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Social Capital and Exchange in Networks

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Social Capital and Exchange in Networks

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Starting from Coleman's Linear System of Action as a social action theory the paper derives a generalized social exchange model taking explicitly transaction costs into account. In the absence of formal institutions like money exchange is organized in networks of social relations among actors. In contrast to perfect economic markets social exchange organized in networks implies actor specific transaction cost corresponding to the risk of opportunistic behavior in equilibrium. Hence, beyond actors' resource endowments actors ability to improve her utility via exchange is additionally restricted by transaction costs determined by her position within the given network structure. In the framework of the generalized social exchange equilibrium the following results are shown: (i) a generalized Walras equilibrium can be defined taking explicitly into account for actor specific transaction costs; (ii) in equilibrium social capital can be conceptualized as both as an individual resource corresponding to transaction costs faced by individual actors' due to her specific network position as well as an collective resource corresponding to total transaction costs occurring among actors given the total network structures. (iii) formally, for a specific exchange network a social capital index can be defined in equilibrium as the Hicksian equivalent compensation comparing actors utility in the actual exchange equilibrium with her utility she would receive in a perfect market exchange equilibrium. (iv) applying our theory empirically to political exchange implies in the contra intuitive result that as long as external effects of exchange exists minimizing transaction cost does generally not imply maximizing social welfare.

Key words: social capital, Coleman's Linear system of Action, network theory, formal modeling of political exchange

1 Introduction

There is a burgeoning literature on social capital in all branches of social sciences, i.e. in economics (e.g. Alesina et al. 2000, Becker 1996, Knack/Keefer 1997, Dasgupta, Serageldin 1999), political science (e.g. Putnam 1993 and 2000, Hardin 1999, van Deth, Maraffi, Newton, Whiteley 1999) and sociology (e.g Granovetter, Coleman 1988, Fukuyama (1995), Portes 1998). Some scholars even consider social capital as one of the potentially most influential research paradigma in social sciences (see Hardin 1998: 4). However, social capital is not uniquely conceptionalized at the theoretical level, nor has a consistent empirical measurement of social capital been derived, yet.

Generally, the idea of social capital corresponds to the effect of social relations and networks of such relations on social behavior and institutions. At a theoretical level, social capital can be understood as an attempt to overcome shortcomings of both the classical sociological and (neo-)classical economic approach to human behavior. The sociological approach to human behavior is often criticized as an oversocialized conception of man providing no engine of action, i.e. individual action is completely determined by the environment (Coleman 1988, Wrong 1961). In contrast, the economic approach to human behavior, in particular the neoclassical approach is criticized as an undersocialized concept of man, as it neglects completely the impact of actual social organization of economic transactions on these transactions (see new institutional economics literature, in particular Williamson 1975, 1981). Interestingly, Granovetter even argues that both approaches, the economic approach as an undersocialized conception of man and the sociological approach as an oversocialized conception of man, have "in common a conception of action and decision carried out by atomized actors” (Granovetter 1985: 485). Hence, both approaches neglect the impact of social structures on actors’ behavior. Social capital can be understood to overcome this criticism by integrating social structures among individual actors in a comprehensive theory of action.

Beside this common feature, the various approaches on social capital found in the literature differ significantly. First, approaches differ regarding their causal relation. Some scholars like Coleman and Granovetter focus on how specific social structures restrict or facilitate individual behavior at the micro-level, while other focus on collective outcome at the macro-level. In particular most political scientists’ and economists’ interest in social capital is “motivated primarily by the linkage between levels of social capital and collective outcomes; high levels of social capital appear to be crucial for such measures of collective well-being as economic development, effective political institutions, low crime rates, and lower inefficiencies of other social problems such as teen pregnancy and delinquency” (Brehm and Rahn 1997: 1000). Analogously to Coleman and Granovetter they also focus on trust, norms and networks, i.e. characteristics on the individual level. But, the central concern is with the question how individual-level factors facilitate cooperation at the collective level, i.e. performance of the political institutions and of the economy (see for example Putnam 1993 or Knack/Keefer 1997).

Secondly, approaches differ regarding their way of integrating social structure in a theory of action. Most scholars interpret the impact of social structures as a resource that is available to an individual or corporate actor and is valuable in facilitating certain actions. In contrast, Becker (1996) interprets social capital as the impact of social structures on individual preferences (see also Hardin 1999).

Finally, approaches differ regarding their methodological level. While many scholars like Putnam or Fukujama use the term social capital in a more metaphorical sense, both Coleman and Granovetter suggest but do not explicitly model various mechanisms through which networks of social relations affect actors' behavior.

A formal modeling of how social structures affect actors' behavior has been provided by or Raub and Weesie (1990), Greif (1993) and Calvert (1995) on the basis of game theoretical models[1]. Although these models contribute significantly to the understanding of the impact of networks of social relations on the emergence of cooperation in social exchange situations, some questions and shortcomings remain. In particular, these models are highly abstract and thus allow only for a qualitative conception of social capital, but do not provide a quantitative conception or empirical measurement of social capital. Secondly, these approaches focus on sequential dyadic exchange situations, while more complex exchange relations, e.g. competition among different exchange partners are not taken into account.

In this framework the paper suggests a generalization of Coleman's social exchange model taking explicitly transaction costs into account. In the absence of formal institutions like money or formal contracts, exchange is organized in networks of social relations among actors. In contrast to perfect economic markets, social exchange organized in networks implies actor specific transaction cost corresponding to the risk of opportunistic behavior in equilibrium. Hence, beyond actors' resource endowments actors' ability to improve their utility via exchange is additionally restricted by transaction costs determined by their position within the given network

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[1] Becker (1996) also provides a clear formal model of social capital in a neoclassical framework.

structure. In the framework of the generalized social exchange equilibrium the following results are shown: (i) a generalized Walras equilibrium can be defined taking explicitly actor specific transaction costs into account; (ii) in equilibrium social capital can be conceptualized; (iii) a quantitative social capital index can be defined in equilibrium at both the micro and macro level that can also be estimated empirically on the basis of observed transfer networks; (iv) comparative static analysis imply that individual social capital corresponding to a specific network organization is the higher the higher the relative access of an actor to other actors and vice versa from other actors to this actor. (v) assuming external effects of exchange implies the contra intuitive result that minimizing transaction cost does generally not imply maximizing social welfare; (v) from a collective perspective network organizations of exchange in comparison to an organization based on formal institutions, like contracts, are less efficient especially in a dynamic perspective, since the former provide lower incentives for actors to invest in technical progress; (vi) nevertheless, a change from less to more efficient social organizations is generally not Pareto-dominant, therefore from society's perspective efficient organizational change might be blocked by actors expecting an utility loss. Historically, network organization emerged first as a spontaneous order in a process of evolutionary rationalism in the sense of Hayek (1973: 38 p), while the emergence of an organization mainly based on formal institutions occurs at a later stage of economic development in a process of constructive rationalism (see Hayek 1973: 33), i.e. can be interpreted as the result of a rationalized collective decision within formal political institutions (see also Richter/Furubotn 1999), path dependence plays an important role for the historical evolution of social organization. If spontaneous network organization is characterized by an economically dominant elite of central brokers, later change to more efficient formal institutions might be blocked politically by these brokers expecting a welfare loss from this change.

The rest of the paper is organized as follows: In section 2 first the theoretical model is derived and a social capital index is defined. Moreover, comparative static and dynamic results of our model are discussed on the basis of simulation analyses of a simple social exchange model. In section 3 it is demonstrated how the social capital index can be derived empirically on the basis of observed transfer networks, while section 4 summarized main results.

2 Exchange in networks: a formal approach

2.1 Access networks and the emergence of reciprocity in social exchange networks

A core problem of social exchange among rational actors is the creation of a social order that avoids opportunistic behavior. One of the first scholars realizing this fundamental problem of social order was David Hume: "Your corn is ripe today; mine will be tomorrow. 'tis profitable for us both, that I should labour with you today, and that you should aid me tomorrow. I have no kindness for you, and know you have as little for me. I will not, therefore, take any pains upon your account; and should I labour with you upon my own account, in expectation of return, I know I should be disappointed, and that I should in vain depend upon your gratitude. Here then I leave you to labour alone; You treat me in the same manner. The seasons change;

and both of us lose our harvests for want of mutual confidence and security." (Hume, 1776).

The economic exchange theory solves the problem of opportunistic behavior by assuming the existence of appropriate formal institutions, a perfect market or contracts within actors could exchange commodities without transaction costs.

Taking into account that on the one hand a lot of social interaction corresponds to social exchange, e.g. informal exchange in the absence of appropriate formal institutions (Coleman 1990) and on the other hand also economic exchange within formal institutions is still often plagued by the problem of opportunistic behavior due to transaction cost (see Williamson 1975, Wilson 1985, North 1990, Furubotn/Richter 1999), the question arises how social exchange beyond appropriate formal institutions can be understood.

First approaches to this question are the classical contributions of Homans (1961) und Blau (1964). Both authors explained the emergence of social exchange via the assumption of a norm. Blau introduced the norm of reciprocity and Homan the norm of distributive justice. Of course, assuming exogenously that actors' behavior is restricted by norms, the problem of opportunistic behavior is circumvented by definition. But, as Coleman and Granovetter pointed out this is not a real solution of the problem. In particular, the question is under which condition the exogenously assumed norms can be derived as an endogenous informal institution in equilibrium.

In this regard both Coleman and Granovetter suggest but do not explicitly model various mechanisms through which networks of social relations affect actors' behavior including respecting the norm of reciprocity. In particular Granovetter

(1985) stresses that reputation as an important mechanism inducing actors to abstain from otherwise individually profitable opportunistic behavior. Reputation arises from the embeddedness of action. Action can be temporarily or socially embedded or both. Formal models allowing for cooperation in social dilemmas focus on reputation effects resulting from temporarily embedded action (Axelrod 1984) as well as from both socially and temporarily embedded action (Raub/Weesie 1990, Greif 1993, Calvert 1995). Although these models contribute significantly to the understanding of the impact of networks of social relations on the emergence of cooperation in social exchange situations, some questions and shortcomings remain. First, these models are highly abstract, their main focus is the explanation how information networks as well as networks of repeated interactions induce cooperation among actors. Hence, while these models allow for a qualitative conception of social capital, they do not provide a quantitative conception or empirical measurement of social capital. Secondly, these approaches analyze reputation in the framework of infinitely repeated Prisoner's dilemma (PD) games or one-sided PD games with complete information. In particular, they focus on sequential dyadic exchange situations. Therefore the interdependence of Ego's exchange relations with different Alters is not explicitly considered. Since many empirical economic and social transactions correspond to a simultaneous competition among different exchange partners these models appear rather restrictive. Thirdly, the assumption of complete information seems a rather realistic. In most social situations actors are uncertain about specific relevant characteristics of other actors (see for example Kreps and Wilson (1982), Milgrom and Roberts (1982)).

In this framework we suggest a neoclassical model of social actions corresponding to Coleman's Linear System of Action (LSA). In contrast to the LSA we do not assume that opportunistic behavior of actors is completely avoided via the existence of appropriate formal institutions. But we assume that exchange is organized in informal networks, where reputation effects induce actors to abstain from opportunistic behavior. In contrast to the game theoretical models mentioned above, we assume that actors engage in repeated exchange simultaneously with different other actors, where they are generally uncertain about other actors' reputation.

Formally, we assume that each actor i knows for each potential exchange partner j in the network a specific probability distribution $f(t_{ij})$ over the interval $t_{ij} \in (0, z_{ij})$, where $f(t_{ij})$ denotes the probability that an actor j will defeat being offered a transfer of the amount t_{ij} by actor i. The probability of actors' defection $f(t_{ij})$ is monoton increasing in tij and approaches 1 for $t_{ij}=z_{ij}$. The threshold value z_{ij} varies for each pair of actors i,j of N and is a function of actors' embeddedness in the overall network structure of social relations defined on the set of actors N.

Generally, it would be possible to derive the explicit correspondence of actor specific thresholds (zij) and networks of repeated exchange relations as well as information networks among actors, in the framework of an accordingly defined exchange game (see Buskens 1999). But since this is not the main focus of this paper, it will be sufficient to broadly outline a simple exchange game to justify assumptions made in our generalized social exchange model including actor specific transaction costs.

A simple exchange game

Consider the following perfect and complete information one-sided Prisoner's Dilemma game, which mainly corresponds to a game suggested by Greif (1993) captures the essence of our argumentation. There is a finite set N including 2n actors. Actors are subdivided into two separate groups N_1 and N_2 of an equal size of n. Each actor of group N1 possess a specific amount w of a commodity C1, while each actor of the group C2 possess each a the amount w of a different commodity C2. Both actor types have preferences for both commodities C1 and C2. Hence, given an exogenously fixed exchange rate v, actors of the group N1 want to exchange commodity C1 against commodity C2 and vice versa actors of the group N2 want to exchange C2 against C1. Further, we assume that given the exchange rate v both actor types $i \in N1$ and $j \in N2$ want to exchange a maximal amount of ca. Actors live an infinite number of periods and have a discount factor $\delta \leq 1$. In each period a subset of actors of group N1 and a subset of actors of N2 are matched in pairs to engage in exchange transactions. Further, we assume that for a given actor of group N2 the probability to be matched with an actor of group N1 is r<1. Then the probability that an individual actor will not be matched with any other actor is given by (1-r) > 0. Once two actors i,j are matched in a period, they play the following OPSD (see Greif 1993). Actor i chooses an amount t_{ij} of commodity C1 he wants to exchange at the given exchange rate v and transfers this amount to actor j. Actor j can then cooperate, e.g. return the amount vt_{ij} of commodity C2 to actor 2, or defeat, e.g. keep the amount t_{ij} without any return. After the trade has been done, the actor i can costlessly report the behavior of actor j to members in his group N1. We assume that information flows are incomplete in group N1, i.e. the information of actor i will reach an actor $k \in N1$ only with a probability $p < 1$. Moreover, we assume that exchange relation among matched actors do not with certainty continue, i.e. assume that successful exchange will only be continued by a probability $q<1$. An Actor i receives a pay-off U ($w-t_{ij}$, vt_{ij}) and U($w-t_{ij}$, 0), respectively, if actor j cooperates or cheats. Accordingly, actor j receives a pay-off of U(w-tij, vtij) and a pay-off of U(w, vt_{ij}) if he cooperates or cheats in this period. U is a well-behaved concave utility function representing actors' individual preferences.

Proposition 1: Cooperation is sustained in equilibrium as long as actor i offers a transfer $t \in (0, t_{max})$. Moreover, t_{max} is a positive monotonic function of p, r and q.

Proof: appendix

Thus, the higher actors are embedded in repeated exchange relations (i.e. the higher r and q) and the more dense the information network of group N1 (i.e. the higher p), the higher is the maximal amount actors can exchange.

In a next step we extend our exchange game by assuming that the set N2 is subdivided in two different subsets, N21 and N22, respectively. We further assume that actor $i \in N1$ is now paired simultaneously with two actors $j \in N21$ and $k \in N22$.

Moreover, we relax the assumption of perfect information, i.e. we assume that actors do not know exactly the type of their trading partner. In particular we assume that actors do only know for each actor j a probability f(tij) that she will cheat being offered a transfer of tij. Moreover, f(tij) is positive increasing in tij. For simplicity, we assume that it holds for f(tij):

$$f^{ij}(t_{ij}) = \begin{cases} 1 - \left[\dfrac{z_{ij} - t_{ij}}{z_{ij}} \right]^{X_{ij}} & \text{for } \mathrm{t_{ij}} < \mathrm{z_{ij}} \\ 1 & \text{otherwise} \end{cases} \qquad 0 < X_{ij} < 1$$

Obviously, z_{ij} equals just the minimal offer for which an actor j would cheat with certainty in an exchange relation with actor i. As it is not the focus of the paper at hand, we will not explore the equilibrium of the extended game in detail. However, given the risk averse (concave) preferences it follows quite plainly that in equilibrium actor i would certainly exchange with both actors j and k. Moreover, transaction with actor j will be the higher in comparison with actor k the, higher z_{ij} in comparison to z_{ik}. That is the more actor i is socially related with actor j in comparison to actor k, the higher is c.p. their exchange transaction in equilibrium.

Define the matrix **A**=[z_{ij}] as an access matrix among actors. Taking all relevant social relations into account it follows that relative embeddedness of actors i and j in comparison to actors i and k corresponds to the relative access z_{ij} compared to z_{ik}. Hence, the access network summarized relevant characteristics of the underlying social organization including multiple networks of different social relations.

Finally, we also can define a more complex exchange system including more than one exchange game, e.g. assume actors can additionally exchange two other commodities C3 and C4. Moreover, assume that exchange for these goods is analogously organized in an exchange game as described above for the good C1 and

C2, where partitions and matching probabilities might be different in comparison to the exchange game for C1 and C2. Obviously, the existence of other exchange relations within the set N c.p. reduces opportunistic behavior in any specific exchange game. Note, that analyzing a specific exchange relation in this more complex exchange system including more than one exchange game the complete relevant social structure can still be summarized in an access matrix. In this regard the term 'socially embedded economic exchange' can be directly interpreted. Hence, economic exchange that despite the existence of formal institutions is characterized by high transaction costs due to opportunistic behavior, like for example the diamond business, appears feasible as long as it is embedded in other social exchange relations like friendship or family relations. In this context, socializing with economic trading partners implies a reduction of opportunistic behavior since the potential to punish defeating partners is increased via embeddedness in other valuable social exchange relations. Given this framework, the importance of tertiary organization highlighted by Putnam (1993), Keefer (1997) or Alesina et al. (2000) for political or economic performance follows straightforwardly, since these organization offer a potential for general social exchange among actors which might imply higher reputation effects and hence higher efficiency in economic or political exchange. But, it also follows directly from our approach that the number of tertiary organization is neither an necessary nor a sufficient indicator for high social embeddedness. For example, it might be the case that society is in fact highly segregated in various different groups each having their own tertiary organizations that are not socially related to each other. Greif characterized these organizational structures as collectivists societies which c.p. imply only a limited social embeddedness of economic transaction and hence economic efficiency. Note, that while social embeddedness is in fact low for this type of organization, number of tertiary organization might be quite high, in particular even higher when compared to a more integrated society.

2.2 A generalized social exchange model including transaction costs of exchange

Given the general expositions and justifications above we will now derive our generalized social exchange model. Starting point is Coleman's "Linear system of Action" (LSA) (Coleman 1990). Consider a social exchange system comprising a set N of n actors that exchange m control resources. Let i, j, r $\in$ N denote the indices for an actor of the set N. Moreover, let M = {1,...m} denote the set of resources actors exchange and let k,l $\in$ M denote the indices for a specific resource in M. Each actor is equipped with a specific resource endowment, where C^a_{ik} denotes the endowment of actor I regarding resource k. Moreover, $c^i=(C_{i1},\ldots,C_{im})$ denotes the vector of resources consumed by an individual actor i and C_{ik} is the amount of a resource k consumed by an actor i. Actors' preferences over resources can be represented by a well-behaved concave utility function $U^1_i(c^i)$.

Actors can exchange resources with each other, where T_{ijk} denotes the amount of a resource k, which actor i transfers to actor j. Accordingly, $t^{ik}=\{T_{i1k},\ldots,T_{i2k}\}$ is the vector of total transfers an actor i undertakes to other actors regarding a resource k. Analogously $t^i=\{t^{i1},\ldots,t^{im}\}$ denotes the vector of all resource transfers an actor undertakes to all other actors.

Now, according to the exposition above, transfers to other actors imply generally the risk of opportunistic behavior of other actors. Higher risk reduces expected utility derived from a transaction, hence higher risk can be interpreted as transaction cost, i.e. a decrease of expected utility. Moreover, according to our expositions above the risk of opportunistic behavior increases with the amount of a transaction, i.e. transaction cost are a monotonic increasing function of transfers, where for a given transferred amount implied transaction costs depend on the actual transaction partner.

Formally, total expected utility of an actor I derived from exchange with different exchange partners is a function of transfers (ti) and the risk f(t) that exchange partner will defeat V(c,t,f(t)). In general, expected utility is a complicated function, thus to make analysis traceable we assume the following Cobb-Douglas form $U^i(c^i,t^i)$, which is a specific first order approximation of V (see Sadoulet/de Janvry 1994):

$$U_i(c^i,t^i) = \left[U_i^1(c^i)\right]^{1-X_t} * \left[U_i^2(t^i)\right]^{X_T}$$

(1) $$mit:$$

$$U_i^1(c^i) = \prod_{k\in M} C_{ik}^{\;X_{ik}} \qquad \sum_{k\in M} X_{ik} = 1$$

$$U_i^2(t^i) = \prod_{k\in M,\, j\in N} (\alpha_{ijk} - T_{ijk})$$

The second term $[U^2(t)]$ in eq. (1) can be interpreted as individual transaction costs. Analogously to the dual conception of marginal disutility derived from working time and positive marginal utility derived from leisure as non-working time (see Deaton and Muellbauer 1980), this term described the utility an actor derives from non-exchange and hence avoidance of transaction costs. Accordingly, marginal transaction costs are defined as marginal disutility dU/dT_{ijk} derived from transfers to other actors. The utility parameter α_{ijk} corresponds to $z_{ijk,}$ the minimal amount of a resource k an actor i can transfer to another actor j implying opportunistic behavior with certainty. Therefore, the lower α_{ijk} the higher are transaction costs for a given transfer T_{ijk}.

Derivation of individual demand for and supply of resources

To derive individual demand and supply of resources, assume for the moment that exchange rates among resources are exogenously determined. Let V_{ik}/V_{il} denote the actor specific relative prices and let $v^{ik} = \{V_{i1},...,V_{in}\}$ denote the vector of actor specific prices. Under this assumption the individual demand and supply functions can be derived from the following (expected) utility maximization:

(2)
$$\begin{aligned}
&\underset{c^i,t^i}{Max}\, U(c^i,t^i)\\
&s.t.\\
&\sum_{k\in M} C_{ik} * V_{ik} \leq \sum_{k\in M} C^a_{ik} * V_{ik} + \sum_{k\in M}\sum_{j\in N} T_{ijk} * (V_{jk} - V_{ik})\\
&c^i, t^i \geq 0
\end{aligned}$$

The maximization problem in eq(2) directly delivers the individual supply and demand correspondences $c^i(v)=\{C^{i1}(v),...,C^{im}(v)$ and $t(v) = \{T^{i11}(v),..T^{in1}(v),...,T^{im1}(v),...,T^{inm}(v)\}$, respectively. Note that despite the assumption of a concave and continuous utility function U(c,t) eq. (2) defines upper-hemicontinuous correspondences, where supply (T_{ijk}) will generally not be continuous functions of prices v, i.e. supply will be zero as long as it holds: $V_{jk} < V_{ik}$.

Definition of an exchange equilibrium

Formally, the social exchange system defined above still corresponds to a simple Arrow-Debreu exchange economy (Arrow/Debreu 1954). The exchange equilibrium corresponds with the exchange equilibrium of an interregional exchange economy including transaction costs (see Takayama and Judge, 1971), that is a social exchange equilibrium is a price vector v* that fulfills the following conditions:

$$\sum_j (T_{ijk} - T_{jik}) + C_{ik} - C_{ik}^{a} \leq 0 \quad \forall k \in M \ \forall i \in N$$

(3) $$T_{ijk} = T^{ijk}(v^*) \quad \forall i, j \in N \ \forall k \in M$$

$$C_{ik} = C^{ik}(v^*) \quad \forall i \in N \ \forall k \in M$$

As long as quasi-concave utility functions are assumed, the existence of an exchange equilibrium can be proved applying Negishi's optimization program approach (see Takayama and Judge 1971). Analogously the equilibrium can be calculated numerically given specified utility functions and resource endowments applying an iterative Negishi program[2].

Of course, the applied equilibrium concept implicitly assumes that individual actors do not take into account the impact of their individual demand and supply on equilibrium prices. Thus, as long as the number of actors is not sufficiently large, this assumption appears restrictive. On the one side, a lot of empirical applications in fact involve a large number of actors and thus competition among these actors is correctly reflected in our model. On the other side main conclusions regarding social

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[2] We thank Tom Rutherford from the University of Colorado for giving us this advice and providing us with an iterative Negishi-Program as well as a Mixed Complementary Program written in GAMS/Menos to solve the equilibrium numerically (see also next section below).

capital drawn from the competitive exchange equilibrium including transaction costs will not change if other equilibrium concepts are considered, e.g. assuming actors do take into account the impact of their individual behavior on equilibrium prices.

Theoretical conception und definition of social capital

Coleman defines social capital in analogy to physical and human capital as a resource of persons or corporate actors that facilitate certain actions. In contrast to other forms of capital, social capital inheres in the structure of relations between and among actors (Coleman 1988: 98). Hence, physical capital is created by changes in materials to form tools that facilitate production, and human capital is created by changes in persons that bring about skills and capabilities that make them able to act in new ways (see Coleman 1988: 100). Analogously, Coleman concludes that "social capital, however, comes about through changes in the relation among persons that facilitate action" (Coleman 1988: 100). Note further that capital in any form can be separated into a quantity and a value component. Moreover, the value of a specific quantity of capital, physical, human or social, corresponds to the additional utility actors can derive from using it. The question is what determines the social value of a given quantity of a specific capital form, that is the value assigned by a set of multiple actors? The best indicator for the social value of physical as well as human capital is its equilibrium price derived in economic equilibrium. But, given the fact that capital can be created, there exist at least two equilibrium prices, one derived in economic equilibrium before capital good was created and another one after it has been created. Obviously, there is no general rule deciding which of the prices is the right one. Taking the original equilibrium price, i.e. the one before new capital was created, has the advantage that various scenarios of capital formation can be compared with each other, since valuation founds on the same basis.

Analogously, social capital can be measured by the additional utility actors can derive from a specific social structure, i.e. social organization of action. Circumventing the problem of ordinal utility, a straightforward indicator for this additional utility can be seen in the additional income that is generated given a specific social organization of exchange when compared to an atomistic organization of society without any exchange.

At a first glance it seems appropriate to measure this additional income by directly the sum of net income gains in the exchange equilibrium, e.g. by $\sum_{jk} t_{ijk} * \Delta V_{ijk}$, where $\Delta V_{ijk} = V_{jk} - V_{ik}$.

But, obviously this measure neglects actors transaction costs.

Therefore, taking transaction cost explicitly into account we define social capital of a given social organization α as the difference of the Hicksian compensated variations dW_α-dW_0 (see Deaton and Muellbauer 1980), where dW_α and dW_0 are defined comparing the atomistic organization and comparing the actual social organization α with a perfect market exchange equilibrium, respectively.

(4)
$$\begin{aligned} SK_i(\alpha) &= dW(\alpha) - dW(\alpha_0) \\ dW(\alpha) = dP_i \quad &= e_i(p_{\alpha_M}, U_i(c^\alpha, t^\alpha) - P_i(\alpha_M)) \end{aligned}$$

In eq. (4) e_i denotes the expenditure function that is dual a function to the primal utility function U_i (see Deaton und Muellbauer 1980).

Moreover, we have to take into account that the social organization allowing for exchange remains stable for a longer period of time. Therefore, the additional income has to be capitalized over the relevant period of time. The capitalized income stream generated for an individual actor by exchange relation induced by a specific social organization, is a measurement of the social capital this social organization translated for an individual actor.

At a macro level social capital can be accordingly defined as the sum of individual capitalized income streams.

Neglecting external effects in consumption it follows quite plainly that from society's perspective the optimal social organization can be defined as a perfect market organization excluding any transaction costs. Moreover, for an atomistic organization α_0 individual utility is derived from resource endowment only, i.e. $U^2(\alpha)*U^1_i(c^a_i)$. Note again, that in exact terms eq. (4) defines the rent on social capital received in one period, while total social capital equals the capitalized rent over all relevant time periods. Of course, assuming a constant capitalization factor both measures are equivalent.

2.3 Some comparative static results

To characterize some relevant properties of the exchange equilibrium, consider the following example of a simple exchange equilibrium. 5 actors i,j=1,…,5 exchange two resources m=1,2. Each actor has preferences over resources she consumed and transfers she made represented by an (expected) utility function defined in eq.(1). Further, social organization of exchange is reflected in an access matrix $A = [\alpha_{ij}]$.

Given the theoretical expositions above, the question that arises is: What theoretical implication can be derived from our social exchange model? For example, can we derive general patterns between a specific forms of network organizations and specific properties of the exchange equilibrium relevant from individual or collective perspective. Fro example, which impact has the access matrix A on the social capital of individual actors or total efficiency of transfers in the system. Intuitively we would expect that the better access, individually and collectively, implies a higher social capital. In particular, from a collective perspective the optimal social organization should be a perfect market organization, implying perfect access among all actors without any transaction cost.

Formally, this kind of general theoretical results could be derived from comparative static analysis of the exchange equilibrium. But, since in the general case comparative static analyses are tentative, we derive central comparative static results on the basis of a simulation analysis.

To this end we have to specify our exchange equilibrium, e.g. we have to specify the matrix of resource endowment $\mathbf{C^a}$, the utility parameter **X** and the access matrix **A**. In detail the assumed matrices are specified in the appendix.

According to assumed specification of our social exchange system, we can identify two actor-types, actors 1-3 on the one hand and actors 4-5 on the other. Actors 1-3 possess a fixed amount of resource 2 and actors 4 and 5 possess a fix amount of resource 1. Further, actors have preferences over both resources, where actors 1-3 have more interest in resource 1 and actors 4 and 5 have relatively higher interest in resource 2. Thus, they are searching access to each other to exchange resources.

For notational convenience we denote the first actor-type as suppliers and the last as demanders. In essence, supplier search for access to demanders and vice versa, where access is generally limited implying transaction cost. Moreover, suppliers on the one hand and demanders on the other hand have similar resource endowments and preferences, respectively. For example, suppliers could be considered as interest groups searching for access to lobby political agents as demanders of political influence resources. According to political exchange models lobbying can be conceived as exchange of influence resources like political support against political control (see Coleman 1971 or for new developments of Coleman's approach Pappi/Henning 1998, 1999 and Henning 2000). Alternatively, actors 1-3 could be considered as down-stream industries searching for access to supply their produced intermediate goods to the final consumer industries, actor 4 and 5, respectively[3].

Note further, that despite the above mentioned similarity actors 1-3 differ regarding their structural embeddedness. Actor 3 has a prominent broker position having relatively good access to all other actors, while actors 1 and 2 have only limited direct access to their final trading partners actors 4 and 5. In a political exchange game, actor 3 could be interpreted as a peak organization including actors 1 and 2 as sublevel members. Analogously, in an economic exchange game actor 3 could be

[3] In both cases, the political exchange game and the economic exchange game, it seems realistic that interest groups or intermediate industries have no direct interest in their resources. But, assuming that these actors in fact possess an input resource L, labor for example, that can be transformed into the intermediate good (political influence) or alternatively in another good C3 these actors prefer. Now assuming linear transformations (at least locally) it follows directly, that actors in fact do have induced preferences over the produced intermediate good C2. In particular, exchange behavior can be equivalently derived from maximization of U(C1, C2) instead of U(C1, C3).

interpreted as the main broker managing intermediate input demand of consumption industries.

To simulate comparative static effects we further assume that access structures A1 are slightly changed according to the access matrix A2 tabled in the appendix. According to matrix A2, actor 3 lost his prominent broker position regarding exchange among actor 1 and 4. According to A2 these two actors have good direct access to each other. Finally, we also assume that exchange is in fact organized by formal institutions that completely avoid transaction cost. We call this a market organization α_M.

Now, the exchange equilibrium of all three specified exchange model can be computed. For the social exchange equilibrium corresponding with imperfect access, A1 and A2 respectively, we apply a Negishi program algorithm, while under the assumption of a perfect market organization social exchange equilibrium corresponds to a simple Walras equilibrium. Equilibrium prices and transfers as well as the social capital indices for individual actors and the total set of actors are summarized in tables 1 and 2 and graphics 1 and 2, respectively, stated in the appendix.

Main comparative static results derived from the comparison of equilibrium outcomes implied by A1, A2 and a perfect market, respectively, are summarized in the following propositions. Since propositions are derived from simulation analysis drawn conclusions appear only intuitively plausible, while a full formal proof is not yet provided[4].

[4] Note that most propositions can also be derived from strict comparative static analysis of a simple exchange game (see Henning 2002).

Proposition 2: The Social capital of an actor i is a non-decreasing function in both his own access (z_{ij}) to other actors and the access of other actors to him (z_{ji}).

The only difference between A1 and A2 is the increased relative access among actors 1 and 4, $\alpha 12 = \alpha 21$ increased from 0.1 to 0.9. However, this change implies that the social capital of these two actors increases, see table 2 in the appendix. Intuitively this result is conceivable also in general, since assuming an improved access for a pair of actors i and j implies that the original equilibrium distribution (c1*,t1*) under the original social organization, say $\alpha 1$, would still be feasible under the new organization, say $\alpha 2$. Moreover, due to their mutual better relative access both actors i and j observe a higher or at least equal utility[5] for the distribution (c1*,t1*) under $\alpha 2$ when compared with $\alpha 1$, while all other actors observe exactly the same utility. Hence, since all actors maximize their utility, actors i and j will only engage in further trading iff they can improve their utility. Therefore, in the final equilibrium c2*t2* corresponding with $\alpha 2$ both actors, i and j, will observe a higher utility when compared to their utility derived under $\alpha 1$.

Proposition 3: The Social capital of an actor i is non-increasing in the access (z_{kj}) among other actors.

[5] Utility will be the same if under $\alpha 1$ actors do not engage in direct transfers to each other.

It follows from the comparison of the social capital indices in table 1 that all actors despite actors 1 and 4 weakly prefer the social organization $\alpha 1$ to $\alpha 2$. Moreover, all actors directly exchanging resources with actors 1 or 4 in equilibrium of $\alpha 1$, observe a utility loss assuming a change from $\alpha 1$ to $\alpha 2$. In contrast, actor 2 not trading directly with actors 1 nor actor 4 observes the same utility under both organizations. Intuitively, improved access among a pair of actors induces additional transfers among these actors. These transfers c.p. reduce transfers from other actors to these actors. Given the strict convexity of U in transfers it follows that actors observe a net gain from any transfer in equilibrium. Therefore, reducing transfers of other actors implies c. p. a decrease in their utility.

Overall, propositions 2 and 3 imply the following results. A social organization of exchange α is the more favorable from the perspective of an individual actor the higher his access to other actors and the higher the access of other actors to him in comparison to average access structures in the network. Moreover, from proposition 2 and 3 we can intuitively conclude that in more complex exchange systems better relative access of actor i to other actors with high resource endowments and/or high preferences for resources implies c.p. a higher social capital index for actor i. Vice versa, it is favorable for an actor i if other actors have good access to him who are equipped with high resource endowments or to which well equipped actors have good access.

Definition: Define $y(\alpha)$ welfare equivalent income distribution under perfect market organization corresponding to the welfare distribution in the exchange equilibrium induced by the social organization α. Further, we define a social preferences over organizations on the basis of welfare equivalent income distributions. In particular, from a society perspective a social organization α is preferable in comparison to another organization α' s if a lump sum resource transfer mechanism LM can be defined such that the welfare equivalent income distribution $Y(\alpha)$applying LM is pareto-optimal to the welfare equivalent income distribution $y(\alpha')$ corresponding to the organization α'.

Proposition 4: From a society perspective a social organization α is preferable in comparison to another organization α' if the sum of individual social capital indices is higher for this organization, i.e. as long as it holds: sum $Sci(\alpha)$ > sum $SCi(\alpha')$.

The proof of proposition 4 follows directly from the definition of the social capital index and the definition of our social choice function. Obviously, this definition implies that social preferences correspond to the welfare criteria suggested by Kaldor and Hicks.

Proposition 5: A change from a social organization α to an organization α', where by assumption α' is preferred by the society, is generally not pareto-optimal. Thus, even a change from an inefficient network organization to a perfect market organization is generally not pareto-optimal.

To prove proposition 5 it is sufficient to show that there exists one counter example. As can be seen from table 1, our simple change system provides such an example. In particular, actor 3 prefers the imperfect social organization α when compared to the perfect market economy. Intuitively this is conceivable given the explicit transfer structures implied by α. As can be seen from graphic 1 in the appendix according to centralized access structures, all transfers among suppliers and demanders (actors 1-3 and actors 4-5, respectively) are brokered by actor 3. Given the strict convexity of the utility function in transfers t_{ijk} it follows that actor 3 observes a net gain from brokerage in equilibrium. Hence, from an individual perspective imperfect access structures under α are preferable even when compared to perfect access, since actor 3 realized high net gains from brokerage.

Proposition 6: If external effects of exchange exists: minimizing transaction costs of exchange does no more correspond to maximizing society's welfare. Therefore, the sum of individual social capital is no more a consistent measure social capital at the macro level.

To prove Proposition 6 assume our simple example is in fact a political exchange game, where C2 corresponds to political control, e.g. the power to make political decisions and C1 is a political influence resource, e.g. political support. Further, assume that not all interest groups of the society are members of the policy network, that is some interest groups are excluded from political exchange. Moreover, assume final political decision relevant for the total society is made according to a mean voter decision rule (see Pappi/Henning 1998). The mean voter decision rule implies that the final policy decision B is simply the weighted mean of ideal positions of actors, where the individual weights equal political control resources actors hold by actors in the political exchange equilibrium. Now, assume society's preferences over policy positions can be represented by the median voter holding a position of BM. Then if access of interest groups to politicians is extremely biased, it can happen that the political decision resulting without political exchange is closer to the median voter position when compared to the political decision resulting from exchange organized in a bias access network. An other example of negative external effects of exchange would by considering exchange relations within a criminal organization like the mafia. Reducing transaction cost of exchange within this subset of society implies more crime and violence and hence is certainly negative from society's perspective.

2.4 Economic performance and the evolution of social organization in time

Neglecting external effects of exchange in a static equilibrium organization of exchange is the more efficient the lower c.p. transaction costs among actors. In this regard Greif (1993) suggests a very interesting distinction between a collectivists societies in which economic exchange is mainly organized in informal networks and an atomistic organization of society in which exchange is mainly organized in specialized formal institutions, like courts, contracts, etc., while social relations play only a minor role. Greif's formal analysis clearly imply that from a static perspective formal institutions, once they function appropriately, correspond to a more efficient organization of economic transaction. Greif highlights that formal institutions lower especially transaction costs between different groups of cultural beliefs existing within a large society, while network organizations can only generate sufficient reputation effects in smaller homogenous groups.

Beyond Greif's static analysis a network organization impedes economic efficiency in a dynamic perspective as it impedes competition among actors. To make this point more clear consider again our example above. Assume that in fact actors 1-3 do not possess a fix amount of resource 2, but instead of labor L and that labor can be transformed into resource 2 according to a linear technology, e.g. $C^a_{i2}=b_i*L_i$. Now, an increase in b_i corresponds to technological progress, e.g. an efficiency growth. Of course, generating technological progress demands for resources, e.g. time input. Hence, actors have to invest in technological progress. The higher the expected pay-off of t.p. the higher are the incentives of individual actors to invest in t.p. Now, in a network organization incentives are c.p. lower when compared to a market organization, since possible gains from t.p. are partly taken away from actors due to increasing marginal transaction costs. This holds especially true for possible competitors out side an established network, e.g. for actors that are not part of a exchange network yet, but would have to enter the exchange game. Given the extremely high entry barriers for new actors induced by a network organization implies that competition from potential suppliers does not work. Hence, especially in the long run network organizations are characterized by a relatively low rate of technical progress when compared to an atomistic organization based on formal institutions.

Another interesting point raised by Greif is the question why collectivist societies stick with their comparatively inefficient network organization. Greif explained this phenomenon by pointing out the path dependency of institutional development. In particular, he emphasized the impact of the formation of cultural beliefs (see Greif 1993: 932). Although we consider Greif's explanation as highly relevant, we like to focus on another aspect of the emergence of social institutions. Greif implicitly seems to assume that change of social organization is a process of evolutionary rationality (see Hayek 1973). This is conceivable as long as the emergence of network organizations are considered which correspond to spontaneous order emerging as a result of informal decentralized individual actions.

In contrast, following Richter and Furubotan the emergence of formal market institutions is more a process of constructive rationalism (see Hayek 1973). Accordingly, we follow Weingast et al. interpreting organizational change from informal networks to formal market institutions as actors choosing the rules of the exchange game maximizing their expected profits. Now, it follows from proposition 5 that in particular central brokers in a network organization might prefer this organization to a more efficient market organization. Hence, it is conceivable that in a collectivists' society under specific conditions central brokers manage to form a coalition that is able to block a change to a more efficient formal organization of exchange. Path dependence might still play an important role, since starting from a natural society evolution of a social organizations corresponds first to a spontaneous emergence of various forms of network organizations. At a later stage of economic development formal institutions are introduced as a more efficient organization. Generally, at this stage society's organization is sufficiently developed. Especially, the choice of a new social organization corresponds to a centralized formal decision-process made within specialized political institutions. Hence, political power of various interest groups has an important impact on the choice. Now, it crucially depends on the actual network organization historically established. If the organization is dominated by a subset of central brokers that are also economically successful due their prominent network position, it is conceivable that these brokers form a powerful political coalition blocking any further organizational change. On the other hand, if an established network organization is more symmetric, a sufficient political majority expecting gains from the more efficient formal organization might succeed. Interestingly, it might be the case that in the beginning collectivists societies comprising of multiple dense networks being connected over a small subset of brokers are more efficient than more sparse network organizations comprising of equal actors. Hence, social structures enhancing economic efficiency in the beginning of economic development might turn out to be a major obstacle to efficient organizational change at a later stage.

3 Empirical measurement of social capital on the basis of observed transfer networks

An important objection against the theory of social capital is the problem of empirical application. For example, Diekmann (1993) argues against the concept of social capital as it cannot be measured empirically and hence is hardly applicable empirically. As a matter of fact so far hardly any empirical measurement of social capital exists that is consistently derived from a theoretical model. Most empirical applications of the concept of social capital are based on an ad hoc measurement of social capital (see Putnam 1993, Alesina et al. 2000).

In contrast, our social exchange model including transaction costs can be estimated empirically on the basis of observed transfer networks. For example, Henning (2000) provides an empirical application of a political exchange model including transaction costs, where the model has been estimated on the basis of observed policy networks.

In detail, the following estimation procedure can be used. Assume for a specific social exchange system one observed relevant transfers T_{ijk} among actors. Then, it holds in equilibrium of the social exchange model for each actor i:

(5)

$$P_i = \sum_{k=1}^{m}\sum_{j=1}^{n} T_{ijk} V_{jk} - \sum_{l=1}^{n} T_{lik} V_{ik} + C_{ik}^{a} V_{ik} = \sum_{k=1}^{m} (1 - s_{ik}) \sum_{j=1}^{n} T_{ijk} V_{jk}$$

$$\text{with} \qquad \mathrm{s_{ik}} = \frac{\sum_{l \neq i}^{n} T_{lik} V_{ik}}{\sum_{j=1}^{n} T_{ijk} V_{jk}} = \frac{1}{TOT_{ik}} \frac{\mathrm{Im}_{ik}}{Ex_{ik}}$$

Im_{ik} and Ex_{ik} denote total import and exports of actor I regarding resource k, while TOT_{ik} denote the terms of trade, e.g. the export price index in relation to the import price that it holds for resource k and actor i in equilibrium. Moreover, assuming actor i has any turnover for resource k it holds in equilibrium (otherwise we can set V_{ik} =0):

(6)

$$\sum_{l \neq i}^{n} T_{lik} V_{ik} = \mathrm{s_{ik}} \sum_{j=1}^{n} T_{ijk} V_{jk} \Leftrightarrow V_{ik} \,\mathrm{Im}_{ik} = s_{ik} \sum_{j=1}^{n} T_{ijk} V_{jk}$$

$$V_{ik} C_{ik} = X_{ik} P_i$$

$$V_{ik} = \frac{1}{C_{ik} + Ex_{ik}} \left[X_{ik} P_i + s_{ik} \sum_{j=1}^{n} T_{ijk} V_{jk} \frac{Ex_{ik}}{\mathrm{Im}_{ik}} \right]$$

Since eq.(5) and (6) are linear in prices v and income P we can write these equations in matrix notation:

(7)

$$\begin{aligned} p &= \mathrm{T^S} v \\ v &= (I - \mathrm{T^c})^{-1} \mathrm{X}_{\mathbf{diag}}^{\mathbf{k}}\, p \end{aligned} \quad \Rightarrow \quad \begin{aligned} v &= M\, v \\ \mathrm{M} &= (I - \mathrm{T^c})^{-1} \mathrm{X}_{\mathbf{diag}}^{\mathbf{k}} \mathrm{T^s} \end{aligned}$$

Thus, assuming the matrix **M** is know, equilibrium prices (v) and incomes (p) can be computed from the eigenvector equation (7). Further, the matrix M can be calculated on empirically observed transfers as well as an empirically observed interest matrix **X**. The only variables that are not directly observable are the terms of trade, but these can at least approximatively be estimated on the basis of observed transfer networks (see Henning 2000 for details).

Given calculated equilibrium prices and incomes, relevant transaction cost parameters could be estimated econometrically on the basis of the specified export functions:

$$(8) \qquad T_{ijk}(v) = \alpha_{ijk} - \frac{\beta_i}{(V_{jk} - V_{ik})} P_i$$

A problem might be the estimation of the coefficients α_{ijk}, if estimations are based on one observation of transfers. An interesting alternative estimation approach would be to estimate the coefficients α as a function of path distances d_{ij} among actors derived from observed transfer and social networks, e.g. $\alpha_{ijk} = \alpha_{0k} + \alpha_{1k} * d_{ij}$. Moreover, one could also assume that α-parameters are a function of different path distances derived from each single observed network.

Summary

Starting from Coleman's and Granovetter's path breaking contribution to the concept of on social capital the paper derives a social capital index in the framework of a neoclassical social exchange model taking explicitly into account transaction costs.

The conceptions of transaction costs corresponds to formal modeling of how social structures affect actors' behavior provided by or Raub and Weesie (1990), Greif (1993) and Calvert (1995) on the basis of game theoretical models[6]. Although these models contribute significantly to the understanding of the impact of networks of social relations on the emergence of cooperation in social exchange situations, some questions and shortcomings remain. In particular, these models are highly abstract and thus allow only for a qualitative conception of social capital, but do not provide a quantitative conception or empirical measurement of social capital. Secondly, these approaches focus on sequential dyadic exchange situations, while more complex exchange relations, e.g. competition among different exchange partners are not taken into account.

In this framework the paper suggests a generalization of Coleman's social exchange model taking explicitly transaction costs into account. In the absence of formal institutions like money or formal contracts, exchange is organized in networks of social relations among actors. In contrast to perfect economic markets, social exchange organized in networks implies actor specific transaction cost corresponding to the risk of opportunistic behavior in equilibrium. Hence, beyond actors' resource endowments actors' ability to improve their utility via exchange is additionally restricted by transaction costs determined by their position within the given network structure. In the framework of the generalized social exchange equilibrium the following results are shown: (i) a generalized Walras equilibrium can be defined taking explicitly actor specific transaction costs into account; (ii) in equilibrium social

[6] Becker (1996) also provides a clear formal model of social capital in a neoclassical framework.

capital can be conceptualized; (iii) a quantitative social capital index can be defined in equilibrium at both the micro and macro level that can also be estimated empirically on the basis of observed transfer networks; (iv) comparative static analysis imply that individual social capital corresponding to a specific network organization is the higher the higher the relative access of an actor to other actors and vice versa from other actors to this actor. (v) assuming external effects of exchange implies the contra intuitive result that minimizing transaction cost does generally not imply maximizing social welfare; (v) from a collective perspective network organizations of exchange in comparison to an organization based on formal institutions, like contracts, are less efficient especially in a dynamic perspective, since the former provide lower incentives for actors to invest in technical progress; (vi) nevertheless, a change from less to more efficient social organizations is generally not Pareto-dominant, therefore from society's perspective efficient organizational change might be blocked by actors expecting an utility loss. Historically, network organization emerged first as a spontaneous order in a process of evolutionary rationalism in the sense of Hayek (1973: 38 p), while the emergence of an organization mainly based on formal institutions occurs at a later stage of economic development in a process of constructive rationalism (see Hayek 1973: 33), i.e. can be interpreted as the result of a rationalized collective decision within formal political institutions (see also Richter/Furubotn 1999), path dependence plays an important role for the historical evolution of social organization. If spontaneous network organization is characterized by an economically dominant elite of central brokers, later change to more efficient formal institutions might be blocked politically by these brokers expecting a welfare loss from this change.

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Appendix

Proof of Proposition 1

The defined OSPD game corresponds to the OSPD defined by Greif (1993: 918). Therefore, our proof is similar to the proof given by Greif. In particular, we denote by h_c and h_h the probability that an actor j will be engaged in an exchange with another actor in the next round of the game assuming that he cheated and was honest, respectively. Obviously, it holds:

$$h_h = r$$
$$h_c = r(1-p)$$

It is sufficient to show that for given p and q, an actor j cannot gain from cheating one period as long has he is offered no more than an amount of t_{max}. Analogously to Greif, denote by V_h the present value of lifetime expected utility of an agent engaged in exchange who, whenever engaged in exchange, is honest. Denote by V^u_h the present value of lifetime expected utility of an agent not engaged in exchange who, whenever engaged in exchange, is honest. Denote by V^u_c is the present value of lifetime expected utility of a cheater in period 1 who will be honest in the future if he will be engaged in exchange again. These lifetime expected utilities are given by:

$$V_h = U(t, z-t) + \delta q V_h + (1-q) V_h^u$$
$$V_i^u = \delta h_i V_h + \delta (1-h_i) V_i^u \quad , i = h, c$$

Cheating once yields U(t,z) + V^uc as the agents expected lifetime utility. Hence an agent will not cheat as long as it holds: Vh > U(t,z) + V^uc. Substituting and rearranging yields (see also Greif 1993: 944):

(a1)
$$U(t, z-t) \geq A\, U(t,z)$$
$$\text{with}$$
$$A = \left[1 - \delta q - \delta(1-q)\frac{h_h}{1-\delta+\delta h_h}\right]\frac{1}{1-\delta\dfrac{h_c}{1-\delta+\delta h_c}}$$

It holds that A < 1, thus it follows directly that cooperation will be achieved for t=0. Moreover, it follows that the relation of U(t,t-z) to U(t,z) is non-increasing in t. For simplicity this is easily shown assuming a Cobb-Douglas form for U, then it follows:

$$\frac{\partial\left(\dfrac{U(t, z-tv)}{U(t,z)}\right)}{\partial t} = \frac{\partial\left(\dfrac{z-tv}{z}\right)^{\mu}}{\partial t} = -\mu\left(\frac{z-tv}{z}\right)^{\mu-1} < 0$$

Hence, for any A<1 there exists a finite amount t_{max} such that the inequality (a1) just becomes an equation and for transfers higher than t_{max} the inequality changes i.e. cooperation breaks down.
Now, according to the implicit function theorem it follows for the comparative static of t_{max}:

$$\frac{\partial t_{\max}}{\partial A} = -\frac{-1}{\frac{\partial\left(\frac{U(t,z-tv)}{U(t,z)}\right)}{\partial t}} < 0$$

Moreover, it follows by straightforward algebra, that A is decreasing in q, p and r as well as in δ.
Q.E.D.

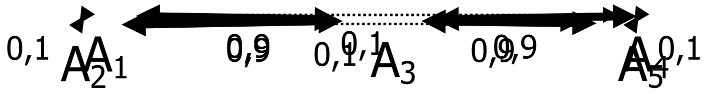
Table 1: Social capital indices derived for Access matrices A1 and A2

Actors	Income stream		Social capital index			Hick's equivalent compensation	
	Social Organization						
	α_1	α_2	α_1	α_2	αM	$\alpha 1$	$\alpha 2$
A1	224	222	167.553	168.546	170.85	-3.299	-2.306
A2	93	93	127.35	127.52	129.14	-1.794	-1.624
A3	449	216	98.271	98.01	98.129	0.142	-0.119
A4	300	290	95.288	95.938	96.777	-1.489	-0.839
A5	396	950	123.474	123.239	125.53	-2.054	-2.289
Total	1462	1771	611.936	613.253	620.43	-8.494	-7.177

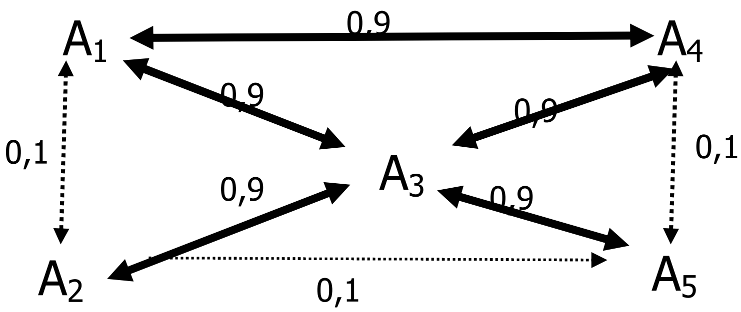
Table 2: Resource endowment $\boldsymbol{C^a}$ *and Interest* $\boldsymbol{X}$

	Control endowment		**Interest**	
	C^a_{i1}	C^a_{i2}	X_{i1}	X_{i2}
A1	0.4	0	0.3	0.7
A2	0.3	0	0.4	0.6
A3	0.2	0	0.3	0.7
A4	0.05	0.5	0.6	0.4
A5	0.05	0.5	0.7	0.3
Total	1	1	1	1

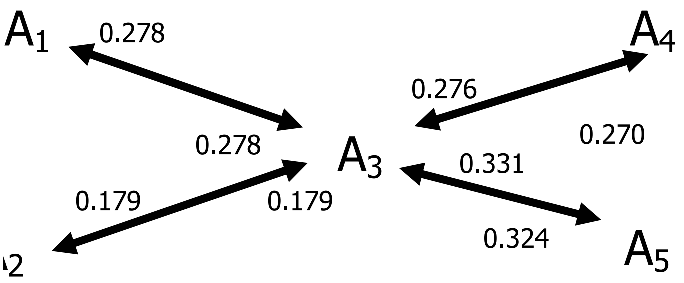
Graphic 1:Access matrix A1



Graphic 2: Access matrix A2



Transfer matrix T(A1)



Transfer matrix T(A2)