THE EFFECTS OF EXTERNALITIES ON PARTNER CHOICE AND PAYOFFS IN EXCHANGE NETWORKS

RIJKSUNIVERSITEIT GRONINGEN

THE EFFECTS OF EXTERNALITIES ON PARTNER CHOICE AND PAYOFFS IN EXCHANGE NETWORKS

Proefschrift

ter verkrijging van het doctoraat in de
Gedrags- en Maatschappijwetenschappen
aan de Rijksuniversiteit Groningen
op gezag van de
Rector Magnificus, dr. F. Zwarts,
in het openbaar te verdedigen op
donderdag 26 april 2007
om 13.15 uur

door

Jacob Dijkstra
geboren op 24 januari 1976
te Leeuwarden

Promotor:	Prof. dr. F.N. Stokman
Copromotor:	Dr. M.A.L.M. van Assen
Beoordelingscommissie:	Prof. dr. D. Willer
	Prof. dr. W. Raub
	Prof. dr. C.C.P. Snijders

ISBN 9789036730198

Preface

Many people have contributed to the writing process of this dissertation. Let me take this opportunity to thank a few of them.

The ongoing collaboration with my promotor Frans Stokman, who also was my advisor when I wrote my master's thesis, has always been intellectually stimulating and satisfying to me. He aroused my interest for the subject matter of this dissertation in the first place, motivated me when my head dropped, encouraged me to visit conferences, and in general showed confidence in my abilities. He also brought me in contact with David Willer, with whom I have had many interesting discussions over the course of the last few years. Moreover, David was a generous host when I visited the University of South Carolina in the spring of 2005. I would like to thank him, his wife Pat, and all the staff members and PhD students at the sociology department at USC who helped me out and made me feel at home during my stay there.

The advice, the lessons and above all the friendship of Marcel van Assen are priceless to me. Visiting Marcel, Marieke, Janna and (later) Nathan in Tilburg, writing articles and visiting conferences with Marcel, and discussing details of our papers (and frequently our lives) in long conversations over the phone were both the most instructive *and* the most enjoyable things I did as a PhD student. I sincerely hope this was just the beginning of our collaboration.

Jan Kornelis and I share our entire academic career: we were trained at the same institute to be a teacher, we taught at the same school, we went to the same university (when we went there the first day, we even rode the same bike), we shared an office as PhD students, and we are now both postdocs at the RuG, still sharing the same office. Apart from all this, we have the same last name and play in the same band (different instruments, though). Sometimes people mistake one of us for the other. Recently, this started happening to me, too. Thus, I can honestly say, 'Jan, you were always there for me.'

Many beer-mats in many pubs in Groningen bear the evidence of the philosophical genius of Niek Benedictus. His aphorisms treat many different subjects, ranging from language to underwear. Niek and I share the same philosophy of life. It can basically be summarized in two sentences. If you've never been to Paris, you've never been anywhere. If you have never been to Paris with Niek and I, you've never really been there.

If you think writing a dissertation is hard, try having a relationship with a PhD student. Marije has pulled this off and for some inexplicable reason she seemed to enjoy it. She even decided to buy a house with me. Her love, support and encouragement is what this dissertation is made of.

Groningen, March 9, 2007

Contents

1

Introduction and conclusions

1.1 Introduction

This dissertation is concerned with explaining actors' partner choices and payoffs in exchange relationships. Exchange relationships can occur whenever two or more actors, either individuals or organizations, depend on each other for valuable outcomes. In exchange, actors transmit and receive various commodities. When these commodities are services or tangible goods, we generally speak of economic exchange, whereas exchange of intangibles like social approval or prestige is frequently called social exchange. Hence, the exchange perspective is applicable to many topics of interest to social scientists. For instance, Homans (1958: 606) states that 'social behavior is an exchange of goods, material goods but also non-material ones, such as the symbols of approval and prestige', Molm (1997: 12) asserts that 'much of what we need and value in life (e.g., goods, services, companionship, approval, status, information) can only be obtained from others. People depend on one another for such valued resources, and they provide them to one another through the process of exchange', and Braun (1993: 1) observes that 'exchange of (control over) scarce resources is a fundamental feature of economic and social life. People exchange physical goods, services, time, social approval, respect, attention, courtesies, pleasantries, or favors.'

In the literature, there is little consensus about how economic and social exchange should be distinguished.[1] The current dissertation focuses on bilateral exchange relationships in which actors negotiate directly over the transfer of commodities, but it does not make a distinction between economic and social exchange. Instead of making this distinction, we adopt the meta-theoretical strategy to theory construction, advocated by for instance Wippler and Lindenberg (1987) and Coleman (1990). Thus, we analyze exchange and bargaining behavior by constructing a rational model of the individual actor and comparing actual human behavior to the predictions of this model. We argue this strategy can be applied to social and economic exchange alike and agree with Braun (1993: 2) when he writes '(…) there is no a priori reason why economic or non-economic exchange and related issues should be consequences of different behavioral principles at the level of individual actors.' Therefore, when we refer to economic exchange in the remainder of this dissertation, we mean 'exchange in markets', whereas by social exchange we mean 'exchange outside markets'. No different behavioral principles are assumed.

1.1.1 Exchange in economics, game theory and sociology

A central result from microeconomics is the general equilibrium theorem (see for instance Kreps 1990). This theorem states that in situations of pure exchange, where actors have an endowment in the form of a bundle of commodities and a utility function that specifies their preference orderings over commodity bundles, actors will end up in an equilibrium, where the exchange ratios between goods (i.e., the ratio at which one commodity is exchanged for another) correspond to equilibrium prices. This equilibrium is Pareto efficient, meaning no actor can increase his utility without decreasing the utility of at least one other actor. Coleman (1972, 1990) used the general equilibrium approach from economics as a model of social exchange. The theorem assumes a large number of actors and no access constraints with respect to who exchanges with whom. An exchange system meeting these assumptions is referred to as a *perfectly competitive market*.

The opposite of the perfectly competitive market is a situation of *bilateral monopoly*, in which two actors engage in exchange and neither has an alternative partner. Contrary to the equilibrium prices arising in the competitive market, this situation is indeterminate with respect to the exchange ratio, meaning that only an interval within which the mutually profitable exchange ratio will lie can be specified (Edgeworth, 1881). Solving this problem of indeterminacy is the subject of game theoretical bargaining theory. Non-cooperative game theory, in which actors' strategies are modeled, models bilateral monopoly as a game where actors make offers and counteroffers (e.g., Rubinstein 1982; Sutton 1986). In cooperative game theory, where the set of feasible outcomes is modeled, much attention has been devoted to selecting a solution on the basis of axiomatic analyses of the bargaining situation. The two best-known models from this approach are the solutions of Nash (1950, 1953) and Kalai and Smorodinsky (1975). The second chapter of this dissertation investigates an important issue in bargaining in a bilateral monopoly, namely, whether bilateral exchange can be validly represented by the problem of two actors having to agree on the division of a fixed prize, or 'profit pool'.

In the remaining chapters of the present dissertation we take an intermediate position in between the perfectly competitive market and bilateral monopoly, in the sense that we focus on *exchange in networks*. Exchange networks are central in the majority of exchange studies from sociology and social-psychology and the current dissertation is part of this tradition. In an exchange network, a connection between two actors indicates the existence of an exchange opportunity between them. Unconnected actors cannot exchange with each other. Network exchange theory in sociology and social psychology investigates the effect of the structure of the exchange network on the distribution of outcomes of exchange across the network members. In experiments conducted to test theories in this field, the assumption is usually made that subjects' utilities equal their points scored in the experiment.

As will be argued throughout this dissertation, many bilateral exchanges have consequences for the well-being of third parties, outside the exchange relationship. The major innovation of this dissertation is the study of such *externalities of exchange* within the standard framework of exchange network research. Externalities of exchange are defined as direct consequences (positive or negative) of exchanges, for the well-being of actors that are not themselves involved in the exchange. Externalities are currently not within the scope of network exchange theory in sociology and social-psychology. The present dissertation therefore expands the scope of sociological network exchange theory to study the effects of externalities of exchange on the outcomes in exchange networks.

This dissertation mainly considers two outcomes of exchange relationships, viz., (i) the payoffs or utility gains of the exchange partners, and (ii) actors' choices of exchange partners from a set of available actors. Thus, we have the following two central research questions to be answered in this dissertation.

Research Question 1: What are the consequences of externalities in exchange networks for the distribution of payoffs or utility gains across network members?

Research Question 2: What are the consequences of externalities in exchange networks for the partner choices of actors in exchange networks?

The research questions are answered in three ways: (i) by formulating an abstract and general rational choice theory (elaborated extensively in Chapter 4) to derive hypothetical answers, (ii) by testing hypotheses derived from this theory in experiments (Chapters 3, 5 and 6), and (iii) by using the theoretical insights gained from the previous chapters for developing an exchange model to predict the outcomes of collective decision making with externalities (Chapter 7).

In the following sections of this chapter the constituent elements of the research questions are elaborated and the dissertation is placed in the broader context of sociological and social-psychological exchange research. The next section discusses different types of exchange and indicates which type is investigated here. The subsequent section elaborates on two central concepts in this research: networks and externalities. The theoretical and empirical approaches used in the studies reported in this dissertation are discussed in the two sections after that. The two final sections of this chapter, entitled 'What have we done and what did we find?' and 'What have we learned and where do we go from here?', provide an overview of the dissertation, summarize its results, and try to draw some conclusions.

1.2 Direct negotiated exchange

The classifications according to whether exchange is *reciprocal* or *negotiated*, and according to whether it is *productive*, *direct*, or *indirect* provide more insight than the distinction between economic and social exchange. These two dimensions (reciprocal/negotiated and productive/direct/indirect) are theoretically independent, thus creating six possible types of exchange.

In reciprocal exchange '(…) actors' contributions to the exchange are separately performed and nonnegotiated. Actors initiate exchanges (e.g., with an offer of help) without knowing whether, when, or to what degree others will reciprocate.' In negotiated exchange '(…) actors engage in a joint-decision process, such as explicit bargaining, in which they reach an agreement on the terms of the exchange' (Molm 1997: 25).

In direct exchange '(…) each actor's outcomes depend directly on the other actor's behavior. A provides value to B, and B to A (…). In generalized exchange the reciprocal dependence is indirect: a benefit received by B from A is not reciprocated directly, by B's giving to A, but indirectly, by giving to another actor in the network or group. Eventually, A will receive a "return" on her exchange from some other actor in the system, but not from B (…). In productive exchange (…) *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).

All chapters of this dissertation analyze direct, negotiated exchange. Therefore, all experiments reported in chapters 2, 3, 5 and 6 involve the explicit negotiations of pairs of subjects about direct transfers of valuable commodities. In Chapter 7, collective decision making is conceptualized as direct, negotiated exchange of actors' positions on the issues that have to be decided. However, all we do in Chapter 7 is construct an exchange based model to predict the decisions that will be taken, without testing whether the decision making *process* actually conforms to an exchange of positions.

1.3 Networks and externalities

1.3.1 Networks

If there is a connection between two actors in an exchange network, these actors have the possibility to exchange, but no obligation to do so. If there is no link between two actors, an exchange between them is not possible. Typically, an actor can exchange with some but not all of the other actors in the network. As an example, the 3-Line network used in Chapters 2 and 5 is depicted in Figure 1 below. The links in the 3-Line network indicate that actors A and C can each exchange with actor B, but not with each other.

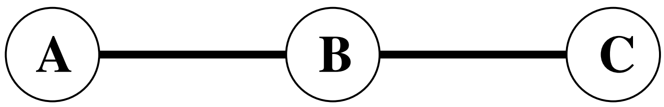

Figure 1: The 3-Line network

The network thus determines who can access whom for negotiating an exchange. Sociologists such as Granovetter (1985) have recognized the importance of this *social embeddedness* for social theory. Access constraints can arise because of a variety of reasons, such as *personal*, *cultural* or *social* differentiation (Braun, 1993). An instance of a personal access constraint is difference in physical location. Differences in for instance ethnicity or ideological commitments can cause cultural barriers to arise, while for example different positions in a hierarchy may cause social access constraints. Kranton and Minehart (2001) define a network connection as anything that makes a particular bilateral exchange possible or adds value to such an exchange. Customized equipment or a specific asset for instance, forms a connection between two firms. But also relationships with extended family members or personal connections between managers can form links that facilitate business transactions (see for instance Stokman, Ziegler and Scott 1985).

In sociological and social-psychological network exchange theory the exchange networks are typically static and exogenously given. In chapters 3, 5 and 7 of this dissertation the networks arise endogenously from the actors' endowments of goods and their preferences. In the other chapters, the networks are determined exogenously by the experiment leader. In addition, all networks in this dissertation are static. Thus, actors in the networks do not have the possibility to break links *from*, or add new links *to* the network.

1.3.2 Externalities

Economists and game theorists have been known for studying the effects of externalities, without the use of network structure (see for instance Kagel and Roth 1995 and Shapley and Shubik 1969). Kreps (1990: 203) defines externalities as '(…) situations where the consumption of some good(s) by one consumer affects the utility of another'. Mas-Colell, Whinston and Green (1995) define an externality to be present whenever the well-being of an actor is *directly* affected by the actions of another actor. In line with these definitions, we define externalities of exchange as direct consequences (positive or negative) of exchanges, for the well-being of actors that are not themselves involved in the exchange. The word 'directly' appears in both the definition of externalities used in this dissertation and in the definition of Mas-Colell et al. and is crucial. It signifies that effects that are 'mediated by the market', such as changes in market prices or exchange ratios, caused by changes in supply or demand or changes in network structure, are not regarded as externalities. The examples below will make the intuition clear.

Take for instance the case of a labor union negotiator, whose exchange and bargaining behavior in negotiations determines the outcomes for the union members. These union members do not themselves negotiate with management representatives, but do experience the consequences of the behavior of the negotiator in terms of changes in wages or work hours, etc. Thus, the union members experience externalities.

Or take the situation of a family of which one member uses the family budget to purchase consumption goods for the entire household. In this case exchanges of the exchanging household member have effects for non-exchanging members: the latter can consume the commodities bought by the exchanging member and cannot dispose of the money spent to purchase the goods.

As will be argued in more detail in Chapter 7, externalities also play a crucial role in collective decision making. Two actors in a decision making situation might reach a compromise by exchanging their positions on two issues that have to be decided. Such exchanges typically take the form of agreements of the kind ‘if you support me on this issue, I’ll support you on the other.’ The exchanging actors thereby change the decisions taken on these issues, and thus change the outcomes for other actors who were not involved in the exchange, but are involved in the decision making. In addition to the examples above, Chapter 5 argues that well-known interdependence situations such as markets, households, public good games and resource dilemmas can be fruitfully analyzed from the perspective of externalities of exchange.

Thus, the constituent elements of this dissertation, exchange, networks and externalities all have high scientific and societal relevance. As will be argued throughout this dissertation, studying these three components together yields important additional insights in what determines the outcomes of bargaining and exchange processes.

1.4 Theoretical approach

1.4.1 Background

There exist many theories in the field of sociological and social-psychological network exchange research that predict the outcomes in exchange networks (e.g., Bienenstock and Bonacich 1992; Braun and Gautschi 2006; Burke 1997; Cook and Emerson 1978; Cook and Yamagishi 1992; Friedkin 1992, 1995; Skvoretz and Fararo 1992; Willer 1999; Yamaguchi 1996). The central question these theories answer is whether and how an actor’s utility from exchange is influenced by that actor’s position in a network. For instance, referring back to Figure 1, if actor B were limited to making only 1 exchange, we would predict that A and C would compete for access to B, who would consequently get all the surplus from exchange. Moreover, one of the peripheral actors A and C would be excluded from exchange.

In the mainly experimental research in this field, the most prominent force that determines actors’ utilities is exactly this form of *exclusion*. Roughly speaking, exclusion occurs whenever an actor has more possible exchange partners than the number of exchanges he can complete. At least one of his potential exchange partners is then excluded from exchange. Referring to Figure 1, to prevent exclusion A and C will make ever better offers to B, thereby increasing B’s utility from the exchange and decreasing their own. Apart from exclusion, Szmatka and Willer (1995) distinguish 4 other types of connections in exchange networks that determine actors’ utilities. The papers in the current dissertation deal solely with exclusively connected networks (Szmatka and Willer

1995). More specifically, in all theory and experiments in this dissertation (chapters 2 through 6) the 1-exchange rule is applied, meaning each actor can exchange only once.

From the point of view of this dissertation, the most important characteristic of the theories mentioned above is that none analyzes the problem of externalities in exchange networks. Therefore, an important task to be completed in this dissertation, and one that is undertaken in Chapter 4, is the adaptation of theories of exchange networks such that they are capable of dealing with externalities. To this end, Chapter 4 scrutinizes power-dependence theory (Cook and Emerson, 1978), exchange-resistance theory (Willer, 1987) and core theory (Bienenstock and Bonacich, 1992). These theories are arguably the most prominent theories from sociological and social-psychological exchange theory and are closely related to cooperative game theoretical solutions for the bilateral case: power-dependence theory is related to the kernel solution, Heckathorn (1980) proved that the exchange-resistance solution is equivalent to the previously mentioned solution of Kalai and Smorodinsky (1975), and the core is itself a well-known solution from cooperative game theory.

1.4.2 Theory development and testing in this dissertation

The derivation and testing of hypotheses in Chapter 3 are the basis for an adaptation of core theory developed in Chapter 4, called the *generalized core solution*. This generalized core solution is used to derive hypothesis throughout chapters 5, 6 and 7. This solution is based on simple rationality principles, most notably on the notion of Pareto efficiency for connected actors. Two connected actors in an exchange network are in a Pareto efficient situation whenever it is impossible to find an (alternative) exchange agreement between them that increases the utility of at least one actor, without decreasing the utility of the other.

There are a number of reasons for choosing core theory as the basis for the derivation of hypotheses. Importantly, none of the theories, including core theory, has been shown to always yield a solution for any exchange network, be it with or without externalities. In core theory, however, ‘no solution’ has a substantive meaning. It means that the rationality requirements laid down in core theory cannot be met in the situation analyzed, and thus that ‘there should be no stable power differences or exchange patterns’ (Bonacich 1998: 194). Secondly, as will be argued in Chapter 4, core theory provides the best opportunity for adaptation to exchange networks with externalities. Finally, we believe core theory, with its use of rationality principles from economics, provides the best link with the aforementioned meta-theoretical strategy of Wippler and Lindenberg (1987) and Coleman (1990).

1.5 Empirical approach

1.5.1 Experiments

In chapters 3, 5 and 6 the hypotheses derived are tested empirically in laboratory experiments. In these experiments subjects were brought in a network position, such as positions A, B and C in Figure 1. In each round of an experiment, subjects could negotiate with their exchange partners over the transfer of valuable resources. There were two kinds of resources in the experiments, namely X and Y. A subject's payoffs in an experiment were determined by the number of units of each kind of resource he owned at the end of each round, and the value of each kind of resource to him. These values, or numbers of points per unit of resource, were determined exogenously by the experiment design. Whenever two subjects were connected in the network, the ratio of the value of resource Y to the value of resource X was different for both subjects, making mutually profitable exchange between them possible. In the case of externalities, subjects' payoffs also depended on the resources some other subject in the experiment held after each round. At the end of the experiment, the payoffs of each subject were converted to money and paid out to them. Thus, a subject's monetary reward depended on his own behavior (via the exchanges he completed) and possibly on the behavior of others (via the externalities).

In Chapter 2, the 'network' consisted of a link between only two players, i.e., Chapter 2 investigates bilateral exchange. Chapter 2 addresses a different issue than the other chapters, namely the question of whether a bilateral exchange of commodities can validly be represented by two actors negotiating over the split of a profit pool of fixed size. The hypotheses tested in Chapter 2 are not derived from generalized core theory, but from the Nash, equiresistance and equidependence solutions to bilateral bargaining. The experiments reported in Chapters 3, 5 and 6 concern networks of 3 or 4 actors, and address the issue of externalities in exchange networks.

In the experiments in Chapter 3 subjects negotiated with each other in a face-to-face setting, in which offers and counteroffers were made through filling out specially prepared supply and demand forms. These experiments were conducted at the Rijksuniversiteit Groningen (RuG). The experiments reported in chapters 2, 5, and 6, were all conducted in a computerized fashion, using the ExNet 3.0 computer program, developed by Willer and colleagues at the University of South Carolina (USC) in Columbia. The experiments reported in chapters 5 and 6 were held at the USC, whereas the experiments reported in Chapter 2 were conducted at the RuG.

1.5.2 Field data

In Chapter 7 we use the insights gained from the preceding chapters to develop a model to analyze collective decision making in the European Union (EU) from an exchange perspective. Chapter 7 uses data collected by Thomson, Stokman, Achen and König (2006), which they used for testing a large number of models that predicted decision outcomes of EU decision making. The data contain 66 proposals of the European Commission (EC), discussed by the Council in the period of January 1999 – December 2000. The Council consists of the Ministers of the members states, who deal with the relevant policy areas in their home country. The actors in the decision making arena are the 15 member states at the time of data collection (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Portugal, Spain, Sweden and the United Kingdom), the European Parliament and the EC.

Choosing collective decision making as a field of application for exchange theory has a number of advantages. Firstly, its societal relevance is large and obvious. Secondly, many formal models of collective decision making already exist (see Thomson et al. 2006) and have been tested, meaning there are standard and validated data collection procedures and many alternative predictions to contrast with our new theory. Thirdly, the exchange perspective has already proven its efficacy in this context (for instance Stokman and van Oosten 1994; Thomson et al. 2006), even though these exchange models did not take externalities into account.

1.6 What have we done and what did we find?

1.6.1 Introduction

In this section we briefly summarize each chapter from the book, including its main results. The results provide answers to the research questions, and thus determine what all this research teaches us. Each chapter in the book except the current, is written as an independent paper, submitted to a scientific journal. Therefore, we give the title of each paper as we go along.

1.6.2 Chapter 2. Transferring goods or splitting a resource pool: testing consequences of the violation of a basic assumption in exchange research

The problem this chapter addresses stems from the fact that in the traditional approach used in the vast majority of studies in the field of network exchange, an exchange relation is represented as two actors having the opportunity to split a common resource pool (SRP). This approach is generally assumed to be equivalent to a situation of pure exchange (PE), in which two actors each have an endowment of commodities that they can transfer in exchange. In Chapter 2 the validity of this assumption is investigated by pitching the two approaches against each other in an experiment.

Large outcome differences between SRP and PE in our experiment, would shed doubts on the validity of the majority of research in the field of exchange networks, that has used the SRP approach. Moreover, large outcome differences in our *bilateral* experiment would raise questions concerning the existence or disappearance of such differences in exchange *networks*, which is the context of most exchange research.

The results presented in Chapter 2 indicate that the validity of research using the SRP approach for exchange is questionable, since the outcomes obtained when using the SRP approach differed markedly from those obtained when using the PE approach. Three main conclusions can be drawn from Chapter 2. Firstly, the bargaining theories used in Chapter 2, the Nash bargaining solution (Nash 1950), the Raiffa-Kalai-Smorodinsky (RKS) solution (Kalai and Smorodinsky 1975) and the Kernel solution (Friedman 1986; Shubik 1982), yielded worse predictions of the bargaining outcomes in the PE approach than in the SRP approach. This suggests that the predictive success of exchange theories reported in many studies using the SRP approach, is an overestimation. Secondly, the prediction of equal payoffs for the two exchange partners, which is the prediction of the Kernel, had the most explanatory power. This suggests that power-dependence theory (e.g., Cook and Emerson, 1978), which is based on the same principle as the Kernel, does best when investigating pure exchange. Thirdly, many exchanges observed in the experiment were not Pareto efficient. This suggests that the assumption of Pareto efficiency, that all bargaining and exchange theories mentioned before make, is very strong. It raises questions concerning the conditions under which Pareto efficiency is met.

The PE approach is preferable when studying externalities of exchange, since externalities in real life frequently occur whenever actors share the possession or consumption of commodities. Therefore, in experiments with externalities in this dissertation the PE approach is used.

1.6.3 Chapter 3. Effects of externalities on exchange in networks: an exploration

This paper is a first exploration of the effects of externalities in exchange networks. In it we address both our main research questions by conducting an experiment using the 3-Line network of Figure 1. There were two conditions in this experiment: no externalities and positive externalities between A and C. In the latter condition an exchange of A (C) with B also yielded a positive outcome for C (A). In Chapter 3, simple rationality principles are employed to derive hypotheses concerning whether A or C will exchange with B (addressing Research Question 2), and what the outcomes will be for all the players (addressing Research Question 1), in both experimental conditions. These simple rationality principles are the basis for the generalized core theory of Chapter 4.

Results corroborated our hypotheses: the positive externalities between A and C had a weak but significant effect on the partner choice of subjects and a strong effect on the distribution of the outcomes across the subjects. These results are thus a first indication that externalities are an important factor influencing the outcomes of exchange situations. Moreover, the corroboration of our hypotheses shows that the effects of externalities can in principle be predicted with rational choice theory.

1.6.4 Chapter 4. Externalities in exchange networks: an adaptation of existing theories of exchange networks

This chapter investigates how to extend the scope of three prominent theories in the field of network exchange research, namely, core theory, power-dependence theory and exchange-resistance theory, to the problem of externalities in exchange networks, to yield hypothetical answers to the two research questions central in this dissertation. A generalization of core theory, called generalized core theory, is derived. It is shown that externalities in exchange networks can be predicted to change actors' payoffs and partner choices. The investigated theories yield precise predictions concerning the occurrence and magnitude of these effects.

Some general properties of the theories were investigated. For core theory, the general proposition was established that the core of a network without externalities is a subset of the generalized core of the same network, with *positive* externalities. No such relation between a network without externalities and the same network with *negative* externalities was established. With respect to power-dependence and exchange-resistance theory, it was shown that their predictions enable us to theoretically separate the effect of i) the network structure, ii) the externalities, and iii) the interaction between network and externalities, on the outcomes of exchange.

Generalized core theory provides the basis for the derivations of hypotheses in all subsequent chapters. The basic idea of it is that an outcome (i.e., a pattern of partner choices with an associated payoff distribution) is in the generalized core if and only if there is no pair of connected actors in the network that can conclude an alternative agreement between the two of them such that at least one of them improves his payoff with respect to the given outcome, without causing a loss to the other.

1.6.5 Chapter 5. The comparison of four types of everyday interdependencies: externalities in exchange networks

This chapter focuses on testing the answers on Research Question 1. Again using the 3-Line network of Figure 1, four experimental conditions are introduced, with different externalities between A and C in each. These conditions are models of four well-known every day interdependence situations: (i) the market, (ii) the tragedy of the commons or resource dilemma, (iii) the public good problem, and (iv) the household. It is thus shown that these situations can all be studied within the general framework of exchange networks with externalities.

The interdependence situations mentioned above are traditionally represented by standard social dilemma games. Chapter 5 argues that the analysis of these situations in the context of exchange networks with externalities is closer to many real-life situations than this traditional approach. Arguably the main advantage of the externalities in exchange networks approach is that it includes the behavior of third parties. For instance, in the public good condition in the experiment, externalities between A and C are such that they play a public goods game: A (C) gets a larger profit when C (A) exchanges with B, than when he himself exchanges with B, and thus both A and C want the other actor to complete the exchange. However, if both A and C are reluctant to negotiate with B, this will affect B. Thus, B can be predicted to adapt his bargaining behavior vis-à-vis A and C (for instance, by making better offers), and thus influence the behavior of A and C in their public good game. These third party effects are common in real life dilemma situations (think for instance of the state lowering taxes to tempt more civilians to abstain from tax evasion), but are not investigated when using the traditional social dilemma games.

Hypotheses derived from generalized core theory predicted varying levels of payoffs to be earned by actors A and C in the different interdependence situations. The least favorable exchange ratios for A and C were predicted in the resource dilemma, and the best were predicted to occur in the household and public good conditions. No difference in payoffs was predicted between the latter two. These effects were indeed found in the data and all hypotheses were corroborated.

An important implication of studying the effect of externalities in exchange networks is that subjects in the experiments have to be endowed actual resources. Here the distinction between the SRP and the PE approach from Chapter 2 comes into play. Chapter 5 shows that the traditional SRP design, in which actors negotiate over the division of a fixed pool of points, is inappropriate. This was demonstrated clearest by the resource dilemma condition in Chapter 5. In this condition we predicted that actors A and C would consent to losses in their exchanges with B. Endowing subjects with resources (i.e., employing the PE approach) facilitates these losses, since subjects have the possibility to sell their resources for a ‘price’ so low they actually lose points. Dividing a fixed pool of points (i.e., using the SRP approach) does not permit such losses, since the worst outcome for a subject in this approach is simply to get nothing from the pool (i.e., receive a payoff of 0).

1.6.6 Chapter 6. Effects of externalities on patterns of exchange

This chapter focuses on how externalities influence the partner choice in exchange networks, and thus investigates the answers of generalized core theory on Research Question 2. Two externality conditions were created such that different exchange patterns were predicted in the simplest exchange network with two different exchange patterns, the 4-Line, shown below in Figure 2. Since each actor can exchange only once, the two exchange patterns are: (i) A exchanges with B, and C exchanges with D, and (ii) B exchanges with C. In the latter case A and D are excluded from exchange.

Figure 2: The 4-Line network

Hypotheses were derived by comparing the predictions for the two experimental conditions and by comparison to data from previous experiments on the 4-Line, without externalities. In experiments with the 4-Line without externalities, the second exchange pattern mentioned above (i.e., exchanges between B and C), is reported to occur in 17.5% of exchange opportunities. In the first experimental condition in this paper negative externalities were introduced between A and C, such that more occurrences of exchanges between B and C were predicted by generalized core theory. In the second experimental condition negative externalities between B and D were added, such that generalized core theory predicted yet more exchanges between B and C. These hypotheses concerning the changes in exchange patterns were confirmed. As was the case in Chapter 5, the externalities in Chapter 6 also created a well-known dilemma situation, viz., the resource dilemma, between actors A and C, and between actors B and D.

1.6.7 Chapter 7. Outcomes of collective decisions with externalities predicted

In Chapter 7 we apply the exchange perspective to collective decision making, by conceiving of decision making as a process of position exchanges between groups of actors, in line with the Position Exchange Model (PEM) of Stokman and Van Oosten (1994). This study addresses Research Question 1, by focusing on predicting what decisions will be taken: given the preferences of the actors, a certain final decision implies a payoff distribution. An answer to Research Question 2 (concerning who exchanges with whom) is derived, but not tested. In fact, like the PEM, the Externalities Exchange Model (EEM) developed in Chapter 7 predicts the outcomes of a collective decision making process, by acting *as if* actors exchange, without testing whether or not they actually do.

None of the existing formal models of collective decision making (see Thomson et al. 2006 for an overview) take into account externalities that occur whenever actors try to find a compromise, be it through position exchanges or through some other (assumed) process of negotiation and mutual accommodation. Thus, the EEM is the first formal model of collective decision making to take externalities into account. It does so elaborating on the rationality principles of the generalized core, developed in Chapter 4, in roughly the following way. Given the actors' positions on the issues that have to be decided, and the initially expected outcomes of the issues, the EEM constructs four coalitions of actors on each pair of issues. Then the EEM searches for shifts of the expected outcomes, that are Pareto efficient under the given coalition structure. In such a Pareto efficient outcome shift, no coalition of actors can increase the payoff of one of its members, without (i) simultaneously decreasing the payoffs of at least one of its other members (called the EEM_w), or (ii) simultaneously decreasing the payoffs of *any* other actor (called the $EEM_{b\&w}$). This can be interpreted as the core solution, given the structure of four coalitions imposed by the EEM. Whenever Pareto efficient outcome shifts are not feasible (i.e., the core is empty), the EEM uses the initially expected outcome as its prediction. Whenever the set of Pareto efficient outcome shifts is non-empty, the EEM uses the Generalized Nash Bargaining Solution of Chae and Heidhues (2004) to find a single point within the set of Pareto efficient outcome shifts, and uses this point as its prediction.

Chapter 7 hypothesizes that the EEM does better than the models in Thomson et al. (2006), and most notably better than the Compromise Model (CM) of Achen, that was said to outperform many more sophisticated models (Thomson et al. 2006). Our results corroborated this hypothesis. The relative accuracy of the predictions of the EEM compared to the CM is indirect evidence that groups of actors exchange in order to increase their utilities. The relative accuracy of the EEM compared to the PEM points to the determining influence externalities have on the outcomes of decision making, and the necessity of accounting for them in any model of decision making.

1.7 What have we learned and where do we go from here?

1.7.1 Introduction

In this section we will try to indicate what we have learned from the papers in this dissertation. First, we will come came back to the Research Questions and inspect the answers we have formulated to them. Then we will discuss the wider implications of these answers for exchange research and real-life exchange situations. Subsequently, the limitations of the research presented in this dissertation are discussed. Finally, we will indicate possible directions for future research.

1.7.2 Answering the research questions

Two research questions concerning the effects of externalities in exchange networks guided the studies reported in this dissertation. Research Question 1 pertained to the utility distribution across actors in the network, and Research Question 2 concerned their partner choices. Throughout the dissertation we have derived hypothetical answers to these questions under different conditions, from generalized core theory, that was developed in Chapter 4. The answers thus derived generally held up in the face of data. Therefore, we can say that if we want to assess the effects of externalities in any exchange network, applying generalized core theory to the network both with and without externalities, and then comparing the different predictions, is a good first answer. The generalized core tells us to look for payoff distributions and associated exchange patterns, such that no connected dyad can conclude an alternative and mutually profitable agreement, to assess the effects of externalities in exchange networks.

This is a strong result. It implies that research questions 1 and 2 could be answered by applying the relatively simple rationality principles of individual and dyadic rationality. Moreover, Chapter 7 showed that insights from generalized core theory provide a fruitful basis for constructing a successful theory of collective decision making. Of course the answers to our research questions are far from definitive. Therefore the final subsection of this section provides suggestions for further study.

1.7.3 Implications

The results reported in this dissertation have implications for real-life exchanges and exchange network research. They show that whenever externalities exist in an exchange situation, it is insufficient to know only actors' resource endowments and utilities, together with the network structure, to make sensible predictions concerning the outcomes of the exchange process. One needs to know the size and sign of the externalities as well. This dissertation showed these externalities may crucially influence the outcomes. Thus, in for instance collective decision making situations such as parliaments and labor-management negotiations, exchanges of two parties may well have profound effects for other parties involved in the decision process. As this dissertation indicates, the structure of these externalities might dramatically alter the outcome with respect to a similar situation without externalities.

There are at least two implications for experimental exchange research. Firstly, as was shown in Chapter 2, if we want to investigate pure exchange, we have to conduct experiments with a pure exchange design. More precisely, when modeling behavior in exchange processes in which the transfer of goods is central, we cannot validly assume that an exchange relationship can be represented by the opportunity of two actors to split a fixed resource pool, but have to endow actors with actual resources. In addition, if we want to study the effects of externalities, we also have to use the latter approach to enable subjects to accept losses in their exchanges. And if we choose to use the pool split approach, we have to indicate what social process, if not pure exchange, *is* investigated.

Secondly, as chapters 5 and 6 showed, social dilemma research might also profit from the methodology employed in this dissertation, specifically with respect to the effects of the behavior of third parties. We have argued in these chapters that conceptualizing social dilemmas in terms of exchange networks with externalities yields an approach that is closer to many real-life dilemma situations. This is a claim that raises interesting issues concerning differences in behavior observed in traditional dilemma experiments and 'exchange-with-externalities-dilemmas'.

1.7.4 Limitations of the current studies

The studies in the current dissertation have limited scope in a number of respects. Although the theoretical formulations in Chapter 4 were rather general, the empirical tests in the experiments reported were very limited. First of all, only two different network structures were employed, albeit with a fair variety of externality conditions in them. The two networks, 3-Line and 4-Line, are very simple, and raise the question whether the relative success of generalized core theory isn't due to this simplicity.

Secondly, the entire dissertation concentrated on direct, negotiated exchange. Such self-limitation is necessary, if one wants to have at least a slight probability of arriving at an answer to one's research questions, but it does leave questions concerning the effects of externalities in networks with other types of exchange.

Thirdly, the experiments are limited in the sense that we have employed the 1-exchange rule throughout, implying that each actor in an exchange network can exchange only once. Relaxing this rule and allowing more exchanges per actor creates interesting new questions.

In addition to the experiments, the field application to collective decision making in Chapter 7 has its own limitations. First of all, the exchange perspective was applied entirely in the 'as-if-mode', meaning that the question of whether the *process* of collective decision making can validly be represented as a process in which actors exchange their positions, was not addressed. Secondly, collective decision making is only one instance of a real-life application of exchange theory to situations of exchange with externalities. It still remains to be shown that there exist other substantive fields to which the ideas from this dissertation can be fruitfully applied.

1.7.5 Directions of future research

The limitations of the current studies immediately suggest a number of directions for future research. First of all, the predictions of generalized core theory for exchange networks with externalities should be investigated using larger and more complex network structures than the ones used in this dissertation. Secondly, the effects of externalities should also be investigated in networks with connection types other than exclusion (see Szmatka and Willer 1995), types of exchange other than direct, negotiated exchange (see Molm 1997), and networks where actors can make more than 1 exchange. Thirdly, concerning the application of the exchange perspective to collective decision making, it would be interesting to investigate the *process* of decision making with externalities directly, for instance by conducting experiments similar to the ones reported in this dissertation.

In addition to the issues arising from the limitations of this dissertation, there are a number of other directions in which to expand this research. For instance, as was demonstrated in chapters 5 and 6, externalities create dilemma-like situations for actors in the network, such as the resource dilemma. Comparing actor behavior and its outcomes across traditional dilemma experiments and exchange networks with externalities therefore appears to be a promising direction for future research. In fact, in a future paper, results from regular prisoners dilemma research will be compared to results of prisoners dilemmas induced by externalities in exchange networks.

The experiments reported in chapters 2, 3, 5 and 6 showed many violations of the rationality principles underlying generalized core theory, suggesting they are not so ‘simple’ after all, from the point of view of the actors in the network. One line of future research might therefore be directed at replacing the rationality principles underlying the generalized core with more behaviorally founded assumptions.

All the chapters in this dissertation focused on the outcomes of the bargaining and negotiation process, and on how these outcomes are influenced by externalities. However, one might also take the process of bargaining and negotiating as the dependent variable. The ExNet 3.0 computer program used for the data collection during the experiments registers all offers and counteroffers made, thus making it particularly easy to make a start with investigating the bargaining process, and how this process is influenced by externalities. Such investigations might provide valuable information concerning the behavioral foundation of principles of rationality. It might also shed light on questions surrounding how subjects learn and adapt their behavior in an exchange environment.

The predictions of generalized core theory have not been tested against alternative predictions of other theories, basically because the latter were not available. However, in addition to core theory, Chapter 4 also scrutinized power-dependence and exchange-resistance theories. On top of using principles of rationality, these theories invoke 'social-psychological' concepts such as *dependence* and *resistance*. It would be interesting to investigate whether these theories with their added social-psychological content can improve the accuracy of predictions for exchange networks with externalities, both in experimental and field data.

In Chapter 7 the issue of *networks* was circumvented by partitioning actors into groups, or coalition, and conceptualizing of exchange as taking place between these coalitions. On the other hand, the original exchange theory in this field, of Stokman and van Oosten (1994), only regards bilateral exchange between individual actors without taking the network structure into account. A challenging direction for future research is to investigate whether bringing real exchange networks into this field can improve our understanding of collective decision making.

Finally, Chapter 2 will no doubt not be the final word on the issue of how to best represent an exchange relation in experiments. Interesting issues surround this matter, such as the question of how the lack of Pareto efficiency we observed in many of experimental conditions using the PE approach interacts with the structure of the network. Under what conditions will such 'irrational' behavior disappear and what conditions exacerbate it?

Notes

1. For different distinctions between social and economic exchange see for instance Blau (1964, 1968), Cosmides(1988), Ekeh (1974), Emerson (1962, 1964), Molm (1997) and Willer (1999).

2

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.

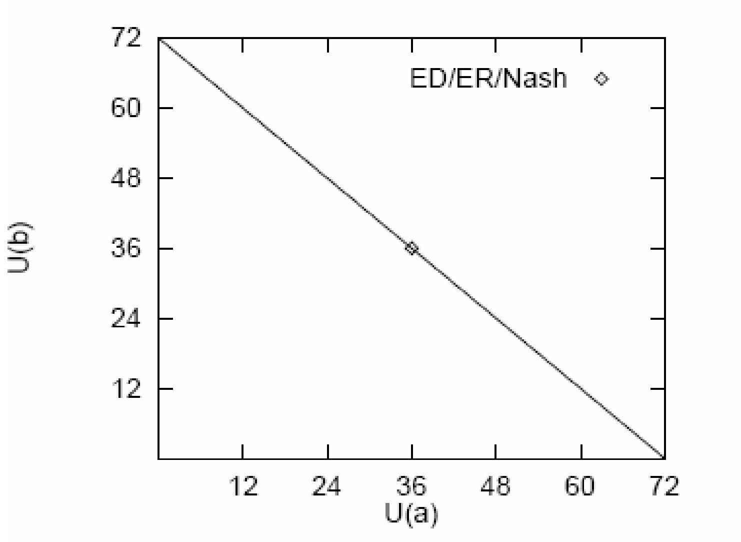

Figure 1a: Payoff space of conditions 1 (SRP) and 2

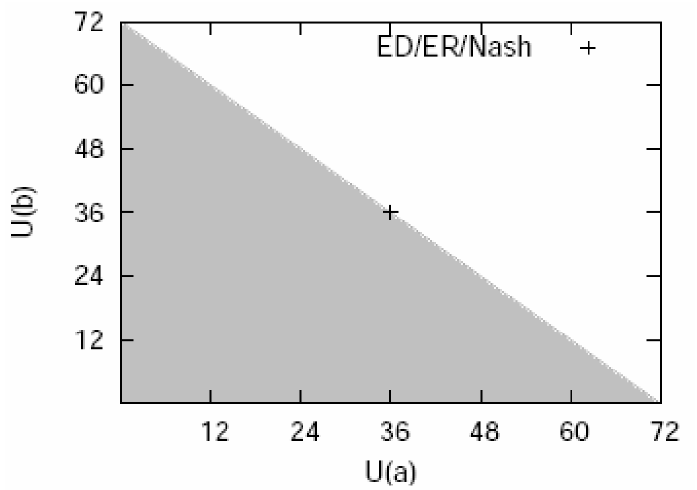

Figure 1b: Payoff space of condition 3

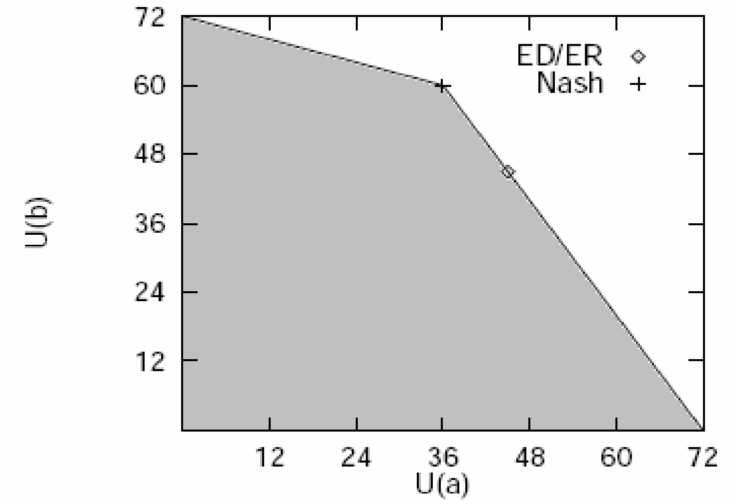

Figure 1c: Payoff space of condition 4

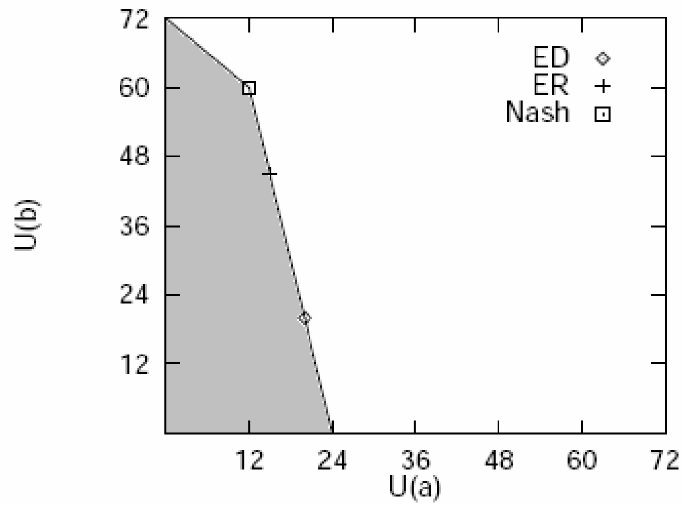

Figure 1d: Payoff space of conditions 5 (typical PE)

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 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

	Characteristics			
Condition	(i) Splitting a fixed pool of points	(ii) Pareto efficiency enforced	(iii) Constant sum across Pareto efficient agreements	(iv) Identical maxima
1 (SRP; Fig.1a)	Yes	Yes	Yes	Yes
2 (Fig.1a)	No	Yes	Yes	Yes
3 (Fig.1b)	No	No	Yes	Yes
4 (Fig.1c)	No	No	No	Yes
5 (typical PE; Fig.1d)	No	No	No	No

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(agreement)*;
3. the conditional probability that agreements are Pareto efficient given that agreements are reached, *p(Pareto|agreement)*;
4. the conditional probability that actors' payoffs are equal given that agreements are reached, *p(equal|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 π_A and π_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(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(Pareto|agreement)* < 1.
Hypothesis 4: *p(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).

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

	Dependent Variables				
Conditions	Payoffs	P(agreement)	P(Pareto |agreement)	P(equal |agreement)	Variance payoff B
2	<u>H1a</u>	↓ H2a		↓ <u>H4a</u>	↑ <u>H5a</u>
3	<u>H1a</u>		↓ <u>H3a</u>		
4	<u>H1c</u>			↓ (H4b)	↑ H5b
5 (typical PE)	H1b	↓ H2, <u>H2b</u>	<u>H3</u>	↓ H4, H4c	↑ <u>H5</u>, <u>H5c</u>

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*(*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 5 (typical PE) because the ER solution is not affected by linear transformations of payoffs, but the ED solution is.[1]

Two reasons underlie the expectation that *p(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(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*(*equal*|*agreement*) to decrease as one goes from condition 1 (SRP) to condition 5 (typical PE). Firstly, we believe *p*(*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*(*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*(*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

	Actors	A		B	
Condition	Goods	X	Y	X	Y
2 (Fig.1a)	E	1	0	0	90
	U	18	1	90	1
3 (Fig.1b)	E	18	0	0	90
	U	1	1	5	1
4 (Fig.1c)	E	18	0	0	30
	U	3	3	5	1
5 (typical PE; Fig.1d)	E	18	0	0	30
	U	1	1	5	1

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.[3] 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 *in*efficient 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.[4] 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.[5]

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.[6] 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

	Dependent Variables				
Conditions	Pay-offs (A first)	P(agreement)	P(Pareto lagreement)	P(equal lagreement)	Variance payoff B
1 (Fig.1a; SRP)		0.73	1	0.54	4.12
2 (Fig.1a)	33.17 (1.90)	0.87	1	0.37	81.16
	38.83 (1.90)				
3 (Fig.1b)	32.85 (2.75)	0.89	0.73	0.67	157.74
	33.69 (2.50)				
4 (Fig.1c)	41.28 (1.22)	0.92	0.63	0.57	93.33
	41.05 (1.73)				
5 (typical PE; Fig1.d)	14.79 (1.09)	0.82	0.39	0.41	218.54
	28.33 (4.51)				

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.[7] 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.

Table 5: Estimated payoffs for A and B in condition 5 (typical PE); mixed models with subject pairs as level 2

Dependent Variable		All agreements	Pareto efficient agreements only
Payoff B	Intercept	30.55 (4.85)	30.27 (4.65)
	Round	1.16 (0.65)	-1.32 (1.01)
	Comparison	-11.58 (12.23)	-8.50 (9.73)
Payoff A	Intercept	14.68 (1.06)	
	Round	1.14 ** (0.32)	
	Comparison	2.45 (2.55)	

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

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.[8]

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(agreement)	H3: P(Paretolagreement)	H4: P(equallagreement)
Intercept	1.04 *** (0.30)	0.76 (0.40)	0.26 (0.47)
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(agreement), and conditional probabilities p(Paretolagreement), and p(equallagreement), 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(agreement) 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(equallagreement) 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

Dependent Variable		Condition 2	Condition 3	Condition 3 Pareto efficient only	Condition 4	Condition 4 Pareto efficient only
Payoff B	Intercept	36.94 *** (2.08)	32.02 *** (3.34)	35.96 *** (3.95)	40.83 *** (1.94)	44.13 *** (1.18)
	Round	-0.28 (0.40)	1.61 (1.09)	1.85 (1.41)	2.38 ** (0.66)	0.39 (0.63)
	Comparis	6.27 (3.88)	3.23 (4.84)	-0.31 (5.07)	1.30 (3.41)	0.88 (1.96)
Payoff A	Intercept		30.83 *** (3.67)		40.79 *** (1.48)	
	Round		0.40 (1.08)		2.29 *** (0.51)	
	Comparis		4.26 (5.35)		2.07 (2.61)	

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.

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

	Dependent Variable [1]		
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.[9] 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 severable 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 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.

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 $U_{AY}U_{BX}/U_{BY} - U_{AX} = U_{BX} - U_{AX}U_{BY}/U_{AY}$ 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(equal|agreement) (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(equal|agreement).

3

Effects of externalities on exchange in networks: an exploration*

* This chapter is co-authored with Marcel van Assen and was published in *Sociological Theory and Methods* 21(2): 279-294

Abstract

This paper is an exploration of the effects of externalities in exchange networks. Externalities of exchange arise when an exchange has direct consequences for the payoffs of actors who do not take part in the exchange. An experiment was conducted, employing the exclusively connected Line3 network, with two conditions; exchange with externalities, and exchange without. Externalities had a weak effect on partner selection, and a strong effect on the exchange rate. The results confirmed our predictions derived with an adaptation of core theory.

3.1 Introduction

In exchange individuals transmit and receive commodities. Exchange should not solely be conceived of as economic exchange (e.g., Blau 1964; Homans 1958; Lawler and Ford 1995; Molm 1997). Social interaction in general can also be perceived as exchange since "(…) much of what we need and value in life (e.g., goods, services, companionship, approval, status, information) can only be obtained from others. People depend on one another for such valued resources, and they provide them to one another through the process of exchange" (Molm 1997: 12).

The issue in exchange on which research of sociologists has mainly concentrated, is the effect of networks on the choice of exchange partners and the rates of exchange (for example, see the special issue on network exchange in *Social Networks*, volume 14, and Willer 1999). The network represents which actors have the possibility to exchange with which other actors. If there is a connection between two actors in the network, the two actors have the *possibility* to exchange, but *no obligation* to do so. If there is no link between two actors, an exchange between them is not possible. One of the simplest examples of an exchange network, for obvious reasons sometimes called Line3, is presented in Figure 1.

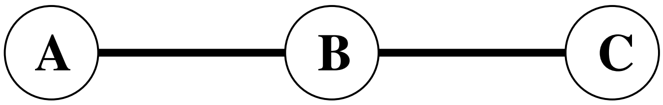

Figure 1: The Line3 exchange network

In the Line3 network, the actors on positions A and C do not have the possibility to exchange with each other, while B (i) can exchange with both A and C, (ii) can exchange with either A or C, but not both, or (iii) has to exchange with both A and C in order to gain from either exchange. In the literature exchange situation (i) is called a *null connected Line3 network*, situation (ii) is called an *exclusively connected Line3 network*, and situation (iii) is called an *inclusively connected Line3 network* (e.g., Willer 1999).

The present paper investigates the effects of externalities in an exclusively connected Line3 network. The simplicity of the Line3 network allows a complete focus on the effects of externalities, without having to worry about complex network effects. In the literature on exchange networks without externalities, such a Line3 network is said to be a *strong power* network, because the central B-actor is generally predicted to obtain much larger payoffs than the peripherals, A and C. Suppose that the two possible exchanges in the Line3 network can be represented as a split of a common resource pool of 24 points and that two connected actors can split these 24 points in any way they wish, as long as both agree to the division. If they fail to reach agreement, however, both get nothing. Then A and C are expected to outbid each other because only one of them can exchange with B, while the other actor is then necessarily *excluded* from the exchange. Theories of exchange predict that B obtains all of the points in the pool, while experiments revealed that B commonly obtains the lion's share of the pool, that is, 20 points or more. Hence, B is said to have power over A and C.

In the present study we make a start with the investigation of the effects of *externalities* on exchange in networks. To understand what externalities are we turn to the description of externalities in a standard textbook on microeconomics, Mas-Colell, Whinston, and Green (1995). Mas-Colell et al. (1995: 350) describe economic situations *without* externalities as situations in which an actor's preferences or utilities are defined solely over the set of goods that she might herself decide to consume. An *externality* is defined to be present whenever the well-being of an actor is *directly* affected by the actions of another actor (1995: 352). The phrase '*directly*' in the definition is crucial. It signifies that all effects that are mediated by prices are no externality effects. Before applying the definition of externalities to exchange networks, we note that one extreme example of externalities, *public goods*, is a popular research topic in sociology. If an actor provides a unit of a public good (the action), all other actors benefit (the direct result of the action). Because the other actors benefit, the externality effect is called *positive*.

In the context of exchange networks we define externalities as direct consequences (positive or negative) of exchanges for the well-being of actors that are not involved in the exchange. Externalities in the Line3 network would exist if after an exchange of two actors the profit of the third actor is directly affected as well. For example, if A and B obtain 16 and 8 points in their exchange with each other respectively, and C obtains 4 points as a direct consequence of this exchange between A and B, then C experiences *positive* externalities of the exchange between A and B. If for example 4 points are subtracted from C's profits after the exchange between A and B, he is experiencing *negative* externalities. It is important to note that if C's profit is unaffected, i.e., no points are added or subtracted due to the exchange between A and B, there are *no* externalities. Mas-Colell et al. (1995) explicitly state that the *exclusion* of C, when A and B exchange, is *not* an externality effect of the exchange between A and B. Hence, their definition of externalities, that we apply in the present paper as well, excludes both the exclusion of actors and the outbidding process from externality effects because both are the result of 'the price mechanism of the market'. Exclusion and the outbidding process are merely two instances of *interdependence* that are present in exchange networks whether there are externalities of exchange or not. The vast majority of network exchange research is indeed aimed at exclusion and the outbidding process in networks and how they influence actors' outcomes.

Note that in many empirical instances of exchange, coalition formation takes place between actors, to attenuate the effects of both the outbidding process and externalities. Thus, coalition formation is a frequently observed solution to problems posed by competition and externalities. The current paper focuses on the problem of externalities in exchange networks per se, without considering the possibility of coalition formation. We argue that it is of central importance to study the problem that coalitions might try to solve, i.e., externalities in exchange networks, before one can assess in what way and to what extent coalition formation offers a solution. This way insight is gained both in externality situations in which coalition formation naturally occurs (such as in households), and situations in which it is obstructed, for instance by social, geographical, legal or ideological barriers (e.g., political parties that refuse to cooperate because of ideological differences).

The societal relevance and theoretical significance of studying exchanges with externalities follow from the abundance of examples of exchange with externalities in real-life. Some exchanges with externalities that most of us are familiar with and experience on a daily base, are exchanges of and between members of a household. The father's purchases in the supermarket (the exchange of money for products) are experienced as externalities by the other members of the household: less money to spend on other products or activities, and the possibility to consume the products bought by the father. These externalities might be either positive or negative, depending on how the actors that experience the externalities value the money spent and the products bought. Note that in particular the children in the household experience externalities all the time, since they commonly do not have their own budget, or a very limited one. In firms too, do we find exchanges with externalities. A well-known example is the *principal-agent problem* (e.g., Pratt and Zeckhauser 1985; Coleman 1990, Chapter 7). The problem is that an owner of a firm (the principal) hires a manager (the agent) to satisfy the interests of the principal. The agent, however, has his own interests and acts accordingly. Therefore his actions and exchanges may not entirely satisfy the interests of the principal.

Another example is collective decision making in the public sector. In a division in Parliament for instance, two political parties may agree to exchange their voting positions concerning two issues that have to be decided upon. Since this "logrolling" changes the eventual outcome of the vote, the exchange affects other political parties that are not involved in the agreement. In other words, the political parties that do not exchange experience externalities. Since the exchange may shift the outcome of the division either toward or away from the position of a particular party not involved in the exchange, the externality may be evaluated positively or negatively by that party (Arregui et al. 2004, 2006; Stokman, van Assen, van der Knoop and van Oosten 2001; van Assen, Stokman and van Oosten 2003).

All the examples above have in common that actors in the given context (be it the family, the firm, or society) share a stock of resources, events, or a common environment. Because of the fact that these resources, events and environments are shared, behaviors and exchanges of one of the actors that affect this stock of resources, events or environments, affect all the actors that share in them. Externalities thus illustrate how not only the network of exchange possibilities, but also the (either public or private) property of resources might affects actors' well-being in exchange networks.

Although examples of exchanges in real-life are abundant, research on effects of externalities on exchange has been scarce. Exceptions are studies on the effect of exchanges of voting positions in collective decision making on actors' well-being and on possible conflicts between them (Stokman et al. 2001; van Assen et al. 2003; Arregui et al. 2004, 2006;). However, these studies do not test experimentally the effect of externalities on exchange in networks. Therefore, the present study attempts to provide a first answer to the general questions: What are the consequences of externalities in exchange networks for (1) the actors' choices of exchange partners, and (2) the exchange rates at which agreement is reached, compared to networks without externalities?

As a first step to answering the general questions (1) and (2), the effects of externalities are examined in the simplest of exchange networks: the exclusively connected Line3 network. We will investigate this network both with and without externalities to see whether and how externalities influence partner selection and exchange rates. Hypotheses for these two conditions are based on predictions of core theory (e.g., Bienenstock and Bonacich 1992), after suitably adapting this theory. Core theory is prominent in the field of network exchange research. Moreover, it is based on a set of simple and transparent rationality requirements, which makes it an excellent starting point for the analysis of this new problem. The properties of the adapted core theory for exchange networks with externalities in general are investigated in a future paper.

As opposed to most research on exchange in networks, the exchange situations in this paper are represented by actors having *endowments* and different *preferences* for them. This is also the representation of (pure) exchange situations as employed by economists (Edgeworth 1881; Hildenbrand and Kirman 1988; Kreps 1990) and by social scientists that can be considered as the originators of research on exchange networks in sociology (Cook and Emerson 1978; Emerson 1962; 1972a; 1972b; Homans 1958). The advantage of this representation over the common resource pool split representation is that the relations are made explicit between the (public or private) property of resources, profits from exchange, and the resulting externalities.

In the next section the Line3 network and externalities used in the experiment are described. The Line3 network in this paper represents an exchange situation in which an exchange between either A or C with B leads to *positive* externalities for the actor not involved in the exchange. This exchange situation is linked to real-life examples in this section. In the subsequent section predictions of the effects of externalities on exchange for the exclusively connected Line3 network are derived. The section after that describes the experimental test of these predictions. The paper is concluded with a general discussion of our results and with suggestions for further research.

3.2 The Line3 network

In the exclusively connected network studied here the three actors are endowed with units of goods X and Y they can transmit in exchange. Moreover, they obtain a possibly different number of points or 'utilities' for a unit of X and Y. An infinite number of exclusively connected Line3 exchange networks are possible, differing with respect to endowments and utilities. The actors' endowments (E) and utilities (U) used in the experiment of the present paper are shown in Table 1. These endowments and utilities are constant across the two conditions (with and without externalities) of the experiment.

Table 1: Actors' (A, B, C) endowments (E) and utilities (U) in the exclusively connected Line3 exchange network

	A		**B**		**C**	
	X	**Y**	**X**	**Y**	**X**	**Y**
E	0	60	12	0	0	60
U	3	1	1	1	5	1

As can be seen in the fourth row of Table 1, B is indifferent between one unit of X and one unit of Y, because he obtains one point for each. The third row shows he has 12 units of X and no units of Y. In the fourth row of Table 1, we can see that A and C are more interested in X than in Y, while the third row indicates that they each have 60 units of Y and no units of X. Hence, both A and C are interested in an exchange with B of some units of Y for some units of X.

The experimental procedures are such that *if* an agreement is reached, B always has to transfer all of his 12 units of X. This way, any mutually profitable exchange between B and either A or C is Pareto-efficient. Pareto-inefficient exchanges can thus not be negotiated in this experiment. B wants A and C to transmit at least 12 units of Y for his 12 units of X (since he is indifferent between one unit of X and Y). At this exchange rate B would earn a profit of 0 (12 – 12). If A were B's partner, A would earn 24 (3*12 – 12). If C were B's partner, C would earn 48 (5*12 – 12). A and C are willing to transmit at most 36 and 60 units of Y, respectively. At these exchange rates A and C would both earn 0 (3*12 -36 and 5*12 – 60, respectively). If B completed the exchange with A, B would earn 24 (36 – 12), whereas completing the exchange with C would yield B 48 (60 – 12). Thus, the AB and BC exchange relations can be interpreted as the opportunity to divide 24 and 48 points, respectively.

There are two conditions in the experiment, one without externalities and one with positive externalities. In the no-externalities condition there is no direct consequence of an exchange between B and A (C) on the payoff of C (A). For example, if A exchanges

24 units of Y for 12 units of X, A gains 3x12–24 =12, B gains 24–12=12, and C gains nothing. The consequence of the exchange between A and B is that C is excluded, however, by definition this is not an externality.

In the positive externalities condition externalities are introduced by *joining* the resources of actors A and C before and after the exchange. Consequently, the joint resources of A and C determine the payoffs of A (C); they share *both* resources X and Y. Before the exchange A and C together have 120 units of Y and 0 units of X. After the exchange they together have 12 units of X and 120 units of Y *minus the units of Y one of them transferred to B*. Thus, if A (C) transfers a certain number of units of Y, then C (A) experiences the consequences of this transfer, as if he had made the transfer himself. Using the same example as above, if A exchanges 24 units of Y for 12 units of X, both A and B again gain 12, but C now gains 36 (–24x1 + 5x12). Note that C's payoff is larger than A's payoff because C values X more than A. C experiences *positive externalities* of the exchange: C didn't take part in the exchange himself, but benefited from it anyhow. In the experiment, C always experiences positive externalities, independent of the exchange rate. However, A only experiences positive externalities if the price for the 12 units of X is less than 36 units of Y. If C transmits more than 36 units of Y, which seems an unlikely event, A loses and thus experiences *negative externalities*.

A real-life example of an exchange situation without externalities, resembling the structure of the Line3 network, would be A and C outbidding each other on a market to buy the last 12 oranges of B with their US dollars. Using the same example, positive externalities exist if for example A and C live in the same household, and either A or C pays a price for the oranges that is less than the value of the oranges for both of them. We also have positive externalities when principal A wants to make a deal with B, and either the principal himself or the principal's agent C makes a profitable deal. In that case A and C have the same budget at their disposal, but C can accept other prices, e.g., because C underestimates his principals evaluation of the goods in the exchange. See van Assen et al. (2003) for another interpretation of Table 1 as exchange with externalities in the context of collective decision making.

3.3 Theory

In the Line3 network without externalities, a simple rational analysis predicts that A and C bid against each other to obtain B's 12 units of X. Subsequently, it is expected that A stops increasing his bid when C offers 36 units of Y, because A would incur a loss if he offered more than 36; the value of the 12 units of X to A, is only 3*12 = 36. To C, however, the value of the 12 units of X is 5*12 = 60. Therefore, it is predicted that C always exchanges with B at a price between 36 and 60 units of Y for the 12 units of X, and A is excluded. This prediction is also the prediction of core theory and of exchange in economics (Edgeworth 1881). In general, in the exclusively connected exchange network without externalities it is predicted by core theory that A and C outbid each other and that the actor who is willing to pay the highest price will exchange with B. Therefore, our first hypotheses concerning partner selection (Hypothesis 1) and exchange rate (Hypothesis 2) are:

Hypothesis 1: Without externalities, B will always exchange with C.
Hypothesis 2: Without externalities, B receives between 36 and 60 units of Y.

In the externalities condition, only the exchange rate is relevant to A and C, and not *who* is exchanging. Hence, there is no reason for A and C to compete and start an outbidding process like the one we saw in the case without externalities. They have to make a tacit decision who will make the exchange with B. No coalition is permitted for reaching this decision in the experiment, because we want to investigate the effect of externalities per se on the exchange outcome. Note that coalition formation is a possible solution for dealing with externalities.

The advantage of B has disappeared because the introduction of externalities removed the competition between A and C. Theory predicts that the strong power network has become a so-called *equal power* network.

Core theory requires that each logically possible coalition get no lower payoff than the members of that coalition can guarantee by cooperating amongst themselves. Thus, since A and B can guarantee a total payoff of 24 by exchanging with each another, a payoff vector can only be in the core if the sum of the payoffs of A and B is at least 24. In the same vein, the sum of payoffs of B and C must be at least 48. To find the core, all logically possible coalitions must be considered. Therefore, also the 3-player coalition between A, B and C must be taken into account. This coalition can guarantee itself a total of 72 points, by letting B exchange with either A or C, and transferring 12 units of Y to B. The payoff of B is then 0, while A gets 24 and C gets 48 points. Thus the core predicts an extreme power advantage for A and C. However, this prediction is peculiar, since it is based on what the 3-player coalition can guarantee itself. In our experiment, however, 3-player coalitions could not be formed: B exchanged with either A or C, i.e., only 2-player coalitions between connected actors were allowed. Consequently, core theory in its present form is not suited to deal with network exchange with externalities.

To obtain a prediction from core theory that is more suited to our theoretical problem, we modify core theory by only allowing 2-player coalitions between *connected* actors. Thus, the 3-player coalition as well as the coalition between the unconnected A and C are disregarded. Core theory then predicts that either A or C exchanges with B and offers at least 12 units of Y. Combining the predictions for the condition without externalities with the predictions for the condition with externalities then yields another two hypotheses with respect to partner selection (Hypothesis 3) and exchange rate (Hypothesis 4), corresponding to our research questions. Without externalities we predicted that C always exchanges with B while with externalities we predict that either A or C will make the exchange.

Hypothesis 3: The proportion of exchanges between B and C is larger in the network without externalities than in the network with externalities.

Without externalities we predict that A and C outbid each other while with externalities we predict no competition between A and C.

Hypothesis 4: Without externalities, on average more units of Y are transferred to B than with externalities.

3.4 Experiment

3.4.1 Subjects

Eight groups of three students participated in the experiment, hence in total 24 subjects participated. The subjects were recruited from different departments of Groningen University in order to minimize the probability that the subjects knew each other. Subjects were rewarded for participation with money.

3.4.2 Design

Half of the groups started with a session of exchanges *with* externalities, followed by a short break, and then a session of exchanges *without* externalities. The other groups completed the sessions in reverse order. Each session contained six bargaining rounds in which the subjects could exchange. The subjects were randomly allocated to positions in the network and did not change network positions for the duration of the experiment.

3.4.3 Procedure

Subjects and experimenter were seated in the same room. Each of them could see all others, except A and C who could not see each other in order to prevent them to communicate. In the case of externalities, communication between A and C could result in having them act as one united actor or coalition instead of as two separate actors with a shared budget. Coalition formation between A and C would reduce the network to dyad. Since we want to study the Line3 it is essential that A and C do not act as one united actor. At the start of the experiment the subjects received a detailed instruction. The instruction included a simulation bargaining round to make sure that the subjects were familiar with the bargaining procedure and the reward system. The instruction made clear to both A and C whether both or none of them experienced the externalities. B was not aware of the experimental condition, i.e., whether or not externalities were present. Subjects were not permitted to speak to each other, but were allowed to ask questions to the experimenter in the course of the experiment.

Bargaining occurred with a demand and supply form. The form for A is depicted in Figure 2, those for B and C were similar. In the experiment, units of X were represented by red chips and units of Y by blue chips.

A offers B	…. ….	blue chips
B accepts A’s offer		yes / no
A confirms		yes / no

Figure 2: Demand and supply form used for actor A in the experiment

An actor initiates an exchange by offering a number of chips to his intended partner by filling in the blanks on the first line of the form. The recipient responds on the same form by either accepting or rejecting the offer by crossing off yes or no. If he accepts the offer, the initiator either confirms the acceptation (and completes the exchange) or not, by crossing off yes or no. If neither an offer is accepted nor the acceptation confirmed, no exchange is carried out and new offers can be made. The three types of actions (offer, accept, confirm) are also used in computerized experiments of exchange (e.g., Skvoretz and Willer 1993).

All communication was made public by B, who showed the forms to A and C. Hence, all subjects had complete information with respect to the bargaining. However, they were not informed on the payoffs that other subjects received after an exchange. Because we did not want the exchanges to be determined by equity considerations, they were only informed on each other’s initial endowments (the E row in Table 1) and how much each actor was *maximally* and *minimally* willing to supply or receive in the exchange. That is, A (C) knew that B would not transfer his 12 units of X for fewer than 12 units of Y, whereas B knew that A (C) would not give more than 36 (60) units of Y, but they did not know the payoffs (the U row in Table 1) of other players. After each round the experiment leader computed the actors’ payoffs and wrote them on a piece of paper that was handed out privately to each subject. For A and C the computation showed the payoffs earned in exchange and the externality separately.

A bargaining round ended after 200 seconds *or* when the exchange was completed. After the bargaining round the number of points earned by the subjects was written down on a reward form positioned on their desk in front of them. After the experiment, which was completed in approximately 90 minutes, the total number of points was calculated and transformed linearly into a monetary reward. After the transformation the subjects earned in between 8 and 12 euros with an average of approximately 10 euros.

3.5 Results

3.5.1 Partner selection

In each of the conditions of the experiment a maximum of 48 exchanges was possible. In the condition without externalities 44 exchanges were actually completed. Twenty-five (56.8%) of these were between B and C. This is a clear violation of Hypothesis 1 that asserted that exchanges without externalities would take place *only* between B and C. Inspecting the last round of each session only we find that 7 of the 8 possible exchanges occurred, but that of these seven, only 4 were between B and C. Again, this violates Hypothesis 1, and the violation doesn't disappear in later rounds of the sessions. In the condition *with* externalities 43 exchanges were completed, of which 18 (41.9%) took place between B and C. The difference between the conditions with respect to the proportion of exchanges between B and C is in the direction predicted by hypothesis 3. Testing this difference with a Chi-square test shows that it is marginally significant, assuming that all observations are independent (Chi-square = 1.95, $p = 0.082$, one tailed).

3.5.2 Exchange rate

The average rate of exchange without externalities between A and B was 27.26 and 31.45 between C and B, resulting in an overall average rate of exchange of 29.64, with a robust standard error equal to 1.95 [1]. The average rate of exchange with externalities between A and B was 23.28 and 23.57 between C and B, resulting in an overall average of 23.40, with a robust standard error equal to 1.55. The prediction of core theory, expressed in hypothesis 2, that the number of units of Y transferred are in the interval [36,60] when exchange was without externalities, was not confirmed. Only 6 out of 44 exchanges without externalities were in the core. A finding that offers some support for core theory is the observation that the average number of Y transferred increased with round. It might be that if more than six rounds were played, the number of Y units transferred would eventually be in the core. Below we will estimate the effect of round as part of the comparison between the two externality conditions with respect to the exchange rates.

Our main hypothesis, Hypothesis 4, concerning the effect of externalities on the exchange rate, cannot be tested with ordinary linear regression analysis. The reason is that regression analysis requires independent observations, while the exchange rates of consecutive rounds within one session are correlated. Moreover, these sessions are nested within groups. Consequently, the standard errors of the regression analysis are incorrect. The statistical method that takes into account the dependencies within sessions and groups is the hierarchical linear modeling or multilevel approach (e.g., see Snijders and Bosker 1999; Raudenbush and Bryk 2002). Therefore, the effects were estimated and tested with multilevel analysis. We also ran a regression analysis on our data. The estimates of both analyses were almost identical, however, the standard errors of the estimates differed. Model fit in multilevel analysis is assessed with the deviance statistic. The difference between the deviances of two models is chi-squared distributed with degrees of freedom equal to the difference in the number of parameters of the models.

Three models were estimated. First of all the empty model. In the empty model only an intercept was estimated for the average number of units of Y transferred to B. The deviance of the model was 514.58. Secondly, Model I was estimated with the number of units of Y transferred to B regressed on two variables: 1) the order of the externality conditions in the experiment (Order), and 2) the bargaining round (Round). The variable Order had a value 0 for the first session, and a value of 1 for the second session. The variable Round was centered by subtracting 2.5 from all the values. Thus, after centering, the variable Round ranged from -2.5 to +2.5. As a result, the intercept can be interpreted as the average exchange rate for the first session in the average round.

The estimates, their standard errors, and the fit of Model I are summarized in the second and third column of Table 2. The effects of Round and Order were not significant ($p > 0.10$). Model I did not improve the fit in comparison to the empty model ($\chi^2 = 2.49$, $df = 2$, $p > 0.10$).

Table 2: Summary of the results of the multilevel analysis of the exchange rate in the experiment

	Model I		Model II	
	Coeff.	S.E.	Coeff.	S.E.
Intercept	27.34	1.98	31.35	2.30
Order	–1.59	2.32	–3.66	3.27
Round	0.33	0.23	1.00****	0.30
Externalities			–8.11**	3.27
Externalities*Order			4.33	6.17
Externalities*Round			–1.35 ***	0.43
Deviance	512.090		490.291	

Note: Parameters are estimated with Full Maximum Likelihood. The degrees of freedom of the test for Round and Ext*Round are 81, and 12 for the other effects.
**** $p < 0.001$, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

To assess the effects of externalities on the exchange rate we added the variable Externalities to the model, as well as the interactions Externalities*Order and Externalities*Round. We call this model, Model II. The variable Externalities had the value 0 when exchange was *without* externalities and 1 when exchange was *with* externalities. Including externalities and its interactions profoundly increased the model fit in comparison to Model I ($\chi^2 = 21.80$, df = 3, $p < 0.001$). It is concluded that the number of units transferred to B was different, depending on whether externalities were present or not. The effect of externalities per se was to decrease the average by 8.11 units ($p < 0.001$), confirming Hypothesis 4: the advantage of B was smaller when externalities were present in the exclusively connected Line3 network.

The effect of externalities can also be observed from Figure 3. In Figure 3 the average number of Y units transferred to B is depicted as a function of two variables: (i) whether the session started with externalities (‘Experiment’ = 1) or not (‘Experiment’ = 0), and (ii) round in the experiment. Because in the experiment each group played six rounds in each of the two sessions, a total of twelve rounds were played. The vertical line in Figure 3 indicates the separation of the two sessions. As can be seen from Figure 3, all the averages for the rounds with externalities, except for the first round in session two, were lower than those without externalities.

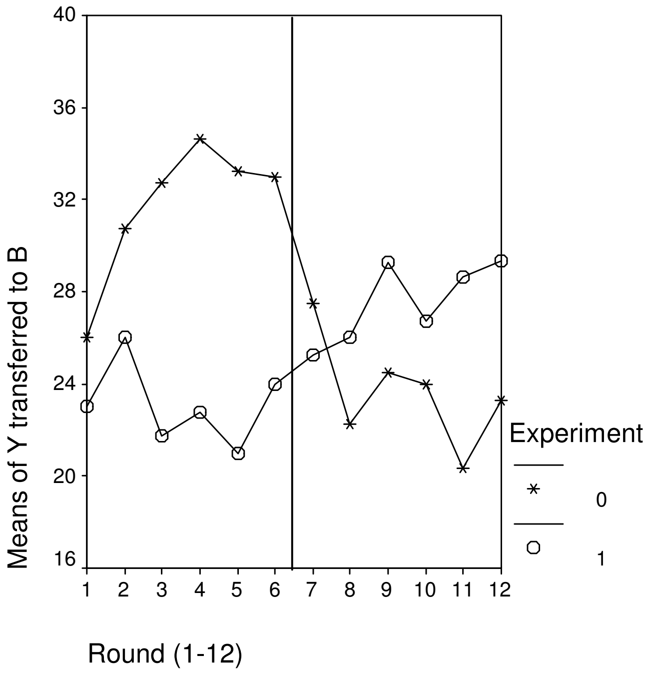

Figure 3: Average number of Y units transferred to B in the course of the experiment. The circles (stars) denote the exchange rate in the condition that started with (without) externalities

On average the number of Y units transferred to B was 3.66 units lower in the second session than in the first. However, this effect of Order was not significant ($p > 0.10$). The effect of Externalities was larger in the first session than in the second. That can be inferred from the fact that in Figure 3 the average difference between the two lines is largest in the first session. This interaction Externalities*Order was due to the anchor that the number of Y units transferred in the last round of the first session provides for the first round in the second session. However, this interaction effect was not significant ($p > 0.10$).

The effects of Round and Externalities*Round were significant. If exchange was without externalities, the average number of Y units transferred increased with on average 1.00 unit per round (effect of Round, $p < 0.001$). This effect was due to the competition between A and C. If exchange was with externalities, the average decreased with on average $1.00 - 1.35 = -0.35$ units per round. This decrease was not significant ($p > 0.10$).

3.6 Discussion

The present study is a first exploration of the effects of externalities on partner selection and exchange rates in exchange networks. An experiment was carried out with an exclusively connected Line3 network, containing two conditions, one without and one with externalities. An adaptation of core theory was used to guide the experiment and make predictions. In the experiment positive externalities between A and C were introduced in an exclusively connected Line3 network. On the basis of an adaptation of core theory we expected that the proportion of exchanges between B and C would be larger in the network without externalities than in the network with externalities, and that the number of units of Y transferred to B would be larger in the network without externalities than in the network with externalities. We found that our hypothesis concerning partner selection (Hypothesis 3) was corroborated, however based on a marginally significant difference between the conditions. Furthermore, we found a significant difference between the conditions with respect to the exchange rate, corroborating Hypothesis 4.

The predictions of core theory for the condition without externalities proved to be off the mark: the consistent exclusion of the least interested actor A was not observed, and only in 6 out of 44 instances was the number of units of Y transferred to B in the predicted interval of [36, 60] . One explanation might be that six rounds of play were not enough for power to fully develop in the network without externalities; the number of units of Y transferred to B *were* increasing in round, as predicted.

The rejection of core theory's predictions in the condition without externalities may at first come as a surprise, since the core is a solution concept that has shown to provide quite accurate predictions of exchanges and exchange rates in equally valued exchange networks. However, in experiments using equally valued strong power exchange networks, extreme outcome distributions are not often observed. While core theory predicts low power actors to obtain zero or one point, in experiments a low power actor obtains on average 2 or more points when he exchanges with a strong power actor. More importantly, core predictions have not been so successful in predicting exchanges and exchange rates in unequally valued networks, such as studied here. The network in this paper is unequally valued, since the sum of points divided in an exchange between A and B is 24, whereas in an exchange between B and C, 48 points are divided. Bonacich and Friedkin (1998) observed that inefficient exchange relations, such as the relation AB in the current experiment, are still very frequently used. Molm, Takahashi, and Peterson (2003) observe the same phenomenon. In their unequally valued exchange condition they observed that more than half of the subjects did not carry out their most efficient exchange, even though their resistance to do so could cost them more than $10 on average (Molm et al. 2003: 139). Both studies attribute these effects to an actor's strong aversion to make unequal exchanges. Bonacich and Friedkin (1998: 170) therefore propose to extend social exchange models to include equity effects. Anyway, the previous reflections suggest that a disconfirmation of the core theories' prediction of the rate of exchange without externalities is not in disagreement with previous research.

Further theoretical and experimental research on exchange with externalities is necessary, for two complementary reasons. Firstly, and most importantly, examples of exchange with externalities are abundant in real-life. Secondly, the huge amount of results on exchange without externalities cannot be generalized to exchange with externalities; the experiment reported here demonstrated that the effect of the structure of an exchange situation on the exchange rate depends on whether externalities are present or not.

One issue for further research is the effect of negative externalities on exchange outcomes, e.g., in the Line3 network studied in the present paper. In the present paper we demonstrated both theoretically and experimentally that positive externalities removed the competition between A and C and thereby decreased B's payoff. Using core theory it can be derived that negative externalities *increase* the competition between A and C compared to the no-externalities condition. Preliminary results of an experiment with negative externalities corroborate this prediction.

The results reported in this paper will be used to further the theoretical development of core theory, and other network exchange theories. This, however, is the subject of a future paper.

Notes

1. The observations or exchange rates were not independent. In the same group of three subjects up to six exchange rates were observed, that are thus dependent. Therefore we calculated the correct or ‘robust standard error’ of the mean that takes into account this dependency (e.g., Snijders and Bosker 1999: 23). The robust standard error is larger than the uncorrected standard error, and their difference is larger the more dependent the observations from the same group of subjects. This dependency was very high in our data, hence the robust standard errors were considerably larger than the uncorrected standard errors.

4

Externalities in exchange networks: an adaptation of existing theories of exchange networks*

* This chapter is currently under review at *Rationality and Society*. I would like to thank Marcel van Assen, David Willer and Phil Bonacich for their helpful comments.

Abstract

The present paper extends the focus of network exchange research to *externalities* in exchange networks. Externalities of exchange are defined as direct effects on an actor's utility, of an exchange in which this actor is not involved. Existing theories in the field of network exchange do not inform us on how externalities are predicted to affect behavior in exchange networks. Three prominent theories in the field, core theory, power dependence theory and exchange resistance theory, are extended to exchange networks with externalities, allowing three main conclusions about the expected effects of externalities in exchange networks: externalities i) change actors' payoffs, ii) change the exchange pattern, and iii) change the power distribution across actors. The investigated theories yield predictions concerning the occurrence and magnitude of these effects. A method is proposed to separate the effect of i) the network, ii) the externalities, and iii) the interaction between network and externalities.

4.1 Introduction

In the social sciences a fair amount of research is devoted to exchange networks. The issue on which this research has mainly concentrated, is the effect of networks on the choice of exchange partners and the ratios of exchange (for example, see the special issue on network exchange in *Social Networks*, volume 14, and Willer 1999). In this line of research, an actor's connections in a network represent with whom the actor can exchange. If there is a connection between two actors in the network, these actors have the possibility to exchange, but no obligation to do so. If there is no link between two actors, an exchange between them is not possible. Generally, exchange possibilities are represented as the opportunity of two actors to divide a pool of valuable resources or 'profit points', usually of size 24.

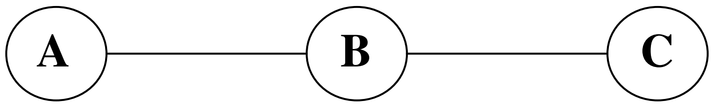

Figure 1a: The Line3 exchange network

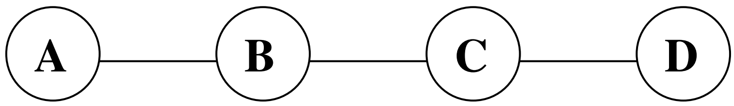

Figure 1b: The Line4 network without externalities

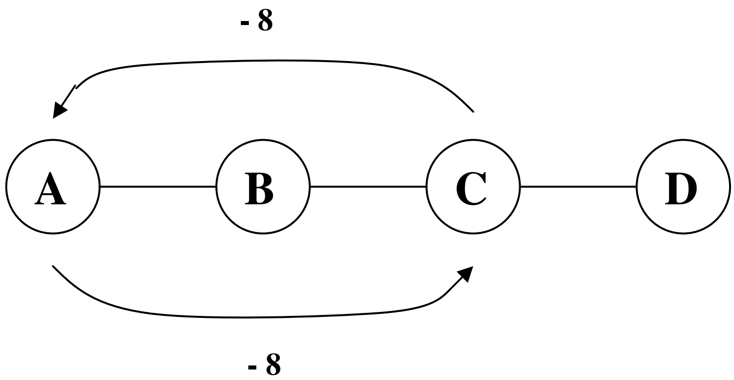

Figure 1c: The Line4 network with externalities of -8 between A and C

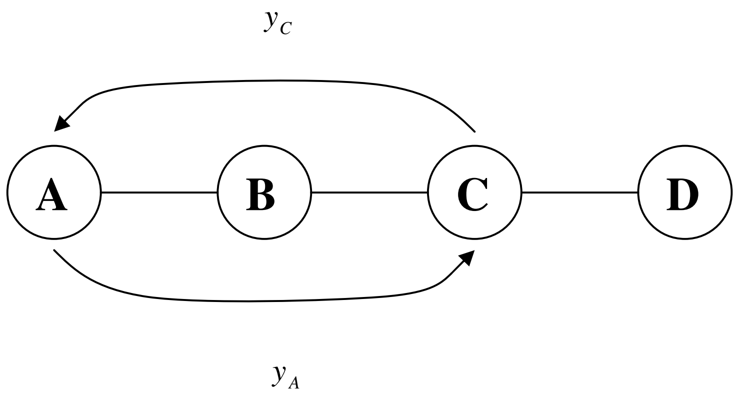

Figure 1d: The Line4 network with externalities of y_A and y_C, between A and C

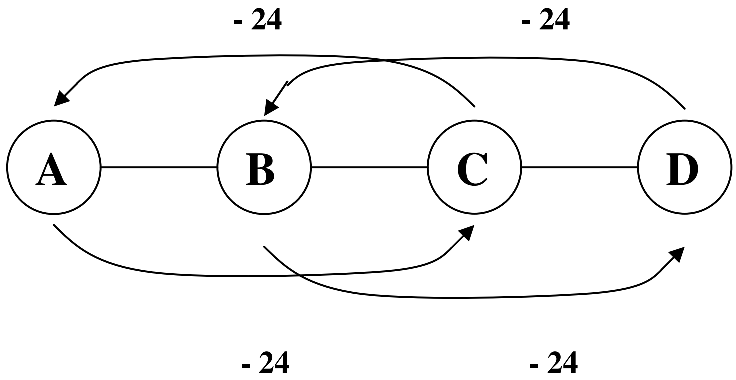

Figure 1e: The Line4 network with externalities of -24 between A and C, and between B and D

One of the simplest examples of an exchange network, for obvious reasons sometimes called Line3, is presented in Figure 1a. In the Line3 network, the actors in positions A and C do not have the possibility to exchange with each other since they are not connected. B can negotiate and (possibly) exchange with both A and C. If actors fail to reach agreement, neither gets any points. In most studies actors are limited to making only 1 exchange. Theories in the field of exchange network research seek to predict who exchanges with whom and what will be the payoff for each of the actors.

In the current paper we will extend the basic framework (1 exchange per actor, and exchange represented as the opportunity to divide a pool of 24 points) by introducing *externalities*. As we will show below, externalities occur in many real-life exchange situations, and affect the outcomes of exchange. The aim of the present paper is to analyze existing theories in the field with the objective to extend them to exchange with externalities. We define externalities the way they are commonly defined in economics. In the words of Mas-Colell, Whinston, and Green (1995, p.350) economic situations *without* externalities are situations in which an actor's preferences or utilities are defined solely over the set of goods that she might herself decide to consume. An *externality* is defined to be present whenever the well-being of an actor is *directly* affected by the actions of another actor (1995, p.352).

In the context of exchange networks, externalities of exchange are defined as direct consequences (positive or negative) of exchanges for the well-being of actors who are not involved in the exchange. Externalities in the Line3 network of Figure 1 would exist if after an exchange of two actors the profit of the third actor is directly affected as well. For example, if A and B obtain 16 and 8 points in their exchange with each other respectively, and C obtains 4 points as a direct consequence of this exchange, then C experiences *positive* externalities of the exchange between A and B, equal to 4. If for example 4 points are subtracted from C's profits after the exchange between A and B, C is experiencing *negative* externalities of 4. It is important to note that if C's profit is unaffected, i.e., no points are *directly* added or subtracted due to the exchange between A and B, there are *no* externalities. Thus, according to the definition of externalities we employ, the *exclusion* of C when A and B exchange is *not* an externality effect of the exchange between A and B. Also a possible outbidding process of A and C to be able to exchange with B is not connected to externalities. Exclusion and the outbidding process are merely two instances of *interdependence* that are present in exchange networks, whether there are externalities of exchange or not. If we were to include exclusion and outbidding in the definition of externalities, virtually any interdependency in an exchange network would be an externality and the concept would loose its usefulness.

There exists a considerable amount of research on the concept of externalities. However, existing models that explicitly allow for externalities (see for instance the generalization of the Shapley value by Myerson 1976) assume that all actors in the economy can exchange with each other. The problem studied in the present paper deviates from this by focusing on externalities in exchange *networks*, in which interaction possibilities are limited by network connections.

Many instances of strategic interaction commonly studied in the social sciences, can be conceptualized as exchange problems with externalities. Resource dilemmas for instance, can be analyzed as a network of exchange relations in which a number of players use a common resource as a source of supply of exchangeable commodities (think for instance of fishermen sharing waters). By all using the same resource to their own benefit, the players deplete the resource, thereby ending up in a Pareto inefficient equilibrium. The benefit of analyzing such a situation as an exchange network with externalities, is that it allows one to investigate the interaction between the externality structure and the relations in the exchange network. What are the effects of the externalities on other players in the network that are not subject to externalities themselves (such as consumers, or retailers of fish)? What are the effects of the network structure on how players in the resource dilemma play the game? How do the externalities affect the exchange ratios in the network (e.g., the price of fish) or the partner choice? Answers to these questions become feasible only when the externality structure and the larger social structure surrounding it, are studied in concert.

The societal relevance of studying externalities of exchange follows from the abundance of examples of exchanges with externalities in real-life. Some exchanges with externalities that most of us are familiar with and experience on a daily basis, are exchanges of and between members of a household. The father's purchases in the supermarket (the exchange of money for products) are experienced as externalities by the other members of the household: less money to spend on other products or activities, and the possibility to consume the products bought by the father. Note that in particular the children in the household experience externalities all the time, since they commonly do not have their own budget, or a very limited one. Another example is collective decision making. In a division in Parliament for instance, two political parties may agree to exchange their voting positions concerning two issues that have to be decided upon. Since this "logrolling" changes the eventual outcome of the vote, the exchange directly affects other political parties that are not involved in the agreement. In other words, the political parties that do not exchange experience externalities. Since the exchange may shift the outcome of the division either toward or away from the position of a particular party not involved in the exchange, the externality may be evaluated positively or negatively by that party (Stokman, van Assen, van der Knoop, van Oosten 2000; van Assen, Stokman, van Oosten 2003).

A crucial insight that is gleaned from thinking about examples of externalities of exchange is that these externalities arise when certain actors *share resources* that are exchanged. Thus, the fishermen experience externalities because they share access to the fishing grounds; household members experience externalities because they share the available household commodities; political parties experience externalities because they share the power to shift the outcome of decision making in a certain direction. The important point is that actors that share a resource cannot use it in exchange with each other, since both actors already 'own' it. Thus, an externality relation between two actors is logically distinct from an exchange relation.

Since many resources are shared, exchanges with externalities can be expected to be no less common in real-life than exchanges without externalities. However, research on effects of externalities on exchange networks has been scarce. More specifically, existing theories in the field of network exchange do not inform us on how externalities are predicted to affect actors' behavior in exchange networks. The present paper aims to meet this challenge, by analyzing three prominent theories from the field of network exchange research, and indicating how they can be extended and applied to the problem of externalities. Our aim is to adapt and apply each of the theories, while not changing their basic assumptions. That is, modifications or extensions of the theories in order to apply them to exchange with externalities do not affect the theories' predictions regarding exchange *without* externalities. In the words of Lakatos (1970, p.116), our purpose is to devise theories with 'excess empirical content'.

In the next section we discuss the core solution, originally introduced to the field of network exchange by Bienenstock and Bonacich (1992). We show how the core solution can be fruitfully adapted to the problem of externalities in exchange networks. Moreover, in making this adaptation, we find that the core of an exchange network *without* externalities, is always a subset of the newly defined core in the *same* network, with *positive* externalities. An advantage of the core solution is that it is based on a minimal number of simple assumptions about individual actors and coalitions. More specifically, in our adaptation of the core to the problem of externalities we will see that we only have to make rather straightforward assumptions about individuals and connected dyads. A drawback of the core however, is that in small, not fully connected networks it does generally not yield 'point predictions', i.e., exact ratios of exchange, but mostly specifies an interval wherein the exchange ratio is predicted to lie. Two prominent exchange theories that mend this drawback at the cost of the loss of at least part of the simplicity advantage are exchange resistance theory (for instance Willer 1999) and power dependence theory (for instance Cook and Yamagishi 1992). By making some additional assumptions about individual actors, and defining a condition under which exchange is predicted to occur (equiresistance and equidependence, respectively) these theories manage to predict an exact ratio of exchange. Section 2 is devoted to the investigation of power dependence theory under the condition of externalities in exchange networks, and section 3 scrutinizes exchange resistance theory. In sections 2 and 3 we find that these solutions too, can be fruitfully extended to exchange networks with externalities.

A means is introduced that enables one to decompose an actor's payoff into a part attributable to the network, a part attributable to the externalities, and a part attributable to the interaction between network and externalities. This method therefore explicates what the predicted effect of externalities is, and is able to theoretically separate its effect from the effect of the network. Section 4 concludes the paper and indicates directions for future research.

In the remainder of the paper we will illustrate the application of the theories using 4 numeric examples. These examples are no more than illustrations. They have been chosen to investigate the behavior of the examined theories under different externality conditions, and are not derived from real-life exchange situations. The theories however are generally applicable to exchange networks of various shapes.

4.2 The core solution

4.2.1 Exchange without externalities

The core solution was originally introduced to the field of network exchange by Bienenstock and Bonacich (1992). Based on the assumption that exchanges can be represented as the opportunity to divide a fixed pool of resources, Bienenstock and Bonacich (1992) have shown that exchange networks can be conceptualized as cooperative games with transferable utilities. Such a game is described by the *characteristic value function* (see for instance, Friedman 1986).

Let N be the set of players in the game. The characteristic value function v assigns a total payoff v(S) to every subset $S \subset N$ of players, that they can realize among themselves, *despite* the actions of $N \setminus S$, i.e., the players not in S. Thus, v(S) represents the total payoff that a coalition S can guarantee itself; the coalition can be sure to achieve at least this payoff. According to the assumption of transferable utility, this total payoff can be divided among the members of S in any conceivable way.

Using the characteristic value function, one can define the core solution. Let (x) be a payoff vector, such that x_i represents the payoff for player *i*. A payoff vector (x) is in the core if it meets the following three rationality requirements:

i) $x_i \geq v(\{i\})$ *for every* $i \in N$ (individual rationality),

ii) $\sum_{i \in S} x_i \geq v(S)$ *for every* $S \subset N$ (coalition rationality), and

iii) $\sum_{i \in N} x_i = v(N)$ (group rationality).

In words: the core consists of the set of payoff vectors such that no coalition (including 1-person coalitions) receives less than it can guarantee itself.

In exchange networks, coalition formation is understood to mean ‘reaching agreement to exchange’ in connected pairs. Thus, the problem with the conceptualization of exchange networks as cooperative games in characteristic function form, is that in exchange networks no other coalitions S than individuals and connected dyads can form. Therefore, rationality requirements that pertain to coalitions larger than dyads, or to coalitions of unconnected players have no meaning: the coalitions cannot form and therefore cannot change the payoff vector.[1] However, if we restrict all actors in the network to at most 1 exchange then, as is shown by Bonacich and Bienenstock (1995), Proposition 1 holds:

Proposition 1: If coalitional rationality holds for every dyad it also holds for any larger coalition.

Table 1: The characteristic value function of the Line 4 (Figure 1b) without externalities

$$v(\{A\}) = v(\{B\}) = v(\{C\}) = v(\{D\}) = 0$$
$$v(\{AB\}) = v(\{CD\}) = v(\{BC\}) = 24$$
$$v(\{AC\}) = v(\{AD\}) = v(\{BD\}) = 0$$
$$v(\{ABC\}) = v(\{ABD\}) = v(\{ACD\}) = v(\{BCD\}) = 24$$
$$v(\{ABCD\}) = 48$$

We discuss an example to clarify the point. Consider the Line4 network in Figure 1b. For each subset of players, find the maximum number of exchanges that can be completed between members of this subset, given the exchange network. Then multiply this number by 24, the value of each of the exchanges. For instance, the coalition between players A, B and C has a characteristic value of 24, since only one exchange can be completed between members of this coalition. The characteristic value function of the Line 4 is depicted in Table 1, where coalitions are enclosed in curly brackets. According to Proposition 1, if we find a feasible payoff vector that satisfies the rationality requirements of individuals and two-person coalitions, this payoff vector also satisfies all other rationality requirements. Such a payoff vector is for instance $(x) = (12,12,12,12)$. The reader can easily verify that exchange outcomes in which A divides 24 points with B, and C divides 24 points with D, and in which the sum of payoffs for B and C is at least 24, satisfy the rationality requirements for individuals and 2-person coalitions *and* are in the core, i.e., satisfy all other rationality requirements.

4.2.2 Exchange with externalities

The previous analysis and proposition pertain to exchange networks as they have been studied in the literature thus far, i.e., without externalities. If we want to study externalities and apply the core solution, the first question arising is how to incorporate externalities in the characteristic value function. A first candidate answer readily presents itself: strictly adhere to the definition of a coalition's characteristic value as the maximum value a coalition can guarantee itself, despite the actions of others. We'll check the implications of this answer, by introducing externalities in the Line4 network of Figure 1b. Assume negative externalities exist between A and C. More specifically, say that whenever C exchanges, A gets a payoff of -8, additional to any payoffs A receives in her own exchanges. Assume that, mutatis mutandis, the same holds for C. This situation is depicted in Figure 1c. The arrow in this figure that points from C to A, indicates the externality for A, if C exchanges. Similarly, the arrow from A to C indicates the externality for C, if A exchanges.[2] Note that these arrows do not indicate a direct transfer of resources, but an externality. In keeping with the definition of characteristic value above, we compute the characteristic value function for this game in Table 2.

Table 2: The characteristic value function of the Line4 (Figure 1c), with negative externalities of -8 between A and C

$$v(\{A\}) = v(\{C\}) = -8$$
$$v(\{B\}) = v(\{D\}) = 0$$
$$v(\{AB\}) = v(\{CD\} = 16$$
$$v(\{BC\}) = 24$$
$$v(\{AC\}) = 0$$
$$v(\{AD\}) = -8$$
$$v(\{BD\}) = 0$$
$$v(\{ABC\}) = v(\{ACD\}) = 16$$
$$v(\{ABD\}) = v(\{BCD\}) = 24$$
$$v(\{ABCD\}) = 32$$

The characteristic value of the individual players A and C has dropped from 0 to -8: neither of them alone can prevent the other from exchanging, and the maximum each can *guarantee* herself is thus -8. If A and C were to form a coalition, they would not be able to complete an exchange with each other (given the network structure), but they could agree not to exchange at all and thus guarantee a total payoff of 0.[3] Hence, the value of the coalition between A and C is 0. Note how the characteristic values of the coalitions between A and B and between C and D has fallen from 24 to 16; they can split 24 points among themselves, but they cannot prevent the negative externality for C or A, respectively. Finally, we observe that the characteristic value of the coalition of all players has dropped from 48 to 32: two exchanges can be completed in which a total of 48 points is divided, but two members of the coalition (A and C) each experience an externality of -8.

Now that we have incorporated externalities in the characteristic value function, let us try to find a payoff vector (x), that lies in the core. To that end we introduce a vector (y), that gives the payoffs for the players, *without* externalities. The vector (y) thus simply gives the division of the 24 points for each *exchanging* pair. In line with Proposition 1, we start by looking at individual actors and 2-person coalitions. Assume $(y) = (12, 12, 20, 4)$. With the assumed externalities this gives rise to the payoff vector $(x) = (4, 12, 12, 4)$. This vector meets all rationality requirements for individual actors and 2-person coalitions. According to Proposition 1, this vector should then meet all the remaining rationality requirements and consequently be in the core. However, $(x) = (4, 12, 12, 4)$ fails to meet the rationality requirement of for instance the triad $\{ABD\}$. The value of this coalition is 24, as can be read from Table 2. However, under $(x) = (4, 12, 12, 4)$, this coalition gets a sum of merely 20. Hence, we find that Proposition 1 fails to hold generally, when externalities are involved (a similar example could be constructed with positive externalities).[4]

In exchange networks with externalities, coalitions between more than 2 players, and coalitions between unconnected players cannot be disregarded when determining the core. However, these coalitions are precluded by the rules of network exchange, since coalition formation is interpreted as exchange, and exchange is only allowed between two connected actors. For exchange networks with externalities, we thus cannot apply the traditional core, and are left with only 2 sensible rationality requirements:

i) $x_i \geq v(\{i\})$ *for every* $i \in N$ (individual rationality), and

ii) $\sum_{i \in S} x_i \geq v(\{i, j\})$ *for every connected* $i, j \in N$ (rationality of connected dyads).

This gives rise to a first attempt to define a 'generalized core solution': a payoff vector (x) is in the generalized core whenever it meets the two rationality requirements mentioned above. Note how, according to Proposition 1, the generalized core is identical to the traditional core in exchange networks without externalities.

Table 3: The characteristic value function of the Line4 (Figure 1c), with positive variable externalities between A and C

$$v(\{A\}) = v(\{B\}) = v(\{C\}) = v(\{D\}) = 0$$
$$v(\{AB\}) = v(\{BC\} = v(\{CD\}) = 24$$

The generalized core as formulated above has a serious drawback. To demonstrate this we consider an example. In the example of Figure 1c, we considered 'constant' externalities: the size of the externality depends only upon whether or not a certain actor exchanges, and not on the payoff this actor receives in this exchange. Nothing in the definition of externalities however, precludes 'variable' externalities, i.e., externalities that depend on the payoff of some other actor. Consider again the network of Figure 1b, and assume that variable, positive externalities exist between A and C. More specifically, assume that A gets the same payoff as C, in addition to any payoffs A receives in her own exchanges. Assume that, mutatis mutandis, the same holds for C.[5] Thus, A and C now possibly gain from two sources: receipts from their own respective exchanges, and the gains the other player earns in her exchange. This situation is depicted in Figure 1d, where y_A and y_C indicate the shares of the resource pool A and C appropriate in their own exchanges, respectively. We then compute the characteristic value function in Table 3. Since coalitions of unconnected players and coalitions larger than two players cannot form, we omit them.

Note how the characteristic values of A and C are 0: alone they cannot guarantee that the other player will exchange (in which case they would receive the positive externality), and thus all they can guarantee themselves is 0. The same holds for the two-person coalitions: A and B cannot assure by themselves that C and D will conclude an exchange nor that C will receive a strictly positive payoff in such an exchange. Hence, the maximum A and B can *guarantee* themselves is 24. Now, consider the vector $(y) = (10,10,12,12)$, that registers the players' payoffs without externalities. With externalities this gives rise to the payoff vector $(x) = (22,10,22,12)$. The vector (x) easily meets the two rationality requirements of the generalized core solution. However, vector (y) has an undesirable feature in the light of rationality: players A and B each receive 10 points in their exchange, and thus leave 4 of the twenty-four points 'on the table', or 'undivided'. In other words: A and B exchange in a Pareto *inefficient* manner. Such inefficient exchanges are thus not precluded by the two rationality requirements stated above. Since Pareto efficiency at the dyadic level is a basic requirement that any rational choice theory should satisfy, we add this requirement to the two rationality requirements of the generalized core. Thus, the generalized core is finally defined as the set of payoff vectors (x) such that,

i) $x_i \geq v(\{i\})$ *for every* $i \in N$ (individual rationality),

ii) $\sum_{i \in S} x_i \geq v(\{i, j\})$ *for every connected* $i, j \in N$ (rationality of connected dyads),

iii) $\sum_{i \in S} y_i \geq w(\{i, j\})$ *for every exchanging* $i, j \in N$ (Pareto-efficiency of exchanging dyads), where $w(\{i, j\})$ is the characteristic value of pair $\{i, j\}$ without externalities.

Firstly, note how requirement ii) pertains to all connected dyads whereas requirement iii) pertains to *exchanging* dyads only. Thus, for all connected dyads, we require that they receive at least their characteristic value (requirement ii)). For exchanging dyads we pose the additional requirement that they maximize their payoffs, regardless of what other players do, i.e., regardless of any externalities (requirement iii)). Secondly, note how in an exchange network without externalities, the characteristic value of a connected pair is by definition equal to the size of the pool of points to be divided, guaranteeing all exchanges to be efficient. Thus, the generalized core in networks without externalities still equals the traditional core. Note that like the core, the generalized core does not necessarily exist nor is it necessarily unique when it exists.

It is instructive to investigate the behavior of the generalized core in exchange networks with externalities. Shapley and Shubik (1969) have shown that if the core of an economy is non-empty, it is also non-empty when positive externalities are added. A similar proposition can be proved for the generalized core in exchange networks.

Proposition 2: The (generalized) core without externalities is a subset of the generalized core with positive externalities.

The proof of Proposition 2 can be found in the Appendix. This proposition implies that if the core without externalities is non-empty, the generalized core with positive externalities is also non-empty and includes the core without externalities. The intuition behind Proposition 2 is that positive externalities don't change the characteristic values of connected dyads. To illustrate the proposition we refer once again to the example of Figure 1d. Take the payoff vector $(y) = (10,14,14,10)$. This vector is in the (generalized) core without externalities. With externalities between A and C according to Figure 1d, $(y) = (10,14,14,10)$ implies a payoff vector with externalities of $(x) = (24,14,24,10)$, which is in the generalized core of this network (see Table 3 for characteristic values). The generalized core in the network with externalities is strictly larger than the core without externalities because there are positive externalities. Consider for instance the vector $(y) = (24,0,0,24)$, which is *not* in the core without externalities. With the positive externalities of Figure 1d, $(y) = (24,0,0,24)$ implies $(x) = (24,0,24,24)$, which *is* in the generalized core with externalities.

A straightforward but important corollary of the proposition above, is that any 'exchange pattern' that can occur in the core without externalities, can occur in the generalized core with positive externalities. In other words, if in a network without externalities, there exists a payoff vector in the core such that two actors exchange with each other, there exists a payoff vector in the generalized core of the same network with positive externalities, such that the same two actors exchange with each other. Loosely speaking, according to the generalized core, positive externalities cannot 'force' the exchange pattern to change.

To round up the examples of Figures 1c and 1d, we give their the entire generalized cores. In the generalized core of Figure 1c, A exchanges with B, and C exchanges with D. Moreover, the sum of the pool shares that B and C receive is at least 32, i.e., $y_B + y_C \geq 32$. In the generalized core of Figure 1d, two exchange patterns are feasible. Either B exchanges with C, in which case C should receive the entire resource pool

($y_C = 24$), or B exchanges with A, and C exchanges with D. In this last exchange pattern, any division of the resource pools is admissible.

Contrary to positive externalities, negative externalities *do* sometimes change the feasible exchange pattern in the generalized core. This is the case because, contrary to positive externalities, *negative* externalities change the characteristic value of individual actors and dyads. Once more consider the Line4 network of Figure 1b. Assume negative externalities exist between both A and C, and B and D. More specifically, assume that whenever A exchanges, C looses 24 points, additional to any points C might gain in exchanges she herself completes, and that A similarly looses 24 points whenever C exchanges. Assume that, mutatis mutandis, the same externality relation exists between B and D. This situation is depicted in Figure 1e. The characteristic value function is shown in Table 4.

Table 4: The characteristic value function of the Line4 (Figure 1e), with negative externalities between A and C and between B and D

$$v(\{A\}) = v(\{B\}) = v(\{C\}) = v(\{D\}) = -24$$
$$v(\{AB\}) = v(\{CD\}) = -24$$
$$v(\{BC\}) = 24$$

Consider the vector $(y) = (0,12,12,0)$, which implies B and C exchange with each other and split the 24 points evenly. The vector $(y) = (0,12,12,0)$ implies the payoff vector $(x) = (-24,12,12,-24)$, which meets the rationality requirements of the generalized core. However, $(y) = (0,12,12,0)$ is not in the core without externalities. In other words, the large negative externalities induce B and C to exchange with each other, a situation inadmissible in the core without externalities, but rational in the generalized core with externalities. Moreover, the original exchange pattern in the core without externalities, i.e., A exchanging with B and C with D, *cannot* occur in the generalized core with externalities. The generalized core in this example consists of all exchanges between B and C. A general relationship between the generalized core in networks without externalities and in networks with negative externalities, such as we found for positive externalities in the previous proposition, was not found. More specifically, as illustrated by the most recent example, the generalized core of an exchange network with negative externalities is not necessarily a subset of the generalized core without externalities.

4.3 Power dependence theory

4.3.1 Exchange without externalities

Power dependence theory was conceived by Emerson (1964, 1962) as a general theory of power relations '(…) in an effort to resolve some of the ambiguities surrounding "power", "authority", "legitimacy", and power "structures"(…)' (Emerson 1962, p.31). After its first formulations, the theory was applied to predict exchange ratios in exchange networks (for instance, Cook and Emerson 1978, Cook et al. 1983, Cook and Yamagishi 1992). Central in the theory is the concept of *dependence*. In exchange networks, Cook and Yamagishi (1992) define the dependence of actor i on actor j (D_{ij}), as the amount of extra profit i gets in the i-j exchange over i's best available alternative. This best alternative of i is referred to as i's *conflict payoff* in the remainder of the text. Denoting i's payoff in exchange with j as y_{ij}, and i's conflict payoff as y_{ij}^{con}, we can write $D_{ij} = y_{ij} - y_{ij}^{con}$. Power dependence theory claims that actors will agree at the point where their mutual dependences are equal, i.e., where $D_{ij} = D_{ji}$. Moreover, in exchange networks, power dependence theory predicts that mutual dependences will be equal, *throughout the network* (Cook and Yamagishi 1992). That is, $D_{ij} = D_{ji}$ for each pair of connected actors i and j.[6, 7]

To illustrate how this *equidependence* principle operations in exchange networks without externalities, we again consider the Line4 network of Figure 1b. Assume that A exchanges with B and C with D. Then we know that $y_{BA} = 24 - y_{AB}$ and $y_{DC} = 24 - y_{CD}$.[8] The expressions for the conflict payoffs, dependences and the equidependence principle for these relations, are given in table 5. The conflict payoffs for actors A and D are 0: neither has an alternative exchange partner to respectively B and C. Actors B and C however, have each other as alternatives. B will then have to offer C at least y_{CD}, i.e., the payoff of C in the exchange with D. Therefore, the value of the conflict payoff for B, in her exchange with A, is $24 - y_{CD}$. A similar reasoning holds for actor C. Setting the dependences within the A-B and C-D relations equal to each other, yields equations (1) and (2) in table 5. Solving for y_{AB} and y_{CD} yields $y_{AB} = 8$ and $y_{CD} = 16$, which implies $y_{BA} = 16$ and $y_{DC} = 8$. It now remains to check the B-C relationship. According to the computations above, both B and C can earn 16 in their best alternatives to each other. Thus, $y_{BC}^{con} = y_{CB}^{con} = 16$. This means that the sum of the conflict payoffs of actors B and C exceeds 24, the amount to be divided by B and C, if they were to exchange with each other. Cook and Yamagishi (1992) dub this a *latent relation*. They state that '(…) the maximum profit an actor can obtain in a latent relation is the profitoverlap minus the best alternative of his exchange partner' (p.252). Therefore, in our example we get $y_{BC} = y_{CB} = 24 - 16 = 8$. Now we are ready to determine the actors' dependence. We find $D_{BC} = D_{CB} = 8 - 16 = -8$. Thus we find that given the payoffs computed before, the mutual dependences of B and C are equal. Moreover, they are negative, indicating that both can earn larger profits in their best alternatives.

4.3.2 Exchange with externalities

Introducing externalities in exchange networks, means that an actor's payoff is not merely a function of the share of the resource pool she appropriates for herself, but also of the actions of some other actor(s), distant in the network. In power dependence theory externalities can influence both an actor's conflict payoff and/or her actual payoff. To illustrate how externalities are incorporated in power dependence theory we once again consider the example of the Line4 network of Figure 1c, with the negative externalities of -8 between A and C. Assume again that A exchanges with B and C exchanges with D. Actors A and C will now get a total payoff consisting of the share of the pool they appropriate in their exchanges with B and D, respectively, and the externality of minus 8. Thus, $x_A = y_{AB} - 8$ and $x_C = y_{CD} - 8$, where *y* indicates payoffs without externalities and *x* indicates payoffs with externalities.[9] For B and D we have $x_B = 24 - y_{AB}$ and $x_D = 24 - y_{CD}$. The expressions for the conflict payoffs, dependences and the equidependence principle for the A-B and C-D relations are given in Table 6.

The conflict payoff for A is set at -8; A has no alternative exchange partners and *we assume that if A fails to exchange with B, B will exchange with C*. In that case A will get a negative payoff of 8. A will also receive this negative externality when exchanging with B, since *we assume then C will exchange with D*. Note how the italicized text above amounts to making a 'worst case scenario' assumption with respect to the conflict payoff of A: whether or not A exchanges, we assume that in the rest of the network the worst possible scenario unfolds, regarding externalities. We will return to this point when summarizing the analysis of power dependence theory.

In the current example, the negative externality 'cancels out' in the dependence of A on B, as can be seen by comparing tables 5 and 6. In both tables A's dependence on B consists of the share of the resource pool A appropriates in exchange with B. This makes perfect sense: since A cannot avoid the negative externality, it shouldn't influence her negotiation behavior. The same is not true for C, however. C *can* avoid the negative externality by exchanging with B, thereby precluding an exchange of A. Therefore, we read from Table 6 that C's conflict payoff consists simply of $24 - y_{BA}$: the externality of -8 is not included. The conflict payoff of actor B with respect to actor A is also affected by the externality, in the following way. B has to offer C at least the payoff C earns in

Table 5: Dependences and equidependence for the A-B and C-D relations in the Line4 network without externalities (Figure 1b).

Relation	Conflict Payoff	Dependence	Equidependence
A-B	$y_{AB}^{con} = 0$	$D_{AB} = y_{AB} - 0$	
			$y_{AB} = y_{CD} - y_{AB}$ (1)
	$y_{BA}^{con} = 24 - y_{CD}$	$D_{BA} = (24 - y_{AB}) - (24 - y_{CD})$	
C-D	$y_{CD}^{con} = 24 - y_{BA} = 24 - (24 - y_{AB}) = y_{AB}$	$D_{CD} = y_{CD} - y_{AB}$	
			$y_{CD} - y_{AB} = 24 - y_{CD}$ (2)
	$y_{DC}^{con} = 0$	$D_{DC} = y_{DC} - 0 = 24 - y_{CD}$	

Table 6: Dependences and equidependence for the A-B and C-D relations in the Line4 network, with externalities of -8 between A and C (Figure 1c).

Relation	Conflict Payoff	Dependence	Equidependence
A-B	$x_{AB}^{con} = -8$	$D_{AB} = y_{AB}$	$y_{AB} = y_{CD} - y_{AB} - 8$ (3)
	$x_{BA}^{con} = 24 - x_{CD} = 24 - (y_{CD} - 8)$	$D_{BA} = (24 - y_{AB}) - (32 - y_{CD})$	
C-D	$x_{CD}^{con} = 24 - y_{BA} = 24 - (24 - y_{AB}) = y_{AB}$	$D_{CD} = y_{CD} - 8 - y_{AB}$	$y_{CD} - 8 - y_{AB} = 24 - y_{CD}$ (4)
	$x_{DC}^{con} = 0$	$D_{DC} = y_{DC} - 0 = 24 - y_{CD}$	

exchange with D, i.e., $x_C = y_{CD} - 8$. In this payoff the externality is included, which implies that B's conflict payoff in the relation with A becomes $24 - (y_{CD} - 8)$. Setting the mutual dependences in the A-B and C-D relations equal to each other yields equations (3) and (4), respectively. Solving for y_{AB} and y_{CD} yields $y_{AB} = 5\frac{1}{3}$ and $y_{CD} = 18\frac{2}{3}$, which implies $y_{BA} = 18\frac{2}{3}$ and $y_{DC} = 5\frac{1}{3}$. These are the shares of the resource pools the actors get in their exchanges, i.e., the payoffs *without* externalities. Adding the externalities we have $x_A = -2\frac{2}{3}$, $x_B = 18\frac{2}{3}$, $x_C = 10\frac{2}{3}$ and $x_D = 5\frac{1}{3}$. At these payoffs, the mutual dependences are equal in all relations and the B-C relation is again latent.

Comparing this outcome to the outcome for the Line4 network without externalities, shows how the externalities and the network interact to influence the actors' payoff throughout the network. We already observed how the negative externality doesn't influence the dependence of A upon B, since A cannot avoid the negative externality. However, since C can avoid the negative externality through exchange with B, C's dependence on B is enhanced. B's dependence on C is not affected, and thus B's negotiation position vis-à-vis C is strengthened. Moreover, since C is more dependent on B and is thus a more 'willing' alternative for B, B's dependence on A is lowered. This strengthens B's negotiation position vis-à-vis A. Thus, the negative externalities between A and C have given B a better negotiation position, which is reflected in the larger payoff B receives in exchange. The payoff of actor D is also affected. Since C experiences a negative externality of 8 when exchanging with D, but not when exchanging with B, the relative value of the C-D relationship for actor C is lowered, i.e., C's dependence on D becomes smaller. This is reflected in the lower payoff of actor D (and the larger share of the pool C appropriates in the C-D exchange).

So, externalities do not only affect the payoffs of the actors that are subject to its condition, but also the payoffs of other actors through connections in the network. The same conclusion can be drawn from the generalized core from the previous section. However, because we now have a point prediction, the effects of the network, of externalities per se, and of the interaction between the network and externalities can be theoretically decomposed by comparing the same network with and without externalities.

We can write an actor's payoff as the sum of three variables: $O_i = O_{iN} + O_{iE} + O_{iExN}$. The network effect ($O_{iN}$) is the prediction in the network without externalities. The externalities effect (O_{iE}) is the direct impact of the externalities on an actor's payoff, for instance the deduction of 8 in the previous example. The remainder of the payoff is interpreted as the interaction between network shape and externalities. We have made this decomposition of payoffs for the example above in Table 7. Thus we see that additional to the direct effect on the payoffs of A and C, externalities interact with the network to produce an additional change in the payoffs of $2\frac{2}{3}$. Since the externalities render C more eager to exchange with B, and make the relationship with D less valuable to C, this interaction effect is positive for the structurally advantaged positions B and C. For the structurally disadvantaged A and D, the interaction effect is negative.

Table 7: Decomposition of payoffs in Line4 network with externalities of -8 between A and C (Figure 1c), according to the equidependence principle

Actor	Decomposition $O_i = O_{iN} + O_{iE} + O_{iExN}$
A	$O_A = 8 - 8 - 2\frac{2}{3} = -2\frac{2}{3}$
B	$O_B = 16 + 0 + 2\frac{2}{3} = 18\frac{2}{3}$
C	$O_C = 16 - 8 + 2\frac{2}{3} = 10\frac{2}{3}$
D	$O_D = 8 + 0 - 2\frac{2}{3} = 5\frac{1}{3}$

As we discussed in the previous section, externalities can be variable. In the previous section we discussed the example of Figure 1d. These variable externalities pose no special challenge to the application of power dependence theory we just illustrated. Instead of including an externality of -8 in the payoff functions of A and C, the externalities for A and C now become y_C and y_A, respectively. Computing the point of equidependence for this situation yields $y_A = y_B = y_C = y_D = 12$, which implies $x_A = x_C = 24$ and $x_B = x_D = 12$. We decompose these payoffs in Table 8. In this table we see that the interaction effect has an absolute value of 4 for all actors. For the peripherals this effect is positive, for the central actors it is negative. Thus, we see that the interaction between externalities and network structure can benefit structurally disadvantaged actors, like A and D, and hurt structurally advantaged actors.

Table 8: Decomposition of payoffs in Line4 network with externalities of y_C and y_A, respectively, between A and C. (Figure 1d)

Actor	Decomposition $O_i = O_{iN} + O_{iE} + O_{iExN}$
A	$O_A = 8 + 12 + 4 = 24$
B	$O_B = 16 + 0 - 4 = 12$
C	$O_C = 16 + 12 - 4 = 24$
D	$O_D = 8 + 0 + 4 = 12$

The example of Figure 1e demonstrates how externalities are predicted by the generalized core to change the exchange pattern, i.e., the pattern of who exchange with whom. Assuming that A exchanges with B and C exchanges with D we determine the equidependence solution for this example. This yields $y_A = y_D = -8$ and $y_B = y_C = 32$, which implies $x_A = x_D = -32$ and $x_B = x_C = 8$. This result has two problems. Firstly, both A and D get less in total than their conflict payoffs (-24). Secondly, and related to the first point, the mutual dependences *within* the exchanging pairs are negative (-8), signaling that both players in each pair can get a larger payoff in their best alternative. For B and C, their best alternative is exchanging with each other, and for A and D it is not exchanging at all. Now assume an exchange between B and C. We then get $x_A = x_D = -24$ (by definition) and $y_B = y_C = x_B = x_C = 12$. This solution solves the problem of A and D getting less than their conflict payoffs. Moreover, the conflict payoffs for B and C are 0: if B wanted to exchange with A, B had to offer A a total payoff of at least -24. This implies that B would have to offer A at least a share of the pool of size 0, giving B a share of 24. With externalities subtracted this would yield a total payoff of -24 for A and 0 for B. The same holds for C and D. Thus, the second problem is also solved: the mutual dependences of B and C are positive (12). The equidependence principle therefore predicts an equal exchange between B and C, and thus a change in exchange pattern.

There is at least one theoretical issue still to be resolved, concerning the application of externalities to power dependence theory, as illustrated above. To determine the effect of externalities on the conflict payoffs and the actual payoffs of an actor, assumptions have to be made on what happens in the rest of the network. In the Line4 examples in this paper we assumed for instance that if A and B failed to reach agreement, B would exchange with C. The externality that C caused for A (either, -8, y_C, or -24, in our examples) was then taken as A's conflict payoff. However, power dependence theory as such offers no guidance in the determination of 'what happens in the rest of the network'.

It is an important question however, since the externality effects an actor experiences will generally differ, depending on what happens in distant parts of the network. A solution is to opt for the 'worst case scenario'. For instance, if an actor experiences positive externalities from another actor, but can't be sure this other actor exchanges, one chooses not to include the positive externalities in the first actor's payoffs. Note how the generalized core solution *does* itself offer an answer to this problem: an actor's characteristic value is the value an actor can maximally *guarantee* herself, i.e., the worst case scenario.

4.4 Exchange resistance theory

4.4.1 Exchange without externalities

Heckathorn (1978, 1980, 1983a) developed a theory of the bargaining process in bilateral bargaining situations, in which the concept of *resistance* was introduced. In this theory, an actor i's resistance R_{ij} to an outcome y_{ij} is defined as $R_{ij} = \dfrac{y_{ij}^{\max} - y_{ij}}{y_{ij}^{\max} - y_{ij}^{con}}$, in which $y_{ij}^{\max}$ is the maximum profit actor i can obtain in exchange with actor j. The theory claims that actors i and j agree at the point where their resistances are equal, i.e., where $R_{ij} = R_{ji}$. This point is called the point of *equiresistance*. The resistance concept was subsequently introduced to network exchange by Willer and Anderson (1981). Through time, many different variations of applications of the equiresistance principle to exchange networks have sprung up (see Willer 1999, for an overview). To make the discussion in the current section comparable to the one in the previous, we choose simply to replace the equidependence principle from that section with the equiresistance principle. That is, we determine the exchange-resistance solution for a network, by requiring that mutual resistances in all relations in the network be equal. More formally, we require that $R_{ij} = R_{ji}$, for each connected pair of players i and j. The same approach was taken by van Assen (2003).

To illustrate how this equiresistance principle operations in exchange networks without externalities, we once more consider the Line4 network of Figure 1b. Assume that A exchanges with B and C with D. The expressions for the conflict payoffs, maxima, resistances and the equiresistance principle for these relations are given in Table 9. The maxima for all the actors in the network are 24: the size of the pool to be divided.[10] The determination of the conflict payoffs is identical to Table 5 in the previous section. Computing the actors' resistances and setting them equal within the A-B and C-D relationships yields equations (5) and (6). Solving for y_{AB} and y_{CD} yields $y_{AB} = 9.17$

Table 9: Resistances and equiresistance for the A-B and C-D relations in the Line4 network without externalities (Figure 1b).

Relation	Conflict Payoff	Maximum	Resistance	Equiresistance
A-B	$y_{AB}^{con} = 0$	$y_{AB}^{\max} = 24$	$R_{AB} = \frac{24 - y_{AB}}{24}$	
				$\frac{24 - y_{AB}}{24} = \frac{y_A}{y_C}$ (5)
	$y_{BA}^{con} = 24 - y_{CD}$	$y_{BA}^{\max} = 24$	$R_{BA} = \frac{24 - (24 - y_{AB})}{24 - (24 - y_{CD})} = \frac{y_{AB}}{y_{CD}}$	
C-D	$y_{CD}^{con} = 24 - y_{BA} = y_{AB}$	$y_{CD}^{\max} = 24$	$R_{CD} = \frac{24 - y_{CD}}{24 - y_{AB}}$	
				$\frac{24 - y_{CD}}{24 - y_{AB}} = \frac{y_{CD}}{24}$ (6)
	$y_{DC}^{con} = 0$	$y_{DC}^{\max} = 24$	$R_{DC} = \frac{24 - (24 - y_{CD})}{24} = \frac{y_{CD}}{24}$	

and $y_{CD} = 14.83$, respectively.[11] This implies $y_{BA} = 14.83$ and $y_{DC} = 9.17$. It remains to check the B-C relationship. According to the computations above, both B and C can earn 14.83 in their best alternatives to each other. Thus, $y_{BC}^{con} = y_{CB}^{con} = 14.83$. This means that the sum of the conflict payoffs of actors B and C exceeds 24, the amount to be divided by B and C, if they were to exchange with each other. Similar to the previous section, and again following Cook and Yamagishi (1992), we dub this a *latent relation*. As in the previous section we assert that in a latent relation the payoff of an actor is the size of the resource pool minus the partner's best alterative, which yields $y_{BC} = y_{CB} = 24 - 14.83 = 9.17$. Moreover, we take the same approach with respect to the maximum payoffs, i.e., the maximum payoff of an actor in a latent relation is the size of the resource pool minus the conflict payoff of the partner in the latent relation. This amounts to simply setting an actor's maximum payoff in a latent relation equal to her payoff in that relation, thereby setting the resistance in a latent relation equal to 0, by definition. Thus, with the payoffs calculated above, we have equal mutual resistances throughout the network. Comparing with the previous section, we see that the equiresistance principle allocates the peripherals A and D a larger payoff than does the equidependence principle.

4.4.2 Externalities in exchange networks

Compared to the equidependence principle, the equiresistance principle has one additional parameter: the maximum payoff. We adapt the maximum payoff to the situation of externalities by defining it as the size of the resource pool plus the externalities, *given the exchange pattern under consideration*. Note how the size of the resource pool is fixed, but how externalities might be variable, possibly rendering the maximum payoff variable.

To illustrate how externalities are incorporated in exchange resistance theory we reconsider the example of Figure 1c, with the negative externalities of 8 between A and C. Assume again that A exchanges with B and C exchanges with D. We then get the same payoffs for A and C as in the previous section, i.e., $x_A = y_{AB} - 8$ and $x_C = y_{CD} - 8$. Moreover, the maxima for these actors are $y_{AB}^{\max} = y_{CD}^{\max} = 24 - 8 = 16$: the size of the resource pool plus the externalities, given the exchange pattern. For B and D we have $x_B = 24 - y_{AB}$, $x_D = 24 - y_{CD}$ and $y_{BA}^{\max} = y_{DC}^{\max} = 24$. The expressions for the conflict payoffs, maxima, resistances and the equiresistance principle for these relations are given in Table 10. The computations of the conflict payoffs are identical to the ones in the previous section.

Table 10: Resistances and equiresistance for the A-B and C-D relations in the Line4 network, with externalities of -8 between A and C (Figure 1c).

Relation	Conflict Payoff	Maximum	Resistance	Equiresistance
A-B	$x_{AB}^{con} = -8$	$x_{AB}^{\max} = 16$	$R_{AB} = \frac{16-(y_{AB}-8)}{16-(-8)} = \frac{24-y_{AB}}{24}$	
				$\frac{24-y_{AB}}{24} = \frac{y_{AB}}{y_{CD}-8}$ (7)
	$x_{BA}^{con} = 24 - x_{CD} = 32 - y_{CD}$	$x_{BA}^{\max} = 24$	$R_{BA} = \frac{24-(24-y_{AB})}{24-(32-y_{CD})} = \frac{y_{AB}}{y_{CD}-8}$	
C-D	$x_{CD}^{con} = 24 - x_{BA} = y_{AB}$	$x_{CD}^{\max} = 16$	$R_{CD} = \frac{16-(y_{CD}-8)}{16-y_{AB}} = \frac{24-y_{CD}}{16-y_{AB}}$	
				$\frac{24-y_{CD}}{16-y_{AB}} = \frac{y_{CD}}{24}$ (8)
	$x_{DC}^{con} = 0$	$x_{DC}^{\max} = 24$	$R_{DC} = \frac{24-(24-y_{CD})}{24} = \frac{y_{CD}}{24}$	

Note how the resistance of actor A is not affected: the externality cannot be avoided, i.e., it results in a subtraction of 8 from all parameters in the resistance equation. Like in the previous section, the conflict payoff of actor C is not affected by the externality, since C can avoid it by exchanging with B. However, since C's maximum payoff and payoff in the exchange with D are changing, C's resistance is modified. The resistance of B is changed via the conflict payoff, just like in the previous section on the equidependence principle. The resistance of D is unaffected by the externality. Computing the actors' resistances and setting them equal within the A-B and C-D relationships yields equations (7) and (8). Solving for y_{AB} and y_{CD} yields $y_{AB} = 6.70$ and $y_{CD} = 17.30$, which implies $y_{BA} = 17.30$ and $y_{DC} = 6.70$. With externalities we get: $x_A = -1.3$, $x_B = 17.3$, $x_C = 9.3$ and $x_D = 6.7$. The B-C relation is again latent, since the sum of their total payoffs exceeds 24.

Table 11: Decomposition of payoffs in Line4 network with externalities of -8 between A and C, according to the equiresistance principle (Figure 1c)

Actor	Decomposition $O_i = O_{iN} + O_{iE} + O_{iExN}$
A	$O_A = 9.17 - 8 - 2.47 = -1.3$
B	$O_B = 14.83 + 0 + 2.47 = 17.3$
C	$O_C = 14.83 - 8 + 2.47 = 9.3$
D	$O_D = 9.17 + 0 - 2.47 = 6.7$

Given the predictions of the equiresistance principle for the Line4 network with and without externalities, we can again decompose the actors' payoffs, by writing them as the sum of the network effect, the externalities effect and the interaction between network and externalities. This is done in Table 11. Comparison of tables 7 and 11 shows that the equidependence and equiresistance principles differ with respect to their predictions, in both the network *with* and *without* externalities. Moreover, the tables show that the predictions are qualitatively the same, in the sense that they predict a negative interaction effect for the peripheral A and D, and a positive interaction effect of the same magnitude, for the central B and C.

Variable externalities pose no special challenge to the application of the equiresistance principle we just illustrated. Computing the point of equiresistance for the example of Figure 1d yields $y_A = y_B = y_C = y_D = 12$, which implies $x_A = x_C = 24$ and $x_B = x_D = 12$, which is identical to the prediction of power dependence theory.

Like power dependence theory, exchange resistance theory also predicts changes in the exchange pattern in the example of Figure 1e. Assuming an exchange between B and C , both get a payoff of 12, whereas A and D get a payoff of -24. This is again the same prediction as the one made by the equidependence principle.

Thus, we see that the equiresistance principle can be equally well adapted to the case of externalities, as the equidependence principle. The unresolved issue of what happens in the rest of the network also exists when considering the equidependence principle. Like power dependence theory, exchange resistance theory offers no guidance in this matter. Choosing the worst case scenario is again a possible solution.

4.5 Discussion

Caused by the fact that actors share resources, exchanges with externalities are abundant in real life and occur in a wide variety of contexts, such as households, resource dilemmas and collective decision making problems. This paper offers the first theoretical study of externalities in exchange networks. The combined study of exchange networks and externalities, offers the opportunity of investigating interactions between externalities and the social structure in which they occur.

The analyses from this paper allow three main conclusions about the theoretically expected effects of externalities in exchange networks. Externalities i) change actors' payoffs, ii) change the exchange pattern (who exchanges with whom) and iii) change the relative power distribution across actors, with respect to exchange networks without externalities. Furthermore, we have shown that three prominent theories from the field can be fruitfully adapted to the problem of externalities, and yield predictions concerning the occurrence and magnitude of these effects. These theories have been adapted in such a way, that their predictions for networks without externalities are unaltered, extending the empirical content of these theories.

In addition, some general properties of these theories were investigated.

For core theory, the general proposition was established that the core of a network without externalities, is a subset of the generalized core of the same network with positive externalities. With respect to power dependence and exchange resistance theory, it was shown that their point predictions enables one to theoretically separate the pure effect of the externalities, from the effect of the interaction between network and externalities.

The insights gained in this paper have real-world implications. Consider for instance collective decision-making situations. The current paper shows that the effects of a process of logrolling on the well-being of third parties, depends critically on the interaction between the shape of the policy network and the externalities. Actors that possess a seemingly powerful position in the network, might experience a marked decrease in their well-being, because of the interaction between network and externalities. Alternatively, the interaction between network shape and externalities might increase their power. Thus, it is insufficient to know only the shape of the police network and the feasible exchanges in it. The current paper argues that externalities play a significant role in determining the eventual outcome, and might even lead to the neglect of exchange relations, that would have been used had no externalities existed.

In the examples discussed in the current paper, the equidependence and equiresistance principles made qualitatively identical predictions, regarding the effects of externalities. Future research should be aimed at finding networks and externality situations, for which these theories make quantitatively and possibly qualitatively different predictions, concerning the effects of externalities.

One might pose that core theory has two problems: i) the (generalized) core doesn't necessarily exist, and ii) when it does exist, the solution is not necessarily unique. However, we argue that instead of problems, these are mere characteristics of the (generalized) core solution. The (generalized) core embodies a list of rationality requirements that the solution vector (if any) should meet. If such a vector doesn't exist, but if nonetheless these rationality requirements are thought of as a good model of what is going on in (network) exchange, the outcomes in empirical networks that have no core should be unstable. Bonacich and Bienenstock (1995) indeed find that coreless networks without externalities are unstable. Moreover, it is scientifically unsound to a priori demand that a theory always yield a unique prediction, in terms of an exact exchange ratio. Such a requirement presupposes that an equilibrium of some kind always exists. This is a statement however, that should follow from theory, not precede it.

Similarly, the predictions of the equidependence and equiresistance principles: i) do not always exist, and ii) when they do they are not necessarily unique. Moreover, when using the equidependence and equiresistance principles, one has to make assumptions regarding 'what happens in the rest of the network', to determine the externalities an actor experiences. Neither theoretical principle itself offers a solution to this problem, and it thus remains an unresolved issue. It is of course possible to compute *several* solutions, under different assumptions on what happens in the rest of the network, and compare these solutions to outcomes in (experimental) data.

Notes

1. One could of course take another conception of exchange networks, in which coalitions larger than dyads *are* possible. See Simpson and Macy (2001) for an investigation in this direction.
2. As an empirical illustration of this kind of externality, think for instance of A and C as two political parties, that have identical points of view regarding two issues, but have opposite priorities concerning them. The negative externality is then caused by the fact that if A reaches a compromise with party B, A gives up her position on the issue that is most important to C. Thus, C thereby loses an ally (A) on an important issue, decreasing the probability of a positive result on this issue for party C. Mutatis mutandis, the same holds for A, with the exception that C can not only negotiate with B, but also with party D. There are several possible reasons why an exchange between A and D might by unfeasible. A and D might have nothing of value to offer to each other, or there might be ideological barriers between them, prohibiting exchange.
3. Note how this amounts to stretching the definition of coalition formation in exchange networks. Before, it meant reaching agreement to exchange, now it also includes the agreement to abstain from exchange.
4. The core of the game of Table 2 actually contains only 1 payoff vector, namely $(y) = (8,16,16,8)$, which implies $(x) = (0,16,8,8)$. If the externality becomes larger negative than -8, the core is empty.
5. As an empirical illustration of this kind of externality, again think of A and C as two political parties that have identical points of view regarding two issues. Moreover, assume they have identical priorities concerning them. The positive, variable externality is then caused by the fact that if A reaches a compromise with party B, C experiences the same increase in utility. Mutatis mutandis, the same holds for A, with the exception that C can not only negotiate with B, but also with party D. Thus, since A and C hold the same positions on the issues, and since the issues have the same relative weight to them, an ally for the one, is an ally for the other.
6. Cook and Yamagishi (1992) introduce an algorithm to compute the point of equidependence throughout the network. We will not use that algorithm here, but use the method of solving systems of simultaneous equations instead. When there is more than one solution, the algorithm of Cook and Yamagishi gives the 12-12 resource split as the solution. When using simultaneous equations, all solutions are found.
7. Note how this requirement *doesn't* imply that the dependences of all actors in the entire network are equal.
8. Note how this amounts to assuming Pareto efficiency.

9. Note how we drop the second subscript of x_{ij}, because the payoff of actor i is now a function of more than her gains in her exchange relationship with j.
10. Alternatively, one could interpreted an actor's maximum payoff as the size of the resource pool minus the conflict payoff of the actor's partner. Van Assen (2003) has shown that with this interpretation, the equiresistance principle reduces to the equidependence principle.
11. There exists a second solution, namely $y_{AB} = 62.83$ and $y_{CD} = -38.84$. However, we dismiss this solution, since actor A gets more than her maximum payoff and actor C gets less than her conflict payoff.

Appendix: Proof of proposition 2

Proposition 2: The (generalized) core without externalities is a subset of the generalized core with positive externalities.

Proof. We proof this proposition by showing that introducing positive externalities in a network doesn't change the characteristic value of individual actors and dyads.

Let *i* and *j* be two actors in a network, and let *i* experience positive externalities from an exchange of *j*. The characteristic value function *v* assigns a total payoff v(S) to every subset $S \subset N$ of players, that they can realize among themselves, *despite* the actions of $N \setminus S$, i.e., the players not in S .Since i experiences the externality only 'with the help of j', $v(\{i\})$ doesn't change. Let *i* be capable of exchanging with another actor *k*. Since *i* experiences the externality only when *j* exchanges, and since $j \notin \{i,k\}$, $v(\{i,k\})$ doesn't change. It remains to show that $v(\{i,j\})$ doesn't change. Assume *i* and *j* are unconnected. Then $v(\{i,j\})$ remains 0. Now assume *i* and *j* are connected. Actor *i* cannot experience an externality from actor *j* that springs from an exchange between *i* and *j*, since externalities by definition are direct consequences of an exchange experienced by actors not involved in the exchange. Therefore, externalities for *i* can only be caused by an exchange of *j* with an actor other than *i*, which implies $v(\{i,j\})$ doesn't change. Note that only coalitions need to be considered having 1 or 2 actors.

Now assume (y) is a payoff vector *without* externalities, i.e., (y) reflects how actors in the network split the characteristic values of their (two-person) coalitions. Let (x) be the payoff vector *with* positive externalities, that results from (y). Since the characteristic values of individual actors and dyads don't change because of positive externalities, and $(x) \geq (y)$, any payoff vector (y) that is in the core without externalities is in the generalized core with positive externalities. This completes the proof.

5

The comparison of four types of everyday interdependencies: externalities in exchange networks*

* This chapter is co-authored with Marcel van Assen and is forthcoming in *Rationality and Society*. We would like to thank Frans Stokman for his helpful suggestions.

Abstract

Actor behavior is compared theoretically and experimentally in four well-known everyday interdependence situations; (i) the market, (ii) the tragedy of the commons or resource dilemma, (iii) the public good problem, and (iv) the household. It is shown that the four situations can be studied within one general framework of exchange networks with externalities. Core theory is generalized to exchange with externalities and applied to derive predictions concerning differences in behavior in the four situations. The experiments corroborate the prediction that competition is most fierce in the resource dilemma, fierce in the market, and absent in the public good problem and household.

5.1 Introduction

The focus of the present study is the theoretical and experimental comparison of actor behavior in four well-known everyday interdependence situations: (i) the market, (ii) the tragedy of the commons, also known as the resource dilemma, (iii) the public good problem, and (iv) the household. We model actor behavior in these situations as an exchange of resources, and study these four interdependence situations in the framework of a simple exchange network with externalities.

Exchange is typically thought of as the process through which individuals transmit and receive commodities. The significance of exchange is not limited to economic contexts (e.g., Blau 1964; Homans 1958; Lawler and Ford 1995; Molm 1997). Social interaction in general can also be perceived as exchange since "(…) much of what we need and value in life (e.g., goods, services, companionship, approval, status, information) can only be obtained from others. People depend on one another for such valued resources, and they provide them to one another through the process of exchange" (Molm 1997: 12).

An important branch of exchange research is devoted to investigation of specific exchange situations, called *exchange networks*. The issue on which this research mainly concentrates, is the effect of networks on the choice of exchange partners and the ratios of exchange (for example, see the special issue on network exchange in *Social Networks*, volume 14, and Willer 1999). In this line of research, an actor's connections in a network represent with whom the actor can exchange. If there is a connection between two actors in the network, these actors have the *possibility* to exchange, but no *obligation* to do so. If there is no link between two actors, an exchange between them is not possible. The central question is then whether and how an actor's profit or utility from exchange is influenced by that actor's position in the network.

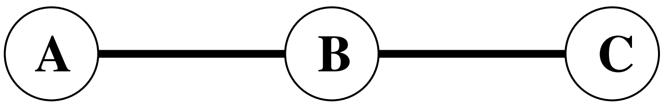

Figure 1: The Line3 network

Figure 1 contains the *Line3 exchange network*. The links in this network indicate that actors A and C can each exchange with actor B, but not with each other, whereas B can exchange with both A and C. In this paper we model the four interdependence situations mentioned earlier by introducing *externalities* in exchange networks, using the 1-exchange rule. This rule implies that B can exchange with either A or C, but not both.

Externalities of exchange are defined as *direct* (positive or negative) consequences of exchanges, for the well-being of actors who are not involved in the exchange. Externalities in the network of Figure 1 would exist if after an exchange of two actors the profit of the third actor would be affected as well. For example, if A and B exchanged with each other and C experienced an increase in profit or utility as a direct consequence of this exchange, then C would have experienced a (positive) externality of the exchange between A and B. It is important to note that the fact that C is possibly *excluded* from exchange when A and B exchange with each other, is *not* interpreted as an externality. The same holds for a possible process of *competition* between A and C for access to B. Exclusion and competition are merely two forms of interdependence that can be present in an exchange network, regardless of whether externalities exist or not.[1]

Although exchange networks have been studied extensively, the effect of externalities on exchange in networks has been neglected in both theoretical and empirical research. The sole exception is research on collective decision making (Stokman, et al.; van Assen, Stokman, and van Oosten 2003). This research focuses on the fact that a bilateral exchange of two voting positions changes the expected outcome of the vote, which directly affects other political parties that are not involved in the exchange. Many real-life exchanges, other than those found in collective decision making, also have externalities for parties not involved in the exchange (examples are given below). There is no reason to suppose that exchanges with externalities are less common then exchanges without. The neglect of studying effects of externalities on exchange in networks is therefore quite remarkable.

An important cause of externalities of exchange lies in the fact that in certain social situations actors share the possession of certain resources. Exchanges of one of the actors that affect the stock of shared resources then affect all actors that share these resources. To consider the general case, assume a group of actors, of which a member engages in a bilateral exchange of resources with an actor outside the group. Then externalities of exchange can create the four interdependence situations studied in this paper by systematically varying the resources group members share (see Table 1).

Table 1: A typology of four interdependence situations based on whether resources transferred and received by actors in a group are shared or not

		Sharing transferred resources	
		No	Yes
Sharing received resources	No	Market	Resource Dilemma
	Yes	Public Good	Household

If actors in the group neither share the resources they transfer nor the resources they receive (upper left cell Table 1), then the situation can be characterized as a *market*. Consider, for instance, customers buying their groceries in a supermarket; customers (group members) buying their own groceries with their own money from the supermarket (an actor from outside the group). If group members share only the resources they transfer (upper right cell), the situation can be characterized as a *resource dilemma* or *tragedy of the commons problem*. For example, fishermen (group members) sharing access to fishing waters but not the revenues of selling the fish to others outside the group. The basic characteristic of *public good problems* is that actors share the resources they receive but not the ones they transfer (lower left cell). For example, a person (group member) buying beer for herself and her friends (fellow group members) in a bar. Finally, in many exchanges of members of a household both resources transferred and received are shared (lower right cell). For example, the wife (group member) buys a sofa in a store (actor from outside the group) from the common family budget. Note that both sofa and budget are owned by all family members. Therefore, this fourth interdependence situation is called the *household*.

It is important to remark that these four interdependence situations are defined by the resources actors share, being the fundamental characteristic distinguishing them. In some social dilemma research, resource dilemmas and public good problems are presented as equivalent with respect to payoff possibilities, and only different with respect to the framing of the experimental task. For instance, resource dilemmas and public good games are sometimes referred to as 'take some' (taking from a common resource) and 'give some' (contributing to a public good) games, respectively (e.g., Dawes 1980; Poppe and Zwikker 1996; Rutte, Wilke and Messick 1987; Van Dijk and Wilke 2000). As will be shown later, the interdependence situations in this paper are not equivalent with respect to payoffs, i.e., are not merely reframings of one and the same situation.

Note how sharing resources in the interdependence situations causes externalities. Transmitting or receiving a shared resource directly affects the utility of all actors in the group, regardless of which group member is involved in the exchange. For example, consider the resource dilemma. A transfer of resources (catching and selling fish) of one fisherman brings about a loss to all fishermen (by increasing their marginal costs of catching fish, since additional fish is harder to catch, and 'overfishing' decreases the rate of reproduction of fish) since these resources are shared by all fishermen. However, since the received resources (the revenue of selling the fish) are not shared, only the fisherman making the exchange profits.

We make three comments about our classification. Firstly, note that we consider interdependence situations in which the behavior of group members is affected by actors from outside the group. In classic examples of some of these situations, e.g., the 'tragedy of the commons' of Hardin (1968), actors from outside the group are not present. In Hardin's example a group of herdsmen each tries to keep as many cattle as possible on the common pasture. However, since our focus is on an exchange between a group member and an actor outside the group, the resource dilemma we studied *is* affected by behavior of actors outside the group that have an interest in the situation. Secondly, as was observed previously, the interaction can be understood as the actual transfer of physical goods but also as the performance of a behavior that produces value for another. Thirdly, note that the classification is exhaustive; all four possibilities of resource sharing are covered.

The focus of the present study is the theoretical and experimental comparison of the interaction between group members and actors from outside the group in the four interdependence situations: market, resource dilemma, public good problem, and household. The interaction is a bilateral transfer of resources, that is, it is conceived of as the exchange of resources. Sharing resources between members of a group induces externalities of exchange. Our research problem thus concerns the effect of externalities or type of interdependence on the ratio of resources exchanged.

The next section describes how the four interdependence situations are modeled by the Line3 exchange network with the 1-exchange rule, as used in the experiments. The four experimental conditions only differ with respect to the resources shared, as explained above. In the theory section we formulate our theory and hypotheses. The theory is an adaptation of the core solution, a well-known theory in research on exchange networks (e.g., Bienenstock and Bonacich 1992). The hypotheses concern predictions of differences of exchange ratios in the four interdependence situations. The subsequent section describes the experiments, followed by the results section. A discussion concludes the paper.

5.2 Sharing resources and externalities in the line3 exchange network

In by far the largest portion of the literature in the field of exchange network research, exchange possibilities are represented as the opportunity to divide a pool of valuable resources or ‘profit points’ (see for instance, Bienenstock and Bonacich, 1995, 1992; Bonacich, 1998, 1995; Cook and Yamagishi, 1992; Cook et al., 1983; Cook and Emerson, 1978; Heckathorn, 1983a; Karr, 2000; Lovaglia, et al., 1995; Markovsky et al., 1993; Skvoretz and Burkett, 1994; Skvoretz and Willer, 1993; Thye, Lovaglia, and Markovsky 1997; Willer and Skvoretz, 1997). In the present paper we must deviate from this practice, however, since we investigate the exchange of possibly shared resources. Therefore, instead of giving subjects the opportunity to divide a fixed number of points, we endow them with units of valuable resources that they can subsequently use in exchange.

Table 2: Actors, goods, endowments (E) and utilities (U) in the Line3 structure

Actors	**A**		**B**		**C**	
Goods	X	Y	X	Y	X	Y
E	1	0	0	48	1	0
U	24	1	48	1	24	1

The endowments used in our experiment are presented in Table 2. The first row of Table 2 indicates the three actors of the Line3 network. The second row shows there are two goods, X and Y, in the network. The third row depicts each actor's initial possession or endowment (E) of these goods. Thus, actors A and C each possess 1 unit of X and no units of Y. Actor B holds no units of X and 48 units of Y. The final row of Table 2 indicates the value or utility (U) of 1 unit of each of the goods for the actors. Thus, for actors A and C a unit of X is 24 times more valuable than a unit of Y. For actor B, a unit of X is 48 times more valuable than a unit of Y.

The endowments and utilities of Table 2 make profitable exchanges feasible between A and B, and between B and C. In return for transferring her 1 unit of X to B, actor A wants to receive at least 24 units of Y, whereas actor B is willing to transmit at most 48 units of Y. The same holds for actor C. Thus, in both exchange relations profitable exchanges are feasible in which A (C) transmits her unit of X to B and receives a number of units of Y between 24 and 48 in return. For example, assume A (C) gets 30 units of Y in return for her unit of X. The profit of actor A (C) is then 30 – 24 = 6, whereas B earns 48 – 30 = 18. Note how the sum of the profits of the two exchange partners in each exchange relation is 24. In Table 2, this is true for all possible exchange ratios. Also note that we only consider profits earned in exchange, i.e., we do not consider the value of the initial endowment. In the experiment reported below, this was also the case; subjects were only paid for points gained in exchange, not for the value of their initial endowment. An important feature of the endowments and utilities in Table 2 is that any exchange between A (C) and B is Pareto efficient: given any exchange ratio there is no alternative exchange ratio that yields more utility for one of the exchange partners, without decreasing the utility of the other. This is true because A and C each have only 1 unit of X and thus must transfer their entire endowment of X in any exchange.

An additional implication of the utilities depicted in Table 2 is that A and C cannot profitably exchange with each other. Thus, the network structure of Figure 1 is endogenously determined by the utilities of Table 2. An important restriction that we impose on the Line3 network, both theoretically and experimentally, is that actors are assumed to be able to complete only 1 exchange (this is commonly called the 1-exchange rule, e.g., Willer 1999). This implies that either A or C exchanges with B, but not both.

The Line3 presented in Table 2 is employed in the experiments to characterize the four interdependence situations as follows: A and C share (i) no resources in the market, (ii) only resource X in the resource dilemma, (iii) only resource Y in the public good problem, and (iv) both resources in the household. Hence A and C constitute the group, B is the actor for outside the group, X is the resource transferred, and Y is the resource received by the group members. If A and C share X, they receive payoffs from all units of X owned by both of them.

We now show how the resource dilemma and public good problem originate from situations in which only one good is shared. Consider first the resource dilemma. An exchange of A (C) with B means C (A) incurs a loss since he loses X without receiving Y. Therefore, both A and C have an incentive to outbid the other player by demanding fewer and fewer units of Y. In fact, it is rational for A and C to accept a loss (up to the size of the externality) in their exchange with B, to prevent receiving the externality. However, in doing this, A and C create a situation that is Pareto inefficient: both players incur a loss, one through the exchange with B and the other through the externality. This situation could have been prevented had A and C decided not to exchange with B. However, given that A (C) doesn't exchange with B, C (A) has an incentive to complete an exchange with B. Both players have a 'dominant strategy' (always underbid the other player), but in following this strategy end up in a collectively inefficient situation (both A and C incur a loss). This is the defining characteristic of the resource dilemma.

Now consider the situation in which only the good received is shared. Both A and C have an incentive to let the other player exchange with B and incur the cost of exchange, whereas they themselves profit more from the exchange. This interdependence situation deviates from the public good game most often studied in the literature, in the sense that not exchanging with B is not a 'dominant strategy': if A (C) doesn't exchange with B, C (A) should, to gain at least some points. It thus resembles a chicken game. However, the fundamental characteristic of the public good game is that it '(…) deals with situations in which goods and services (…) are to be realized through individual contributions, whereas consumption is not dependent on the individual contributions' (Van Dijk and Wilke 2000: 92), which is the case in our current public good game.

5.3 Theory and hypotheses

Many theories of exchange in networks have been developed in the last decades (e.g., for instance Bienenstock and Bonacich 1992; Braun and Gautschi 2006; Burke 1997; Cook and Emerson 1978; Cook and Yamagishi 1992; Friedkin 1992, 1995; Skvoretz and Fararo 1992; Willer 1999; Yamaguchi 1996). However, all these theories assume that exchange is without externalities. Generalizing these theories to network exchange *with externalities* is by no means straightforward. Dijkstra (2005) generalized one of these theories, core theory, to deal with externalities in exchange networks. Core theory is a solution from cooperative game theory originally introduced to the field of exchange networks by Bienenstock and Bonacich (1992). The power of the theory is that it is simple, that is, based upon a minimum number of assumptions. We will discuss both the core solution and the generalized core solution in the light of the four interdependence situations described in the previous section. Our hypotheses are derived from the generalized core theory.

5.3.1 Original core theory and generalized core theory

Original core theory requires that each possible coalition of players (including 1-player ‘coalitions’) get no lower payoff than the members of that coalition can guarantee by cooperating amongst themselves. More formally, let N be the set of players in the game. The characteristic value function v assigns a total payoff $v(S)$ to every subset $S \subset N$ of players, that they can realize among themselves, *despite* the actions of $N \setminus S$, i.e., the players not in S. Thus, $v(S)$ represents the total payoff that a coalition S can be sure to achieve. Using the characteristic value function one can define the core solution. Let **x** be a payoff vector, such that x_i represents the payoff for player i. A payoff vector **x** is in the core if it meets the following three rationality requirements:

i) $x_i \geq v(\{i\})$ *for every* $i \in N$ (individual rationality),

ii) $\sum_{i \in S} x_i \geq v(S)$ *for every* $S \subset N$ (coalition rationality), and

iii) $\sum_{i \in N} x_i = v(N)$ (group rationality).

With respect to exchange networks coalition formation is interpreted as ‘agreeing to exchange’. For instance, in the Line3 market, the only interdependence situation in this paper without externalities, A and B can guarantee a total payoff of 24 by exchanging with each another; $v(AB)$ = 24. Thus, a payoff vector can only be in the core if the sum of the payoffs of A and B is at least 24. In the same vein, $v(BC)$ = 24. To find the core however, *all* logically possible coalitions must be considered. Therefore, also the 3-player coalition between A, B and C must be taken into account. In the Line3 market this coalition can guarantee itself a total of 24 points (*v(ABC)* = 24), by letting B exchange with either A or C. However, in an exchange network such as we are investigating here, coalitions of more than 2 players have no meaning: coalition formation is intended to mean 'agreeing to exchange' and only connected dyads can exchange. Regarding exchange networks without externalities, however, Bonacich and Bienenstock (1995) have shown that if no connected dyad receives less than it can guarantee by itself, this is also true for all other coalitions. Thus, in exchange networks without externalities, coalitions other than connected dyads can safely be disregarded when finding the core because these coalitions do not affect the core. Therefore, the original core solution makes theoretically sensible predictions in exchange networks without externalities.

In the Line3 market the only payoff vector in which the sum of payoffs of both the pair A-B, and the pair B-C is 24, gives 0 to A and C and 24 to B. In terms of the inequalities of core theory, (i) $x_A, x_B, x_C \geq 0$, (ii) $x_A + x_B \geq 24$ and $x_B + x_C \geq 24$, and (iii) $x_A + x_B + x_C \geq 24$ are only met if $x_A = x_C = 0$ and $x_B = 24$. Thus, in the Line3 market the core predicts that B exchanges with either A or C and gives 24 units of Y in return for 1 unit of X.

Unfortunately, in exchange networks with externalities coalitions other than dyads *cannot* be disregarded when trying to find the original core solution. Consider the Line3 household. The coalition between A and B can guarantee itself 24, that is, again *v(AB)* = 24. The fact that this yields a positive externality for C is not included in the value of the coalition between A and B: the core solution, only considers what each coalition can guarantee its own members. Also *v(BC)* = 24. However, the all-player coalition can guarantee itself a maximum total payoff of 48 (*v(ABC)* = 48). This total payoff is achieved if B exchanges with either A or C and transfers 48 units of Y in return for the 1 unit of X. The payoffs of both A and C are then 24, and the payoff of B is 0. Thus, the original core solution in the Line3 household is the opposite of the core solution in the Line3 market: all the surplus of exchange goes to A and C.

Including externalities in exchange networks means the scope of core theory has to be extended. Given this extended scope the proposition of Bonacich and Bienenstock, that any payoff vector that gives each dyad at least what its members can guarantee themselves, is in the core, no longer holds. For instance, consider an exchange between A and B in the household, where B transfers 36 units of Y to A, in return for the 1 unit of X. In this case all the actors get a payoff of 12, which means that the sum of the payoffs in the pair A-B as well as in the pair B-C is 24. However, the sum of all payoffs is 36, which is 12 short of what the all-player coalition can guarantee.

To summarize our reasoning; as opposed to the case of exchange without externalities, coalitions that cannot form (for instance, the all-player coalition) affect the original core solution in the case of exchange with externalities. Hence, the original core cannot be meaningfully applied to exchange with externalities, but can be applied meaningfully when externalities are not present.

Core theory can be generalized to deal with externalities simply by dropping any requirements that pertain to coalitions larger than dyads or coalitions of unconnected players. That is, coalition rationality is limited to connected dyads and group rationality is dropped. One additional assumption is required. This assumption is that if actors in a pair exchange, they exchange in a Pareto efficient manner, i.e., they cannot make an exchange together that yields larger payoffs to both of them. Dijkstra (2005) explains why this additional assumption is needed.[2] Note that the endowments in the Line3 network presented in Table 2 are chosen such that exchanges are necessarily Pareto efficient. Hence, the assumption concerning Pareto efficiency is not relevant in the present study since it always holds in the experiment. The three assumptions of generalized core theory can be described formally as:

i) $x_i \geq v(\{i\})$ *for every* $i \in N$ (individual rationality),

ii) $\sum_{i \in S} x_i \geq v(\{i, j\})$ *for every connected* $i, j \in N$ (rationality of connected dyads),

iii) $\sum_{i \in S} y_i \geq w(\{i, j\})$ *for every exchanging* $i, j \in N$ (Pareto-efficiency of exchanging dyads).

In i) through iii) above, **x** denotes the payoff vector with externalities, **y** is the payoff vector without externalities, and $w(\{i, j\})$ is the characteristic value of pair $\{i, j\}$, disregarding externalities.

The generalized core requires that no individual actor or pair of connected actors get less than they can guarantee by themselves. Intuitively, a payoff vector is in the generalized core when no connected dyad can successfully object to it, in the sense that through exchange the objecting actors can improve their payoffs. It is very important to note that in networks without externalities, the generalized core reduces to the original core. Therefore, generalized core theory is a true generalization of core theory to exchange situations that possibly include externalities.

Applying generalized core theory to the Line3 household we find that any exchange between B and either A or C (in which both exchange partners receive at least 0) is in the generalized core. This is true because when one of the actors A and C exchanges, the other receives the same payoff. The sum of payoffs of B and the exchanging actor is 24 by definition. Then, the sum of the payoffs of B and the actor that doesn't exchange is also 24 by definition. In terms of the inequalities of the generalized core, (i) $x_A, x_B, x_C \geq 0$ and (ii) $x_A + x_B \geq 24$ and $x_B + x_C \geq 24$ are met for any exchange, as long as no actor loses. Assume A exchanges with B. Then $x_A + x_B = y_A + y_B = 24$, i.e., (iii) is met by definition. Since $x_A = x_C$, we get $x_B + x_C = 24$. Mutatis mutandis the same holds when B and C exchange.

5.3.2 Predictions and hypotheses concerning the exchange ratios

The application of generalized core theory yields extreme point predictions in some interdependence situations. In these extreme predictions A and C are predicted to transfer all or half of their resources to B. However, these extreme predictions only occur after many rounds of 'playing the game' by the same subjects. For example, the Line3 market has been studied in many experiments (see van Assen 2003, for references), and it has been found that the payoff of A and C systematically decreases over rounds. Yet, it can take many rounds for their payoff to approach the core theory's predicted payoff. In our experiments the number of rounds is limited. Moreover and importantly, we are mainly interested in the relative comparison of behavior in the four interdependence situations. Therefore we do not focus on point predictions but formulate all hypotheses in terms of comparisons of the average exchange ratios of two interdependence situations.

In the previous subsection two predictions were already derived. In the Line3 market without externalities both the generalized and original core predict that B transfers 24 units of Y. In the Line3 household the generalized core predicts B transfers a number of units of Y from the interval [24, 48]. Hence, our first (statistical, alternative) hypothesis is:

Hypothesis 1: On average A and C receive more in the household than in the market.

Now consider the Line3 public good problem. If A (C) makes the exchange, C (A) profits, that is, externalities are solely positive. Therefore, each exchanging pair can guarantee a total payoff of 24, and each actor can guarantee himself at least 0. Thus, the generalized core requires that (i) $x_A, x_B, x_C \geq 0$ and (ii) $x_A + x_B \geq 24$ and $x_B + x_C \geq 24$. Assume A exchanges with B. Then $x_A + x_B = y_A + y_B = 24$, i.e., (iii) is met by definition. Since A and C share Y, but not X, we have $x_C = x_A + 24$, and $x_B + x_C \geq 24$ is also met by definition. Mutatis mutandis the same holds when B and C exchange. Hence, the prediction of the generalized core for the Line3 public good is identical to the one for the Line3 household: B transfers a number of units of Y from the interval [24, 48].

Hypothesis 2: On average A and C receive the same in the household and public good problem.

Finally, consider the Line3 resource dilemma. Again, each exchanging pair can guarantee a payoff of 24. However, not all actors can guarantee themselves 0 points, and this changes the generalized core solution. If A (C) makes the exchange, C (A) obtains a negative payoff of –24, that is, externalities are solely negative. For instance, assume B exchanges with A and transfers 36 units of Y. Both A and B then earn 12, and C earns –24. The sum of payoffs of B and C is 12 – 24 = –12, which is smaller than 24. Therefore, this exchange ratio isn't in the generalized core: the pair B-C can successfully object to the payoff vector by exchanging. For instance, an exchange between B and C in which B transfers 24 units of Y yields B a payoff of 24 and C a payoff of 0. The sum of their payoffs is now 24, and the new situation is an improvement for both B and C. Given this new exchange ratio, however, A earns – 24. Now the sum of payoffs of A and B is 0, which is again short of 24. Therefore, the pair A and B can raise a successful objection through an exchange in which B transfers yet fewer units of Y. The generalized core requires that (i) $x_A, x_C \geq -24$ and $x_B \geq 0$, and (ii) $x_A + x_B \geq 24$ and $x_B + x_C \geq 24$. Assume A exchanges with B. Then $x_A + x_B = y_A + y_B = 24$, i.e., (iii) is met by definition, and $x_C = -24$. Then, $x_B + x_C \geq 24$ can only be met if $x_B = 48$, implying $x_A = -24$. Mutatis mutandis the same holds when B and C exchange. Thus, the only exchange ratio that is in the generalized core is the one where B transfers 0 units of Y in return for the 1 unit of X. In this case, A and C both lose 24, no matter who exchanges, and B earns 48. Note that generalized core theory predicts that A and C are accepting *losses* in their exchange with B, something actors are never predicted to do in case of exchanges without externalities; a principal assumption of exchange (without externalities) between rational actors is that exchange is mutually profitable. These considerations lead to Hypothesis 3.

Hypothesis 3: On average A and C receive less in the tragedy of the commons than in the market.

The hypotheses implicitly state that competition between group members is different in the four interdependence situations. In resource dilemmas competition is so fierce that group members are prepared to hurt themselves (lose in exchange with B) in order to prevent being hurt even more by someone else (incurring the externality). Competition is also fierce in markets. In markets group members are willing to accept a small gain in order to prevent obtaining nothing. In household and public good problems less or even no competition is predicted.

5.4 Experiments

5.4.1 Subjects

Subjects were undergraduate students from different departments of the University of South Carolina, at Columbia (SC). A total of 66 subjects participated for pay. The average earnings were approximately 15 US dollars for an experimental session that took at least 30 and at most 50 minutes.

5.4.2 Design and procedure

Subjects participated in groups of 3 individuals. The number of groups per condition was determined by an analysis of statistical power. Two groups played the Line3 market, eight groups played the Line3 household, eight groups played the Line3 public good problem and four groups played the Line3 tragedy of the commons. Each group of subjects participated in one of the four games for 10 rounds of maximally 3 minutes each. Hence a total of 220 rounds were played in all.

Subjects entered the experiment room separately. They were randomly assigned a network position (either A, B or C), in which they remained throughout the entire experiment. Subjects were seated in separate rooms where they could neither hear nor see any other subjects. Subjects did not meet before or during the experiment. They usually did meet after the experiment when the money was paid. However, subjects didn't know this in advance.

Upon being seated in their rooms, subjects received a written instruction explaining the experiment.[2] Subjects typically needed less then 10 minutes to read the instructions. After finishing reading the instructions, 3 practice rounds were played, using the Line3 market, i.e., the structure without externalities. After completing the practice rounds all subjects received a written form that indicated how their monetary pay depended on their points and, in the case of externalities, the points of someone else in the game (see note 2). The experiment leader then gave each subject a 10-item quiz to establish their understanding of the game (see note 2). Subjects typically took no longer than 3 minutes to complete the test. The experiment leader then checked the answers on the quiz. A correct answer was worth 20 cents, so the entire quiz was worth 2 US dollars. Very few subjects had any wrong answers. No subject had more than 1 incorrect answer. In case of a wrong answer, the experiment leader asked the subject to rethink the answer and explain it. All problems were then easily solved and all subjects were paid the 2 dollars for the quiz. Subjects were informed of the number of rounds to be played. The 10 experiment rounds then started.

Negotiations in the experiment were completed through computer terminals, employing the ExNet 3 software developed by Willer and associates at the University of South

Carolina. Bargaining was unstructured in the sense that the order and timing of the offers was up to the subjects to decide. Subjects could make any number of offers they wished, to any subjects they were connected with in the network, within the time limit of 3 minutes per round. To carry out an exchange an offer had to be accepted and the acceptation confirmed by the actor initially proposing the offer. A round ended after 3 minutes had elapsed or when an exchange was completed.

Subjects were endowed with the goods and utilities corresponding to their network position (see Table 2). The goods were abstractly labeled X and Y, as in Table 2. After each round of play the resources were replenished. Subjects were able to make 1 exchange per round only. The utilities from the final row of Table 2 were presented to the subjects as points they could earn in the game. In the externality conditions (household, public good problem, tragedy of the commons) subjects A and C were informed privately of how their payoffs depended on exchanges of the other player. Player B was ignorant of both existence and structure of the externalities. Player B was kept ignorant to enable us to observe the pure effects of externalities in a given structure, without the confounding factor of another player (B) anticipating on the externalities. Note that imposing B's ignorance makes rotation of subjects across positions during the experiment impossible.

Each subject earned a fixed amount of money per point. Money per point differed per network position and per game and was private information to the subjects, i.e., subjects didn't know the pay rate of other participants. Subjects only earned money for additional points they scored through exchange, or received as an externality of exchange. This was implemented in the experiment by subtracting the value of the initial resources from the points in each round. This way, subjects did not get money for the resources they started out with, but only for profits made in exchange and for externalities of exchange. The money per point was chosen in such a fashion that the expected earnings of all subjects would be 15 US dollars. Subjects that weren't expected to earn any points, such as A and C in the market, or that were expected to lose points, such as A and C in the tragedy of the commons, earned a base rate irrespective of their earnings in the game to compensate for this. This base rate was private information. At the end of the experiments actors on average gained approximately $15, ranging from a minimum of approximately $6 and a maximum of approximately $25.

5.5 Results

5.5.1 Comparing all four interdependence situations

In total 22 groups played one game for 10 rounds, yielding a theoretical maximum of 220 exchanges. Of these 220 potential exchanges, 199 exchanges were actually completed. To account for the dependencies in the data of the same group we estimated multilevel models to test the hypotheses (e.g., Snijders and Bosker 1999), subsequently called ‘mixed models’. In all the mixed models reported below only the intercept is random. All other effects are fixed.[3]

We first checked whether the exchange ratio was different for the four interdependence situations. We estimated two mixed models with the variable ‘group’ as the indicator for the second level, on all the games. The dependent variable was the number of units of Y transferred by B (Y) to either A or C. The analyses were conducted only on the 199 exchanges that actually occurred.

Table 3: Comparing the four interdependence situations with respect to exchange ratio. Estimates for the null model (Model I) with one random intercept, and the full model (Model II) with random intercepts and fixed effect of Round for each situation. Dependent variable was the number of received resources (Y)

	Model I	**Model II**
	Coefficient	Coefficient
Intercept	31.56***	25.13***
	(1.76)	(3.19)
Round	0.24*	0.04
	(0.11)	(0.32)
Household		9.91*
		(3.56)
Public		11.22**
		(3.57)
Resource		-6.68
		(3.90)
Household* Round		0.12
		(0.36)
Public*Round		1.06**
		(0.36)
Resource*Round		-0.96*
		(0.39)
-2 log-likelihood	1247.51	1175.53

Note: Data shown are mixed model coefficients with standard error in parentheses.
* $p < .05$, ** $p < .01$, *** $p < .001$ (two-tailed tests)

The null model or Model I (see Table 3) that estimated an average exchange ratio and a common effect of Round across all four conditions yielded a fit or –2 log-likelihood (LL) equal to 1247.51 and an intraclass correlation of 0.76. The intraclass correlation is a measure of the dependency of the data in the same group, and can have a value in the interval [0,1]. The value 0.76 signifies that the exchange ratio varied greatly between groups. The average exchange ratio across all groups was 31.56 (S.E. = 1.76), and the effect of Round was significant and positive ($\chi^2_1 = 4.466$, p = 0.03, two-tailed). The variable Round was computed by centering the original rank numbers of the 10 rounds, i.e., Round = rank number round – 4.5. The intercept of 31.57 can then be interpreted as the average number of units of Y transferred by B in the 'average' round.

The full model or Model II estimated a random intercept and a fixed effect of round for each interdependence situation, by including a dummy for three of the four situations. The Line3 market was taken to be the reference game, the other games were labeled Household, Public, and Resource. Model II was a huge improvement over Model I ($\chi^2_6 = 71.976$, p < 0.001) indicating that the exchange ratio indeed differed across the four interdependence situations. The conditions also differed with respect to the effect of Round. There was no effect of Round in the market ($F_{1, 176.99} = 0.02$, p = 0.898) and in the household ($F_{1, 177.01} = 0.10$, p = 0.749). In the public good problem the mean number of Y transferred by B increased over rounds ($F_{1, 177.07} = 8.56$, p = 0.004). In the resource dilemma the mean number of Y decreased over rounds ($F_{1, 176.99} = 6.03$, p = 0.015). These trends are visualized in Figure 2 that depicts the average exchange ratios in all four interdependence situations as a function of Round. In later subsections it is verified which of the situations were different from each other by discussing separately the results corresponding to the four hypotheses.

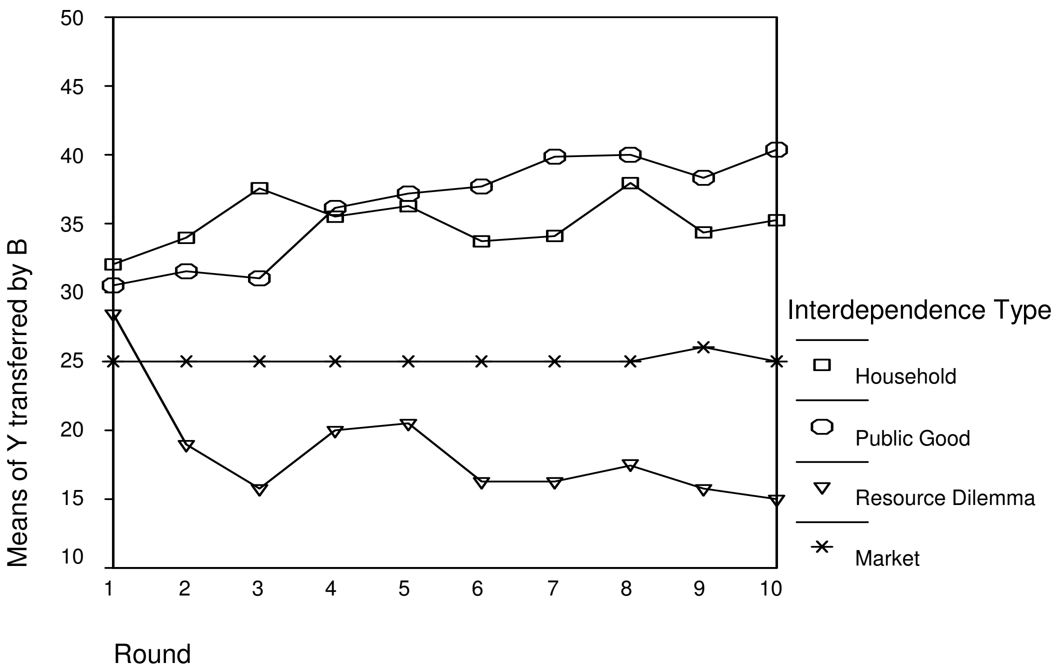

Figure 2: Means of Y transferred to B across rounds in Household, Public Good, Resource Dilemma and Market

Table 4: Comparing the four interdependence situations with respect to time in seconds. Estimates for the null model (Model I) with one random intercept, and the full model (Model II) with random intercepts and fixed effect of Round for each situation

	Model I	**Model II**
	Coefficient	Coefficient
Intercept	129.69***	114.57
	(12.51)	(37.26)
Round	0.66	-2.593
	(1.30)	(4.08)
Household		13.94
		(41.65)
Public		42.74
		(41.69)
Resource		-29.37
		(45.55)
Household*Round		4.26
		(4.58)
Public*Round		6.17
		(4.64)
Resource*Round		-1.76
		(4.98)
-2 log-likelihood	2196.01	2185.78

Note: Data shown are mixed model coefficients with standard error in parentheses.
* $p < .05$, ** $p < .01$, *** $p < .001$ (two-tailed tests)

Core theory does not allow one to derive hypotheses concerning the time needed to reach agreement. However, since ExNet also saved the time needed to reach agreement, we also tested whether the four situations were different with respect to the timing of the exchange. Timing was measured in seconds. The results of the analyses are presented in Table 4. No difference in timing was observed across the four interdependence situations ($\chi^2_6 = 10.23$, p = 0.12), and the effect of Round on timing was never significant.

5.5.2 Comparing the market to the household

Hypothesis 1 states that on average A and C receive more in the household than in the market. To test this hypothesis three mixed model analyses were run, using only the data of the household and market situations.[4] In the market two groups played 10 rounds each. In eighteen of the twenty rounds agreement was reached. The mean Y was 25.11, with a standard error of 0.58. Eight groups played the Line3 household. Of the eighty rounds played, 74 ended in agreement. The mean Y was 35.05, with a standard error of 5.28.

Table 5: Comparing exchange ratios of household (Game = 1) and market (Game = 0). Estimates for Model I with random intercept plus fixed effect of Game, Model II that also includes Round, and Model III that also includes Game*Round

	Model I	**Model II**	**Model III**
	Coefficient	Coefficient	Coefficient
Intercept	25.14***	25.13***	25.13***
	(2.56)	(2.55)	(2.55)
Game	9.93**	9.92**	9.91**
	(2.86)	(2.85)	(2.85)
Round		0.13	0.04
		(0.12)	(0.26)
Game*Round			0.12
			(0.29)
-2 log-likelihood	503.545	502.26	502.10

Note: Data shown are mixed model coefficients with standard error in parentheses.
* p < .05, ** p < .01, *** p < .001 (two-tailed tests)

The intercept in the empty model was 33.08 (S.E = 1.70, -2LL = 511.45). The intra-class correlation was 0.72. In Model I we added the variable interdependence situation or ‘Game’ (household = 1, market = 0). In Model II we added the variable Round. In Model III we added the interaction Game*Round to test whether the effect of Round is different across the two situations. See Table 5 for the results of the analyses.

On average A and C received 9.93 points more in the household than in the market, corroborating Hypothesis 1 ($\chi_1^2 = 7.91$, p < 0.01, 1-tailed). The effect of Round in Model II was not significant ($\chi_1^2 = 1.276$, p > 0.10). The effect of Game*Round was also not significant ($\chi_1^2 = 0.161$, p > 0.10).

Table 6: Comparing exchange ratios of household (Game = 1) and public good problem (Game = 0). Estimates for Model I with random intercept plus fixed effect of Game, Model II that also includes Round, and Model III that also includes Game*Round

	Model I	**Model II**	**Model III**
	Coefficient	Coefficient	Coefficient
Intercept	36.28***	36.32***	36.35***
	(1.66)	(1.64)	(1.63)
Game	-1.21	-1.33	-1.30
	(2.34)	(2.32)	(2.31)
Round		0.60***	1.10***
		(0.13)	(0.17)
Game*Round			-0.95***
			(0.24)
-2 log-likelihood	868.40	847.349	832.26

Note: Data shown are mixed model coefficients with standard error in parentheses.
* p < .05, ** p < .01, *** p < .001 (two-tailed tests)

5.5.3 Comparing public good to household

Hypothesis 2 states that on average A and C receive the same in the household and public good problem. To test this hypothesis again three mixed models were estimated (see Table 6), using only the data of the household and public good situations. In 67 of eighty rounds of the public good problem agreement was reached, the average of Y transferred was 36.22, with a standard error of 7.49. The intercept in the empty model or average exchange ratios across all exchanges was 35.67 (S.E = 1.179, -2LL = 868.66), and the intra-class correlation was 0.48. The effect of Game (household = 1, public good = 0) in Model I was not significant, in agreement with our hypothesis ($\chi_1^2 = 0.27$, p > 0.10). The effect of Round in Model II was significant ($\chi_1^2 = 21.05$, p < 0.01, two-tailed), as well as the interaction in Model III ($\chi_1^2 = 15.09$, p < 0.01). There is no effect of Round in the household, but a significant positive effect of Round in the public good problem ($F_{1,59.14} = 33.45$, p < 0.001). That is, in the course of the experiment A and C gained more points in their exchange with B in the public good game. This effect can also be observed in Figure 2. Additionally, we tested whether the two interdependence situations differed in exchange ratios in only the first three and the last three rounds. No significant difference was found in either case.

We also tested two hypotheses in which we compared each of the household and public good problem to a bilateral exchange situation. It can be argued that with respect to incentives, the household condition effectively reduces A and C to a single actor. If B were to exchange with a single actor, the only outcome to be reasonably expected to would be the one in which both partners earned 12 points, i.e., an exchange in which B transfers 36 units of Y in return for the unit of X.[5] To test this we estimated an empty mixed model to check whether the intercept was significantly different from 36. In line with our expectation, it was not ($F_{1,7.90} = 0.427$, $p = 0.532$). Also for the public good problem we found no significant deviation from 36 ($F_{1,7.98} = 0.022$, $p = 0.886$).

Table 7: Comparing exchange ratios of resource dilemma (Game = 1) and market (Game = 0). Estimates for Model I with random intercept plus fixed effect of Game, Model II that also includes Round, and Model III that also includes Game*Round

	Model I	**Model II**	**Model III**
	Coefficient	Coefficient	Coefficient
Intercept	25.13***	25.17***	25.13***
	(3.00)	(3.00)	(3.00)
Game	-6.68	-6.72	-6.68
	(3.67)	(3.67)	(3.66)
Round		-0.60**	0.04
		(0.20)	(0.33)
Game*Round			-0.96*
			(0.40)
-2 log-likelihood	357.23	348.67	343.16

Note: Data shown are mixed model coefficients with standard error in parentheses.
* p < .05, ** p < .01, *** p < .001 (two-tailed tests)

5.5.4 Comparing market to resource dilemma

Hypothesis 3 states that on average A and C receive less in the tragedy of the commons than in the market. To test this hypothesis again three mixed models were estimated (see Table 7), using only the data of the market and the resource dilemma situations. In the resource dilemma all of the 40 possible exchanges were completed, the mean value of Y was 18.45, with a standard deviation of 7.55. Note that the mean value of Y implies a mean loss for the exchanging A or C subject of 5.55 (24 – 18.45). The mean value of Y, however, differed markedly across the four groups. In two of the groups on average the A and C subjects did not lose or hardly lost on their individual exchanges with B, indicated by average Y values of 22.5 (loss of 1.5) and 24.1 (gain of 0.1). In the other two groups the A and C subjects did concede to losses, with average values of Y of 11.3 (loss of 12.7) and 15.9 (loss of 8.1).

The average exchange ratio across all exchanges was 20.66 (S.E = 2.147, -2LL = 359.881), and the intra-class correlation was 0.53. The effect of Game (tragedy of the commons = 1, market = 0) was significant ($\chi_1^2 = 2.65$, p = 0.05, 1-tailed), corroborating Hypothesis 3. The effect of Round in Model II was negative and significant ($\chi_1^2 = 8.57$, p = 0.003). The interaction effect in Model III was also significant ($\chi_1^2 = 5.51$, p = 0.02). The effect of Round was negative in the resource dilemma ($F_{1,36} = 11.23$, p = 0.002), and there was no effect of Round in the market ($F_{1,65.99} = 1.15$, p = 0.287). See Figure 2 for a visualization of this trend.

Finally, it must be noted again that the observed differences between groups in the resource dilemma were large. In the two groups of which the A and C subjects lost in their exchanges with B, the average number of units of Y transferred by B in the first round was 29. The actor excluded from exchange then experienced the negative externality of 24. In these groups the mean number of Y then sharply dropped in round two, to a level of approximately 12, and stayed at this low level. In the two groups of which the A and C actors didn’t lose or hardly lost in their exchanges with B, the mean number of Y in the first round was 28 and remained at this relatively high level during the remaining rounds, regardless of the negative externalities experienced by the excluded actor. Thus, the difference between these groups is caused by the different reactions of the A and C subjects to the externalities experienced in the first round. Moreover, regardless of whether the number of units of Y dropped in the second round, it remained relatively stable in both types of groups in the subsequent rounds of the experiment.

5.5.5 Comparing proportions of completed exchanges

Core theory predicts that all exchanges are carried out. However, different proportions of completed exchange were observed across conditions. The observed proportions were 0.84, 0.90, 0.93, 1 for the public good problem, market, household, resource dilemma, respectively. Multilevel logistic regressions were carried out to test for differences in pairs. Because the observed proportion was 1 in the resource dilemma, no multilevel logistic regression could be carried out on all four situations simultaneously, or on all pairs containing the resource dilemma. Therefore, we chose the chi-square test for independence on pairs containing the resource dilemma. This test assumes independence of observations, an assumption that is violated in the data. As a consequence of the violation of this assumption the chi-square test is too liberal, that is, the reported p-values are too small. A safeguard is taking a smaller significance level, e.g., 0.01 instead of 0.05.

The analyses demonstrated that the difference between the following pairs of proportions of completed exchanges was at least marginally significant (lower proportion mentioned first): public good and household, (Wald Z = -1.676, p = 0.10), public good and resource dilemma ($\chi_1^2 = 7.29$, p = 0.007), market and resource dilemma ($\chi_1^2 = 4.138$, p = 0.042), and household and resource dilemma ($\chi_1^2 = 3.16$, p = 0.04).

5.6 Discussion

In line with insights from social exchange theory the present paper conceived of interaction as the bilateral transfer of valuable resources, or exchange. The research problem concerned the effect of externalities of exchange, or type of interdependence situation. The interdependence situations studied in this paper are well-known social situations that have been frequently studied in the social sciences. The present paper is the first to distinguish these situations based on the resources shared by certain actors within the same framework of exchange networks with externalities. We argue that this approach has several important advantages. Our approach enabled us to systematically compare, both theoretically and empirically, different interdependence situations. We argue that the possibility to analyze both behavior in different interdependence situations and exchange behavior within one general system of goal directed behavior is of central importance to sociology. We believe that the analysis of interdependence situations within the framework of exchange networks with externalities is closer to many real-life interdependence situations than the traditional analysis of these situations. Traditionally, these interdependence situations are represented by (e.g., public good or, more generally, social dilemma) games which make actors focus on the their actions and the consequences of their actions for themselves and others. We believe that in real-life the focus is more on the goal-directed activity or exchange of the actor, and not on the consequences of it for third parties; e.g., fishermen that deplete their fishing waters are probably more focused on trading with their fish than on the structure of the resource dilemma. To conclude, we argue that the external validity of our analysis may be larger than of the traditional analysis.

An important additional implication of studying the effect of externalities through shared resources in exchange networks is that subjects in the experiments have to be endowed actual resources. Thus, the traditional design in which actors negotiate over the division of a fixed pool of points is inappropriate. This is made most clear in the resource dilemma. In this dilemma we predicted and observed that the basic principle of exchange without externalities, ‘actors only exchange when exchanging leads to mutually profitable outcomes’, does not hold; subjects A and C consent to losses in their exchanges with B. Endowing subjects with resources facilitates these losses, since subjects have the possibility to sell their resources for a price so low they actually loose points. Dividing a fixed pool of points does not allow incurring a loss.

In the present paper we imposed the restriction on actors that they could only exchange once every round. Given this 1-exchange rule, the four interdependence situations are exhaustive: in the market no resources were shared, in the public good problem only resources received were shared, in the resource dilemma only resources transferred were shared, and in the household both resources received and resources transferred were shared. The examples of exchange with externalities offered in the present paper suggest that exchanges with externalities are no less common than exchanges without externalities. Despite the empirical abundance of this phenomenon, however, externalities in exchange networks have hardly been investigated, the sole exception being research on externalities in collective decision making (Stokman et al. 2001; van Assen et al. 2003). The current paper is a start to fill this large gap in the field of exchange research.

The field of network exchange research is rife with theories (see Willer and Emanualson 2005, for an overview). However, generalization of these theories to exchange with externalities is by no means straightforward, and presents a challenge to exchange theorists. Dijkstra (2005) modified and thereby generalized core theory such that it can be applied to both exchanges with and without externalities. Hypotheses derived from (generalized) core theory predicted varying degrees of competition between actors A and C in the different interdependence situations. Competition was predicted to be fiercest in the resource dilemma, followed by the market. No competition was predicted in the household and the public good problem. In the latter two conditions generalized core theory predicted identical exchange ratios, which were predicted to be more favorable to A and C than in the market. The least favorable exchange ratios for A and C were predicted in the resource dilemma. These effects were indeed found in the data and all hypotheses were corroborated, indicating that externalities do matter in exchange situations and have predictable effects on exchange ratios. Some issues concerning the results deserve further attention.

Contrary to the other conditions, we didn't find an effect of round in the market. This might come as a surprise, since previous research on market-like exchange networks (networks with one seller and multiple buyers) demonstrated that the demand of the buyers decreases in round (e.g., Skvoretz and Zhang 1997). The absence of an effect of round is probably due to the fact that the three practice rounds subjects played before the actual experiment were played in the market condition. These practice rounds might thus have provided an anchor for the actual experiment. In the market experiment the conditions didn't change with respect to this anchor situation, leading to outcomes that were stable across rounds. In the other situations, conditions did change with respect to the anchor situation, leading to gradually changing exchange ratios over time. This possible anchoring effect does not confound our results. Quite the contrary; despite the possible anchor, we did observe the predicted differences between the conditions after ten rounds.

With respect to the resource dilemma, we observed a remarkable difference between groups of subjects. In two of the four groups the A and C subjects on average didn't lose in their exchanges with B, whereas A and C subjects in the other two groups did. Loss aversion cannot explain this result, since completing an exchange with B that implies a loss to A (C), prevents an even larger loss for the exchanging actor. An explanation could be based on perceptions of fairness. Subjects in the two groups might consider it fair that a central player such as B harvests the entire surplus of exchange due to her network position, but consider it unfair if more than the exchange surplus is appropriated by B. In any case the results reveal that not only the structure of the resource dilemma determines the results, but also the characteristics of the actors involved in the dilemma. We expect that the possible effect of actor characteristics is overruled by the effect of structure, when the resource dilemma involves more than 2 peripheral actors like A and C; cooperation (not exchanging with B or transferring only a small amount of resources to B) among actors is only possible, if all of them are prepared to so.

Although we formulated no hypotheses concerning the proportions of completed exchanges in the different conditions, we did find some interesting results. The proportions observed seem to mirror the amount of competition between subjects A and C. Proportions were highest in the resource dilemma and lowest in the public good problem. The proportion of completed exchanges in the household was in between these two extremes. This is an indication that externalities also influence the rate of agreement in exchange networks: when externalities enhance competition they seem to increase actors' willingness to reach agreement, whereas externalities that attenuate competition have the opposite effect.

In this paper we focused on one particular outcome of exchange in networks, namely the exchange ratio. Another important outcome of exchange networks not investigated in the present paper is the exchange pattern, i.e., the pattern of who exchanges with whom. In a future paper experiments will be reported that investigate the effects of externalities on both the exchange ratio and partner selection in exchange networks. Similar to the hypotheses concerning the exchange ratio, the hypotheses concerning partner selection will be derived from generalized core theory.

The results predicted for and observed in the laboratory experiments reported in the present paper have implications for real-life exchanges. Whenever externalities exist it is insufficient to know only actors' resource endowments and utilities, together with the network structure, to make sensible predictions concerning the outcomes of the exchange process. One needs to know the size and sign of the externalities as well, as they may crucially influence the outcomes. Thus, in for instance collective decision making situations such as parliaments and labor-management negotiations, exchanges of two parties may well have profound effects for other parties involved in the decision process. As this paper indicates, the structure of these externalities might dramatically alter the outcome with respect to a situation without externalities.

An important question concerns the ecological validity of our conclusions regarding actor behavior in the four interdependence situations. First of all, we only considered very simple situations with only three actors. Secondly, we only considered behavior in the four situations under the 1-exchange rule. Discarding the 1-exchange rule in the Line3 network does not change the predictions of behavior in the household and the public good interdependence situations, but eliminates the advantage of the B actor in the market, and changes the resource dilemma into a prisoner's dilemma game.

Discarding the 1-exchange rule allows the study of other dilemmas, e.g., it transforms the resource dilemma into a prisoner's dilemma; the dominant strategy of both A and C is to exchange with B, but if both A and C exchange with B, both A and C end up with a negative payoff. The Pareto efficient outcome results when both A and C do not exchange with B. This example shows that also prisoner dilemma's can be conceived of as exchanges with externalities. A future paper investigates the difference in outcomes between 'regular' prisoners' dilemmas and two experiments we conducted in which prisoners' dilemmas were embedded in exchange networks.

To conclude, we have only studied one out of many instances of each of four interdependence situations. However, our study shows that all these situations can be fruitfully studied in the same general framework of exchange networks with externalities, and that generalized core theory could provide accurate relative predictions of actor behavior in the instances examined.

Notes

1. If one defines externalities such that exclusion and interdependence are included in the definition, the definition becomes meaningless because all possible effects of an exchange are then by definition externality effects. Our definition allows one to distinguish the effects of exclusion and competition and the direct effects of exchange, i.e., the mere addition or subtraction of payoff as a result of the exchange.
2. The instruction, and test can be obtained from the first author.
3. For example, if one wants to estimate and test the multilevel model with only variable round as predictor, then the following equation is estimated: $Y_{ij} = \gamma_{00} + \gamma_{10}\text{Round} + U_{0j} + e_{ij}$. The random variables U_{0j} and e_{ij} are assumed to be normally distributed with mean zero. Their variances are parameters and are estimated in the multilevel model. U_{0j} is the group-dependent deviation, e_{ij} is the observation-dependent deviation of the prediction. The equation can be expanded by including other predictors, like Game and Game*Round.
4. The parameter estimates obtained by running an analysis separately on two games are identical to those obtained when analyzing the four games altogether (presented in Table 3). However, the standard errors of these estimates differ. Consequently, to test for differences between the games an analysis is required that only compares the two games.
5. In fact, this would be the predicted outcome of classic theories of bilateral monopoly such as the Nash bargaining solution (Nash 1950) and the Raiffa-Kalai-Smorodinsky solution (Kalai and Smorodinsky 1975).

6

Effects of externalities on patterns of exchange*

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

Abstract

Many real-life examples of *exchanges with externalities* exist. Externalities of exchange are defined as *direct* consequences of exchanges for the payoff of actors who are not involved in the exchange. This paper focuses on how externalities influence the partner choice in exchange networks. Two externality conditions are created such that different exchange patterns are predicted in the simplest exchange network with two structurally different complete exchange patterns, the 4-Line. Predictions concerning exchange patterns and ratios are derived from a generalization of the core from game theory. Hypotheses are derived by comparing the predictions for the experimental conditions and by comparison to data from previous experiments on the 4-Line, without externalities. Hypotheses concerning the changes in exchange patterns were confirmed.

6.1 Introduction

A considerable part of the social sciences concerns research devoted to *exchange*. Leading exchange theorists (e.g., Blau 1964; Homans 1958; Molm 1997) have argued that social interaction can be perceived as exchange since "(…) much of what we need and value in life (e.g., goods, services, companionship, approval, status, information) can only be obtained from others." (Molm 1997: 12).

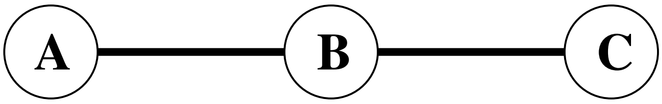

Figure 1a: The 3-Line network

Figure 1b: The 4-Line network

An important branch of exchange research is devoted to the experimental investigation of exchange *networks*. The issue on which this research has mainly concentrated, is the effect of networks on the choice of exchange partners and the ratios of exchange (for example, see the special issue on network exchange in *Social Networks*, volume 14, and Willer 1999). In this line of research, an actor's connections in a network represent with whom the actor can exchange. If there is a connection between two actors in the network, these actors have the possibility to exchange, but no obligation to do so. If there is no link between two actors, an exchange between them is not possible. Consider the network depicted in Figure 1a. The links in this *3-Line network* indicate that actors A and C can each exchange with actor B, but not with each other. The central question is then whether and how an actor's payoff from exchange is influenced by that actor's position in the network. For instance, if actor B were limited to making only 1 exchange, we would predict that A and C would compete for access to B, who would consequently get all the surplus from exchange.

The current paper investigates the effect of *externalities* on exchange. Externalities of exchange are defined as *direct* (positive or negative) consequences of exchanges for the well-being of actors who are not involved in the exchange. In Figure 1a, externalities would exist if after an exchange of two actors the payoff of the third actor would be affected as well. For example, if A and B exchanged with each other and C experienced a change in payoff equal to 4 (-4) as a direct consequence of this exchange, then C would have experienced a positive (negative) externality of the exchange between A and B. It is important to note that the fact that C is possibly *excluded* from exchange when A and B exchange with each other, is *not* interpreted as an externality. The same holds for a possible process of *competition* between A and C for access to B. Exclusion and competition are merely two forms of interdependence that are present in an exchange network, regardless of whether externalities exist or not.

The main research question of the current study is whether and how externalities influence the partner choice of actors in exchange networks. In addition, implications of externalities for the payoffs of actors are examined. To answer the research question, core theory (Bienenstock and Bonacich 1992), a prominent theory in the field of network exchange, is generalized to deal with exchanges with externalities. This generalized core theory helps us to understand the effects of externalities in any exchange network. Predictions of this generalized core theory are derived and tested experimentally for two different externality conditions in the 4-Line network of Figure 1b. The generalization of core theory, the choice of the 4-Line network, and the externality conditions employed in the experiment are explained below.

Before discussing externalities in exchange networks more in detail, we note that outside the field of exchange networks externalities are extensively studied in the social sciences. The *public good problem* is perhaps the best-known example (e.g., Ledyard 1995; Olson 1971). If an actor provides a unit of a public good (the action), all other actors benefit (the *direct* result of the action). Because the other actors benefit, the externality effect is *positive*.

The societal relevance of studying externalities in exchange networks follows from the abundance of examples of exchanges with externalities in real-life. Exchanges with externalities that most of us are familiar with and experience daily, are exchanges of and between members of a household. The father's purchases in the supermarket (the exchange of money for products) are experienced as externalities by the other members of the household: less money to spend on other products or activities, and the possibility to consume the products bought by the father. Note that in particular the children in the household experience externalities all the time, since they commonly do not have their own budget, or a very limited one.

Another example of exchanges with externalities can be found in collective decision-making. In a division in Parliament for instance, two political parties may agree to exchange their voting positions concerning two issues that have to be decided upon. Since this "logrolling" changes the eventual outcome of the vote, the exchange directly affects other political parties that are not involved in the agreement. In other words, the political parties that do not exchange experience externalities. Since the exchange may shift the outcome of the division either toward or away from the position of a particular party not involved in the exchange, the externality may be evaluated positively or negatively by that party (Stokman et al. 2000; van Assen, Stokman and van Oosten 2003).

Many other instances of strategic interaction commonly studied in the social sciences can also be conceptualized as exchange problems with externalities. Some social dilemmas of the ‘tragedy of the commons’ or ‘resource dilemma’ type (Hardin 1968) for instance, can be analyzed as a network of exchange relations. For example, consider the 3-Line network in which B can make only one exchange. A resource dilemma then exists for A and C if the following conditions are satisfied: (i) A and C share a resource, (ii) this resource is transferred to B, (iii) the resource received from B by either A or C is *not* shared by A and C. In our example, if A (C) exchanges with B, C (A) experiences a negative externality: A (C) uses part of the shared resource to acquire a commodity only she enjoys. In a similar vein, a public good problem would exist in Figure 1a if A and C shared the resource they received from B, but not the resource transferred.

Dijkstra and van Assen (2006) studied the resource dilemma and other dilemma situations induced by externalities in the 3-Line network of Figure 1a. Compared to traditional research on social dilemmas, an advantage of conceptualizing these dilemmas as exchanges with externalities is that these dilemmas are no longer studied in isolation. The conceptualization as exchanges with externalities implies that the following two effects are studied as well: i) the effects of externalities on the behavior of actors that do not directly experience externalities themselves, such as the B-actor in the 3-Line resource dilemma delineated above and ii) the effects of these actors on the behavior of actors that *do* directly experience externalities, such as actors A and C in the 3-Line resource dilemma.

The examples above suggest that externalities are abundant in real-life exchange situations. However, they have been neglected in exchange network research. The present paper is one in a series that addresses the effect of externalities on exchange in networks. Dijkstra and van Assen (2006) studied the effects of externalities on the *exchange ratios* in the 3-Line network. The current study mainly focuses on the effects of externalities on the *partner selection* in exchange networks. To this end we examine the 4-Line network of Figure 1b. We have selected the 4-Line network because it is the simplest network such that there exist two *structurally different complete exchange patterns*. A *complete exchange pattern* is a collection of exchanges such that given the network no additional exchanges are possible. Assuming, as we will do throughout, that each actor can only exchange once (this is commonly called the 1-exchange rule, e.g., Willer 1999), the two complete exchange patterns in the 4-Line are: i) A exchanges with B, and C exchanges with D, and ii) B exchanges with C. These exchange patterns are *structurally different* because they involve different combinations of automorphically equivalent actors. Two positions in a network are automorphically equivalent if the positions have identical structural locations in the network (Wasserman and Faust 1994: 469-473).[1] In the 4-Line there are two automorphic equivalence classes, namely the class {A, D} and the class {B, C}. The two complete exchange patterns of the 4-Line are structurally different because complete exchange pattern i) combines members from different automorphic equivalence classes, whereas pattern ii) combines members of one class. In the 3-Line there also exist two complete exchange patterns: i) A exchanges with B, and ii) C exchanges with B. However, since A and C belong to the same automorphic equivalence class, these complete exchange patterns are structurally equivalent.

To answer our main research question, whether and how externalities affect partner choice in exchange networks, we used the 4-Line to construct two experimental conditions in which externalities were varied such that different proportions of exchanges between B and C were predicted. Moreover, the externalities were also constructed such that these predictions also differed from the observed proportion of BC exchanges in the 4-Line *without* externalities.

The next section contains a description of the externality conditions used in the experiments on the 4-Line exchange network. In the third section a theoretical answer to the research question is formulated, by generalizing the core solution. This yields testable hypotheses, formulated in that section. The subsequent section describes the experiments. In the section after that the results are presented, after which a discussion concludes the paper. We justify the rather backwards organization of the paper, discussing the 4-Line network before the theory, by the fact that the theory is best explained and illustrated using the 4-Line as an example. It also economizes on space, since we illustrate the theory and derive the hypotheses simultaneously

6.2 The 4-line and externalities

We study exchange situations in which the actors in the 4-Line network possess a valuable resource that they can use in exchange. Externalities of exchange are implemented by letting actors share certain resources. In by far the largest portion of the literature in the field of exchange network research, exchange possibilities are represented as the opportunity to divide a pool of valuable resources or 'profit points' (for example, see the special issues on network exchange in *Social Networks*, volume 14, and in *Rationality and Society*, volume 9, and Willer 1999). Since we investigate the exchange of possibly shared resources, we had to deviate from this practice.

Table 1: Actors, goods, endowments (E) and utilities (U) in the 4-Line structure

Actors	**A**		**B**		**C**		**D**	
Goods	X	Y	X	Y	X	Y	X	Y
E	1	0	0	48	1	0	0	48
U	24	1	48	1	24	1	48	1

Table 1 presents the endowments and payoffs of the 4-Line used in our experiment. The first row of Table 1 indicates the actors. The second row of Table 1 shows there are two goods, X and Y, in the network. The third row depicts each actor's initial possession or endowment (E) of these goods. Thus, actors A and C each possess 1 unit of X and no units of Y. Actors B and D hold no units of X and 48 units of Y. The final row of Table 1 indicates the value or utility (U) of 1 unit of each of the goods for the actors. Thus, for actors A and C a unit of X is 24 times more valuable than a unit of Y. For actors B and D, a unit of X is 48 times more valuable than a unit of Y.

As can be seen in Figure 1b exchanges between A and C, A and D, and between B and D are impossible. The endowments and utilities of Table 1 make profitable exchanges feasible between all connected pairs of actors in Figure 1b. Based on Table 1, the *payoff changes* of the actors from exchange can be expressed as equations. Let P_i denote the payoff change of actor *i*, and let y denote the number of units of Y transferred in exchange, e.g. from B to A. Then $P_A = y - 24$, and $P_B = 48 - y$. The payoff equations of C and A are identical, and those of D and B as well. For instance, actor A might receive 30 units of Y from B such that $P_A = 6$ and $P_B = 18$, while C receives 36 units of Y from D, yielding $P_C = 12$ and $P_D = 12$. Note that A and C want to receive at least 24 units of Y, whereas actor B and D are willing to transmit at most 48 units of Y. Note also that the sum of the payoffs of any two exchange partners is 24, independently of the exchange ratio *y*. Finally, the payoff changes *P* do not take into account the value of an actor's initial endowments. In the experiments reported below subjects only were paid for payoff changes.

An important feature of the endowments and payoffs in Table 1 is that the outcome of any exchange is Pareto efficient: given any exchange ratio there is no alternative ratio that yields more payoff for one of the exchange partners, without decreasing the payoff of the other. This is true because A and C each have only 1 unit of X and thus must transfer their entire endowment of X in any exchange.

Externalities are introduced in the 4-Line network by making actors share resources. Two experimental conditions are created by varying the externalities. The first condition is the *single resource dilemma*. In this condition actors A and C of Figure 1b share their stock of resource X. Although this resource is shared, both A and C can still dispose of only 1 unit of X in their exchanges. Thus, although they share the consumption of X, A and C cannot individually deplete the entire endowment of 2 units of X for their private exchanges.[2] Resource X is the resource A and C transfer in their exchanges with B and D. The resource they receive in return, resource Y, is *not* shared. This implies that if A exchanges, C incurs a payoff change of –24 (the value of one unit of X to both A and C). And if C exchanges, A incurs a loss of 24. Note that actor C can avoid the externality by exchanging with B, since in the case of a BC-exchange A is excluded. Actor A however, cannot avoid the externality, since C can exchange with either B or D.

The externalities together with the network structure imply the following payoff functions. If C exchanges with B, then $P_A^{srd} = -24$, and $P_C^{srd} = P_C$, where *srd* denotes *single resource dilemma.* If A exchanges with B and C exchanges with D, then $P_A^{srd} = P_A - 24$, $P_B^{srd} = P_B$, $P_C^{srd} = P_C - 24$, $P_D^{srd} = P_D$. We emphasize that if A (C) fails to exchange, he still experiences the externality of –24 if C (A) exchanges. The payoff equations show that an actor's payoff change consist of two elements: (i) payoff changes (gains) earned from exchange, and (ii) externalities (losses) experienced from an exchange of another actor.

The second experimental condition is called the *double resource dilemma*. This is the single resource dilemma with the extra stipulation that B and D share their stock of resource Y. Thus, now not only actors A and C, but also B and D are in a resource dilemma. In the double resource dilemma, if A (C) exchanges then C (A) experiences a negative externality of 24. If B (D) exchanges then D (B) experiences a negative externality of the size of the number of units of Y transferred by B (D). Note how the size of the negative externality that B (D) experiences in the double resource dilemma is variable, whereas the externality for A and C is constant. In the double resource dilemma actors B and C can both escape the negative externalities by exchanging with each other. Actor A (D) cannot avoid the negative externality, because he cannot avoid that C (B) exchanges. In the equations, let *drd* denote the *double resource dilemma*. If B exchanges with C: $P_A^{drd} = -24$, $P_B^{drd} = P_B$, $P_C^{drd} = P_C$, and $P_D^{drd} = -y$. If A exchanges with B, and C exchanges with D: $P_A^{drd} = P_A - 24$ and $P_C^{drd} = P_C - 24$. To express the payoffs of B and D in this exchange pattern, we introduce y_i as to mean the amount of Y transferred by actor *i*. Then, $P_B^{drd} = P_B - y_D = 48 - y_B - y_D$, and $P_D^{drd} = P_D - y_B = 48 - y_D - y_B$. Note again that the payoff change consist of the two elements (i) payoff changes (gains) earned from exchange, and (ii) externalities (losses) experienced from an exchange of another actor.

In the next section we will discuss a theory that enables us to derive predictions of how the externality conditions introduced above affect the expected exchange pattern, i.e., who exchanges with whom, as well as the payoffs.

6.3 Theory and hypotheses

Many theories of exchange in networks have been developed in the last decades (e.g., Bienenstock and Bonacich 1992; Braun and Gautschi 2006; Burke 1997; Cook and Emerson 1978; Cook and Yamagishi 1992; Friedkin 1992, 1995; Skvoretz and Fararo 1992; Willer 1999; Yamaguchi 1996). However, all these theories assume that exchange is without externalities. Generalizing these theories to network exchange *with externalities* is by no means straightforward. Dijkstra (2005) generalized one of these theories, core theory, to deal with externalities in exchange networks. Core theory is a solution from cooperative game theory originally introduced to the field of exchange networks by Bienenstock and Bonacich (1992). The power of the theory is that it is simple, that is, based upon a minimum number of assumptions. We will discuss both the core solution and the generalized core solution in the light of the externality conditions described in the previous section. Our hypotheses are derived from this generalized core theory.

6.3.1 Original core theory and generalized core theory

Original core theory requires that each possible coalition of actors (including 1-player 'coalitions') get no lower payoff than the members of that coalition can guarantee by cooperating amongst themselves. More formally, let N be the set of actors in the game. The characteristic value function v assigns a total payoff $v(S)$ to every subset $S \subset N$ of actors, that they can realize among themselves, *despite* the actions of $N \setminus S$, i.e., the actors not in S. Thus, $v(S)$ represents the total payoff that a coalition S can be sure to achieve. Using the characteristic value function one can define the core solution. Let (x) be a payoff vector, such that x_i represents the payoff for actor i. A payoff vector (x) is in the core if it meets the following three rationality requirements:

i) $x_i \geq v(\{i\})$ *for every* $i \in N$ (individual rationality),

ii) $\sum_{i \in S} x_i \geq v(S)$ *for every* $S \subset N$ (coalition rationality), and

iii) $\sum_{i \in N} x_i = v(N)$ (group rationality).

In words: the core requires that each individual actor (individual rationality), each possible subset of the set of actors (coalition rationality), and the group of all actors (group rationality), receive a payoff at least as large as what all these actors and coalitions can guarantee themselves.

With respect to exchange networks coalition formation is interpreted as 'agreeing to exchange'. We illustrate the application of the core solution to exchange networks by considering the 4-Line network of Figure 1b, *without externalities*. Thus, all resources are private and none are shared. To find the core we must determine the characteristic values of all coalitions. Since exchange requires two actors, each individual actor can guarantee herself a payoff of 0: $v(A) = v(B) = v(C) = v(D) = 0$. Since any pair of connected actors can agree to exchange, all coalitions of connected dyads can guarantee themselves a payoff of 24: $v(AB) = v(BC) = v(CD) = 24$. Since unconnected dyads cannot exchange, the characteristic values of the 2-actor coalitions of unconnected actors are 0: $v(AC) = v(AD) = v(BD) = 0$. In all 3-actor coalitions exactly one exchange can take place. Thus, the characteristic value of each 3-actor coalition is 24: $v(ABC) = v(ABD) = v(ACD) = v(BCD) = 24$. Finally, in the all-actor coalition a maximum of two exchanges can take place. Thus, the characteristic value of this coalition is 48: $v(ABCD) = 48$. The core now consists of all payoff vectors such that each coalition gets at least its characteristic value. The first implication of this is that an exchange between B and C is not in the core: it is impossible to find an exchange ratio between these two actors such that both the AB coalition *and* the CD coalition each earn a sum of 24. Moreover, if B and C exchange the sum of payoffs of all the actors is 24, which is 24 short of $v(ABCD) = 48$, violating group rationality. Thus, the predicted exchange pattern is (AB,CD). Secondly, the sum of payoffs of B and C must at least be 24. If this is true the rationality requirements for all the coalitions are met.

To find the core, *all* logically possible coalitions must be considered. For instance, also the coalition between A and C and the 3-actor coalition between A, B and C must be taken into account. However, in an exchange network such as we are investigating here, coalitions between unconnected actors or of more than 2 actors have no meaning: coalition formation is intended to mean 'agreeing to exchange' and only connected dyads can exchange. However, regarding exchange networks without externalities, Bonacich and Bienenstock (1995) have shown that if no connected dyad receives less than it can guarantee by itself, this is also true for all other coalitions. In other words: if for each pair of connected actors, the sum of their payoffs is at least as large as their characteristic value, then for *each* subsets of N (including N) the sum of payoffs is at least as large as its characteristic value. Thus, in exchange networks without externalities, coalitions other than connected dyads can safely be disregarded when finding the core, because these coalitions do not affect the core. Therefore, the original core solution makes theoretically sensible predictions in exchange networks without externalities.

Unfortunately, in exchange networks with externalities coalitions other than connected dyads *cannot* be disregarded when trying to find the original core solution. That is, if there are externalities coalitions other than connected dyads can affect the solution of the core. Consider the connected dyads of the single resource dilemma. The coalition between A and B can guarantee itself 0. This characteristic value is composed of two elements. Firstly, A and B can exchange and earn a sum of 24. Secondly, A and B cannot avoid an exchange between C and D, in which case A gets a negative externality of 24. Thus, the sum of payoffs that the AB-coalition can *guarantee* its members is 24 – 24 = 0. The same holds for the CD-coalition. Thus, *v(AB)* = *v(CD)* = 0. The coalition between B and C can guarantee its members a sum of 24: if B and C exchange they earn a sum of 24 and prevent the negative externality for C, yielding *v(BC)* = 24. The characteristic values of the connected dyads suggest that the BC-exchange is in the core. However, the original core is empty if also other coalitions are taken into account. Consider the ABD-coalition. The value of this coalition is *v(ABD)* = 24, with A exchanging with B. But then C earns –24 and, consequently, B and C together earn less than the required 24 (since *v(BC)* = 24). Similarly, if B and C exchange, A earns –24 and the sum of payoffs of the ABD-coalition is necessarily smaller than 24. The core is empty because the requirements concerning coalitions *BC* and *ABD* cannot be satisfied simultaneously.

To conclude: coalitions other than connected dyads (e.g., *ABD* in the single resource dilemma) *can* affect the original core solution if exchanges are with externalities. But these coalitions cannot form in an exchange network, rendering the original core solution meaningless. To solve this problem of the core, that doesn't exist without externalities, but occurs when externalities are present, we introduce the generalization of the core. In networks without externalities, this generalized core yields predictions identical to predictions of the original core. Therefore, generalized core theory is a true generalization of core theory to exchange situations that possibly include externalities. In the words of Lakatos (1970: 116) the generalized core has 'excess empirical content'.

We generalized core theory to deal with externalities, simply by dropping any requirements that pertain to coalitions larger than dyads or coalitions of unconnected actors. That is, coalition rationality is limited to connected dyads and group rationality is dropped. The generalized core theory requires one additional assumption, namely "Pareto-efficiency of exchanging dyads".

The three assumptions of generalized core theory can be described formally as:

i) $x_i \geq v(\{i\})$ *for every* $i \in N$ (individual rationality),

ii) $\sum_{i \in S} x_i \geq v(\{i, j\})$ *for every connected* $i, j \in N$ (rationality of connected dyads),

iii) $\sum_{i \in S} y_i \geq w(\{i, j\})$ *for every exchanging* $i, j \in N$ (Pareto-efficiency of exchanging dyads).

In i) through iii) above, (x) denotes the payoff vector with externalities, (y) is the payoff vector without externalities, and $w(\{i, j\})$ is the characteristic value of pair $\{i, j\}$, disregarding externalities.

The last assumption is that if actors in a pair exchange, they exchange in a Pareto efficient manner, i.e., they cannot make a different exchange together that yields larger payoffs to both of them. Dijkstra (2005) explains why this additional assumption is needed.[3] Note that the endowments in Table 1 are chosen such that exchanges are necessarily Pareto efficient. Hence, the assumption concerning Pareto efficiency is not relevant in the present study since it always holds in the experiment.

In words: the generalized core requires that no individual actor or pair of connected actors get less than they can guarantee by themselves. Intuitively, a payoff vector is in the generalized core when no connected dyad can successfully object to it, in the sense that through exchange the objecting actors can improve their payoffs.

6.3.2 *Predictions and hypotheses*

We are mainly interested in the relative comparison of behavior in the 4-Line network under different externality conditions. Therefore we do not focus on point predictions per se, but formulate hypotheses concerning exchange ratios in terms of comparisons of the average exchange ratios of three externality conditions. Note that the application of generalized core theory sometimes yielded extreme point predictions, in which for instance A and C were predicted to transfer all of their resources to B. However, these extreme predictions can only be expected to occur after many rounds of 'playing the game' by the same subjects. In our experiments the number of rounds is limited.

Table 2: Characteristic values v for coalitions of connected actors in 4-Line without externalities (WE), single resource dilemma (SRD) and double resource dilemma (DRD)

Coalition	WE	SRD	DRD
AB	24	0	-48
BC	24	24	24
CD	24	0	-48

Predictions from the generalized core concern both the exchange ratio and the exchange pattern. The characteristic values of all coalitions of connected actors in the 4-Line without externalities, the single resource dilemma and the double resource dilemma are given in Table 2.

6.3.3 *The 4-Line without externalities*

The generalized core prediction for the 4-Line without externalities was already derived: A exchanges with B, C exchanges with D, and the sum of payoffs of B and C is at least 24. The 4-Line without externalities has been studied extensively in the lab. These experiments showed that on average B and C earn approximately 14 points in their exchanges with A and D. For example, Skvoretz and Willer (1993: 810) report an average of 14.05 (standard error of 0.4). Although BC-exchanges are not in the (generalized) core an exchange between B and C is reported to occur in 17.5% of exchange opportunities (Simpson and Willer 1999: 283).

6.3.4 Single resource dilemma

As opposed to the 4-Line without externalities, both exchange patterns (AB,CD) and (BC) are in the generalized core solution of the single resource dilemma. An exchange between B and C is in the generalized core if B earns 24 in this exchange and C earns 0. If this exchange takes place A earns -24 and D earns 0. The sum of payoffs in both the AB coalition and the CD coalition is then 0, and the sum of payoffs in the BC coalition is 24, exactly as required by the generalized core. The other complete exchange pattern, an exchange between A and B, and an exchange between C and D, is also in the generalized core. In this case the requirement is again that the sum of payoffs of B and C be at least 24. This requirement is met if both B and C earn 24 in their respective exchanges. Since C experiences the negative externality of 24, the total payoff for C is 0. A's payoff is -24, B's payoff is 24 and D earns 0. This way, all connected dyads earn exactly their characteristic value.

The observation that exchange pattern BC is feasible in the generalized core of the single resource dilemma but not in the 4-Line without externalities leads to Hypothesis 1:

> Hypothesis 1: In the single resource dilemma, exchange between B and C occurs more often than in the 4-Line without externalities.

Note that the generalized core yields no predictions concerning the relative likelihood of these two exchange patterns. Using the 17.5% of BC-exchanges observed across various experimental conditions on the 4-Line without externalities as a benchmark, we compare the proportion of BC-exchanges in our data from the single resource dilemma to a proportion of 0.175 to test Hypothesis 1.

The generalized core predicts that B will earn the maximum of 24 in the single resource dilemma. Comparing to the 4-Line without externalities this yields Hypothesis 2.

> Hypothesis 2: In the single resource dilemma, B earns more than in the 4-Line without externalities.

Since previous research on the 4-Line without externalities found that B earns an average of approximately 14, we compare the payoff of B in our data from the single resource dilemma to the benchmark of 14 to test Hypothesis 2.

Contrary to actor A, actor C can avoid the negative externality by exchanging with B. According to the generalized core however, such an exchange will only be feasible if it gives B at least as much payoff as B can earn in exchange with A. The maximum payoff that C can earn in the exchange pattern (AB,CD) is 0. This payoff for C results if C earns 24 in her exchange with D. Thus, any payoff larger than 0 in an exchange with B is an improvement for C over exchange with D. Therefore, C will initially seek exchange with B and disregard D, to earn at least some payoff. Since B is A's only possible exchange partner, A and C will compete for access to B and drive B's earnings to the extreme of 24. This reasoning yields a third hypothesis, concerning the order in which exchanges will be completed in the single resource dilemma. Since C will initially seek exchange with B, an exchange between C and D will only occur if and after B has agreed with A.

Hypothesis 3: If the exchange pattern is (AB,CD), then exchange between A and B occurs before an exchange between C and D, in the single resource dilemma.

We test Hypothesis 3 by comparing the proportion of times that the AB exchange occurred first in the data, to a proportion of 0.5: the proportion obtaining when no ordering exists.

6.3.5 Double resource dilemma

The characteristic values of the connected dyads in the double resource dilemma are shown in the last column of Table 2. As opposed to the single resource dilemma, where both exchange patterns are in the generalized core, only pattern (BC) is in the generalized core solution of the double resource dilemma. The coalition of A and B can guarantee its members a maximum sum of payoffs of –48. In this coalition an exchange can occur, resulting in a sum of 24. However, the coalition cannot prevent that A looses 24, through an exchange of C with D. Moreover, the situation for B is worst when D earns 0 in his exchange. In this case D transfers 48 units of Y to C, causing a negative externality for B of 48. Thus, the AB coalition can guarantee its members a joint payoff of – 48 (= 24 – (externality for A) – (maximum externality for B) = 24 – 24 – 48). The same holds, mutatis mutandis, for the coalition of C and D. The coalition of B and C can still guarantee its members a sum of 24: by exchanging with each other both B and C avoid the externalities and divide the 24 points. This last requirement is crucial in finding the generalized core. Given the exchange pattern (AB,CD), there exists no pair of exchange ratios such that the sum of payoffs of B and C is at least 24. The maximum sum that B and C can earn in exchange pattern (AB,CD) is 0.[4] This is less than 24, which implies that the exchange pattern (AB, CD) is not feasible in the generalized core. The alternative exchange pattern (BC), is always in the generalized core. No matter what the exchange ratio between these two actors, the sum of their payoffs is always 24 and the sum of the payoffs in both the AB and the CD coalition is always larger than –48. Thus, as opposed to the generalized core solution in the single resource dilemma, the generalized core in the double resource dilemma contains only exchanges between B and C, yielding our fourth and final hypothesis:

Hypothesis 4: Exchanges between B and C occur more often in the double resource dilemma than in the single resource dilemma.

The intuition based on the generalized core behind Hypothesis 4 is that B and C can both avoid externalities by exchanging with each other. No offer of A and D can improve upon this.

6.4 Experiments

6.4.1 Subjects

Subjects were undergraduate students from different departments of the University of South Carolina, at Columbia (SC). A total of 36 subjects participated for pay. The average earnings were approximately 15 US dollars for an experimental session that took at least 30 and at most 50 minutes.

6.4.2 Design and procedure

Subjects participated in groups of 4 individuals. Each individual was assigned a position in the network (i.e., either A, B, C, or D). Subjects remained in the same position in the network throughout the entire experiment. The experiment leader rolled a die to determine this assignment randomly. Each group of subjects played 1 of the two games for 10 rounds of maximally 3 minutes each. Subjects were informed of the number of rounds to be played. A round ended after 3 minutes had elapsed or when no further exchanges were possible. When actors didn't exchange, they didn't earn any points. Loosing points was still possible because of externalities. The number of groups per game was determined on the basis of an analysis of statistical power. Four groups played the single resource dilemma, and 5 groups played the double resource dilemma. Hence a total of 90 rounds were played in all.

Subjects were endowed with the goods and utilities corresponding to their network position (see Table 1). The goods were abstractly labeled X and Y, as in Table 1. After each round of play the resources were replenished. Subjects were able to make 1 exchange per round only. In the case of externalities, subjects were informed privately only of how *their* payoffs depended on exchanges of the other player. Players that were not subject to externalities were ignorant of the existence of the externalities. These players were kept ignorant to enable us to observe the pure effects of externalities in a given structure, without the confounding factor of other players anticipating on the externalities. Note that imposing this kind of ignorance makes rotation of subjects across positions during the experiment impossible.

Each subject earned a fixed amount of money per point. Money per point differed per network position and per game and was private information to the subjects, i.e., subjects didn't know the pay rate of other participants. Subjects only earned money for payoff changes, that is, by (i) additional points they gained in exchange, and (ii) points they lost as an externality of an exchange of another actor. Hence they did not get money for the resources they started out with. The money per point was chosen in such a fashion that the expected earnings of all subjects would be 15 US dollars. Subjects that weren't expected to earn any points, such as D in the single resource dilemma, or that were expected to loose points, such as A in the single resource dilemma and A and D in double resource dilemma, earned a base rate irrespective of their earnings in the game to compensate for this. This base rate was private information, conveyed to the subjects before starting the game. At the end of the experiments subjects on average gained approximately $15, ranging from a minimum of approximately $6 and a maximum of approximately $25.

Bargaining was unstructured in the sense that the order and timing of the offers was up to the subjects to decide. Subjects could make any number of offers they wished, to any subjects they were connected to in the network, within the time limit of 3 minutes per round. To carry out an exchange, an offer had to be accepted and the acceptation confirmed by the actor initially proposing the offer.

Subjects entered the experiment room separately. They were assigned a network position and were seated in separate cubicles where they could neither hear nor see any other subjects. Subjects did not meet before or during the experiment. They usually did meet after the experiment, when the money was paid. However, subjects didn't know this in advance. Upon being seated in their rooms, subjects received a written instruction explaining the experiment.[5] Subjects typically needed less then 10 minutes to read the instructions. After finishing reading the instructions, 3 practice rounds were played, using the 4-Line network without externalities. After completing the practice rounds, all subjects received a written form that indicated how their monetary pay depended on their points and, in the case of externalities, the points of someone else in the game (see note 5). The experiment leader then gave each subject a 10-item quiz to establish their understanding of the game (see note 5). Subjects typically took no longer than 3 minutes to complete the test. The experiment leader then checked the answers on the quiz. A correct answer was worth 20 cents, so the entire quiz was worth 2 US dollars. Very few subjects had any wrong answers and none had more than 1 incorrect answer. In case of a wrong answer, the experiment leader asked the subject to rethink the answer and explain

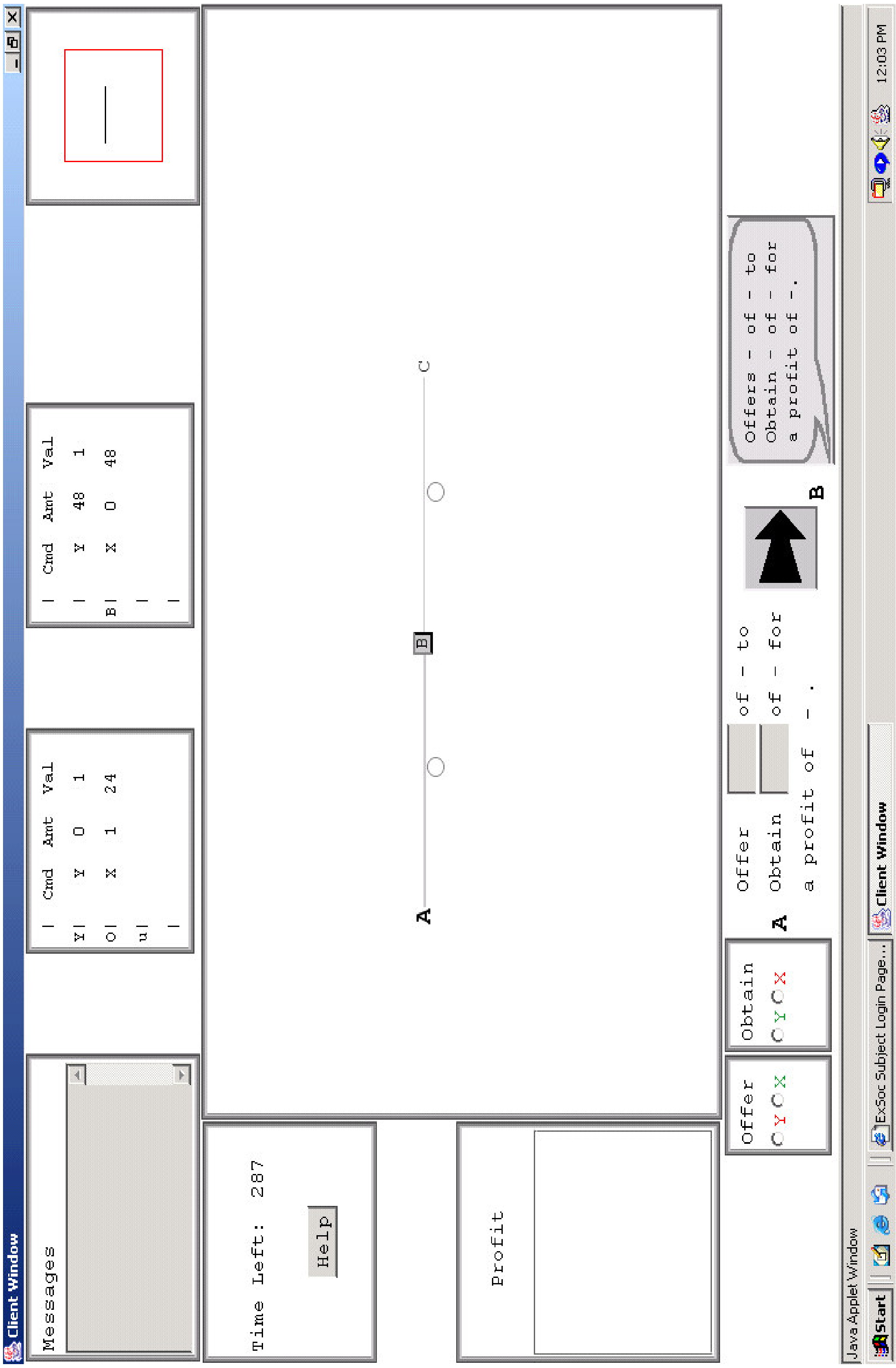

Figure 2: Screen print of actor A of the ExNet program used in the experiments.

it. All problems were then easily solved and all subjects were paid the 2 dollars for the quiz. The 10 experiment rounds then started.

Negotiations in the experiment were completed through computer terminals, employing the ExNet 3 software developed by Willer and associates at the University of South Carolina. An example screen shot is presented in Figure 2.

6.5 Results

Since the same group of subjects played the same game for 10 rounds, the experiments described above yield data that are dependent within groups. We will account for this dependency in different ways described below.

6.5.1 Single resource dilemma

Four groups of subjects played the single resource dilemma, and each group played the game for 10 rounds, yielding a total of 40 rounds. In one of these rounds no exchange was completed. In 18 rounds the exchange pattern (AB,CD) occurred, and in 19 rounds the pattern BC occurred. There were 2 rounds in which only an exchange between A and B occurred. Hypothesis 1 states that more than 17.5% of the exchanges in the single resource dilemma occur between B and C. Nineteen such exchanges were observed on a total of 39, yielding a proportion of 0.487. To account for dependencies in the data, we estimated the sandwich standard error of the logit of this probability. The logit of 0.487 is -0.051, and the sandwich standard error was 0.320, resulting in a 95%-confidence interval of this logit of [-0.679, 0.577]. Expressing the boundaries of this interval in probabilities we obtained [0.336, 0.640] as the 95%-confidence interval for the probability that B and C exchange in the single resource dilemma. The proportion of 0.175 is clearly outside this interval, corroborating Hypothesis 1 ($Z = 4.68$, $p < 0.001$).

Hypothesis 2 asserts that B earns more than 14 in the single resource dilemma. To account for the dependencies in the data we estimated a mixed model, with group of subjects on level 2. The estimated mean was 17.37 with a standard error of 2.33. Although this average exceeded 14, the difference was not significant ($t_{4.004} = 1.44$, $p = 0.11$, one-tailed test), not confirming Hypothesis 2. However, the effect size as measured with Cohen's d indicates a medium effect size ($d = 0.55$).[6]

Hypothesis 3 states that if the exchange pattern (AB,CD) occurs, the exchange between A and B will occur first. This exchange pattern was observed in 18 rounds. In 15 of these the exchange between A and B occurred first, yielding a proportion of 0.83. Multilevel logistic regression shows that this was significantly larger than 0.5, corroborating Hypothesis 3 (Wald $Z = 2.49$, $p = 0.006$, one-tailed). The 95%-confidence interval of the proportion was [0.59, 0.95].

6.5.2 *Double resource dilemma*

Five groups of subjects played the double resource dilemma for 10 rounds, yielding a total of 50 rounds. There were no rounds in which no exchange was completed. The exchange pattern (AB,CD) occurred in 15 rounds and there was one round in which only an exchange between A and B was completed. The mean payoff in exchange, before subtracting the externality effects, was 6.06 (s.d. = 4.92) for A, 16.60 (s.d. = 6.50) for B, 9.47 (s.d. = 7.66) for C and 11.27 (s.d. = 8.11) for D.

Hypothesis 4 states that an exchange between B and C occurs more in the double resource dilemma than in the single resource dilemma. In the double resource dilemma, exchange between B and C occurred in 34 out of 50 rounds, yielding a proportion of 0.68. To account for the dependencies in the data, we estimated a multilevel logistic regression model to test Hypothesis 4. The difference in proportion between the single and the double resource dilemma was then found to be marginally significant (Wald. $Z = 1.45$, $p = 0.074$, one-tailed).

6.5.3 *Additional results*

To test Hypothesis 2, B's payoff in the single resource dilemma was calculated as the average across his payoff in both of his relations. Similarly, we can also test whether B's payoff in his relation with C exceeded 12, the predicted payoff of B in the BC relation in the 4-Line without externalities. In a mixed model, with group of subjects as the second level, the estimated mean payoff for B in BC exchanges was 18.02 (2.28). This was indeed significantly larger than 12 ($t_{4.002} = 2.64$, $p = 0.029$), corroborating again the theory. The effect size was large ($d = 1.26$).

Finally, consider the situations in which only one exchange opportunity remains. That is, the AB (CD) relation after C and D (A and B) have exchanged. A standard theory of rational action would regard the isolated dyad as symmetric in which all possibly experienced externalities are 'sunk costs', that is, the externalities do not matter anymore in the bargaining of the isolated dyad. Consequently, standard theory would predict an average payoff of 12 in the experiments for these dyads. In the isolated dyads of the single recourse dilemma, C obtained 7.02 (2.71) which was marginally significantly smaller than 12 ($t_{4.051} = -1.84$, $p = 0.069$), and B obtained 13 (11.27).[7] Although only marginally significant, the effect size for C was large ($d = 0.98$).

In the isolated dyads of the double resource dilemma, C obtained 14.09 (2.88), which was not significantly different from 12 ($t_{0.331} = 0.73$, $p = 0.364$), and B obtained 15.59 (2.08), which was also not more than 12 ($t_{1.94} = 1.72$, $p = 0.115$). However, the effect size for B was large ($d = 1.11$), whereas the effect size for C was small ($d = 0.26$).

6.6 Discussion

The current paper concerned the effects of externalities in exchange networks. Despite their abundance in real-life exchanges, externalities have hardly been studied in exchange research, the sole exception being externalities in decision making (Stokman et al. 2000; van Assen et al. 2003). The current paper is one in a series that aims to experimentally investigate the effects of externalities on the exchange ratio and the partner choice in exchange networks. In the present paper the emphasis was on analyzing the effects of externalities on partner choice. The results of two experimental conditions were reported, using the 4-Line network. To formulate hypotheses concerning the expected exchange pattern, a generalization of the core solution was introduced. Hypotheses were formulated by comparing the predictions for different externality conditions. Results showed that this comparatively simple theory is able to predict the exchange pattern fairly well: all three hypotheses concerning the exchange pattern were corroborated.

Regarding the hypothesis concerning the exchange ratio in the single resource dilemma, the data also suggested that the B actor earns more than the B actor in the 4-Line without externalities. The fact that the difference was not significant can be the result of a low statistical power; using the intraclass correlation the effective sample size is shown to be equal to 6.124, a very small sample size indeed. Only large effects can be detected with reasonably high probability, when using a small sample size. The estimated effect size for the exchange ratio was 0.55, suggesting a medium effect size. The fact that the other three hypotheses were confirmed demonstrates that all observed effect sizes were large.

To conclude, our research question whether externalities affect partner choice and exchange pattern should be answered affirmatively. The results were anticipated by generalized core theory, a generalization of core theory developed by Dijkstra (2005) that can deal with both exchange networks with, and without externalities. Hence our findings imply that traditional theories of network exchange not taking into account externality effects, cannot be applied to explain or predict behavior in the many instances of exchanges with externalities that occur in real-life.

Only the 4-Line was investigated in the current paper to show that externalities affect the exchange pattern. In future research effects of externalities on partner choice can be investigated in other exchange networks. The present paper demonstrated that the generalized core theory can fruitfully be applied to derive predictions for these networks.

An interesting additional result was that in the isolated dyad CD (that is, after AB already had exchanged) C earned much (almost 5 points) less than half of the resource pool. The negative externality of –24 because of the AB exchange clearly affected the bargaining in the CD relation. Far from being a ‘sunk cost’ this negative externality seems to have made C more eager to exchange with D and more willing to make concessions in order to decrease C’s negative payoff. In the double resource dilemma C’s average payoff was not different from 12. However, when A and B exchanged first *both* C and D experienced a negative externality, which might help explain why payoffs between C and D were more equal in this condition.

In the experiments reported in the present paper externalities were implemented by actors sharing resources. An important implication of studying the effect of externalities through shared resources in exchange networks is that subjects in the experiments have to be endowed actual resources. Thus, the traditional design in which actors negotiate over the division of a fixed pool of points is inappropriate. In general an advantage of endowing subjects with resources is that is facilitates losses in exchanges, since subjects have the possibility to sell their resources for a price so low they actually loose points. Dividing a fixed pool of points does not allow incurring a loss. In the experiments reported in the present paper actor A chose to accept a loss in 2 rounds, whereas actor C accepted a loss once.

We argue that studying externalities in exchange networks is a significant innovation in exchange network research. As was demonstrated in the present paper, externalities create dilemma-like situations for actors in the network, such as the resource dilemma. There are at least two advantages of embedding dilemma situations in exchange networks. First of all the externalities are included in a larger system of goal-directed behavior. That is, actors seek to maximize their payoffs in an exchange network, which has externalities as an additional feature. We argue that this is closer to many real-life externality situations than the traditional approach of studying externalities and dilemmas in isolation. In the traditional approach the experimental situation is such that subjects are expressly focused on solving the dilemma. Secondly, by embedding externalities in exchange networks, their effects on the larger social structure can be studied. Through effects on the exchange ratios and exchange patterns, externalities have effects for actors that are not directly subject to them: there is an interaction effect of networks and externalities.

A future paper will explore the differences alluded to above, between social dilemmas as they are being been investigated commonly and social dilemmas embedded in exchange networks. In this paper results from regular prisoners dilemma research will be compared with data sets that contain prisoners dilemmas induced by externalities in exchange networks.

Notes

1. Instead of automorphically equivalent, Borgatti and Everett (1992: 291) use the terminology structurally isomorphic.
2. Resource dilemmas in which two actors share a resource that they cannot individually deplete are very common in real-life. First, consider two married partners having private wallets containing money from their common bank account. Second, consider two fishermen in the same waters with limited fishing capacity – neither of them can catch all the fish.
3. Without externalities this rationality assumption of connected actors follows directly from coalition rationality. However, in case of exchange with *positive externalities*, coalition rationality of connected actors can also hold if an exchange is not Pareto efficient. Because the spirit of core theory is that actors are rational, and Pareto efficiency is an assumption of rationality of connected actors, this assumption is included as an assumption of generalized core theory.
4. Using the payoff equations of the double resource dilemma, we obtain $P_B^{drd} + P_C^{drd} = 48 - y_B - y_D + y_D - 48 = -y_B$, which attains the maximum of 0 when $Y_B = 0$, since Y_B cannot be negative.
5. The instruction and test can be obtained from the first author.
6. Cohen's *d* for the one-sample case is calculated as $d = (\bar{X} - \mu)/s$. It indicates how many standard deviations the observed value differs from the expected value, and is often interpreted as a *z* or standardized score. Both statistics $\bar{X}$ and *s* are calculated using the mixed model approach. *d* values of 0.2, 0.5, 0.8 indicate small, medium, large effect sizes, respectively.
7. Because of a lack of statistical power a statistical test was not performed: an AB exchange occurred second in only 3 rounds.

7

Outcomes of collective decisions with externalities predicted*

* This chapter is co-authored with Marcel van Assen and Frans Stokman and is currently under review at *European Journal of Political Research*.

Abstract

In collective decision making bilateral deals between actors can increase or decrease the likelihood of finding compromises that are acceptable to all actors, depending on whether such deals have positive or negative *externalities*. Positive externalities mean bilateral deals cause outcomes to become better for actors not involved in the deal, whereas negative externalities mean outcomes become worse for actors not involved in the deal. We develop the first model of collective decision making that takes externalities into account. Given the actors' positions on the issues that have to be decided, the model computes the expected outcomes of the issues and construes four coalitions of actors on each *pair* of issues. Then it searches for alternative expected outcomes, such that no coalition can further increase the payoff of one of its members, either (i) without decreasing the payoffs of at least one of its members, or (ii) without decreasing the payoff of *any* other actor. This generally yields a range of admissible outcome shifts, and the Generalized Nash Bargaining Solution of Chae and Heidhues (2004) is used to pick a single point. The model does better than the Compromise Model of Achen, and other models in Thomson et al. (2006), when tested on data from decisions in the European Union.

7.1 Introduction

In collective decision making situations a group of actors have to accommodate their different positions on the issues that have to be decided in order to reach a final decision. Bilateral deals between (subgroups of) actors can increase or decrease the likelihood of finding compromises that are acceptable to all actors in the group, depending on whether such deals have positive or negative externalities for actors not involved in the bilateral deal. In the case of positive externalities, bilateral deals cause decision outcomes to become better for other actors not involved in the deal, whereas in the case of negative externalities, decision outcomes become worse for actors not involved in the deal. We develop a model where exchange partners explicitly try to avoid negative externalities for other actors to promote decision making by agreement. We test the model in the context of the European Union where a strong norm for unanimity has been observed repeatedly, even under qualified majority voting rules (Mattila and Lane 2001; Thomson, Stokman, Achen and König 2006).

We model collective decision making as decision making about controversial issues with single peaked preference functions, as most well-known models do (Black 1958; Bueno de Mesquita, Newman and Ravushka 1985; Bueno de Mesquita and Stokman 1994; Steunenberg 1994; Tsebelis and Garrett 1996 and many others). Decision making may well require simultaneous decisions on several issues. Different issues should represent rather independent controversial elements of the decision making situation and as a set should cover the full range of possible outcomes.

The dynamics in the decision making process result from actors, with different intensity and potential, trying to realize their preferred outcome on an issue (their initial position), whereas per issue only one outcome that is binding for all actors can be chosen. In a complex situation, possibly involving many actors, actors will try to build a coalition as large as possible behind their initial positions or behind a position that is as close as possible to theirs. This informal bargaining process can be seen as to precede formal decision making and to affect the final positions of the actors in the decision making, aiming at a collective outcome that reflects their interests as much as possible.

The dynamics of bargaining processes in decision making are therefore primarily based on processes to induce or force other actors to change their positions. Three fundamental processes can result in such shifts in positions: *persuasion*, *logrolling*, and *enforcement*.[1] Through *persuasion*, actors aim at changing each other's initial positions as well as the salience of these positions (Stokman, van Assen, van der Knoop, and van Oosten 2000). This is achieved through providing convincing information. Persuasion is particularly a dominant process in settings where common interests are stronger than diversity of interests. In such settings, unanimous cooperative solutions prevail even if formal institutions permit (qualified) majority decisions or final decision making by one or more, but not all, individuals.

Logrolling and enforcement typically do not affect initial positions and saliences. *Logrolling* can be seen as a process of negotiated exchanges between two (subgroups of) actors. The result is that actors are willing to support another position on an issue that is of relatively less importance to them in exchange for support of other actors on the issue that is relatively more important to them. Such bilateral deals between (subgroups of) actors create cooperative win-win solutions for the exchanging partners, but not necessarily for all actors. In a similar vein, actors can feel *enforced* to support another position under the pressure of power. The two processes logrolling and enforcement are primarily likely if actors' initial positions fundamentally differ because of the different weighing of ultimate goals. In such situations, arguments do not help to bring initial positions closer to one another, so coalitions can be built only through processes that affect the final or voting positions of actors.

In the social sciences, models have been developed to predict final outcomes of decision making on the basis of the formal decision making procedure, the so-called procedural models, and for each of the above bargaining processes. In the present paper we compare the predictions of our newly developed model with predictions of models in all these classes.

For persuasion processes that are oriented to encompass the full set of all actors, the Nash Bargaining Solution is applicable if certain conditions are fulfilled. Achen (2006) shows that the weighted mean of the positions of the actors can be used as a first approximation of the Nash Bargaining Solution if the reversal point of no-agreement is very unattractive and the actors are risk averse. Each of the positions is then weighted by the product of the power times the salience of the actor. That solution was earlier known as the Compromise Model (CM) (Van den Bos 1992; Stokman and Van den Bos 1994). In the present paper the CM is the baseline model to which all other models' performances are compared.

Procedural models are based on a careful analysis of the formal decision making procedures. Given the complexity of European Union decision making procedures, it is not surprising that scholars have different views on them. We compare the predictions of our newly developed model with two different well-known interpretations, namely the *Procedural Model* of Steunenberg and Selck (2006) on the one hand and the *Tsebelis Model* of Tsebelis (1996) on the other.

The best-known bargaining model assuming decision making is characterized by a process of enforcement, is the model of Bueno de Mesquita (1994; Bueno de Mesquita, Newman and Rabushka 1985). In this model actors try to strengthen the coalition surrounding their position by compelling or persuading other actors to change their positions. In the model, each actor decides whether or not to challenge the position of each other actor on an issue. The outcome of this decision is determined by the expected outcome of the challenge, which is in turn evaluated according to its expected effect on the decision outcome of the issue. In the present paper the predictions of Bueno de Mesquita's model are compared to predictions of our newly developed exchange model and to the outcomes of EU decision making.

A prominent model of logrolling processes or exchange was developed by Coleman (1972, 1990). He devised an exchange model for social exchange that has been adapted for and applied to collective decision making as well (Marsden and Laumann 1977; Laumann, Knoke and Kim 1987; König 1997; Pappi and Henning 1998). Coleman assumed that actors have interest in some events and control over other events. By exchanging control over events, mutually beneficial outcomes can be achieved. The solution is an analytic solution, based on the competitive equilibrium approach assuming that actors are price-takers. The model does not give insight into which actors exchange with which other actors at the micro level. Moreover, the major mechanism in this model is that of a market of private goods and the necessary adaptations to collective goods (binding outcomes for all) are not straightforward (see Stokman and van Oosten 1994).

In addition to the Coleman model, we investigated two other models of exchange applied to EU decision making. One of them, the *Procedural Exchange* model proposed by König and Proksch (2006), is an extension of the Coleman model in which informal bargaining and procedural voting elements are combined. The second model is the voting *Position Exchange Model* (PEM) model of Stokman and van Oosten (1994). This model assumes collective decision making is based on the micro process of bilateral exchanges of voting positions. As a consequence, positive and negative externalities of such exchanges for other actors can be assessed (van Assen, Stokman and van Oosten 2003).

In their standard textbook of microeconomics, Mas-Colell, Winston and Green (1995) define an *externality* to be present whenever the well being of an actor is *directly* affected by the actions of another actor. If an actor or a group of actors shifts its position on one or more issues, it will affect the outcome of the decision(s). As the outcome of a decision is binding for all actors, this implies that such a shift has *externalities* for all other actors. If the outcome moves away from the position of another actor, the externality is *negative*; if it moves towards the position of another actor, the externality is *positive*. We may assume that bilateral exchanges with negative externalities for others do not serve an overall consensus of all actors. If such bilateral exchanges have only positive externalities for other actors, the parochial interests of the exchanging partners coalesce with those of the whole group and we can assume that such exchanges facilitate an outcome that is acceptable for all. Within a setting where the formal or informal decision rules are based on overall consensus, we therefore assume that actors attempt to avoid bilateral exchanges with negative externalities.

The PEM enables one to investigate positive and negative externalities for others, but does not include assumptions about possible effects of positive or negative externalities for the exchange rates and/or choice of exchange partners. Application of the model in the context of the European Union, for example, showed that the negative externalities of model-predicted bilateral exchanges were about twice the size of the positive externalities (Arregui, Stokman and Thomson 2006). The authors used this finding as their main argument why the PEM did not improve on the predictions of the CM in this study, whereas it did in many other studies (e.g. Achterkamp 1999, Bueno de Mesquita and Stokman 1994, Rojer 1996). Given the fact that the European Union is a setting with a strong norm of decision making by consensus, we expect that actors adapt their exchange behavior to avoid such negative externalities. That's why we develop the *Externalities Exchange Model* (EEM) in this paper; the first formal exchange model that takes externalities into account. The EEM is based upon the game theoretic Generalized Nash Bargaining Solution (GNBS) of Chae and Heidhues (2004), and takes the CM and the PEM, that both do not take externalities into account, as its starting points. The EEM is a model of *group* exchange that incorporates externalities, in contrast to the PEM. Since the EEM is strongly related to the PEM, a separate section is devoted to the PEM later in the text. The other models that were applied are now briefly discussed.

Apart from the models mentioned above, we evaluate the performance of three other models of collective decision making. These models were all applied by Thomson, Stokman, Achen and König (2006) in their study of European Union decision making. The *Domestic Constraints Model* of Bailer and Schneider (Thomson et al. 2006, Chapter 6) models the influence of domestic politics in the member states on decision making at the European level. The *Coalition Model* of Boekhoorn, van Deemen and Hosli (Thomson et al. 2006, Chapter 7) examines the dynamics of coalition formation, both within the Council and between the Commission, the EP and the Council. Finally, Widgén and Pajala (Thomson et al. 2006, Chapter 9) present their *Issue Line Model*, in which the multi-issue decision situation is reduced to a single dimension, before being decided upon. For details on these models we once more refer to Thomson et al. (2006).

The next section discusses the general structure of collective decision making and the CM. Thereafter, the PEM and externalities in collective decision making are discussed. In the subsequent section the EEM is introduced. In the section after that, we briefly discuss the design of the study. The next section shows the results of our analysis and the paper is concluded with a discussion.

7.2 The structure of collective decision making and the CM

The models referred to in the introduction all assume the same structure of collective decision making. It is assumed that there exists a finite set *M* of controversial issues, which can each be represented by a one-dimensional interval scale. These issues are *mutually exclusive* and *exhaustive*, i.e., an actor can take a position on one issue, irrespective of his position on another issue (mutual exclusiveness), and the issues together cover the entire collective decision problem (exhaustiveness).

It is assumed that each actor *n* from the finite set of actors *N*, takes a position, x_{nm}, on the scale of each issue *m*, representing *n*'s most preferred outcome of *m*. Furthermore, each actor *n* is assumed to have a *salience*, s_{nm}, for each issue *m*, expressing the relative importance of issue *m* to the actor *n*. Finally, each actor *n* has a *capability*, c_n, reflecting *n*'s potential to affect the final outcome of each of the issues in *M*. The actors' positions, saliences and capabilities are assumed to be common knowledge. Based on this common knowledge, all actors are supposed to have a common *expected outcome*, O_m, of each issue *m*. In the CM, the PEM and the EEM, O_m is assumed to be the weighted average of the actors' positions, with weights equal to the actors' capabilities times their saliences:

$$O_m = \frac{\sum_n c_n s_{nm} x_{nm}}{\sum_n c_n s_{nm}} \qquad (1).$$

The CM predicts that the outcome of issue *m* is equal to O_m as defined in (1). Both the PEM and the EEM use Equation (1) as the commonly expected outcome of an issue, before a possible exchange.

7.3 The position exchange model and externalities

The basic idea of the PEM is that pairs of actors can mutually increase their utilities compared to their utilities of the expected outcome in (1) by exchanging their positions on pairs of issues. The PEM assumes that actors have single-peaked preferences: an actor's initial position on an issue represents his preferred outcome, and any deviation of the final outcome from it, is evaluated as strictly worse. The utility of actor *n* (U_n) over the outcomes of all the issues in *M* is assumed to be:

$$U_n = -\sum_{m \in M} s_{nm} \mid x_{nm} - O_m \mid \qquad (2).$$

Equation (2) shows that an actor's utility is assumed to be (i) additive over all issues, and (ii) decreasing linearly in the absolute distance of the outcome from the actor's position, with the salience of the issue determining the rate of decrease.[2]

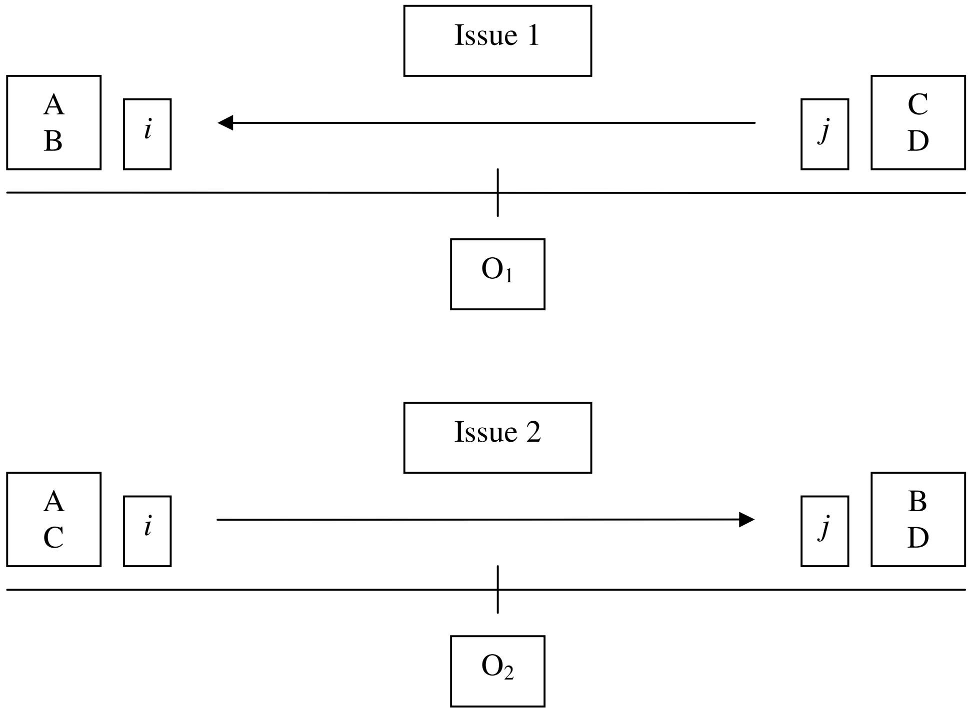

Figure 1: Exchange between actors $i \in A$ and $j \in D$ on issues 1 and 2. O_1 and O_2 indicate the expected outcomes on issues 1 and 2, respectively, before the exchange. A, B, C, and D indicate groups of actors

In the PEM, two actors are assumed to be able to exchange on a pair of issues only if they have positions on opposing sides of the expected outcomes on both issues.[3] With two issues, and their expected outcomes, we can partition the set of actors into four groups, *A*, *B*, *C*, and *D*, as is shown in Figure 1. Members of group *A* are on the left hand side of the expected outcomes on the interval scales of both issues, those of group *D* are on the right side of both issues. Members of group *B* are on the left hand side of the expected outcome on issue 1, and on the right hand side on issue 2, with members of *C* having opposite positions. From this it immediately follows that members of *A* can only potentially exchange with members of *D*, and members of *B* can only potentially exchange with members of *C*.

Exchange between two actors is profitable only if the actors have different relative saliences for the two relevant issues. Without loss of generality, assume two actors, *i* and *j*, and two issues, 1 and 2. Assume *i* and *j* are on opposite sides of the expected outcomes of issues 1 and 2. Denote the changes in the expected outcomes on issues 1 and 2, caused by position shifts of actors *i* and *j*, as δ_1 and δ_2, respectively. Then *i* and *j* can only exchange profitably if either (3) or (4) is true.

$$\frac{s_{i1}}{s_{i2}} \leq \frac{\delta_2}{\delta_1} \leq \frac{s_{j1}}{s_{j2}} \tag{3}$$

$$\frac{s_{i1}}{s_{i2}} \geq \frac{\delta_2}{\delta_1} \geq \frac{s_{j1}}{s_{j2}} \tag{4}$$

Equations (3) and (4) show that exchange is only mutually profitable if the *exchange ratio* ($\frac{\delta_2}{\delta_1}$) is in between the relative saliences. See Appendix A for a proof of why this is true. If (3) holds, *i* shifts his position on issue 1 in the direction of *j*, whereas *j* shifts his position on issue 2 in the direction of *i*. Issue 1 is then called the *supply issue* of *i* and the *demand issue* of *j*, whereas issue 2 is the demand issue of *i* and the supply issue of *j*. If (4) holds, issue 2 is the supply issue of *i* and issue 1 is the supply issue of *j*. The latter situation is depicted in Figure 1.

In the PEM all possible bilateral exchanges are determined for each pair of issues from *M*. For each of these exchanges, position shifts are determined such that the utility gains of the exchange partners are equal and at a maximum. The exchanges are then listed in the order of the size of the utility gains. The exchange with the highest utility gains is then executed, and all other possible exchanges involving one or both of the partners of this first exchange, and in which these partners use the same supply issues as in this first exchange, are deleted from the list. This process is then repeated with the remaining exchanges on the list, until the list is empty. Then, (1) is applied to all issues with the new actor positions, and these are the predictions of the PEM. See Stokman and van Oosten (1994) for details.

7.3.1 Between-group and within-group externalities

That externalities occur in collective decision making is immediately apparent from (2) and the fact that position shifts affect the outcome of (1). Van Assen et al. (2003) analyzed externalities in decision making, making a distinction between *within-group* and *between-group* externalities.

Assume, without loss of generality, that actor $i \in A$ exchanges with actor $j \in D$, with issues 1 and 2 as supply issues for *j* and *i*, respectively, i.e., the situation as depicted in

Figure 1. In the process of exchanging, both expected outcomes are shifted towards the positions of the members of group *B*, and away from the positions of the members of group *C*, who thus experience externalities of the exchange between *i* and *j*. Most members of *B* receive a windfall profit on both issues, and thus experience *positive* externalities [4], whereas the externalities for members of *C* are negative. In line with van Assen et al. (2003) we refer to this kind of externalities as *between-group* externalities: actors *i* and *j*, who are members of groups *A* and *D*, cause externalities for the members of the *other* groups *B* and *C*.

Externalities also exist for *same* group members of an exchanging actor. These externalities are referred to as *within-group* externalities. There are three possible causes of *negative* within-group externalities. If none of these causes is present, there are no or only positive within-group externalities. The three causes are: (i) the outcome shifts are in the wrong direction, (ii) the outcome shifts are in the right direction, but do not have a profitable exchange rate, and (iii) the shifts are in the right direction, have a profitable exchange rate, but at least one of the shifts is too large. Without loss of generality, consider actor $k \in A$, a fellow group member of actor *i*. Assume that the exchange between *i* and *j* mentioned above takes place. Thus, O_1 is shifted in the direction of x_{i1}. Since $k \in A$, O_1 is also shifted in the direction of x_{k1}.

Case (i) occurs whenever the relative saliences of groups are 'intermixed'. This would be the case if $\frac{s_{i1}}{s_{i2}} \geq \frac{\delta_2}{\delta_1} \geq \frac{s_{j1}}{s_{j2}} \geq \frac{s_{k1}}{s_{k2}}$. In this case, *k* disagrees with *i* on which issue to demand and which issue to supply in exchange with *j*. Case (ii) occurs whenever the relative saliences of two group members are on opposite sides of the exchange ratio. This would occur if $\frac{s_{i1}}{s_{i2}} \geq \frac{\delta_2}{\delta_1} \geq \frac{s_{k1}}{s_{k2}} \geq \frac{s_{j1}}{s_{j2}}$. In this case, *k* agrees with *i* on the direction of exchange (demanding issue 1 and supplying issue 2), but feels that too large a shift on issue 2 has been conceded, relative to the shift on issue 1 obtained. Now consider case (iii). Even when the rate is profitable for all group members some actors in the group might still lose, when the outcome on their demand issue is shifted past their most preferred outcome.[5] All actors of group *A* gain from the exchange if the sum of utilities resulting from both outcome shifts is nonnegative, or, more formally,

$$s_{i1}[\delta_1 I_{1\delta} + (2\,|\,O_1 - x_{i1}\,| - \delta_1)(1 - I_{1\delta})] - s_{i2}\delta_2 \geq 0 \forall i \in A \qquad (5).$$

In (5) $I_{1\delta}$ is an indicator function equal to 1 if $\delta_1 < |\,O_1 - x_{i1}\,|$ on *i*'s demand issue 1, and 0 otherwise. Hence no within-group externalities exist if (5) holds in the exchanging groups.

To summarize, in the CM no exchanges take place. In the PEM bilateral exchanges on pairs of issues occur, but cause between-group or within-group externalities, that are not taken into account in the PEM. In the EEM we develop below, we account for externalities in two variants, depending on whether no negative externalities are allowed whatsoever, or only negative within-group externalities are prohibited.

7.4 The externalities exchange model

The basic idea of the EEM is that all members of two groups of actors can increase their utilities compared to their utilities of the expected outcome in (1) by exchanging their positions on a pair of issues. Unlike the PEM, the EEM does not explicitly model position shifts of individual actors, but directly models the shifts in the expected outcomes of the pair of issues. Generally, a pair of expected outcome shifts can be caused by an infinite number of different position shifts of the individual actors. There are two variants of the EEM: the $\mathrm{EEM}_{\mathrm{b\&w}}$ in which both negative within-group externalities *and* negative between-group are prohibited, and the $\mathrm{EEM}_{\mathrm{w}}$ in which negative within-group externalities are prohibited, but negative between-group externalities are allowed for.

We argue that the $\mathrm{EEM}_{\mathrm{w}}$ and $\mathrm{EEM}_{\mathrm{b\&w}}$ might be applicable in different decision making situations. The $\mathrm{EEM}_{\mathrm{b\&w}}$ might be applicable in situations where the grand coalition of all actors in *N* is salient. In such a situation any negative externality, whether between-group or within-group, can be considered inadmissible. The $\mathrm{EEM}_{\mathrm{w}}$ might be applicable in situations where subsets of actors tend to cluster in the same group (i.e., *A*, *B*, *C*, or *D*) across issue pairs. Here the group structure might be more salient, and the focus might be on avoiding negative within-group externalities, but not on avoiding negative between-group externalities.

The EEM assumes that two groups of actors exchange. Based on Figure 1, two of such group exchanges exist: either between groups *A* and *D*, or between groups *B* and *C*. In the EEM, the predictions of the CM are taken as the initially expected outcomes of the issues. Then, for all possible pairs of issues, alternative outcomes are sought that are Pareto efficient and nonnegative for all actors involved. In the $\mathrm{EEM}_{\mathrm{b\&w}}$ such an outcome means that no actor in *N* can increase his utility without causing a utility loss to at least one other actor in *N*. In the $\mathrm{EEM}_{\mathrm{w}}$ such an outcome means that no member of either of the two exchanging groups can increase his utility without causing a loss to at least one other actor from these two groups. Positive externalities are allowed in both variants. The set *PE* of exchanges yielding Pareto efficient and positive outcomes of both EEM variants, is discussed below. Thereafter, we discuss the GNBS to select one exchange of *PE* that yields the EEM prediction. Finally, we discuss a procedure to deal with situations involving more than two issues.

7.4.1 The PE set under EEM_w

To avoid negative within-group externalities, none of the three causes mentioned earlier must occur. Without loss of generality, assume again a group exchange between *A* and *D*, such that the expected outcome of issue 1 is shifted towards *A* and the expected outcome of issue 2 is shifted towards *D*, as depicted in Figure 1. Causes (i) and (ii) of negative within-group externalities can then be avoided if and only if $\frac{s_{a1}}{s_{a2}} \geq \frac{\delta_2}{\delta_1} \geq \frac{s_{d1}}{s_{d2}}$, for all $a \in A$ and $d \in D$, and (iii) is avoided if (5) holds.

Assume (i) to (iii) can be met simultaneously by a non-empty set Δ of outcome shifts (δ_1, δ_2). Denote the maximum value of δ_m in Δ as $\delta_m^{\max 1}$. A subset of Δ might not be feasible, i.e., some values of δ_1 and δ_2 might not be possible because the actors in the groups are not powerful enough to affect this shift. Define $\delta_m^{\max 2}$ as the maximum outcome shifts that can be affected by all actors in *D* and *A* [6], and $\delta_m^{\max} = \min(\delta_m^{\max 1}, \delta_m^{\max 2})$. Then the set of feasible issue shifts Δ and Δ^w can be defined as:

$$\Delta = \{\delta = (\delta_1, \delta_2) : 0 \leq \delta_1 \leq \delta_1^{\max}, 0 \leq \delta_2 \leq \delta_2^{\max}\} \quad (6),$$

$$\Delta^w = \{\delta = (\delta_1, \delta_2) : 0 \leq \delta_1 \leq \delta_1^{\max}, 0 \leq \delta_2 \leq \delta_2^{\max}, \frac{s_{a1}}{s_{a2}} \geq \frac{\delta_2}{\delta_1} \geq \frac{s_{d1}}{s_{d2}} \forall a \in A \wedge d \in D\} \quad (7),$$

where it is understood that shifts are in the appropriate direction. The set *PE* or Δ_{PE}^w is a subset of Δ^w and is described formally in Appendix B. If negative within-group externalities cannot be avoided then Δ_{PE}^w is defined to have only one element, (0, 0).

7.4.2 The PE set under $EEM_{b\&w}$

Denote the *PE* set under $EEM_{b\&w}$ by $\Delta_{PE}^{b\&w}$. $\Delta_{PE}^{b\&w}$ is a subset of Δ_{PE}^w. From the discussion of between-group externalities it follows immediately that negative between-group externalities can be avoided if and only if one of the groups in Figure 1 has no members while the outcomes of the issues are shifted in the direction of the possibly remaining, non-exchanging group. In terms of our example exchange between *A* and *D*, condition $C = \{\varnothing\}$ should be added to (7) to find $\Delta^{b\&w}$. A second and final condition to be added is that all actors in *B* should profit from the exchange,

or $\sum_{m=1}^{M} (s_{im}[\delta_m I_{m,\delta} + (2 | O_m - x_{im} | - \delta_m)(1 - I_{m,\delta})) \geq 0 \forall i \in B$. $I_{m,\delta}$ is an indicator function equal to 1 if $\delta_m < | O_m - x_{im} |$ and 0 otherwise. $\Delta_{PE}^{b\&w}$ is a subset of $\Delta^{b\&w}$ and is formally described in Appendix B. If negative externalities cannot be avoided then $\Delta_{PE}^{b\&w}$ is defined to have only one element, (0, 0).

7.4.3 *Selecting one element from PE*

To single out an element from the *PE* set the EEM uses the Generalized Nash Bargaining Solution (GNBS) of Chae and Heidhues (2004). Chae and Heidhues generalized the solution of Nash (1950) to situations of group bargaining, which has a number of desirable properties.[7] The GNBS is the value of δ that maximizes the weighted product of utility gains, or

$$\underset{\delta \in \Delta_{PE}}{Max} \prod_{n \in N^*} [U_n(\delta)]^{r_n} \qquad (8),$$

with utility gain U_n, and group of actors N^*. In the case of the EEM$_w$ $N^* = A \cup D$ or $N^* = B \cup C$, in the case of EEM$_{b\&w}$ $N^* = N$. The GNBS weighs the utility of each actor by the reciprocal of the size of the group to which he belongs. Correspondingly, the EEM takes as weights the capability of the actor relative to the total capability of the group to which he belongs. Letting G_n denote the group of which actor *n* is a member, the relative capability of *n*, r_n, is then:

$$r_n = \frac{c_n}{\sum_{i \in G_n} c_i} \qquad (9),$$

with $G_n = N$ in the case of the EEM$_{b\&w}$, and G_n equals the group to which *i* belongs (*A*, *B*, *C*, or *D*) in the case of the EEM$_w$. In the case of the EEM$_{b\&w}$, this yields the GNBS without group structure.

If Δ_{PE} contains only (0, 0) then the EEM identifies this as the solution, which is equal to that of the CM. If it contains more elements, a unique solution to the maximization problem of (8) exists if the utility space is compact and convex. That this is true is shown in Appendix C. Hence the EEM model always identifies a unique solution.

Two comments are warranted on the GNBS. First, note that while negative externalities within N^* are avoided, the GNBS also takes into account positive externalities through the product of the weighted utilities in (8). Second, (9) shows that actors' weights are computed *within* groups, implying that the weights within each group sum to 1. This in turn implies that each group is 'equally influential' in determining the solution to (8), regardless of its number of members or their relative capabilities compared to other groups. That is, whether a group consists of one or many members, whether these members are each individually powerful or weak, for profitable exchange to occur, the group is needed anyhow. There is an analogy to a monopolistic market: the fact that the supplier is only 1 actor facing a multitude of demanders doesn't imply that the supplier is weak. For profitable exchange to occur, he is simply needed. However, note that in the EEM the summed capabilities of a group *do* determine the group's power to shift the expected outcomes of the issues.

7.4.4 Procedure in case of more than 2 issues

In case of more than 2 issues choices have to made concerning which group exchanges to execute. The following procedure is suggested and employed in our application:

- (i) Compute (1) for all issues
- (ii) Compute the prediction of the EEM for all $M(M\text{-}1)$ exchange possibilities
- (iii) Actors vote for their most preferred exchange opportunity
- (iv) Select from the list of (remaining) issue pairs the one with the highest weighted votes
- (v) Eliminate all issue pairs from the list containing one of the two issues on which the exchange in (iv) took place
- (vi) If the list is not empty after (v), go back to step (iv)

On each of the $M(M\text{-}1)/2$ issue pairs there are 2 exchange opportunities, one between groups A and D, and one between groups B and C. If no exchange is possible or PE is empty, the solution of the EEM is identical to the solution of the CM, and $U = 0$.

We generalized the idea of voting for positions or outcomes to the voting procedure in (iii) in which actors vote for exchanges instead of positions. It is assumed that each actor votes for that exchange opportunity in the list that yields him the largest positive utility change. Hence we assume myopic actors and exclude strategic voting.[8] An actor's vote is weighted by the capability of the actor, relative to the sum of capabilities of all actors in N. The exchange with the highest sum of weighted votes is executed first. Actors vote only once, at the beginning of the process. If there is a tie, one issue pair is selected at random. In the data analyzed in this study, ties didn't occur.

The voting procedure is identical for the $EEM_{b\&w}$ and the EEM_{w}. Thus, whether both negative between-group *and* negative within-group externalities are avoided, or *only* negative within-group externalities are avoided, *all* actors get to vote for their most preferred exchange. This way, the EEM always accounts for within-group externalities in the voting procedure.

7.5 Research design

The current paper uses the data collected by Thomson et al. (2006), which they used for testing a large number of models that predicted decision outcomes of EU decision making. In this section we briefly describe the data and the way they were collected. For details we refer to Thomson et al. (2006).

The data concern 162 controversial issues in 66 proposals of the European Commission, discussed by the Council in the period of January 1999 – December 2000. The Council consists of the Ministers of the members states, who deal with the relevant policy areas in their home country. The actors in the decision making arena are the 15 member states at the time of data collection (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Portugal, Spain, Sweden and the United Kingdom), the European Parliament (EP) and the Commission.

Data on the relevant issues within each Commission proposal and the positions, saliences and capabilities of the actors were collected by means of interviews with 125 experts on the matter. The EP and Commission were conceived of as unitary actors in their dealings with the Council. Decision making within the EP and the Commission is thus not taken into account.

There are two dimensions determining the decision procedure to which a proposal is subjected. The first pertains to the involvement of the EP. Under *consultation* the EP can merely give its view on the proposal, whereas under *co-decision* the EP has actual influence on the decision. The second dimension pertains to the majority needed in the Council when voting for a proposal. Here the distinction is between the *qualified majority* rule and the *unanimity* rule. Under unanimity, formally all EU Member States have equal weight, under qualified majority larger Member States have more votes than smaller ones, at the time of the study ranging from 10 votes for the four largest Member States to two votes for Luxembourg. Under qualified majority, 62 votes are required to reach a decision.

Within each proposal the experts distinguished between 1 and 6 issues, each of which is construed as a one-dimensional interval scale. The experts were asked to indicate, for each issue, the most preferred outcome for each actor, which was taken as this actor's *position* on the issue. In the data, the position scales were standardized so that the extremes are 0 and 100, defined by the most extreme positions favored by any of the actors. Not all actors had a position on all issues: on average 15.61 of the 17 actors took positions on each of the 162 issues. Of the 162 issues in the data set, thirty-three of these have only two possible positions, and are called *dichotomous*.

The experts also estimated the *salience* of each of the issues for each of the actors, on a scale of 0 to 100. A score of 0 indicates that the issue is of no importance whatsoever for the actors, whereas a score of 100 indicates that the issue is of the highest importance to the actor.

Actors' *capabilities* were estimated using the Shapley Shubik Index (SSI: Shapley and Shubik 1954). To apply the SSI, all permutations of the actors in a decision making situation are considered. For each permutation, the actor that turns a losing coalition into a winning coalition is called *pivotal*. The SSI of an actor is then the number of times an actor is pivotal divided by the number of permutations.

All models are applied to each proposal separately. For instance, in the EEM, only exchanges using two issues from the same proposal are analyzed. Exchanges concerning issues from different proposals are assumed not to occur since the proposals were dealt with by the EU at different points in time.

7.6 Results

The predictions of the EEM were compared to those of the CM, the PEM and the other models from Thomson et al. (2006). First, we will present the descriptive statistics of the EEM and the other models, followed by a comparison of the EEM to the CM on all the issues involved. After that, we will present the results of separate analyses on dichotomous and non-dichotomous issues, comparing the EEM to the CM. Then, we will present the results of comparisons of the EEM to the other models from Thomson et al. (2006).

The main statistical tools used are sequential regression and logistic regression analysis. In each case, the observed outcome of the issues is regressed on the model predictions. We examine and test to what extent the outcome can be predicted using the EEM prediction, both alone and in addition to what can be predicted using the other models CM, PEM, etc.

7.6.1 Descriptives

The data contain 162 issues. The EEM analyzes Pareto efficient outcome shifts with respect to the CM, on *pairs of issues*, within one proposal. There were fourteen proposals in the data with just one issue, for which the EEM, CM, and PEM provide the same prediction. Our results only concern the 148 issues for which the three models' predictions might differ.

Of these 148 issues, the EEM_w's predictions differed from the CM's on 65, indicating that negative within-group externalities could frequently be avoided when exchanging. Of these 65 issues, the $EEM_{b\&w}$ differed from the CM on only 9, indicating that both negative between-group *and* negative within-group externalities could seldom be avoided. The upper-right triangle in Table 1 shows the correlations of all the models'

Table 1: Pearson Correlations between models and observed outcome; upper-right triangle contains all issues lower-left triangle contains non-dichotomous issues only; N in parentheses

	Outcome	CM	$EEM_{b\&w}$	EEM_w	Proc	PEM	Domestic	Coalition	P.E.	Tsebelis	Coleman	I.L.	BdM
Outcome	-	0.47**	0.47**	0.51**	0.24*	0.43**	0.38**	0.44**	0.34**	0.31**	0.28**	0.26**	0.35**
		(162)	(148)	(148)	(107)	(137)	(162)	(162)	(113)	(113)	(113)	(113)	(162)
CM	0.44**	-	0.99**	0.94**	0.53**	0.76**	0.76**	0.98**	0.52**	0.46**	0.75**	0.39**	0.49**
	(129)		(148)	(148)	(107)	(137)	(162)	(162)	(113)	(113)	(113)	(113)	(162)
$EEM_{b\&w}$	0.41**	0.99**	-	0.96**	0.54**	0.78**	0.76**	0.96**	0.52**	0.46**	0.80**	0.34**	0.50**
	(116)	(116)		(148)	(96)	(137)	(148)	(148)	(101)	(101)	(101)	(101)	(148)
EEM_w	0.44**	0.93**	0.94**	-	0.54**	0.83**	0.70**	0.91**	0.50**	0.47**	0.76**	0.30**	0.48**
	(116)	(116)	(116)		(96)	(137)	(148)	(148)	(101)	(101)	(101)	(101)	(148)
Procedural	0.32**	0.60**	0.61**	0.60**	-	0.51**	0.37**	0.51**	0.71**	0.71**	0.34**	0.66**	0.23*
	(88)	(88)	(78)	(78)		(91)	(107)	(107)	(105)	(105)	(105)	(105)	(107)
PEM	0.32**	0.79**	0.81**	0.85**	0.53**	-	0.45**	0.73**	0.44**	0.47**	0.46**	0.26*	0.40**
	(114)	(114)	(114)	(114)	(77)		(137)	(137)	(96)	(96)	(96)	(96)	(137)
Domestic	0.38**	0.71**	0.69**	0.62**	0.42**	0.46**	-	0.74**	0.41**	0.36**	0.65**	0.32**	0.31**
	(129)	(129)	(116)	(116)	(88)	(114)		(162)	(113)	(113)	(113)	(113)	(162)
Coalition	0.40**	0.97**	0.95**	0.89**	0.57**	0.76**	0.70**	-	0.51**	0.45**	0.73**	0.35**	0.44**
	(129)	(129)	(116)	(116)	(88)	(114)	(129)		(113)	(113)	(113)	(113)	(162)
Procedural Exchange	0.38**	0.56**	0.57**	0.55**	0.74**	0.47**	0.47**	0.51**	-	0.85**	0.36**	0.76**	0.10
	(93)	(93)	(82)	(82)	(86)	(81)	(93)	(93)		(113)	(113)	(113)	(113)
Tsebelis	0.27**	0.50**	0.51**	0.51**	0.72**	0.50**	0.42**	0.47**	0.85**	-	0.30**	0.76**	0.14
	(93)	(93)	(82)	(82)	(86)	(81)	(93)	(93)	(93)		(113)	(113)	(113)
Coleman	0.31**	0.71**	0.76**	0.72**	0.36**	0.49**	0.58**	0.70**	0.40**	0.34**	-	0.18**	0.27**
	(93)	(93)	(82)	(82)	(86)	(81)	(93)	(93)	(93)	(93)		(113)	(113)
Issue Line	0.26*	0.38**	0.31**	0.27*	0.65**	0.23**	0.37**	0.30**	0.71**	0.71**	0.18**	-	0.07
	(93)	(93)	(82)	(82)	(86)	(81)	(93)	(93)	(93)	(93)	(93)		(113)
BdM	0.35**	0.43**	0.43**	0.42**	0.21	0.44**	0.20*	0.40**	0.12	0.13	0.24*	0.07	-
	(129)	(129)	(116)	(116)	(88)	(114)	(129)	(129)	(93)	(93)	(93)	(93)	

Note: *. Correlation is significant at the 0.05 level (2-tailed); **. Correlation is significant at the 0.01 level (2-tailed) predictions with each other and with the observed outcome of the decision making process.

Of the 148 issues, 32 were dichotomous and 116 were non-dichotomous. The EEM_w's predictions differed from the CM's on 11 of the dichotomous and 54 of the non-dichotomous issues. Of these issues the $EEM_{b\&w}$'s predictions differed on 2 of the dichotomous issues and on 7 of the non-dichotomous issues. The lower-left triangle of Table 1 shows the correlations for non-dichotomous issues only. The predictions of the EEM and the CM for dichotomous issues lie in the interval [0, 100]. Observed outcomes, however, are either 0 or 100. To evaluate the number of hits of each model in case of dichotomous issues, we set model predictions in the interval [0, 50) equal to 0 and predictions in the interval [50, 100] equal to 100. The proportions of correct predictions of the CM, the $EEM_{b\&w}$ and the EEM_w were then 0.64, 0.66 and 0.72, respectively. These proportions were all significantly larger than 0.5 ($p = 0.082$, $p = 0.056$, $p = 0.011$, 1-tailed binomial test, respectively). The proportions of all other models were lower than 0.72, except for the PEM that had a proportion of 0.88.

7.6.2 Comparing the $EEM_{b\&w}$ to the CM

The $EEM_{b\&w}$'s predictions differed from the CM's on only 9 issues. The correlations between the models' predictions and the outcome on these issues were 0.51 for the $EEM_{b\&w}$, 0.44 for the EEM_w, 0.38 for the CM, and 0.15 for the PEM, respectively. Thus, as expected, the $EEM_{b\&w}$ predicted best on this sample of 9 issues. Note that no powerful statistical test could be performed because of the low number of cases.

Table 2: Regression estimates; standard errors in parentheses; observed outcome as dependent variable; Model I with CM only; Model II with CM and EEM_w

	All issues OLS Regression (N = 148)		**Non-dichotomous issues OLS Regression (N = 116)**		**Dichotomous issues Logistic Regression (N = 32)**	
	Model I	**Model II**	**Model I**	**Model II**	**Model I**	**Model II**
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Constant	15.63***	15.58***	21.27***	21.43***	-2.06***	-2.70***
	(6.37)	(6.21)	(6.94)	(6.90)	(0.88)	(1.03)
CM	0.67***	-0.15	0.57***	0.15	0.04****	-0.17*
	(0.11)	(0.30)	(0.12)	(0.31)	(0.01)	(0.12)
EEM_w		0.82***		0.42*		0.22**
		(0.28)		(0.28)		(0.12)
-2LL					34.83	26.41***
R^2	0.215	0.258***	0.176	0.192*		

Note: 1-tailed t-test when OLS regression and 1-tailed Wald Z-test when logistic regression, for parameters. For R^2 and -2LL significance of change was tested with 1-tailed F-tests and 1-tailed χ^2-tests, respectively. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

7.6.3 Comparing the EEM_w to the CM

The results of sequential regression and logistic regression analyses on all cases are summarized in Table 2. In the first step of the sequential analyses the CM was entered, in the second step the EEM_w. The main result of these analyses was that adding the EEM_w prediction to the equation improved the prediction of the outcome.

If all cases were analyzed simultaneously, adding the EEM prediction increased R^2 by 0.043 (F = 8.49, df1 = 1, df2 = 145, p = 0.002, 1-tailed). This corresponds to a small to intermediate effect size (Cohen 1988). Keeping constant the CM's prediction, a unit increase in the EEM_w's was associated with an average increase in the outcome equal to 0.82. If only non-dichotomous issues were analyzed, the explained variance increased by 0.016 (F = 2.23, df1 = 1, df2 = 113, p = 0.069, 1-tailed), which corresponds to a small effect. Here, the coefficient of the EEM_w's prediction was 0.42. Finally, if only dichotomous issues were analyzed the EEM_w also improved the prediction of the outcome significantly ($\chi^2 = 8.42$, df = 1, p = 0.002, 1-tailed). Controlling for the CM's prediction, a unit increase in the EEM_w's prediction on average increased the odds of outcome 100 by a factor 1.25.

It is also important to note that before adding the EEM_w's prediction the CM's prediction explained a significant part of the outcome, but that this was no longer true after entering the EEM_w's prediction. That is, the EEM_w could explain what was explained by the CM, and explained part of the outcome that could not be explained by the CM. A strange result was that the coefficient of CM was negative in case of dichotomous issues (Wald Z = 2.23, p = 0.932, 1-tailed); controlling for the EEM_w's prediction, if CM predicted a larger probability of outcome 100, then this outcome was *less likely*. We can only attribute this strange result to sampling error.

The analyses were also performed only on 65 those issues for which the EEM_w and CM produced different predictions. Because of a lack of cases, the analysis could not be performed on dichotomous issues only. Taking all issues together, adding the EEM_w to the CM significantly increased R^2 by 0.102 (F = 9.18, df1 = 1, df2 = 62, p = 0.002, 1-tailed), corresponding to an intermediate to large effect size. Adding the EEM_w to the CM for non-dichotomous issues only also significantly increased R^2, by 0.031 (F = 2.17, df1 = 1, df2 = 51, p = 0.044, 1-tailed), corresponding to a small to intermediate effect size.

We also tested whether the predictive success of the EEM_w and the CM differed across decision procedures (either consultation or co-decision, and either qualified majority voting or unanimity), and policy areas (internal market, agriculture and other areas). Only an effect of policy area was found; both the EEM_w and CM performed worse on non-dichotomous issues in the area of the internal market, compared to the other policy areas (R^2-change = 0.076, p = 0.004 and, R^2-change = 0.061, p = 0.013, 2-tailed, respectively).

7.6.4 Comparing the EEM_w to the other models

There were only 14 dichotomous issues for which all the models discussed earlier provided a prediction, which was too low a number to reliably estimate a logistic regression model. Concerning the non-dichotomous issues, there were 75. Table 3 shows the estimates of the OLS regression including all models, on these 75 issues.

Table 3: OLS Regression estimates; standard errors in parentheses; observed outcome as dependent variable; Model I with CM only; Model II with CM and EEM_w; Model III with CM, EEM_w and PEM; Model IV with all models; N = 75

	Model I	**Model II**	**Model III**	**Model IV**
	Coefficient	Coefficient	Coefficient	Coefficient
Constant	26.00*** (8.99)	28.50*** (8.35)	28.40*** (8.39)	34.14*** (9.95)
CM	0.54*** (0.15)	-0.64** (0.35)	-0.61** (0.36)	-1.97*** (0.75)
EEM_w		1.15*** (0.32)	1.25*** (0.36)	1.22*** (0.37)
PEM			-0.13 (0.22)	-0.01 (0.26)
Procedural				-0.02 (0.15)
Domestic				0.12 (0.15)
Coalition				0.82 (0.52)
Procedural Exchange				0.42*** (0.16)
Tsebelis				-0.29** (0.16)
Coleman				0.01 (0.12)
Issue Line				0.09 (0.18)
BdM				0.08 (0.12)
R^2	0.161	0.291***	0.294	0.401

Note: 1-tailed t-test for parameters. For R^2 significance of changes was tested with 1-tailed F-tests. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

In Model II, adding the EEM_w to the model with only the CM, yielded a significant increase in R^2 of 0.13 (F = 13.21, df1 = 1, df2 = 72, p = 0.0005, 1-tailed). This increase corresponds to a large effect (Cohen 1988). We note that the improvement caused by the EEM_w for these 75 issues was much larger than the improvement for all 116 non-dichotomous issues. Adding the PEM in Model III yielded an insignificant increase in R^2 of 0.003 (F = 0.34, df1 = 1, df2 = 71, p = 0.281, 1-tailed). Adding all the other models in Model IV increased R^2 with 0.107, which was not significant (F = 1.41, df1 = 8, df2 = 63, p = 0.105). In Model IV, the parameters of the Procedural Exchange and the Tsebelis models were significant (t = 2.64, p = 0.005, and t = -1.83, p = 0.036, 1-tailed, respectively), although the latter was negative. Models II, III and IV show that adding other models yielded a *negative* parameter for the CM, which produces a weird interpretation. The parameter of the EEM_w was significantly positive in all models.

Analyzing all 148 issues, we also compared the EEM_w to all models other than the CM, by starting with the other model and then adding the EEM_w. For non-dichotomous issues, this always led to a significant increase in R^2. Hence, the EEM_w could explain part of the outcome that could not be explained by each of the other models alone. For dichotomous issues, the EEM_w did not significantly reduce -2LL when added to the PEM ($\chi^2 = 0.086$, df = 1, p = 0.385, 1-tailed). Finally, we reversed the order of analysis, i.e., we started with the EEM_w and then added another model. For non-dichotomous issues this led to a marginally significant increase in R^2 of 0.019 (F = 2.09, df1 = 1, df2 = 79, p = 0.076, 1-tailed) only when adding the Procedural Exchange Model, which corresponds to a small effect. However, this one marginal significant effect can be explained by chance alone, i.e., if the null hypothesis is true in all 8 tests.[9] For dichotomous issues, -2LL *was* significantly decreased when adding the CM to the EEM_w ($\chi^2 = 4.46$, p = 0.015, 1-tailed). However, the parameter for the CM was then *negative* (-0.17, with S.E. = 0.12), indicating the predictive failure of the CM. The only other model that significantly decreased -2LL when added to the EEM_w, while simultaneously having a positive parameter value, was the PEM ($\chi^2 = 5.32$, p = 0.01, 1-tailed).

7.7 Conclusions and discussion

In decision making contexts with a strong norm of unanimity, such as the European Union, externalities of exchanges between (subgroups of) actors play an important role in the decision making process. Negative externalities impede the achievement of a general consensus, and will be frowned upon, whereas positive externalities promote general consensus and will be applauded. Despite the abundance of externalities in decision making and despite the fact that field and experimental data allude to their importance for the outcomes of the decision making process, prior to this paper no formal model existed that accounts for externalities. Thus, the *Externalities Exchange Model* (EEM) developed in this paper is the first formal model of collective decision making that takes externalities of exchange into account.

Two variants of the EEM exist. The $EEM_{b\&w}$ prohibits both negative within-group *and* negative between-group externalities, whereas the EEM_w prohibits only within-group externalities. The EEM models are based on the game theoretic GNBS of Chae and Heidhues (2004). If negative externalities cannot be prevented, the EEM identifies the weighted average of all actors' voting positions as the solutions for a pair of decision issues, which equals the solution of the CM. Otherwise, the EEM prediction equals the GNBS of the set of permissible Pareto efficient group exchanges.

Although based on the principles of bilateral exchange, the EEM does not model positions shifts of individual actors, but directly models shifts in the expected outcomes of the issues. It was proven that the EEM always identifies a unique solution. A procedure was proposed to deal with decision situations consisting of more than two issues. In this procedure all actors vote for the group exchange yielding their largest utility gain. The group exchanges are then carried out in the order of the sum of weighted votes, after deleting those issues that were already used in a previous exchange. The voting procedure thus assumes that actors' weighted votes set the 'agenda', determining the order in which the issues are dealt with. The most powerful actors, i.e., the actors with the largest weights, have the largest influence on this agenda setting. This appears to be a plausible assumption. An additional assumption of the voting procedure is that actors are 'myopic' in the sense that they do not vote strategically. That is, they do not account for the way in which their individual votes add up with the votes of all other actors to produce the eventual order of the group exchanges. Since the EEM is otherwise based on assumptions of rational actor behavior, an elaboration of the EEM might therefore include strategic behavior in the voting phase.

The EEM models were applied to decision making on 162 issues in the EU. Analyses were performed on 148 issues for which the predictions of the EEM, the CM, and the PEM were not identical. In group exchanges involving 65 of these issues, within-group externalities of exchange could be avoided. On only 9 issues out of these 65, negative externalities of exchange could be avoided. On these 9 issues the $EEM_{b\&w}$ outperformed the EEM_w, the CM, and the PEM, as expected, although no statistically powerful test could be performed.

Our analyses focused on comparing the EEM_w to the CM, a model that was said to outperform many more sophisticated models (Thomson et al. 2006). Our results were conclusive: the EEM_w could explain all that was explained by the CM, and additionally explained part of the outcome that could not be explained by the CM. The effect size varied across analyses from almost intermediate to large, and was largest when only the 75 non-dichotomous issues for which all models yielded a prediction were analyzed. A possible explanation for this large effect size is that on these 75 issues the outcome that would obtain when no agreement would be reached was clearly identified, which was not the case for the other issues. When this point of no agreement or reversal point is identified, it becomes easier for actors to determine the value of outcome shifts, since the reversal point provides the scale with a reference point. Consequently, exchange processes are facilitated, since it is easier for actors to negotiate about the size of the shifts. The success of the EEM compared to that of the CM is indirect evidence that groups of actors indeed exchange in order to increase their utilities.

The EEM_w also outperformed the PEM on non-dichotomous issues; it could explain what was explained by the PEM, and explained part of the outcome that could not be explained by the PEM. The success of the EEM_w compared to that of the PEM is indirect evidence supporting the hypothesis that actors, while exchanging, account for negative externalities of exchange for other actors with whom they agree on both non-dichotomous issues. Incorporating all other models as well, there was only minor evidence that the Procedural Exchange model explained part of the outcome that could not be explained by the EEM_w or any of the other models.

The EEM_w outperformed all other models on dichotomous issues, except the PEM, which outperformed the EEM_w. The PEM also outperforms the other models on dichotomous issues in the current paper and in Thomson et al. (2006). It might be that, when dealing with dichotomous issues, exchange is easier to envision for actors than when dealing with non-dichotomous issues. With dichotomous issues, exchange simply means, ‘I vote for you on this issue, if you vote for me on the other.’ No ‘shifting in the direction of the other’ is involved. Therefore, the model of exchange underlying the PEM and the EEM might be closer to the actual decision making process when dealing with dichotomous issues, than when dealing with non-dichotomous ones. This raises interesting research questions concerning the conditions under which exchange actually occurs in decision making and when it is a valid model of it, yielding accurate predictions.

Note that we have presented no data, and thus have performed no tests, concerning the actual decision *process*. Therefore, we cannot be sure whether the conception of decision making as ‘group exchanges without negative externalities’, as assumed by the EEM, is ecologically valid. Nevertheless, the good overall performance of the EEM_w relative to the other models points to the determining influence externalities have on the outcomes of decision making, and the necessity of accounting for them in any model of decision making.

The fact that the solutions resulting from the EEM are Pareto efficient under the relevant coalition structure, doesn’t imply that there exist no actors that could improve on the solution for themselves. More specifically, as the PEM shows, pairs of actors will generally have exchange opportunities that are profitable for both partners, but cause negative externalities for others, possibly including their fellow group members. Hence, abstaining from these exchanges is an indication of solidarity, resembling making contributions to a collective good or cooperating in a resource dilemma (see for instance Hardin 1968). This raises questions concerning the conditions under which such contributions occur. One would expect that in decision making contexts in which the composition of the groups from Figure 1 differs markedly across issue pairs, negative between-group externalities are unacceptable, rendering the $EEM_{b\&w}$ the appropriate model. In more polarized contexts however, where the same groups of actors frequently agree on pairs of issues, negative between-group externalities might be acceptable, but negative within-group externalities are prohibited. We explored this hypothesis for the data analyzed in the current paper. Within the 148 proposals containing 2 or more issues, there were 179 issue pairs. For each pair of actors, we analyzed whether the observed proportion of times they were in the same group, differed significantly from the proportion expected, if actors were randomly distributed over the four groups on each issue pair, given the marginal distributions observed in the data. We indeed found significant clustering in the data. By and large there were two groups of countries distinguishable: countries mostly from northern Europe clustered together on pairs of issues (Austria, Denmark, Finland, Germany, The Netherlands, Sweden and the UK), as did southern member states (France, Greece, Italy, Portugal and Spain). Other actors were either isolated (the Commission and the EP) or hard to place in a single cluster (Belgium, Ireland and Luxembourg). According to our hypothesis, this would indicate that negative between-group externalities were acceptable, possibly explaining the predictive success of the EEM_w compared to the CM.

Investigating the conditions under which negative between-group or within-group externalities are accepted, and the consequences this has for the predictive power of the $EEM_{b\&w}$ and the EEM_w compared to other models, appears a fruitful alley for future research. Especially the clustering found in the data, based on actors' positions on the issues, seems a promising lead. The EEM should be applied to a variety of data sets together with an analysis of the clustering, to see whether our hypothesis from the previous paragraph is corroborated. Another approach would be to design experiments with induced positions, saliences and capabilities to investigate the predictive power of the EEM and the effects of clustering.

Finally, interesting questions arise concerning how the structure of actor positions on issues and the clustering into groups resulting from this, interacts with formal and informal decision rules, such as (the pressure for) unanimity, qualified majority and simple majority, or the urge to compensate losing minorities on future decisions.

Notes

1. In his sociological critique of economic models of politics, Udehn (1996) derives the same three fundamental processes from the literature.
2. Equation (2) does not imply that we impose that each actor's utility is negative. Adding an arbitrary constant to (2) does not change all models' predictions.
3. If both actors are on the same side of the expected outcome, a shift of the position of the actor closest to the expected outcome in the direction of the position of the actor farthest from the outcome is profitable for both actors. Since it is profitable for both, exchange is not necessary.
4. A member of B can experience negative externalities if an issue shift on at least one of the issues is too far. See Appendix B for a formal description of this condition in the formalization of $\Delta_{PE}^{b\&w}$.
5. All actors in one group gain whenever the exchange rate is profitable and $\delta_1 \leq | x_{k1} - O_1 |$ holds for all actors k in that group. One actor k of that group certainly loses if $\delta_1 > 2 | x_{k1} - O_1 |$, since he then loses on both his supply and demand issues. For each actor k there is a value of $y \in (1,2]$ such that k does not profit from the exchange but is indifferent between no exchange and this exchange with a shift equal to $y | x_{k1} - O_1 |$.
6. The maximum outcome shift $\delta_1^{\max 2}$ is equal to $\left| \frac{\sum_{n \in D} c_n s_{n1}}{\sum_{n \in N} c_n s_{n1}} e_1 - \frac{\sum_{n \in D} c_n x_{n1} s_{n1}}{\sum_{n \in N} c_n s_{n1}} \right|$, with e_1 equal to the extreme of the interval scale of issue 1. Similarly,
$$\delta_2^{\max 2} = \left| \frac{\sum_{n \in A} c_n s_{n2}}{\sum_{n \in N} c_n s_{n2}} e_2 - \frac{\sum_{n \in A} c_n x_{n2} s_{n2}}{\sum_{n \in N} c_n s_{n2}} \right|.$$
7. The GNBS is (i) Pareto efficient, (ii) invariant with respect to affine transformations of utility, (iii) independent of irrelevant alternatives and (iv) symmetric, and satisfies the 'representation of a homogeneous group' property. See Nash (1950) and Chae and Heidhues (2004) for details.
8. An example where strategic voting is profitable is this. Assume there are exchange opportunities concerning issue pairs (1,2), (1,3), (3,4) that yield an actor a payoff of 10, 5, 1, respectively. Further assume that either (1,3) or (3,4) will win the competition, and that the actor's vote is decisive in this competition. If he votes for (3,4), (3,4) will win, otherwise (1,3) will win. Then, if he votes for his most preferred option (1,2) he gains 5, but if he votes for (3,4) he gains 1+10 = 11.
9. The probability that the smallest p-value of 7 tests is 0.076 or larger, if the null hypothesis is true in all 7 tests, is 0.469.

Appendix A: conditions for mutually profitable bilateral exchange

Assume *i* and *j* are on opposite sides of the expected outcomes of issues 1 and 2. Using (2), their utilities are $U_i = -s_{i1} \mid x_{i1} - O_1 \mid - s_{i2} \mid x_{i2} - O_2 \mid$ and $U_j = -s_{j1} \mid x_{j1} - O_1 \mid - s_{j2} \mid x_{j2} - O_2 \mid$, respectively. If δ_1 is in the direction of x_{i1}, then both actors' utility changes are $s_{i1}\delta_1 - s_{i2}\delta_2$ and $-s_{j1}\delta_1 + s_{j2}\delta_2$. Since both utility changes must be nonnegative, we obtain $\frac{s_{i1}}{s_{i2}} \geq \frac{\delta_2}{\delta_1} \geq \frac{s_{j1}}{s_{j2}}$. If δ_1 is in the direction of x_{ji1}, then we obtain similarly $\frac{s_{j1}}{s_{j2}} \geq \frac{\delta_2}{\delta_1} \geq \frac{s_{i1}}{s_{i2}}$.

Appendix B: deriving Δ_{PE}^{w} and $\Delta_{PE}^{b\&w}$

First some notation. Assume a group exchange between *A* and *D*, such that the expected outcome of issue 1 is shifted towards *A* and the expected outcome of issue 2 is shifted towards *D*. Let $x_{jm}^{farthest}$ be the position of the member of group *j* farthest from O_m on *j*'s demand issue *m*. Moreover, let $a^{'}$ and $d^{'}$ be the members of A and D that are closest in terms of *relative salience*, hence $\frac{s_{a^{'}1}}{s_{a^{'}2}} \geq \frac{\delta_2}{\delta_1} \geq \frac{s_{d^{'}1}}{s_{d^{'}2}}$. Denote the utility change for actor *n*, as $U_n : \Delta \rightarrow \Re$, and define a utility space $S = \{u \in \Re^{N^*} : u = (U_1(\delta), U_2(\delta), ..., U_N(\delta)), \delta \in \Delta\}$, with $N^* = A \cup D$ or $N^* = B \cup C$ in the EEM$_w$ and $N^* = N$ in the EEM$_{b\&w}$.

Three conditions need to be added to Δ^w to specify Δ_{PE}^{w}. Firstly, all members of both *A* and *D* prefer a shift that results in an outcome somewhere between $x_{jm}^{closest}$ and $x_{jm}^{farthestt}$, over a shift beyond $x_{jm}^{farthest}$. Hence δ's upper bound becomes $\min\{\mid x_{jm}^{farthest} - O_m \mid, \delta_m^{\max}\}$. Secondly, at least one of the groups must shift at least $\min\{\mid x_{jm}^{closest} - O_m \mid, \delta_2^{\max}\}$, because otherwise a further shift with the same exchange ratio is a Pareto efficient improvement. Thirdly, of course, $U_n \geq 0$ for all actors in A and D. Combining the three conditions yields:

$$\Delta_{PE}^{w} = \{\delta = (\delta_1, \delta_2) : (\min\{|x_{A1}^{farthest} - O_1|, \delta_1^{\max}\} \geq \delta_1 \geq \min\{|x_{A1}^{closest} - O_1|, \delta_2^{\max}\},$$

$$\min\{|x_{D2}^{farthest} - O_2|, \delta_2^{\max}\} \geq \delta_2 \geq \frac{s_{d'1}}{s_{d'2}}\delta_1, U_i \geq 0 \forall i \in N^*) \cup$$

$$(\min\{|x_{A1}^{farthest} - O_1|, \delta_1^{\max}\} \geq \delta_1 \geq \frac{s_{a'2}}{s_{a'2}}\delta_2,$$

$$\min\{|x_{D2}^{farthest} - O_2|, \delta_2^{\max}\} \geq \delta_2 \geq \min\{|x_{D2}^{closest} - O_1|, \delta_2^{\max}\}, U_i \geq 0 \forall i \in N^*))$$

Two additional conditions of $\Delta_{PE}^{b\&w}$ are that $C = \{\varnothing\}$ and all actors' utilities should be nonnegative.

Appendix C: S is compact and convex

Utility space *S* is defined above on $\Delta = \{\delta = (\delta_1, \delta_2) : 0 \leq \delta_1 \leq \delta_1^{\max}, 0 \leq \delta_2 \leq \delta_2^{\max}\}$. Note that Δ is compact and convex. Because Δ is compact, *S* is compact as well. *S* is also convex because all U_n are linear. Proof: Assume we have $\delta, \delta' \in \Delta$, $u = (U_1(\delta), U_2(\delta), ..., U_N(\delta))$, and $v = (U_1(\delta'), U_2(\delta'), ..., U_N(\delta'))$. Now consider $\lambda u + (1-\lambda)v$, with $\lambda \in [0,1]$. For each actor *n*, this yields $\lambda u_n + (1-\lambda)v_n = U_n(\lambda\delta + (1-\lambda)\delta')$. Since Δ is convex, $\lambda\delta + (1-\lambda)\delta' \in \Delta$. Thus $\lambda u + (1-\lambda)v = (U_1(\lambda\delta + (1-\lambda)\delta'), U_2(\lambda\delta + (1-\lambda)\delta'), ..., U_N(\lambda\delta + (1-\lambda)\delta')) \in S$, and *S* is convex. Hence the GNBS identifies only one solution from *S*. This solution must be in Δ_{PE} because the GNBS satisfies Pareto efficiency.

References

Achen, Christopher H. 2006. “Chapter 4. Institutional realism and bargaining models.” Pp. 86-123 in *The European Union Decides*, edited by R. Thomson, F.N. Stokman, C.H. Achen, and T. König. Cambridge: Cambridge University Press.

Achterkamp, Marjolein C. 1999. *Influence strategies in collective decision making: a comparison of two models*. ICS dissertation series.

Arregui, Javier, Frans Stokman and Robert Thomson. 2006. “Chapter 5. Exchange and Compromise in the European Union.” Pp. 124-152 in *The European Union Decides*, edited by R. Thomson, F.N. Stokman, C.H. Achen, and T. König. Cambridge: Cambridge University Press.

------. 2004. Bargaining in the European Union and Shifts in Actors’ Policy Positions, *European Union Politics 5*, 47-72.

Bienenstock, Elisa Jayne, and Phillip Bonacich. 1992. “The core as a solution to exclusionary networks.” *Social Networks* 14: 231-243.

Black, Duncan. 1958. *Theory of Committees and Elections*. Cambridge: Cambridge University Press.

Blau, Peter M. 1964. *Exchange and power in social life*. New York: Wiley.

------. 1968. “Social exchange.” *International Encyclopedia of the Social Sciences*.

Bonacich, Phillip. 1987. “Power and centrality: a family of measures.” *American Journal of Sociology* 92: 1170-1182.

------. 1992. “Power in positively connected networks: a critical review.” *Advances in group processes* 9: 21-40.

------. 1995. “Four kinds of social dilemmas within exchange networks.” *Current Research in Social Psychology* 1: 1-6.

------. 1998. “A behavioral foundation for a structural theory of power in exchange networks.” *Social Psychology Quarterly* 61 (3): 185-198.

Bonacich, Phillip, and Elisa Jayne Bienenstock. 1995. “When rationality fails: unstable exchange networks with empty cores.” *Rationality and Society* 7(3): 293-320.

Bonacich, Phillip, and Noah E. Friedkin. 1998. “Unequally valued exchange relations.” *Social Psychology Quarterly* 61: 160-171.

Borgatti, Stephen P., and Martin G. Everett. 1992. “Graph Colorings and Power in Experimental Exchange Networks.” *Social Networks*, 14, 287-308.

Braun, Norman. 1993. *Socially embedded exchange*. Frankfurt am Main; Berlin; Bern; New York; Paris; Wien: Peter Lang.

Braun, Norman, and Thomas Gautschi. 2006. "A Nash Bargaining Model for Simple Exchange Networks." *Social Networks* 28(1): 1-23.

Bueno de Mesquita, Bruce, D. Newman, and A. Rabushka. 1985. *Forcasting political events. The future of Hong Kong.* New haven, CT: Yale University Press.

Bueno de Mesquita, Bruce, D., and Frans N. Stokman (Eds). 1994. *European Community Decision Making: Models, Applications, and Comparisons*. New Haven: Yale University Press.

Burke, Peter J. 1997. "An identity model for network exchange." *American Sociological Review* 62: 134-150.

Camerer, Colin F. 2003. *Behavioral game theory: experiments in strategic interaction*. Princeton, NJ: Princeton University Press.

Chae, Suchan and Paul Heidhues. 2004. "A group bargaining solution." *Mathematical Social Sciences* 48(1): 37-53.

Cohen J. 1988. *Statistical power analysis for the behavioral sciences.* Hillsdale, NJ: Erlbaum.

Coleman, J.S. 1972. "Systems of Social Exchange." *Journal of Mathematical Sociology* 2: 145-163.

------. 1990. *Foundations of social theory*. Cambridge: Harvard University Press.

Cook, Karen S., and Richard M. Emerson. 1978. "Power, equity and commitment in exchange networks." *American Sociological Review* 43: 721-739.

Cook, Karen S., Richard M. Emerson, Mary R. Gillmore, and Toshio Yamagishi. 1983. "The distribution of power in exchange networks: theory and experimental results." *American Journal of Sociology* 89(2): 275-305.

Cook, Karen S., and Toshio Yamagishi. 1992. "Power in exchange networks: a power-dependence formulation." *Social Networks* 14: 245-265.

Cosmides, Leda. 1988. "The logic of social exchange: has natural selection shaped how humans reason? Studies with the Wason selection task." *Cognition* 31: 187-276.

Dawes, Robyn M. 1980. "Social Dilemmas." *Annual Review of Psychology* 31: 169-193.

Dijkstra, Jacob. 2005. "Externalities in Exchange Networks: An Adaptation of existing Theories of Exchange Networks." Unpublished Manuscript.

Dijkstra, Jacob and Marcel A.L.M. van Assen. 2006. "The Comparison of Four Types of Everyday Interdependencies: Externalities in Exchange Networks." Unpublished Manuscript.

Edgeworth, Francis Ysidro. 1881. *Mathematical Psychics*. Fairfield: Kelley.

Ekeh, Peter P. 1974. *Social Exchange Theory*. London: Heinemann.

Emerson, Richard M. 1962. "Power-dependence relations." *American Sociological Review* 27(1): 31-41.

------. 1964. "Power-dependence relations: two experiments." *Sociometry* 27(3): 282-298.

------. 1972a. "Exchange theory, part I: A psychological basis for social exchange." Pp. 38-57 in *Sociological Theories in Progress* 2, edited by J. Berger, M. Zelditch Jr., & B. Anderson. Boston: Houghton-Mifflin.

------. 1972b. "Exchange theory, part II: Exchange relations and networks." Pp. 58-57 in *Sociological Theories in Progress* 2, edited by J. Berger, M. Zelditch Jr., & B. Anderson. Boston: Houghton-Mifflin.

------. 1976. "Social Exchange Theory." *Annual Review of Sociology* 2: 335-361.

Emerson, Richard M., Karen S. Cook, Mary R. Gillmore, and Toshio Yamagishi. 1983. "Valid predictions from invalid comparisons: responses to Heckathorn." *Social Forces* 61: 1232-1247.

Friedkin, Noah E. 1992. "An expected value model of social power. Predictions for selected exchange networks." *Social Networks* 14: 213-229.

------. 1995. "The incidence of exchange networks." *Social Psychology Quarterly* 58: 213-221.

Friedman, James S. 1986. *Game theory with applications to economics*. Oxford University Press: New York, Oxford.

Granovetter, M. 1985. "Economic Action and Social Structure: The Problem of Embeddedness." *The American Journal of Sociology* 91(3): 481-510.

Hardin, Garrett. 1968. "The Tragedy of the Commons." *Science*, 162: 1243-1248.

Heckathorn, Douglas D. 1978. "A paradigm for bargaining and a test of two bargaining models." *Behavioral Science* 23(2): 73-85.

------. 1980. "A unified model for bargaining and conflict." *Behavioral Science* 25: 261-284.

------. 1983a. "Extensions of power-dependence theory: the concept of resistance." *Social Forces* 61: 1206-1231.

------. 1983b. “Valid and invalid interpersonal comparisons: response to Emerson, Cook, Gillmore and Yamagishi.” *Social Forces* 61: 1248-1259.

Hildenbrand, Werner E. and Alan P. Kirman. (1988). *Equilibrium analysis*. Amsterdam, The Netherlands: North-Holland.

Homans, G.C. 1958. “Social behavior as exchange.” *Journal of American Sociology* 62: 597-606.

Kagel, John Henry., and Alvin E. Roth (Eds). 1995. *The handbook of experimental economics*. New Jersey: Princeton University Press.

Kalai, Ehud, and Meir Smorodinsky. 1975. “Other solutions to Nash’s bargaining problem.” *Econometrica* 43: 513-518.

Karr, Linda B. 2000. “New horizons in cross-national experimentation.” *Current Research in Social Psycholgy* 5: 191-205.

König, Thomas. 1997. *Europa auf dem Weg zum Mehrheitssystem. Gründe und Konsequenzen nationaler und parlamentarischer Integration*. Opladen: Westdeutscher Verlag.

König, Thomas, and Sven-Oliver Proksch. 2006. “Chapter 8. A procedural exchange model of EU legislative politics.” Pp. 211-238 in *The European Union Decides*, edited by R. Thomson, F.N. Stokman, C.H. Achen, and T. König. Cambridge: Cambridge University Press.

Kranton, Rachel E., Deborah F. Minehart. 2001. “A theory of buyer-seller networks.” *American Economic Review* 91: 485-508.

Kreps, David M. 1990. *A course in micro-economic theory*. New York: Harvester Wheatsheaf.

Lakatos, Imre, and Alan Musgrave (Eds). 1970. *Criticism and the growth of knowledge*. Proceedings of the international colloquium in the philosophy of science 4. London.

Laumann Edward O., David Knoke, and Yong-Hak Kim. 1987. “Event outcomes.” Pp. 343-373 in *The Organizational State. Social Choice in National Policy Domains*, edited by E.O. Laumann and D. Knoke. Madison: The university of Wisconsin Press.

Lawler, Edward J., and Rebecca R. Ford. 1995. “Bargaining and influence in conflict situations.” Pp. 236-256 in *Sociological perspectives on social psychology*, edited by K.S. Cook, G.A. Fine and J.S. House. Boston, MA: Allyn and Bacon.

Lawler, Edward J., and Jeongkoo Yoon. 1998. “Network structure and emotion in exchange relations.” *American Sociological Review* 63: 89-108.

Ledyard, John O. 1995. "Public Goods: A Survey of Experimental Research." Pp. 111-194 in *The handbook of experimental economics*, edited by J.H. Kagel and A.E. Roth. Princeton, NJ: Princeton University Press.

Lovaglia, Micheal L., John Skvoretz, David Willer, and Barry Markovsky. 1995. "Negotiated exchange in social networks." *Social Forces* 74, 1: 123-155.

Markovsky, Barry , John Skvoretz, David Willer, Micheal J. Lovaglia, and Jeffrey Erger. 1993. "The seeds of weak power: an extension of network exchange theory." *American Sociological Review* 58: 197-209.

Marsden Peter V. and Edward O. Laumann. 1977. "Collective action in a community elite: Exchange, influence, resources and issue resolution." Pp 199-250 in *Power, Paradigms, and Community Research*, edited by R.J. Liebert and A.W. Imershein. London: Sage.

Mas-Colell, Andreu, Micheal D. Whinston, and Jerry R. Green. 1996. *Microeconomic Theory*. New York: Oxford University Press.

Mattila, Mikko and Jan-Erik Lane. 2001. "Why Unanimity in the Council? A Roll Call Analysis of Council Voting." *European Union Politics* 2(1): 31-52.

Michener, H. Andrew, Eugene D. Cohen, and Aage B. Sorensen. 1975. "Social exchange: predicting interpersonal outcomes in four-event, three-person systems." *Journal of Personality and Social Psychology* 32 (2): 283-293.

------. 1977. "Social exchange: predicting transactional outcomes in five-event, four-person systems." *American Sociological Review* 42: 522-535.

Molm, Linda D. 1997. *Coercive power in social exchange*. Cambridge: Cambridge University Press.

Molm, Linda D., Gretchen Peterson, and Nobuyuki Takahashi. 1999. "Power in negotiated and recoprocal exchange." *American Sociological Review* 64: 876-890.

Molm, Linda D., Nobuyuki Takahashi, and Gretchen Peterson. 2003. "In the Eye of the Beholder: Procedural Justice in Social Exchange." *American Sociological Review* 68: 128-152.

Myerson, Robert B. 1976. "Values of games in partition function form." *International Journal of Game Theory* 6(1): 23-31.

Nash, J.F. 1950. "The bargaining problem." *Econometrica* 18: 155-162.

------. 1953. "Two-person cooperative games." *Econometrica* 21: 128-140.

Olson, Mancur. 1971. *The Logic of Collective Action: Public Goods and the Theory of Groups.* Cambridge, MA: Harvard University Press.

Pappi, Franz Urban, and Christian H.C.A. Henning. 1998. “Policy networks: More than a metaphor?” *Journal of Theoretical Politics* 10: 553-575.

Patton, Travis, and David Willer. 1990. “Connection and power in centralized exchange networks.” *Journal of Mathematical Sociology* 16(1): 31-49.

Poppe, Matthijs, and Machteld Zwikker. 1996. “The effect of threshold level on greed, fear, and cooperation in step-level give-some and take-some dilemmas.” Pp. 185-204 in *Frontiers in Social Dilemma Research*, edited by W.B.G. Liebrand, and D.M. Messick. Berlin: Springer.

Pratt, John, W., and Richard J. Zeckhauser. (Eds.) 1985. *Principles and Agents: the structure of business.* Boston, MA: Harvard Business School Press.

Raiffa, Howard. 1953. “Arbitration schemes for generalized two-person games.” Pp. 361-387 in *Contributions to the theory of games II*, edited by H.W. Kuhn and A.W. Tucker. Princeton, N.J.: Princeton University Press.

Raudenbush, Stephen W., and Anthony S. Bryk. 2002. *Hierarchical Linear Models. Applications and Data Analysis Methods.* Newbury Park, CA: Sage.

Rojer, Maurice F.P. 1996. *CAO onderhandelingen: een voorspelbaar, logisch en rationeel proces?* Amsterdam: Thesis Publishers.

Roth, Alvin E. 1995. “Introduction to experimental economics.” Pp. 3-109 in *The handbook of experimental economics,* edited by J.H. Kagel and A.E. Roth. Princeton, NJ: Princeton University Press.

Roth, Alvin E., and Michael W. K. Malouf. 1979. “Game theoretic models and the role of information in bargaining: an experimental study.” *Psychological Review* 86: 574-594.

Rubinstein, Ariel. 1982. “Perfect equilibrium in a bargaining model.” *Econometrica* 50: 97-109.

Rutte, Christel G., Henk A.M. Wilke, and David M. Messick. 1987. “The effects of framing social dilemmas as give-some or take-some games.” *British Journal of Social Psychology* 26: 103-108.

Schellenberg, James A. 1988. “A comparitive test of three models for solving ‘the bargaining problem.’” *Behavioral Science* 33: 81-96.

Schelling, Thomas. 1960. *The strategy of conflict.* Cambridge, Mass.: Harvard University Press.

Shapley, Lloyd S., and Martin Shubik. 1954. “A method for evaluating the distribution of power in a committee system.” *American politcal Science Review* 48: 787-792.

------. 1969. “On the Core of an Economic System with Externalities.” *The American Economic Review* 59(4): 678-684.

Shubik, Martin. 1982. *Game theory in the social sciences: concepts and solutions*. Cambridge, Mass.; London: MIT Press.

Simpson, Brent, and Micheal W. Macy. 2001. “Collective action and power inequality: coalitions in exchange networks.” *Social Psychology Quarterly* 64(1): 88-100.

Simpson, Brent and David Willer. 1999. “A New Method for Finding Power Strucutures.” Pp. 270-284 in *Network Exchange Theory,* edited by D. Willer. Westport, CT: Praeger Press.

Skvoretz, John, and Tracy Burkett. 1994. “Information and the distribution of power in exchange networks.” *Journal of Mathematical Sociology* 19, 4: 263-278.

Skvoretz, John, and Thomas J. Fararo. 1992. “Power and network exchange: an essay toward theoretical unification.” *Social Networks* 14: 325-344.

Skvoretz, John, and David Willer. 1993. “Exclusion and power: a test of four theories of power in exchange networks.” *American Sociological Review* 58: 801-818.

Skvoretz, John and Pidi D. Zhang. 1997. “Actors’ responses to outcomes in exchange networks: The process of power development.” *Sociological Perspectives* 40, 2: 183-197.

Snijders, Tom A.B and Roel J. Bosker. 1999. *Multilevel Analysis: An Introduction to Basic and Advanced Multilevel Modeling*. London: Sage.

Steunenberg, Bernard. 1994. “Decision making under different institutional arrangements: Legislation by the European Community.” *Journal of Theoretical and Institutional Economics* 150: 642-69.

Stokman, Frans N., Marcel A.L.M. van Assen, Jelle van der Knoop, and Reinier C.H. van Oosten. 2001. “Strategic Decision Making.” *Advances in Group Processes* 17: 131-153.

Stokman Frans N., and Jan M.M. Van den Bos. 1994. “The exchange of voting positions in the EC Council.” Pp. 161-184 in *European Community Decision Making: Models, Applications, and Comparisons*, edited by B. Bueno de Mesquita and F.N. Stokman. New Haven: Yale University Press.

Stokman Frans N., Reinier Van Oosten. 1994. “The exchange of voting postions: An object-oriented model of policy networks.” Pp. 105-127 in *European community decision making. Models, comparisons, and applications*, edited by B. Bueno de Mesquita and F.N. Stokman. New Haven, CT: Yale University Press.

Stokman, Frans N., R. Ziegler, and J. Scott (Eds). 1987. *Networks of corporate power: a comparative analysis of 10 countries*. Cambridge: Polity Press.

Stolte, John F., and Richard M. Emerson. 1977. “Structural inequality: position and power in exchange structures.” Pp. 117-138 in *Behavioral Theory in Sociology*, edited by R.L. Hamblin, and J.H. Kunkel. New Brunswick: Transaction Books.

Sutton, J. (1986). “Non-cooperative bargaining theory: an introduction.” *The Review of Economic Studies* 53: 709-724.

Szmatka, Jacek, and David Willer. 1995. “Exclusion, inclusion, and compound connection in exchange networks.” *Social Psychology Quarterly* 58 (2): 123-133.

Thibaut, John W., and Harold H. Kelley. 1959. *The social psychology of groups*. New York: John Wiley and Sons.

Thomson, Robert, Frans N. Stokman, Christopher H. Achen and Thomas König (eds). 2006. *The European Union Decides*. Cambridge: Cambridge University Press.

Thye, Shane, Micheal Lovaglia, and Barry Markovsky. 1997. “Responses to social exchange and social exclusion in networks.” *Social Forces* 75: 1031-1047.

Tsebelis, George and Geoffrey Garrett. 1996. “Agenda setting power, power indices, and decision making in the European Union”, *International Review of Law and Economics* 16: 345-61.

Udehn L. 1996. *The limits of public choice: a sociological critique of the economic theory of politics.* London: Routledge.

Van Assen, Marcel A.L.M. 2001. *Essays on actor models in exchange networks and social dilemmas*. Interuniversity Centre for Social Science Theory and Methodology. Rijksuniversiteit Groningen.

------. 2003. “Exchange networks: an analysis of all networks up to size 9.” *Advances in Group Processes* 20: 67-103.

Van Assen, Marcel A.L.M., Frans N. Stokman, and Reinier C.H. van Oosten. 2003. “Conflict Measures in Cooperative Exchange Models of Collective Decision Making.” *Rationality and Society* 15: 87-115.

Van den Bos, Jan M.M. 1991. *Dutch EC policy making. A model-guided approach to coordination and negotiation.* Amsterdam: Thesis.

Van Dijk, Eric, and Henk Wilke. 2000. “Decision-Induced Focusing in Social Dilemmas: Give-Some, Keep-Some, Take-Some, and Leave-Some Dilemmas.” *Journal of Personality and Social Psyochology* 78, 1: 92-104.

Wasserman, Stanley, and Katherine Faust. 1994. *Social network analysis: methods and applications.* Cambridge: Cambridge University Press.

Willer, David. 1987. *Theory and the experimental investigation of social structures*. New York: Gordon and Breach Science Publishers.

------. (Ed.). 1999. *Network exchange theory*. Westport, CT: Praeger Press.

Willer, David, and Bo Anderson, B. (Eds.) 1981. *Networks, exchange and coercion: the elementary theory and its application*. Elsevier, North Holland.

Willer, David, and Pamela Emanualson. 2005. "Testing Ten Theories." Unpublished Manuscript.

Willer, David., and John Skvoretz. 1997. "Games and structures." *Rationality and Society* 9, 1: 5-35.

Wippler, R. and S. Lindenberg. 1987. "Collective Phenomena and Rational Choice." Pp. 135-152 in *The Micro-Macro Link*, edited by J.C. Alexander, B. Giesen, R. Münch and N.J. Smelser. Berkeley, Cal.: University of California Press.

Yamaguchi, Kazuo. 1996. "Power in networks of substitutable and complementary exchange relations: a rational-choice model and an analysis of power centralization." *American Sociological Review* 61: 308-332.

Samenvatting (Summary in Dutch)

Effecten van externaliteiten op partnerkeuze en nutswinst in ruilnetwerken

1. Inleiding

Dit proefschrift bestudeert de partnerkeuze en de nutswinst van actoren in ruilrelaties. Zulke relaties kunnen ontstaan telkens wanneer twee of meer actoren, zowel individuen als organisaties, van elkaar afhankelijk zijn voor het genereren van voor hen waardevolle uitkomsten. Het ruilperspectief op sociale relaties kan worden toegepast op veel uiteenlopende onderwerpen waarin sociale wetenschappers geïnteresseerd zijn. Zo kunnen veel sociale relaties beschouwd worden als een ruil van fysieke goederen, diensten, tijd, sociale goedkeuring, respect, aandacht, beleefdheden of gunsten. In dit proefschrift ligt de nadruk op bilaterale ruilrelaties waarin er direct wordt onderhandeld over de ruilvoorwaarden. Het gedrag van individuen wordt hierbij gemodelleerd met behulp van principes uit de rationele keuzetheorie, waarna de modelvoorspellingen worden vergeleken met in experimenten of het veld waargenomen gedrag.

In alle hoofdstukken behalve hoofdstuk 2, worden ruilrelaties bestudeerd die ingebed zijn in *ruilnetwerken*. Een ruilnetwerk bestaat uit drie of meer actoren, verbonden door bilaterale ruilrelaties. De aanwezigheid van een ruilrelatie geeft de mogelijkheid weer voor de verbonden actoren om met elkaar te ruilen. Een verplichting om te ruilen is er echter niet. Actoren die niet verbonden zijn door een ruilrelatie kunnen niet ruilen. Deze ruilnetwerken vormen het centrale onderzoeksobject voor de ruiltheorie in de sociologie en de sociale psychologie en dit proefschrift maakt deel uit van deze traditie. Het centrale vraagstuk in deze traditie betreft de invloed van de positie van een actor in het netwerk, op de nutswinst die deze actor verkrijgt uit door hem uitgevoerde ruilen.

Vele bilaterale ruilen beïnvloeden niet alleen de nutswinst van de beide ruilpartners, maar ook van derden die niet deelnemen aan de ruil. Dergelijke *externaliteiten* van ruil zijn het centrale onderwerp van dit proefschrift. Externaliteiten zijn gedefinieerd als directe (positieve of negatieve) gevolgen van een ruil voor het welbevinden van actoren die zelf geen deel hebben aan de ruil.

In dit proefschrift worden bestaande ruiltheorieën uit de sociologie en de sociale psychologie onderzocht met het doel effecten van externaliteiten op de uitkomsten in ruilnetwerken te voorspellen. Hierbij staan steeds twee uitkomsten centraal, namelijk (i) de nutswinst van de ruilpartners en (ii) de keuze van actoren voor een ruilpartner. Dit leidt tot de volgende twee centrale vragen:

Onderzoeksvraag 1: wat zijn de gevolgen van externaliteiten in ruilnetwerken voor de distributie van nutswinsten over de actoren in het ruilnetwerk?

Onderzoeksvraag 2: wat zijn de gevolgen van externaliteiten in ruilnetwerken voor de partnerkeuze van actoren in het ruilnetwerk?

Antwoorden op deze vragen worden langs drie wegen gezocht: (i) er wordt een abstracte rationele keuzetheorie geformuleerd waaruit hypothetische antwoorden worden afgeleid, (ii) deze hypotheses worden getoetst in experimenten en (iii) inzichten uit theorie en experimenten worden aangewend met het doel een ruilmodel te ontwikkelen dat de uitkomsten van collectieve besluitvorming met externaliteiten probeert te voorspellen. Hoofdstuk 2 van dit proefschrift onderzoekt een andere vraag, namelijk of een bilaterale ruil van goederen kan worden weergegeven door twee actoren die een constant surplus verdelen.

1.1 Ruilnetwerken

In een (ruil)netwerk kan een actor dikwijls niet ruilen met *alle* andere actoren. Er bestaan dan *toegangsbarrières* tussen sommige actoren. Dergelijke barrières kunnen om uiteenlopende redenen bestaan. Zo kan een grote fysieke afstand sociale interactie tussen twee actoren onmogelijk maken. Maar ook sociale, culturele of ideologische factoren kunnen een rol spelen, zoals wanneer twee actoren afkomstig zijn uit verschillende etnische gemeenschappen of wanneer zij van elkaar gescheiden worden door een grote afstand binnen een hiërarchie. Anderzijds kan het ontstaan van een ruilrelatie vergemakkelijkt worden door bijvoorbeeld specifieke investeringen ten behoeve van een beoogd ruilpartner, of door persoonlijke relaties of familiebanden. In alle hoofdstukken van dit proefschrift zijn de ruilnetwerken exogeen bepaald door de onderzoeker en statisch. Dit laatste wil zeggen dat actoren relaties aan het netwerk toe kunnen voegen, noch relaties in het netwerk kunnen verbreken.

1.2 Voorbeelden van externaliteiten

Als voorbeeld van een ruilsituatie waarin externaliteiten een belangrijke rol spelen kan het geval dienen waarin een vakbondsonderhandelaar onderhandelt met een werkgever. De leden van de vakbond onderhandelen zelf niet mee, maar ondervinden wel de gevolgen van de uitkomsten behaald door de onderhandelaar. De vakbondsleden ondervinden dus externaliteiten van het ruil- en onderhandelingsgedrag van de onderhandelaar.

Een wellicht wat alledaagser voorbeeld vindt men in gezinnen. Wanneer één gezinslid gebruikmaakt van het gezinsbudget om inkopen voor het gehele gezin te doen, ondervinden de andere gezinsleden externaliteiten van het ruilgedrag van het inkopende gezinslid; de andere gezinsleden kunnen de ingekochte goederen consumeren, maar kunnen niet meer beschikken over het voor deze inkopen uitgegeven geld.

Dit proefschrift behandelt nog een andere ruilsituatie waarin externaliteiten een grote rol spelen, namelijk een situatie van collectieve besluitvorming. Twee actoren in zo'n situatie kunnen een bilateraal compromis sluiten door hun posities op twee punten waarover moet worden besloten te ruilen. Dergelijke ruilen nemen dan bijvoorbeeld de vorm aan van 'ik steun jou op dit punt, als jij mij steunt op het andere'. Door deze bilaterale ruil verandert echter voor alle actoren in de collectieve besluitvormingssituatie de uitkomst. Dat wil zeggen, actoren die niet betrokken zijn bij de ruil ondervinden hiervan wel de gevolgen. Zij ondervinden dus externaliteiten van de ruil. Naast dit meer concrete probleem van externaliteiten in collectieve besluitvorming, bespreekt dit proefschrift nog hoe een aantal bekende situaties van interdependentie, zoals markten en publieke goederen, kunnen worden geanalyseerd aan de hand van ruilnetwerken met externaliteiten.

2. Theorie en data

In de sociologie en de sociale psychologie bestaan veel theorieën die de uitkomsten in ruilnetwerken voorspellen. De centrale vraag die deze theorieën proberen te beantwoorden is of en hoe de nutswinst van een actor wordt beïnvloed door de positie die deze actor inneemt in het ruilnetwerk. Een belangrijke factor die bepalend is voor de nutswinst van een actor is de mate waarin hij van ruilen uitgesloten kan worden. Ook in dit proefschrift staat de werking van uitsluiting voorop, met name doordat in alle experimenten proefpersonen slechts éénmaal kunnen ruilen. Wanneer zij meer dan 1 mogelijke ruilpartner hebben moet er dus een keuze gemaakt worden, die leidt tot uitsluiting van bepaalde actoren (aangenomen dat deze actoren zelf geen alternatieven hebben).

De belangrijkste taak die in dit proefschrift vervuld wordt is de ontwikkeling van een theorie die voorspellingen oplevert van de uitkomsten van ruilnetwerken met externaliteiten. Hiertoe worden de drie prominentste theorieën uit het veld onderzocht, namelijk 'power-dependence theory', 'exchange-resistance theory' en 'core theory'. De laatstgenoemde theorie wordt gegeneraliseerd tot de 'generalized core theory', waaruit hypothesen worden afgeleid die experimenteel worden getoetst.

In deze experimenten werden proefpersonen aan een positie in een vooraf opgesteld ruilnetwerk toegewezen. In iedere ronde van het experiment kon een proefpersoon onderhandelen met anderen (waarmee hij een relatie had in het netwerk), over de ruil van waardevolle goederen. In alle experimenten waren er steeds 2 soorten goederen, namelijk X en Y. Iedere proefpersoon begon iedere ronde met een bepaalde hoeveelheid van het goed X en van het goed Y. De nutswinst van een proefpersoon, of het aantal ‘gescoorde punten’, werd bepaald door het aantal eenheden van ieder goed dat een proefpersoon aan het einde van iedere ronde bezat en de waarde van ieder goed voor de proefpersoon. Deze waarde werd exogeen bepaald door de experimentleider, als het aantal punten dat een eenheid van het goed waard was voor de proefpersoon in kwestie. In het geval van externaliteiten hing de nutswinst van een proefpersoon bovendien af van de hoeveelheid goederen die in het bezit was van een andere actor, elders in het netwerk. Na ieder experiment werden de gescoorde punten omgerekend naar geld dat werd uitbetaald aan de proefpersonen.

In het laatste hoofdstuk van dit proefschrift worden de inzichten uit theorie en experimenten gebruikt om een model te ontwikkelen waarmee collectieve besluitvorming met externaliteiten kan worden geanalyseerd. Om dit model te testen wordt gebruik gemaakt van data die verzameld zijn door Thomson, Stokman, Achen en König (eds. 2006) en die betrekking hebben op besluiten in de Europese Unie. Het gaat om 66 voorstellen van de Europese Commissie uit de periode van januari 1999 tot december 2002. De actoren in deze besluitvormingssituatie waren de 15 lidstaten van dat moment (België, Denemarken, Duitsland, Finland, Frankrijk, Griekenland, Ierland, Italië, Luxemburg, Nederland, Oostenrijk, Portugal, Spanje, het Verenigd Koninkrijk en Zweden), het Europees Parlement en de Europese Commissie.

3. Resultaten per hoofdstuk

In deze paragraaf bespreken we kort de resultaten van ieder hoofdstuk, om zo antwoorden op de twee onderzoeksvragen te formuleren. Ieder hoofdstuk vormt een zelfstandig artikel, opgestuurd naar een wetenschappelijk tijdschrift.

3.1 Hoofdstuk 2

In de meerderheid van alle onderzoeken op het terrein van ruilnetwerken worden ruilrelaties weergegeven door de mogelijkheid van twee actoren om te onderhandelen over de verdeling van een constante hulpbron. Van deze SRP-benadering (*S*plit of a common *R*esource *P*ool) wordt doorgaans aangenomen dat hij equivalent is aan een situatie waarin twee actoren de mogelijkheid hebben om te onderhandelen over de wederzijdse overdracht van waardevolle goederen, ook wel de PE-benadering (*P*ure *E*xchange) genaamd. In Hoofdstuk 2 testen we de geldigheid van deze aanname, door beide benaderingen te vergelijken in een experiment. Grote verschillen in uitkomsten tussen beide benaderingen zou de geldigheid van onderzoek dat gebruikmaakt van de SRP-benadering ten aanzien van ruilrelaties in twijfel trekken.

Op basis van de uitkomsten van het experiment trekken we drie conclusies. Ten eerste zijn de voorspellingen van de in dit hoofdstuk gebruikte ruiltheorieën veel accurater wanneer gebruik wordt gemaakt van de SRP-benadering dan wanneer de PE-benadering wordt gebruikt. Ten tweede is de voorspelling van gelijke winsten voor beide partijen, van alle gebruikte theorieën het beste. Ten derde blijken veel ruilen niet Pareto-efficiënt. Deze resultaten doen twijfel ontstaan over de geldigheid van uitspraken over ruilnetwerken die gebaseerd zijn op onderzoek waarin de SRP-benadering wordt gehanteerd. Veel van dat onderzoek rapporteert een tamelijk groot voorspellend vermogen van ruiltheorieën. De eerstgenoemde conclusie suggereert dat dit grote voorspellende vermogen een artefact zou kunnen zijn van de SRP-benadering. De tweede conclusie wijst theorieën die gebaseerd zijn op gelijke winsten, zoals power-dependence theory (zie bijvoorbeeld Cook en Emerson, 1978) aan als de potentieel best voorspellende. De derde conclusie toont aan dat de assumptie dat ruilen altijd Pareto-effiënt geschieden -een assumptie die bijna altijd wordt gemaakt wanneer de SRP-benadering wordt gehanteerd- een erg sterke aanname is.

3.2 Hoofdstuk 3

In dit hoofdstuk wordt een eerste exploratie ondernomen van het probleem van ruilnetwerken met externaliteiten, d.m.v. een eenvoudig experiment. Zowel de eerste als de tweede centrale onderzoeksvraag komen in dit hoofdstuk aan de orde. Op basis van eenvoudige rationaliteitprincipes worden hypotheses afgeleid die in het experiment getoetst worden. De resultaten bevestigen onze hypotheses: in het onderzochte netwerk hebben externaliteiten een zwakke maar significante invloed op de partnerkeuze van actoren en een sterke invloed op de verdeling van de nutswinsten over de leden van het ruilnetwerk. Deze resultaten zijn derhalve een eerste indicatie van het feit dat externaliteiten een belangrijke rol spelen bij het bepalen van de uitkomsten in ruilnetwerken. Bovendien blijken de effecten van externaliteiten in principe te voorspellen met behulp van eenvoudige rationaliteitbeginselen.

3.3 Hoofdstuk 4

In dit hoofdstuk wordt van drie prominente theorieën op het gebied van ruilnetwerken, te weten power-dependence theory, exchange-resistance theory en core theory, onderzocht hoe ze zodanig uitgebreid of aangepast kunnen worden dat ze zinvolle voorspellingen geven voor ruilnetwerken met externaliteiten. Core theory wordt hierbij omgewerkt tot de generalized core theory. Van de theorieën wordt voorts een aantal algemene eigenschappen onderzocht. Voor core theory wordt de propositie bewezen dat de core-oplossing van een willekeurig ruilnetwerk zonder externaliteiten een deelverzameling is van de generalized core-oplossing van hetzelfde netwerk met positieve externaliteiten. Met betrekking tot power-dependence theory en exchange-resistance theory laat hoofdstuk 4 zien dat de voorspellingen van deze theorieën ons in staat stellen de effecten op de distributie van nutswinsten van (i) de netwerkstructuur, (ii) de externaliteiten en (iii) de interactie tussen netwerkstructuur en externaliteiten te scheiden.

Generalized core theory vormt de basis voor de afleiding van hypotheses in alle volgende hoofdstukken in dit proefschrift. Het centrale idee in deze theorie is dat een uitkomst (een patroon van partnerkeuzes en een bijbehorende distributie van nutswinsten) in de generalized core ligt, wanneer er geen paar van verbonden actoren bestaat, waarvan de leden onderling een alternatieve ruil overeen kunnen komen waarbij tenminste één van hen erop vooruit gaat, zonder dat de ander erop achteruit gaat.

3.4 Hoofdstuk 5

Dit hoofdstuk richt zich op het experimenteel testen van hypotheses die een antwoord geven op Onderzoeksvraag 1. In vier experimentele condities worden vier bekende situaties van sociale interdependentie gemodelleerd, te weten (i) de markt, (ii) de 'tragedy of the commons' of het 'resource dilemma', (iii) het publieke goed probleem en (iv) het huishouden. Er wordt aangetoond dat deze situaties kunnen worden bestudeerd binnen het raamwerk van ruilnetwerken met externaliteiten.

In de hypotheses afgeleid van generalized core theory worden verschillende distributies van nutswinsten voorspeld voor de vier verschillende situaties. Het onderzochte netwerk bestaat uit drie actoren, en heeft de structuur A-B-C, waarbij de letters actoren aangeven en de streepjes de potentiële ruilrelaties. Generalized core theory voorspelt dat de nutswinst voor actoren A en C het laagst is in het resource dilemma en het hoogst in het huishouden en het publieke goed probleem. In het resource dilemma wordt zelfs een negatieve nutswinst voor A en C voorspeld. Tussen huishouden en publieke goed probleem bestaat volgens de generalized core geen verschil in nutswinst. Deze hypotheses worden door de data ondersteund.

3.5 Hoofdstuk 6

In dit hoofdstuk staat Onderzoeksvraag 2 centraal. In een eenvoudig netwerk met vier actoren, dat de structuur A-B-C-D heeft, worden twee experimentele condities met externaliteiten gecreëerd, zodanig dat verschillende proporties ruilen tussen actoren B en C worden voorspeld. Hypotheses voor deze twee condities worden afgeleid door de voorspellingen van generalized core theory te vergelijken met elkaar en met in eerder onderzoek van anderen gevonden proporties van ruilen tussen B en C in hetzelfde netwerk zonder externaliteiten. In laatstgenoemd onderzoek ruilden B en C in ongeveer 17,5% van de gevallen. In de eerste conditie van ons experiment voorspelt de generalized core een hogere proportie ruilen tussen B en C. In de tweede conditie voorspelt de generalized core zelfs uitsluitend ruilen tussen B en C. Deze hypotheses aangaande de partnerkeuze van actoren in ruilnetwerken werden inderdaad bevestigd in de data.

3.6 Hoofdstuk 7

In dit zevende en laatste hoofdstuk passen we het ruilperspectief toe op situaties van collectieve besluitvorming, overeenkomstig het 'position exchange model' (PEM) van Stokman en van Oosten (1994). In hoofdstuk 7 staat Onderzoeksvraag 1 centraal: gegeven de preferenties van de actoren impliceert een bepaalde uiteindelijke beslissing een distributie van nutswinsten over de actoren. Centraal in dit hoofdstuk staat de gedachte dat in contexten waarin er een formele of informele norm bestaat om tot unaniem gedragen beslissingen te komen, actoren negatieve externaliteiten van bilaterale ruilen willen vermijden. Besluitvorming in de EU is zo'n context en daarom wordt het in dit hoofdstuk ontwikkelde 'externalities exchange model' (EEM) getoetst op data die betrekking hebben op deze besluitvorming.

Het EEM is het eerste formele model van collectieve besluitvorming dat in zijn voorspellingen rekening houdt met externaliteiten. Hiertoe worden de rationaliteitprincipes van de generalized core uit hoofdstuk 4 als basis genomen en verder uitgewerkt en aangevuld. Dit gaat globaal op de volgende manier.

Gegeven de posities die de actoren innemen op de punten waarover besloten moet worden en de aanvankelijk verwachte uitkomst van de besluitvorming, construeert het EEM vier coalities van actoren op ieder paar van besluitpunten. Vervolgens zoekt het EEM naar verschuivingen in de verwachte uitkomsten op ieder besluitpunt, zodanig dat, gegeven de eerder geconstrueerde coalitiestructuur, er een Pareto-efficiënte uitkomst resulteert. In zo'n Pareto-efficiënte uitkomst kan geen enkele van de eerder genoemde coalities van actoren de nutswinst van één van zijn leden vergroten zonder tegelijkertijd (i) de nutswinst van een ander lid van de eigen coalitie of de coalitie waarmee geruild wordt te verlagen (dit wordt de EEM_w genoemd) of (ii) de nutswinst van enig andere actor te verlagen (dit wordt de $EEM_{b\&w}$ genoemd). Deze oplossing kan als een core-oplossing worden beschouwd, gegeven de geconstrueerde coalitiestructuur. Wanneer de verzameling Pareto-efficiënte uitkomsten leeg is neemt het EEM de aanvankelijk verwachte uitkomst als voorspelling. Wanneer deze verzameling niet leeg is gebruikt het EEM de 'generalized Nash bargaining solution' van Chae en Heidhues (2004) om één element uit de verzameling te kiezen als voorspelling.

Uit hoofdstuk 7 blijkt dat het EEM het beter doet dan andere modellen, die worden besproken in Thomson e.a. (2006), wanneer deze modellen worden getest op dezelfde dataset van besluiten van de Europese Unie. De resultaten laten voorts zien dat externaliteiten een beslissende invloed hebben op de uitkomst van collectieve besluitvormingsprocessen.

4. Conclusies en vervolgonderzoek

In deze paragraaf bespreken we kort de antwoorden op de onderzoeksvragen die we kunnen formuleren aan de hand van de hoofdstukken in dit proefschrift, de verdere implicaties van de onderzoeksresultaten, de beperkingen van ons onderzoek en enkele suggesties voor vervolgonderzoek.

Wat betreft het beantwoorden van de onderzoeksvragen kunnen we stellen dat als men de effecten van externaliteiten op ruilnetwerken wil voorspellen, het toepassen van generalized core theory leidt tot een goed eerste antwoord. Aan de hand van generalized core theory zoeken we dan naar zodanige distributies van nutswinst en bijbehorende patronen van partnerkeuze dat geen enkel paar verbonden actoren een alternatieve en wederzijds winstgevende ruil kan overeenkomen. In hoofdstuk 7 is gebleken dat dit principe een vruchtbare basis vormt voor de constructie van een succesvolle theorie over collectieve besluitvorming in een context waarin unaniem gedragen beslissingen vooropstaan.

De resultaten uit dit proefschrift laten zien dat zodra er externaliteiten van ruil bestaan, het voor het doen van accurate voorspellingen onvoldoende is om van actoren slechts de goederenvoorraad en preferenties te weten, tezamen met de netwerkstructuur. Voor zinvolle voorspellingen moeten ook de omvang en het teken van de externaliteiten bekend zijn. Dus, wanneer men de uitkomsten van collectieve besluitvormingsprocessen wil voorspellen, zoals die bijvoorbeeld plaatsvinden in collectieve arbeidsvoorwaardenonderhandelingen of in parlementen, moet men ook de externaliteiten expliciet in de voorspelling betrekken.

De studies in het huidige proefschrift zijn om tal van redenen beperkt. Zo worden er, ondanks het feit dat in hoofdstuk 4 een theorie is geformuleerd die in principe toepasbaar is op ieder willekeurig netwerk, slechts twee eenvoudige netwerkstructuren onderzocht. Ook heeft het gehele proefschrift betrekking op directe ruil, waarbij er expliciet over de ruilvoorwaarden wordt onderhandeld. Ook de toepassing van het EEM op collectieve besluitvorming in hoofdstuk 7 kent zijn beperkingen. Zo is het ruilperspectief gehanteerd, zonder dat is vastgesteld of het onderhandelingsproces daadwerkelijk bestaat uit de uitruil van posities door actoren. Er is met andere woorden gedaan *alsof* actoren hun posities ruilen om hieruit vervolgens voorspellingen af te leiden aangaande de verwachte uitkomsten, welke voorspellingen voorts getoetst zijn aan de werkelijk geobserveerde uitkomsten.

Voornoemde beperkingen suggereren een aantal richtingen voor vervolgonderzoek. Zo zouden de voorspellingen van generalized core theory getoetst kunnen worden in netwerken met complexere structuren. In collectieve besluitvorming zou het proces van besluitvorming kunnen worden bestudeerd om te analyseren onder welke voorwaarden dit zich voltrekt overeenkomstig het ruilperspectief.

Naast vervolgonderzoek om de beperkingen op te heffen, zijn er nog andere mogelijke richtingen voor vervolgonderzoek die volgen uit de resultaten uit dit proefschrift. Zo is in de hoofdstukken 5 en 6 aangetoond dat externaliteiten in ruilnetwerken sociale dilemma's kunnen creëren. Vervolgonderzoek zou zich dan ook bezig kunnen houden met het vergelijken van actorgedrag in traditionele sociale dilemma's en sociale dilemma's ontstaan door externaliteiten in ruilnetwerken.

In de experimenten gerapporteerd in de hoofdstukken 2, 3, 5 en 6 zijn schendingen waargenomen van de rationaliteitprincipes die ten grondslag liggen aan de generalized core. Vervolgonderzoek is nodig om de condities te onderzoeken waaronder deze rationaliteitprincipes wel en niet worden geschonden en om ze eventueel te vervangen door meer 'gedragsmatig gefundeerde' assumpties. Voorts zouden theorieën als power-dependence en exchange-resistance, die boven op rationaliteitassumpties nog gebruikmaken van een aantal 'sociaal-psychologische' assumpties, verder kunnen worden onderzocht, waarbij hun voorspellingen moeten worden vergeleken met die van de generalized core.

ICS dissertation series

The ICS-series presents dissertations of the Interuniversity Center for Social Science Theory and Methodology. Each of these studies aims at integrating explicit theory formation with state-of-the-art empirical research or at the development of advanced methods for empirical research. The ICS was founded in 1986 as a cooperative effort of the universities of Groningen and Utrecht. Since 1992, the ICS expanded to the University of Nijmegen. Most of the projects are financed by the participating universities or by the Netherlands Organization for Scientific Research (NWO). The international composition of the ICS graduate students is mirrored in the increasing international orientation of the projects and thus of the ICS-series itself.

1) C. van Liere, (1990), *Lastige Leerlingen. Een empirisch onderzoek naar sociale oorzaken van probleemgedrag op basisscholen.* Amsterdam: Thesis Publishers.
2) Marco H.D. van Leeuwen, (1990), *Bijstand in Amsterdam, ca. 1800 - 1850. Armenzorg als beheersings- en overlevingsstrategie.* ICS dissertation, Utrecht.
3) I. Maas, (1990), *Deelname aan podiumkunsten via de podia, de media en actieve beoefening. Substitutie of leereffecten?* Amsterdam: Thesis Publishers.
4) M.I. Broese van Groenou, (1991), *Gescheiden Netwerken. De relaties met vrienden en verwanten na echtscheiding.* Amsterdam: Thesis Publishers.
5) Jan M.M. van den Bos, (1991), *Dutch EC Policy Making. A Model-Guided Approach to Coordination and Negotiation.* Amsterdam: Thesis Publishers.
6) Karin Sanders, (1991), *Vrouwelijke Pioniers. Vrouwen en mannen met een 'mannelijke' hogere beroepsopleiding aan het begin van hun loopbaan.* Amsterdam: Thesis Publishers.
7) Sjerp de Vries, (1991), *Egoism, Altruism, and Social Justice. Theory and Experiments on Cooperation in Social Dilemmas.* Amsterdam: Thesis Publishers.
8) Ronald S. Batenburg, (1991), *Automatisering in bedrijf.* Amsterdam: Thesis Publishers.
9) Rudi Wielers, (1991), *Selectie en allocatie op de arbeidsmarkt. Een uitwerking voor de informele en geïnstitutionaliseerde kinderopvang.* Amsterdam: Thesis Publishers.
10) Gert P. Westert, (1991), *Verschillen in ziekenhuisgebruik.* ICS dissertation, Groningen.
11) Hanneke Hermsen, (1992), *Votes and Policy Preferences. Equilibria in Party Systems.* Amsterdam: Thesis Publishers.
12) Cora J.M. Maas, (1992), *Probleemleerlingen in het basisonderwijs.* Amsterdam: Thesis Publishers.
13) Ed A.W. Boxman, (1992), *Contacten en carrière. Een empirisch-theoretisch onderzoek naar de relatie tussen sociale netwerken en arbeidsmarktposities.* Amsterdam: Thesis Publishers.
14) Conny G.J. Taes, (1992), *Kijken naar banen. Een onderzoek naar de inschatting van arbeidsmarktkansen bij schoolverlaters uit het middelbaar beroepsonderwijs.* Amsterdam: Thesis Publishers.
15) Peter van Roozendaal, (1992), *Cabinets in Multi-Party Democracies. The Effect of Dominant and Central Parties on Cabinet Composition and Durability.* Amsterdam: Thesis Publishers.
16) Marcel van Dam, (1992), *Regio zonder regie. Verschillen in en effectiviteit van gemeentelijk arbeidsmarktbeleid.* Amsterdam: Thesis Publishers.
17) Tanja van der Lippe, (1993), *Arbeidsverdeling tussen mannen en vrouwen.* Amsterdam: Thesis Publishers.
18) Marc A. Jacobs, (1993), *Software: Kopen of Kopiëren? Een sociaal-wetenschappelijk onderzoek onder PC-gebruikers.* Amsterdam: Thesis Publishers.
19) Peter van der Meer, (1993), *Verdringing op de Nederlandse arbeidsmarkt. sector- en sekseverschillen.* Amsterdam: Thesis Publishers.
20) Gerbert Kraaykamp, (1993), *Over lezen gesproken. Een studie naar sociale differentiatie in leesgedrag.* Amsterdam: Thesis Publishers.
21) Evelien Zeggelink, (1993), *Strangers into Friends. The Evolution of Friendship Networks Using an Individual Oriented Modeling Approach.* Amsterdam: Thesis Publishers.
22) Jaco Berveling, (1994), *Het stempel op de besluitvorming. Macht, invloed en besluitvorming op twee Amsterdamse beleidsterreinen.* Amsterdam: Thesis Publishers.
23) Wim Bernasco, (1994), *Coupled Careers. The Effects of Spouse's Resources on Success at Work.* Amsterdam: Thesis Publishers.
24) Liset van Dijk, (1994), *Choices in Child Care. The Distribution of Child Care Among Mothers, Fathers and Non-Parental Care Providers.* Amsterdam: Thesis Publishers.

25) Jos de Haan, (1994), *Research Groups in Dutch Sociology.* Amsterdam: Thesis Publishers.
26) K. Boahene, (1995), *Innovation Adoption as a Socio-Economic Process. The Case of the Ghanaian Cocoa Industry.* Amsterdam: Thesis Publishers.
27) Paul E.M. Ligthart, (1995), *Solidarity in Economic Transactions. An Experimental Study of Framing Effects in Bargaining and Contracting.* Amsterdam: Thesis Publishers.
28) Roger Th. A.J. Leenders, (1995), *Structure and Influence. Statistical Models for the Dynamics of Actor Attributes, Network Structure, and their Interdependence.* Amsterdam: Thesis Publishers.
29) Beate Völker, (1995), *Should Auld Acquaintance Be Forgot...? Institutions of Communism, the Transition to Capitalism and Personal Networks: the Case of East Germany.* Amsterdam: Thesis Publishers.
30) A. Cancrinus-Matthijsse, (1995), *Tussen hulpverlening en ondernemerschap. Beroepsuitoefening en taakopvattingen van openbare apothekers in een aantal West-Europese landen.* Amsterdam: Thesis Publishers.
31) Nardi Steverink, (1996), *Zo lang mogelijk zelfstandig. Naar een verklaring van verschillen in oriëntatie ten aanzien van opname in een verzorgingstehuis onder fysiek kwetsbare ouderen.* Amsterdam: Thesis Publishers.
32) Ellen Lindeman, (1996), *Participatie in vrijwilligerswerk.* Amsterdam: Thesis Publishers.
33) Chris Snijders, (1996), *Trust and Commitments.* Amsterdam: Thesis Publishers.
34) Koos Postma, (1996), *Changing Prejudice in Hungary. A Study on the Collapse of State Socialism and Its Impact on Prejudice Against Gypsies and Jews.* Amsterdam: Thesis Publishers.
35) Jooske T. van Busschbach, (1996), *Uit het oog, uit het hart? Stabiliteit en verandering in persoonlijke relaties.* Amsterdam: Thesis Publishers.
36) René Torenvlied, (1996), *Besluiten in uitvoering. Theorieën over beleidsuitvoering modelmatig getoetst op sociale vernieuwing in drie gemeenten.* Amsterdam: Thesis Publishers.
37) Andreas Flache, (1996), *The Double Edge of Networks. An Analysis of the Effect of Informal Networks on Cooperation in Social Dilemmas.* Amsterdam: Thesis Publishers.
38) Kees van Veen, (1997), *Inside an Internal Labor Market: Formal Rules, Flexibility and Career Lines in a Dutch Manufacturing Company.* Amsterdam: Thesis Publishers.
39) Lucienne van Eijk, (1997), *Activity and Well-being in the Elderly.* Amsterdam: Thesis Publishers.
40) Róbert Gál, (1997), *Unreliability. Contract Discipline and Contract Governance under Economic Transition.* Amsterdam: Thesis Publishers.
41) Anne-Geerte van de Goor, (1997), *Effects of Regulation on Disability Duration.* ICS dissertation, Utrecht.
42) Boris Blumberg, (1997), *Das Management von Technologiekooperationen. Partnersuche und Verhandlungen mit dem Partner aus Empirisch-Theoretischer Perspektive.* ICS dissertation, Utrecht.
43) Marijke von Bergh, (1997), *Loopbanen van oudere werknemers.* Amsterdam: Thesis Publishers.
44) Anna Petra Nieboer, (1997), *Life-Events and Well-Being: A Prospective Study on Changes in Well-Being of Elderly People Due to a Serious Illness Event or Death of the Spouse.* Amsterdam: Thesis Publishers.
45) Jacques Niehof, (1997), *Resources and Social Reproduction: The Effects of Cultural and Material Resources on Educational and Occupational Careers in Industrial Nations at the End of the Twentieth Century.* ICS dissertation, Nijmegen.
46) Ariana Need, (1997), *The Kindred Vote. Individual and Family Effects of Social Class and Religion on Electoral Change in the Netherlands, 1956-1994.* ICS dissertation, Nijmegen.
47) Jim Allen, (1997), *Sector Composition and the Effect of Education on Wages: an International Comparison.* Amsterdam: Thesis Publishers.
48) Jack B.F. Hutten, (1998), *Workload and Provision of Care in General Practice. An Empirical Study of the Relation Between Workload of Dutch General Practitioners and the Content and Quality of their Care.* ICS dissertation, Utrecht.
49) Per B. Kropp, (1998), *Berufserfolg im Transformationsprozeß. Eine theoretisch-empirische Studie über die Gewinner und Verlierer der Wende in Ostdeutschland.* ICS dissertation, Utrecht.
50) Maarten H.J. Wolbers, (1998), *Diploma-inflatie en verdringing op de arbeidsmarkt. Een studie naar ontwikkelingen in de opbrengsten van diploma's in Nederland.* ICS dissertation, Nijmegen.
51) Wilma Smeenk, (1998), *Opportunity and Marriage. The Impact of Individual Resources and Marriage Market Structure on First Marriage Timing and Partner Choice in the Netherlands.* ICS dissertation, Nijmegen.
52) Marinus Spreen, (1999), *Sampling Personal Network Structures: Statistical Inference in Ego-Graphs.* ICS dissertation, Groningen.
53) Vincent Buskens, (1999), *Social Networks and Trust.* ICS dissertation, Utrecht.
54) Susanne Rijken, (1999), *Educational Expansion and Status Attainment. A Cross-National and Over-Time*

Comparison. ICS dissertation, Utrecht.
55) Mérove Gijsberts, (1999), *The Legitimation of Inequality in State-Socialist and Market Societies, 1987-1996.* ICS dissertation, Utrecht.
56) Gerhard G. Van de Bunt, (1999), *Friends by Choice. An Actor-Oriented Statistical Network Model for Friendship Networks Through* Time. ICS dissertation, Groningen.
57) Robert Thomson, (1999), *The Party Mandate: Election Pledges and Government Actions in the Netherlands, 1986-1998.* Amsterdam: Thela Thesis.
58) Corine Baarda, (1999), *Politieke besluiten en boeren beslissingen. Het draagvlak van het mestbeleid tot 2000.* ICS dissertation, Groningen.
59) Rafael Wittek, (1999), *Interdependence and Informal Control in Organizations.* ICS dissertation, Groningen.
60) Diane Payne, (1999), *Policy Making in the European Union: an Analysis of the Impact of the Reform of the Structural Funds in Ireland.* ICS dissertation, Groningen.
61) René Veenstra, (1999), *Leerlingen - Klassen - Scholen. Prestaties en vorderingen van leerlingen in het voortgezet onderwijs*. Amsterdam, Thela Thesis.
62) Marjolein Achterkamp, (1999), *Influence Strategies in Collective Decision Making. A Comparison of Two Models.* ICS dissertation, Groningen.
63) Peter Mühlau, (2000), *The Governance of the Employment Relation. A Relational Signaling Perspective.* ICS dissertation, Groningen.
64) Agnes Akkerman, (2000), *Verdeelde vakbeweging en stakingen. Concurrentie om leden*. ICS dissertation, Groningen.
65) Sandra van Thiel, (2000), *Quangocratization: Trends, Causes and Consequences.* ICS dissertation, Utrecht.
66) Rudi Turksema, (2000), *Supply of Day Care*. ICS dissertation, Utrecht.
67) Sylvia E. Korupp (2000), *Mothers and the Process of Social Stratification*. ICS dissertation, Utrecht.
68) Bernard A. Nijstad (2000), *How the Group Affects the Mind: Effects of Communication in Idea Generating Groups*. ICS dissertation, Utrecht.
69) Inge F. de Wolf (2000), *Opleidingsspecialisatie en arbeidsmarktsucces van sociale wetenschappers*. ICS dissertation, Utrecht.
70) Jan Kratzer (2001), *Communication and Performance: An Empirical Study in Innovation Teams*. ICS-dissertation, Groningen.
71) Madelon Kroneman (2001), *Healthcare Systems and Hospital Bed Use*. ICS/NIVEL-dissertation, Utrecht.
72) Herman van de Werfhorst (2001), *Field of Study and Social Inequality. Four Types of Educational Resources in the Process of Stratification in the Netherlands.* ICS-dissertation, Nijmegen.
73) Tamás Bartus (2001), *Social Capital and Earnings Inequalities. The Role of Informal Job Search in Hungary*. ICS-dissertation Groningen.
74) Hester Moerbeek (2001), *Friends and Foes in the Occupational Career. The Influence of Sweet and Sour Social Capital on the Labour Market*. ICS-dissertation, Nijmegen.
75) Marcel van Assen (2001), *Essays on Actor Perspectives in Exchange Networks and Social Dilemmas.* ICS-dissertation, Groningen.
76) Inge Sieben (2001), *Sibling Similarities and Social Stratification. The Impact of Family Background across Countries and Cohorts*. ICS-dissertation, Nijmegen.
77) Alinda van Bruggen (2001), *Individual Production of Social Well-Being. An Exploratory Study.* ICS-dissertation, Groningen.
78) Marcel Coenders (2001), *Nationalistic Attitudes and Ethnic Exclusionism in a Comparative Perspective: An Empirical Study of Attitudes Toward the Country and Ethnic Immigrants in 22 Countries*. ICS-dissertation, Nijmegen.
79) Marcel Lubbers (2001), *Exclusionistic Electorates. Extreme Right-Wing Voting in Western Europe*, ICS-dissertation, Nijmegen.
80) Uwe Matzat (2001), *Social Networks and Cooperation in Electronic Communities. A theoretical-empirical Analysis of Academic Communication and Internet Discussion Groups*, ICS-dissertation, Groningen.
81) Jacques P.G. Janssen (2002), *Do Opposites Attract Divorce? Dimensions of Mixed Marriage and the Risk of Divorce in the Netherlands*, ICS-dissertation, Nijmegen.
82) Miranda Jansen (2002), *Waardenoriëntaties en partnerrelaties. Een panelstudie naar wederzijdse invloeden*, ICS-dissertation, Utrecht.
83) Anne Rigt Poortman (2002), *Socioeconomic Causes and Consequences of Divorce*. ICS-dissertation, Utrecht.

84) Alexander Gattig (2002), *Intertemporal Decision Making*, ICS-dissertation, Groningen.
85) Gerrit Rooks (2002), *Contract en Conflict: Strategisch Management van Inkooptransacties,* ICS-dissertation, Utrecht.
86) Károly Takács (2002), Social *Networks and Intergroup Conflict.* ICS-dissertation, Groningen.
87) Thomas Gautschi (2002), *Trust and Exchange, Effects of Temporal Embeddedness and* Network Embeddedness on Providing and Dividing a Surplus. ICS-dissertation, Utrecht.
88) Hilde Bras (2002), *Zeeuwse meiden. Dienen in de levensloop van vrouwen, ca. 1850 – 1950.* Aksant Academic Publishers, Amsterdam.
89) Merijn Rengers (2002), *Economic Lives of Artists. Studies into Careers and the Labour Market in the Cultural Sector*, ICS-dissertation, Utrecht.
90) Annelies Kassenberg (2002), *Wat scholieren bindt. Sociale gemeenschap in scholen*, ICS-dissertation, Groningen
91) Marc Verboord (2003), *Moet de meester dalen of de leerling klimmen? De invloed van literatuuronderwijs en ouders op het lezen van boeken tussen 1975 en 2000*. ICS-dissertation, Utrecht.
92) Marcel van Egmond (2003), *Rain Falls on All of Us (but Some Manage to Get More Wet than Others): Political Context and Electoral Participation*. ICS-dissertation, Nijmegen.
93) Justine Horgan (2003), *High Performance Human Resource Management in Ireland and the Netherlands: Adoption and Effectiveness.* ICS-dissertation, Groningen.
94) Corine Hoeben (2003), *LETS' Be a Community. Community in Local Exchange Trading Systems.* ICS-dissertation, Groningen.
95) Christian Steglich (2003), *The Framing of Decision Situations. Automatic Goal Selection and Rational Goal Pursuit*. ICS-dissertation, Groningen.
96) Johan van Wilsem (2003), *Crime and Context. The Impact of Individual, Neighborhood, City and Country Characteristics on Victimization*. ICS-dissertation, Nijmegen.
97) Christiaan Monden (2003), *Education, Inequality and Health. The Impact of Partners and Life Course*. ICS-dissertation, Nijmegen.
98) Evelyn Hello (2003), *Educational Attainment and Ethnic Attitudes. How to Explain their Relationship.* ICS-dissertation, Nijmegen.
99) Marnix Croes en Peter Tammes (2004), *Gif laten wij niet voortbestaan. Een onderzoek naar de overlevingskansen van joden in de Nederlandse gemeenten, 1940-1945*. Aksant Academic Publishers, Amsterdam
100) Ineke Nagel (2004), *Cultuurdeelname in de levensloop*. ICS- dissertation, Utrecht.
101) Marieke van der Wal (2004), *Competencies to Participate in Life. Measurement and the Impact of School*. ICS-dissertation, Groningen.
102) Vivian Meertens (2004), *Depressive Symptoms in the General Population: a Multifactorial Social Approach.* ICS -dissertation, Nijmegen.
103) Hanneke Schuurmans (2004), *Promoting Well-Being in Frail Elderly People. Theory and Intervention.* ICS-dissertation, Groningen.
104) Javier Arregui (2004), *Negotiation in Legislative Decision-Making in the European Union.* ICS-dissertation, Groningen.
105) Tamar Fischer (2004), *Parental Divorce, Conflict and Resources. The Effects on Children's Behaviour Problems, Socioeconomic Attainment, and Transitions in the Demographic Career.* ICS-dissertation, Nijmegen.
106) René Bekkers (2004), *Giving and Volunteering in the Netherlands: Sociological and Psychological Perspectives.* ICS-dissertation, Utrecht.
107) Renée van der Hulst (2004), *Gender Differences in Workplace Authority: An Empirical Study on Social Networks.* ICS-dissertation, Groningen.
108) Rita Smaniotto (2004), *'You Scratch My Back and I Scratch Yours' Versus 'Love Thy Neighbour'. Two Proximate Mechanisms of Reciprocal Altruism*. ICS-dissertation, Groningen.
109) Maurice Gesthuizen (2004), *The Life-Course of the Low-Educated in the Netherlands: Social and Economic Risks*. ICS-dissertation, Nijmegen.
110) Carlijne Philips (2005), *Vakantiegemeenschappen. Kwalitatief en Kwantitatief Onderzoek naar Gelegenheid en Refreshergemeenschap tijdens de Vakantie*. ICS-dissertation, Groningen.
111) Esther de Ruijter (2005), *Household Outsourcing*. ICS-dissertation, Utrecht.
112) Frank van Tubergen (2005), *The Integration of Immigrants in Cross-National Perspective: Origin, Destination, and Community Effects*. ICS-dissertation, Utrecht.

113) Ferry Koster (2005), *For the Time Being. Accounting for Inconclusive Findings Concerning the Effects of Temporary Employment Relationships on Solidary Behavior of Employees.* ICS-dissertation, Groningen.
114) Carolien Klein Haarhuis (2005), *Promoting Anti-Corruption Reforms. Evaluating the Implementation of a World Bank Anti-Corruption Program in Seven African Countries (1999-2001).* ICS-dissertation, Utrecht.
115) Martin van der Gaag (2005), *Measurement of Individual Social Capital*. ICS-dissertation, Groningen.
116) Johan Hansen (2005), *Shaping Careers of Men and Women in Organizational Contexts.* ICS-dissertation, Utrecht.
117) Davide Barrera (2005), *Trust in Embedded Settings.* ICS-dissertation, Utrecht.
118) Mattijs Lambooij (2005), *Promoting Cooperation. Studies into the Effects of Long-Term and Short-Term Rewards on Cooperation of Employees*. ICS-dissertation, Utrecht.
119) Lotte Vermeij (2006), *What's Cooking? Cultural Boundaries among Dutch Teenagers of Different Ethnic Origins in the Context of School*. ICS-dissertation, Utrecht.
120) Mathilde Strating (2006), *Facing the Challenge of Rheumatoid Arthritis. A 13-year Prospective Study among Patients and Cross-Sectional Study among Their Partners*. ICS-dissertation, Groningen.
121) Jannes de Vries (2006), *Measurement Error in Family Background Variables: The Bias in the Intergenerational Transmission of Status, Cultural Consumption, Party Preference, and Religiosity*. ICS-dissertation, Nijmegen.
122) Stefan Thau (2006), *Workplace Deviance: Four Studies on Employee Motives and Self-Regulation*. ICS-dissertation, Groningen.
123) Mirjam Plantinga (2006), *Employee Motivation and Employee Performance in Child Care. The effects of the Introduction of Market Forces on Employees in the Dutch Child-Care Sector.* ICS-dissertation, Groningen.
124) Helga de Valk (2006), *Pathways into Adulthood. A Comparative Study on Family Life Transitions among Migrant and Dutch Youth.* ICS-dissertation, Utrecht.
125) Henrike Elzen (2006), *Self-Management for Chronically Ill Older People*. ICS-Dissertation, Groningen.
126) Ayse Güveli (2007), *New Social Classes within the Service Class in the Netherlands and Britain. Adjusting the EGP Class Schema for the Technocrats and the Social and Cultural Specialists.* ICS-dissertation, Nijmegen.
127) Willem-Jan Verhoeven (2007), *Income Attainment in Post-Communist Societies*. ICS-dissertation, Utrecht.
128) Marieke Voorpostel (2007), *Sibling support: The Exchange of Help among Brothers and Sisters in the Netherlands*. ICS-dissertation, Utrecht.
129) Jacob Dijkstra (2007), *The Effects of Externalities on Partner Choice and Payoffs in Exchange Networks.* ICS-dissertation, Groningen.
130) Patricia van Echtelt (2007), *Time-Greedy Employment Relationships: Four Studies on the Time Claims of Post-Fordist Work.* ICS-dissertation, Groningen.
131) Sonja Vogt (2007), *Heterogeneity in Social Dilemmas: The Case of Social Support.* ICS-dissertation, Utrecht.