers via the computer program, was not allowed. For each offer made, the computer screen showed both subjects the number of points this would yield them both. Before playing the actual experiment, 2 practice rounds were played in which the experiment leader carefully explained the bargaining procedure to the subjects.
Table 4: Descriptives of dependent variables

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Pay-offs (A first)</th>
<th>P(agreeement)</th>
<th>P(Pareto agreement)</th>
<th>P(equal agreement)</th>
<th>Variance payoff B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Fig.1a; SRP)</td>
<td></td>
<td>0.73</td>
<td>1</td>
<td>0.54</td>
<td>4.12</td>
</tr>
<tr>
<td>2 (Fig.1a)</td>
<td>33.17 (1.90)</td>
<td>0.87</td>
<td>1</td>
<td>0.37</td>
<td>81.16</td>
</tr>
<tr>
<td></td>
<td>38.83 (1.90)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 (Fig.1b)</td>
<td>32.85 (2.75)</td>
<td>0.89</td>
<td>0.73</td>
<td>0.67</td>
<td>157.74</td>
</tr>
<tr>
<td></td>
<td>33.69 (2.50)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 (Fig.1c)</td>
<td>41.28 (1.22)</td>
<td>0.92</td>
<td>0.63</td>
<td>0.57</td>
<td>93.33</td>
</tr>
<tr>
<td></td>
<td>41.05 (1.73)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 (typical PE; Fig.1.d)</td>
<td>14.79 (1.09)</td>
<td>0.82</td>
<td>0.39</td>
<td>0.41</td>
<td>218.54</td>
</tr>
<tr>
<td></td>
<td>28.33 (4.51)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Robust standard errors for payoffs accounting for multilevel structure in brackets

2.4 Results

Table 4 shows the descriptives for all dependent variables across the five conditions. The second column shows the average payoffs, only considering the rounds in which agreement was reached. No average payoff of A and B could be meaningfully calculated for condition 1 (SRP) because the individual actors of a pair cannot be distinguished. The variance for condition 1 (SRP) was calculated as the average sum of squared deviations from 36 of one actor of each pair across all exchanges per condition. The variance of
payoffs in the other conditions was calculated as the variance of B’s payoffs across all exchanges per condition. Since pairs of subjects played a maximum of 6 rounds of bilateral exchange in one condition, the data were structured in a multilevel fashion, introducing dependencies in the data (cf., Snijders and Bosker 1999). These were dealt with in three ways. For testing the payoff predictions (H1) random intercept models with subject pairs as the second level were estimated, subsequently called ‘mixed models’. For testing hypotheses concerning probabilities (H2 to H4) multilevel logistic regression was used, again with subject pairs as the second level. For testing differences in variance (H5) we analyzed both the variances at the level of individual exchanges and at the level of pairs of subjects.

To test our hypotheses concerning the dependent variables we controlled for the effects of Round, and the fact that subjects in some sessions were able to observe the negotiations in other pairs (indicated by the variable Comparison). The variable Round was computed by centering the rank number of the original 6 rounds that each pair played. Thus, Round ranges from -2.5 to +2.5. The variable Comparison had value 1 if subjects were able to observe the negotiations in other pairs and 0 otherwise. Hence the intercept in regression analyses was interpreted as the average payoff of B in the ‘average round’ where pairs cannot observe each other.

2.4.1 Comparing conditions 1 (SRP) and 5 (typical PE)

The first hypotheses concern the average payoffs and present no comparison between the conditions. For condition 1 (SRP) all three bargaining theories expected an equal split, i.e., an average payoff of 36 for both subjects in the pair. The average payoffs of all subjects in this condition were indeed very close to 36 (ranging from 33.20 to 38.80) and the variance of individual exchange was small (4.12), corroborating the predictions of the three bargaining theories as formulated in H1a.
The estimates of A’s and B’s payoffs for condition 5 (typical PE) are shown in Table 5. Two models were estimated; one with all exchanges included (3rd column), and one with only Pareto efficient exchanges included (last column). Only when inefficient exchanges are included is it sensible to estimate the payoffs of A and B separately.

Comparison had no effect on the payoffs. Round had a significant positive effect on the payoffs of A. The corresponding coefficient in the model for B’s payoffs was also positive and marginally significant (p = 0.084). These results are evidence that the efficiency of the exchange increased as more rounds were played in condition 5 (typical PE).

To test H1b, 95%-confidence intervals (CI) were constructed for the average payoffs of A and B using the intercept estimates reported in Table 5. These were [12.60, 16.76] and [21.04, 40.06] for the payoffs of A and B, respectively. This means we could reject all bargaining theories’ predictions concerning B’s average payoff, and all but the ER prediction concerning A’s average payoff. Since all three theories assume Pareto efficiency, we also constructed the 95% CI with only efficient exchanges. This yielded [21.16, 39.38] for B’s average payoff, rejecting all three theories.

A more direct test of each of the bargaining theories is to count the number of times that an exchange rate was exactly equal to a theory’s prediction, because each theory is assumed to operate on the level of individual exchanges. Of the 49 exchanges in condition 5 (typical PE) the proportions of exchanges conforming to the Nash, ER and
ED predictions were, 0.04 (0.04), 0.02 (0.02), 0.25 (0.33), respectively, where proportions based on exchanges within an absolute payoff distance of 2 are given in parentheses. These data revealed that ED was correct for many pairs, while Nash and ER were almost never correct.

Table 6: Multilevel logistic regression estimates comparing condition 1 (SRP) and condition 5 (typical PE); subject pairs as level 2

| Dependent Variable | H2: P(agreeement) | H3: P(Pareto|agreement) | H4: P(equal|agreement) |
|--------------------|--------------------|-------------------------|-----------------------|
| Intercept          | 1.04 ***           | 0.76 (0.40)             | 0.26 (0.47)           |
|                    | (0.30)             |                         |                       |
| Round              | 0.14 (0.12)        | 0.23 (0.14)             | -0.07 (0.12)          |
| Comparis           | -0.09 (0.46)       | 0.85 (0.86)             | -0.51 (0.71)          |
| Condition          | 0.55 (0.43)        |                         | -0.53 (0.61)          |

*Note:* Standard error in parentheses.
* * p < .05, ** p < .01, *** p < .001 (two-tailed tests)

To test hypotheses H2 to H4 on p(agreeement), and conditional probabilities p(Pareto|agreement), and p(equal|agreement), respectively, multilevel logistic regressions were run (see Table 6). The variable Condition is a dummy with values 0 and 1 indicating conditions 1 (SRP) and 5 (typical PE), respectively. The effects of the variables Round and Comparison were not significant in any of the models.

Contrary to what we hypothesized (H2), p(agreeement) was not lower in condition 5 (typical PE) than in condition 1 (SRP) (p > 0.5). Since Pareto inefficient exchanges were observed in condition 5 (typical PE), H3 is confirmed. As expected, p(equal|agreement) was lower in condition 5 (typical PE) than in condition 1 (SRP), although not significantly so (Wald Z = -0.87, p = 0.19, one-tailed). Hence we do not accept H4.

H5, stating that the variance in the payoffs of B is larger in condition 5 (typical PE) than in condition 1 (SRP) is accepted. Both at the level of individual exchanges (variances of 4.12 and 218.54 for (1) and (5), respectively; F_{48,56} = 53.01, p < 0.001) and the level of subject pairs (1.37 and 296.59 for SRP and (5), respectively; F_{12,12} = 215.93, p < 0.001) the difference in variance was significant.
### Table 7: Estimated payoffs for A and B in conditions 2, 3 and 4; mixed models with subject pairs as level 2

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Condition 2</th>
<th>Condition 3</th>
<th>Condition 3 Pareto efficient only</th>
<th>Condition 4</th>
<th>Condition 4 Pareto efficient only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payoff B</td>
<td>Intercept</td>
<td>36.94 ***</td>
<td>32.02 ***</td>
<td>35.96 ***</td>
<td>40.83 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.08)</td>
<td>(3.34)</td>
<td>(3.95)</td>
<td>(1.94)</td>
</tr>
<tr>
<td></td>
<td>Round</td>
<td>-0.28</td>
<td>1.61</td>
<td>1.85</td>
<td>2.38 **</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.40)</td>
<td>(1.09)</td>
<td>(1.41)</td>
<td>(0.66)</td>
</tr>
<tr>
<td></td>
<td>Comparis</td>
<td>6.27</td>
<td>3.23</td>
<td>-0.31</td>
<td>1.30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3.88)</td>
<td>(4.84)</td>
<td>(5.07)</td>
<td>(3.41)</td>
</tr>
<tr>
<td>Payoff A</td>
<td>Intercept</td>
<td>30.83 ***</td>
<td></td>
<td>40.79 ***</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3.67)</td>
<td></td>
<td>(1.48)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Round</td>
<td>0.40</td>
<td></td>
<td>2.29 ***</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.08)</td>
<td></td>
<td>(0.51)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Comparis</td>
<td>4.26</td>
<td></td>
<td>2.07</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(5.35)</td>
<td></td>
<td>(2.61)</td>
<td></td>
</tr>
</tbody>
</table>

*Note: Standard errors in parentheses.  
* p < .05, ** p < .01, *** p < .001 (two-tailed tests)

#### 2.4.2 Results concerning subsequent experimental conditions

To test H1c, 95% CIs were constructed for A’s and B’s average payoffs in condition 4, based on the intercepts from Table 7. Including the Pareto inefficient exchanges (penultimate column of Table 7), we got 95% CIs around the intercepts for the payoffs of A and B of [37.89, 43.69] and [37.03, 44.63], respectively. These CIs imply all the predictions of H1c must be rejected. Analyzing Pareto efficient exchanges only (last column of Table 7) yielded a 95% CI for the payoff of B of [41.82, 46.44], including the value of 45 predicted by ER and ED, corroborating Hypothesis 1cii.

Of the 67 exchanges in condition 4, the proportions of exchanges conforming to the Nash and ER/ED predictions were 0.06 and 0.37, respectively. Proportions based on exchanges within an absolute payoff distance of 2 from the prediction were identical. Hence, Nash predictions were almost always incorrect.
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Two additional observations can be made from Table 7. Firstly, the 95% CI for conditions 2 and 3 contained 36, confirming H1a derived from the three bargaining theories. Secondly, there was a positive effect of Round on the payoffs earned by A and B in condition 4 condition, revealing that exchanges became more efficient as more rounds were played.

Table 8: Wald Z-scores for pairwise comparisons between subsequent conditions, based on multilevel logistic regressions with subject pairs as level 2; Round and Comparison were included as covariates; p-values in parentheses

| Conditions Compared | P(agreement) | p(Pareto|agreement) | p(equal|agreement) |
|---------------------|--------------|------------------|-----------------|
| 1 (SRP) – 2         | 1.83 (0.97)  | -3.49 (< 0.001)  |
| 2 – 3               |              | 2                |
| 3 – 4               | -0.48 (0.31) |                  |
| 4 – 5 (typicalPE)   | -1.27 (0.1)  | -2.42 (0.008)    | -0.96 (0.17)    |

1 All tests are one-tailed
2 H3a is accepted on logical, instead of on statistical grounds. A statistical test could not be performed because the standard error of p(Pareto|agreement) is equal to 0 for (2)

To test hypotheses H2 to H4 concerning subsequent conditions multilevel logistic regression analyses were run on p(agreement), p(Pareto|agreement) and p(equal|agreement). Table 8 shows the Wald Z-scores for the parameters estimated for the dummy variable Condition, that in each comparison had value 0 for the first condition and value 1 for the second condition mentioned. Each Wald Z-score shown corresponds to a hypothesis.

Contrary to what we expected, p(agreement) was higher in condition 2 than in condition 1 (SRP), refuting H2a. P(agreement) was lower in condition 5 (typical PE) than in 4, corroborating H2b. In line with our expectations (Hypotheses 3 and 3a) we found many Pareto inefficient exchanges in conditions 3 through 5. Additionally, we found that the proportion of Pareto efficient agreements in condition 5 (typical PE) was smaller than in condition 4 (Wald Z = -2.42, p = 0.008). In accordance with H4a to H4c, the probability of reaching an equal agreement decreased from conditions 1 (SRP) to 2, 3 to 4, and 4 to 5 (typical PE), but only the difference between conditions 1 (SRP) and 2 was significant, only corroborating H4a.
Each comparison in Table 8 contains Round and Comparison as covariates. The most important effect of Round was to increase the probability of Pareto efficient exchange in the comparison between conditions 3 and 4 (Wald Z = 3.79, p < 0.001, 2-tailed), and 4 and 5 (typical PE) (Wald Z = 4.25, p < 0.001, 2-tailed). As with the results concerning the payoffs, this indicates subjects learned to exchange Pareto efficiently as more rounds were played.

The variance in the payoff of B was higher in condition 2 than in condition 1 (SRP), both at the exchange level and at the level of the subject pairs ($F_{67,56} = 19.69$, $p < 0.001$, and $F_{13,12} = 44.36$, $p < 0.001$, respectively), corroborating Hypothesis 5a. Also, the variance in condition 5 (typical PE) was larger than in condition 4, both at the level of exchanges and pairs ($F_{48,66} = 2.34$, $p < 0.001$, and $F_{12,12} = 17.44$, $p < 0.001$, respectively), corroborating Hypothesis 5c. Hypothesis 5b must be rejected, since the variance in condition 4 was lower than in condition 3 (Table 4). To sum up the hypothesis testing, hypotheses that were corroborated are underlined in Table 2.

### 2.5 Conclusions and discussion

Exchange is typically referred to as PE. However, by far the most dominant paradigm to study exchange is the SRP approach, an abstract representation of exchange. Van Assen (2001) has proved that SRP can only correctly represent PE in some very restrictive well-defined conditions concerning endowments and actors’ preferences, that are unlikely to be satisfied in real-life exchange situations. The question is then, what the validity is of research using the SRP approach, i.e., to what extent can results and conclusions of studies on exchange using the SRP approach be generalized to PE? To answer this fundamental question we compared bargaining outcomes in SRP and PE situations in the simplest exchange situation, bilateral exchange.

Typical PE, as operationalized in condition 5 of our experiment, is different from SRP, as operationalized in condition 1, in four elements; (i) task, (ii) enforced Pareto efficiency, (iii) constant-sum, (iv) equal maximum. The last three elements are present in SRP but not in typical PE. To identify the cause of possible differences in bargaining behavior between SRP and typical PE, four PE conditions were created that differed in the number of elements in common with an SRP. Applying well-known theories of cooperative bargaining or principles of exchange (Nash, RKS or exchange-resistance, Kernel or equidependence) we expected more variance of payoffs and fewer equal payoff agreements in condition 5 (typical PE) than in condition 1 (SRP). Considering the higher cognitive complexity and demands of condition 5 (typical PE) than of condition 1 (SRP) we expected fewer exchanges and more Pareto inefficient exchanges in condition 5 (typical PE) than in condition 1 (SRP).
An experiment was run with the 5 conditions as described above in a full information design corresponding to the design in the majority of experiments on network exchange. On the basis of our results we conclude that the validity of research using the SRP approach for exchange is questionable, since bargaining outcomes obtained when using the SRP approach are different from those obtained using the PE approach. Three main conclusions can be drawn from our results concerning differences in bargaining outcomes between condition 5 (typical PE) and condition 1 (SRP). Firstly, the bargaining theories and exchange principles Nash, ER and ED, all accurately predict the average payoff in condition 1 (SRP) but none of them does so in condition 5 (typical PE). More specifically, our results suggest that as long as PE is constant-sum (as in conditions 2 and 3) the three theories predict well, but if it is not constant sum (as in conditions 4 and 5) they do not. Let us speculate on the possible implications of the first conclusion.

The invalidity of the SRP approach as a representation of typical PE as in condition 5 does not imply that the SRP approach isn’t a valid representation of something. The SRP approach is an appropriate method when investigating allocation problems in which a fixed sum has to be divided. There is a link here with productive exchange in which ‘(…) both actors in the relation must contribute in order for either to obtain benefits. Neither can produce benefit for self or other through his own actions’ (Molm 1997: 21-22). After the surplus has thus been successfully produced, it has to be divided. For this division problem the SRP approach is appropriate. Such a division problem occurs for instance in organizations with a ‘profit-sharing’ regime: given that all members of the organization (including employees, management and shareholders) have collaborated to produce the firm’s profit, (part of) the latter is divided among the organization members. The PE approach is more appropriate than the SRP whenever there is a direct exchange of commodities, such as the exchange of labor effort for wages or (chances to get) promotion, between an employee and management, or the exchange of advice for status between two employees (Blau 1964).

From previous research that uses the SRP approach to study exchange in networks it can be concluded that the many different theories of exchange more or less agree on their predictions for many networks and predict the exchange outcome reasonably accurately (e.g., Braun and Gautschi 2006; Burke 1997; Skvoretz and Willer 1993). Since our study demonstrates that two of the most well-known principles of exchange, equiresistance and equidependence, do not provide accurate predictions on the most simple exchange situation, bilateral exchange, we can also suspect that they do not provide accurate predictions of outcomes of PE in the more complex networks. However, based on the current study, we cannot say anything conclusive on this matter, since we have not studied exchange networks. The effect of network structure on outcomes of PE compared to outcomes of exchange in networks using SRP is an important question to be answered in future research.
Our second main conclusion is that, although none of the theories accurately predicted average payoffs, the equidependence principle has considerable explanatory power. In all PE conditions, a reasonable to large proportion (0.41 to 0.67) of equal payoff agreements were obtained. Because only very few outcomes conformed to the Nash or ER predictions, the proportion of equal payoff agreements was only slightly (and not significantly) smaller in condition 5 (typical PE), where the three solutions were different, than in other PE conditions where the equidependence solution coincided with either one (ER) or two other solutions (Nash and ER). Our findings in favor of equidependence are in agreement with findings of studies on bargaining conducted a considerable time ago. Roth and Malouf (1979: 580-581) cite several studies reporting a strong tendency of outcomes to equal payoffs in bargaining games where the Nash prediction is different from it. In a nice study on bargaining, Schellenberg (1988) compared equidependence to equiresistance and Nash and also found that the most frequent response was that of simple equality (equidependence).

The implication of the second main conclusion could be that theories of exchange other than Power-Dependence Theory, which is based on equidependence, provide accurate predictions in SRP situations because their predictions are close to those of Power-Dependence Theory. That is, it might be that in condition 5 (typical PE) embedded in networks, other theories like Network Exchange Theory using equiresistance, provide a worse fit than Power-Dependence Theory. In any case, our results provide considerable support for the equidependence principle and hence Power-Dependence Theory, and evidence against the equiresistance principle and hence Network Exchange Theory. Note that this evidence could not have been obtained using the SRP approach, because the SRP abstracts away interesting aspects of PE that cause the theories’ predictions to differ.

The oversimplification of PE by using SRP to represent it, was also demonstrated by comparing the variances of payoffs across conditions. If only the task was different (comparing conditions 1 (SRP) and 2), the variance of payoffs already increased. The variance of payoffs in condition 5 (typical PE) was more than 50 times larger than in condition 1 (SRP). To conclude, by abstracting away features of PE, subjects in condition 1 (SRP) ‘knew what to do’ and their behavior consequently showed little variance, and was accurately predicted by all three solutions (predicting the same). However, in condition 5 (typical PE) their behavior varied to a large extent and on average none of theories predicted accurately, although many agreements corresponded to the equidependence principle.

The third main conclusion is that the basic Pareto efficiency assumption of the SRP approach is violated, supporting the view of bounded rational subjects. In condition 5 (typical PE) more than 60% of the agreements was Pareto inefficient. Our results revealed that the inequality of actors’ maxima is the main cause of this inefficiency, because efficiency was considerably larger in the PE conditions 3 and 4, that had equal
maxima. It must be noted that efficiency of exchange increased as more rounds were played. Our findings concerning inefficient agreements are also in line with previous research on bargaining (see again Roth and Malouf 1979: 581). The implication of the third conclusion is that the SRP approach does not recognize that actors have a hard time agreeing upon an efficient exchange. Since inefficiency of exchange is so common and undesirable, we argue that more research should be conducted on the conditions of exchange situations that affect the efficiency of exchange, and on ways to help actors achieve efficiency. To conduct this research the SRP approach has to be abandoned.

We also hypothesized that the probability to reach an agreement was smaller in the PE conditions 2 through 5 (typical PE) than in condition 1 (SRP), because of the complexity of PE compared to SRP and more conflicts between different solution principles. However, we observed larger sample proportions of agreements in the PE conditions than in condition 1 (SRP). A possible explanation is that our PE conditions were not that complex after all, since essential calculations needed for exchange were performed by the ExNet program used in the experiment, the results of which were displayed on the screen. On the other hand, the many violations of Pareto efficiency in the PE conditions do suggest that PE is a considerably complex task. Apparently the actors do not want to forgo a possible gain more in PE than in SRP in spite of the larger conflict and uncertainty in PE.

Our study unequivocally demonstrates that bargaining behavior in typical bilateral PE is different from behavior in an SRP, but to what extent does our study have implications for research on exchange networks using an SRP? Theorists of networks exchange might grant that SRP is fundamentally different from typical PE, but argue that they are mainly interested in the effect of (network) structure on outcomes. By abstracting PE to the simpler SRP one can focus on the effect of structure on outcomes with more statistical power. The argument is convincing and legitimate only if results on ‘exchange’ networks using the SRP approach are not structurally different (i.e., biased) from exchange networks using the PE approach. This still remains to be shown. Our study already suggests that the rather accurate predictions of outcomes in exchange networks using the SRP approach might at least be an artifact, and that the equidependence principle might outperform other theories.

Another observation on exchange network research using the SRP approach can be made after analyzing networks of typical PE relations. It can easily be demonstrated that only under very restrictive conditions on endowments and utilities exchange relations can be represented by SRPs of equal size. However, with a few exceptions (Bonacich and Friedkin 1998; Cook and Emerson 1978; Stolte and Emerson 1977), almost all network exchange research has dealt with sets of exchange relations of equal size. Bonacich and Friedkin (1998) tested several theories, including Power-Dependence Theory, on networks with unequally valued SRPs and observed that these theories did not accurately
Transferring goods or splitting a resource pool: testing consequences of the violation of a basic assumption in exchange research

predict exchange outcomes, contrary to their performance in networks with equally valued relations. In our opinion these results support the statement that much remains to be learned on exchange in networks.
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Notes

1. Condition 5 (typical PE) is obtained from condition 4 by dividing the payoff scale of actor A by 3. This has the effect of lowering the maximum of A from 72 to 24 (Figure 1d). Such linear transformations of payoffs do not affect the predictions of the Nash and ER solutions: the prediction for condition 5 (typical PE) is the same as the one for condition 4, with the payoff of A divided by 3. However, the payoffs predicted by the ED solution are affected by this change in scale. It is said that the Nash and ER solution assume that *interpersonal utility comparisons* are invalid, while ED does not. See also Heckathorn (1983b) and Emerson et al. (1983) for a discussion of this point.

2. Subjects must agree to a division in integer numbers.

3. Requirements (b) and (c) hold if $U_{AY}U_{BX}/U_{BY} - U_{AX} = U_{BY}/U_{AY}$ and $E_{BY} \geq U_{BX}/U_{BY}$, respectively, where $E_{ij}$ and $U_{ij}$ denote respectively actor i’s endowment and actor i’s utility of good j.

4. The upper and lower portions of the Pareto frontier can be written mathematically as $\pi_B = -\frac{1}{3}\pi_A + 72$ for $0 \leq \pi_A \leq 36$ and $\pi_B = -\frac{10}{6}\pi_A + 120$ for $36 \leq \pi_A \leq 72$, respectively.

5. The upper part of this frontier can be written as $\pi_B = -\pi_A + 72$ for $0 \leq \pi_A \leq 12$, whereas the lower part is written as $\pi_B = -5\pi_A + 120$ for $12 \leq \pi_A \leq 24$.

6. Since the computer program used for the experiment ran over the internet, and connection problems sometimes caused the clock in the program to run slower, not all 6 rounds were always played.

7. Note that for calculating the variance, as opposed to the average, it is immaterial which actor’s payoff of the pair is selected for the computation.

8. This implies that the fact that the ER prediction couldn’t be rejected with respect to the payoffs of A is due to the inclusion of Pareto inefficient exchanges, which are, according to the ER solution, not to appear in the first place.

9. Comparis had a significant effect twice: i) when comparing conditions 3 and 4 with respect to $p(Pareto|agreement)$ (Wald $Z = 1.96$, $p = 0.05$, 2-tailed), and ii) when comparing conditions 1 (SRP) and 2 with respect to $p(equallagreement)$ (Wald $Z = -1.99$, $p = 0.05$, 2-tailed). The effect of Round was significant in all but two comparisons: i) the comparison of conditions 1 (SRP) and 2, and ii) the comparison of conditions 3 and 4, with respect to $p(equallagreement)$. 