Interdependencies
Temurshoev, U.

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2010

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):
Temurshoev, U. (2010). Interdependencies: essays on cross-shareholdings, social networks, and sectoral linkages Groningen: University of Groningen, SOM research school

Copyright
Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

Take-down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): http://www.rug.nl/research/portal. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.
CHAPTER 1

Prologue

1.1 Introduction

This thesis was supposed to be only about cross ownership of firms, which was reflected in the title of my research proposal “The consequences of cross-shareholding for ownership structures and economic behavior”. The following quotation from this proposal, written in May 2006, gives a brief description of my original research intentions: “... this project aims at theoretically and empirically (i) constructing and analyzing national and (inter-) regional frameworks of ownership structures, (ii) quantifying the complex network of direct and indirect property relations, and (iii) studying the implication of cross-shareholding for several topics in industrial organization”. Of course, as is, in general, the case for the majority of PhD theses, the current final output addresses only parts of the main issues in my proposal. Other issues addressed in this thesis were not included in the proposal, and were raised and investigated “along the way”.

It is obvious that interdependencies of any kind at very different levels (e.g., individuals, firms, industries, regions, countries) may have a crucial impact on and implications for the activity of agents involved in such networks of bilateral and multilateral interactions. Therefore, it is not surprising that economists devote considerable attention to the complex interrelations between economic agents. As mentioned above, the aim of this research was to analyze the consequences of cross ownership of firms on their behavior and ownership structure. To give a simple example that sketches the complex network of interdependent owners, suppose that individual A owns a share in company B, which has a share in company C. In its turn, firm C owns a share in B. A few readily observable implications of
such shareholdings are the following. Although individual A has no direct interest in C, there is an indirect relation via B. If the operating surplus (profits from ordinary production) of C increases, A benefits through its shares in B. If the operating surplus of B increases, A benefits not only directly but also indirectly (for instance, via the gains in C that are beneficial to B again). It turns out that using ownership distributions of private stockholders and companies, one can derive an analytical framework that totally redistributes ownership from firms to the “real” equityholders (e.g., individuals, the state, municipalities), which provides a basis for evaluating the true ownership structure of an economy. As a result many interesting questions arise: What is the value of the property embedded in shares that real owners hold in companies? How to assess decision making power in the presence of complex ownership links between firms? What is the role of the state or any other owner? What are the implications of firms’ cross ownership on control power of shareholders, and does it have any impact on tacit collusive arrangements of firms? What is the effect of cross-shareholding on prices, outputs, profits, and social welfare? What happens if the structure of cross-shareholding changes? And many more.

While studying these issues, I came across the paper by Ballester et al. (2006) on finding a key player in social networks, where the key player exerts the largest impact on the overall (equilibrium) activity of the network.\(^1\) This important study raised some related questions to me, focusing on which ultimately resulted in two papers that constitute two chapters (5 and 6) of this thesis. By doing so I also crossed the borders of my original research plan, from topics mainly in Industrial Organization to issues in such fields as Network Economics, Interindustry Economics and Social Network Analysis. In what follows these issues will be discussed in more detail.

### 1.2 Industrial organization and finance

Often it is argued that Continental Europe and Japan have an enterprise oriented system of ownership structure, while the Anglo-American system is market oriented. One of the important factors in determining such orientation of the ownership structure of an economy is the presence or absence of complex webs of intercorporate holdings. These are believed to play a prominent role in Continental

\(^1\)I would like to thank José Luis Moraga-González for bringing this paper to my attention, and the industrial organization reading group of the University of Groningen, led by Marco Haan, that made me to delve deeper into the topic.
Europe and Japan. The question is how this ownership complexity can be quantified (which was, in fact, the second point of my original research proposal). Chapter 2 focuses on this issue, where two types of owners are distinguished: primary owners that own intermediary institutions but cannot be owned themselves (e.g., individuals, the state, municipalities), and secondary owners that can own other intermediary institutions but are surely owned themselves by other owners (e.g., companies, banks, industrial corporations). In quantifying ownership interrelatedness both the size of direct and indirect shareholdings and the “average distance” between primary owners and secondary owners are taken into account. The latter is obtained from the average number of secondary owners via whom ownership links between primary owners and secondary owners run. Combining the linkage size and the distance allows us to visualize the cross-shareholding interlocks and the true ownership relations in an industry (economy). The methodology is applied to the banking sector in the Czech Republic, where the complexity of the network of relations between primary and secondary owners are quantified, and the relevant shareholding chains are graphed.

Chapter 2 further explores the link between the proposed measures of ownership network complexity and the degree of separation of dividend and control rights, widely studied in the finance literature. To give an idea of the issue at stake, suppose we have the following ownership chain: $A \rightarrow B \rightarrow C$. That is, firm $A$ owns a share in firm $B$, which in its turn owns a share in company $C$. Hence, although the dividend rights of $A$ in firm $C$ are zero, there is an indirect ownership connection via $B$ that makes it possible for firm $A$ to have positive control rights in $C$ (which may be very large depending of the size of these direct shareholdings). Thus, it is not surprising that there are ample studies in Finance that focus on the issue of separation of ownership and control rights due to pyramiding ownership structures and cross-holdings. It is obvious that in the presence of mutual cross-shareholdings the chains of ownership stakes are not at all easy to trace. Thus, quantifying the control power embedded in such complex ownership networks is also far from trivial. For example, using the well-known “weakest link” methodology that defines the minimum stake along the ownership chain as the corresponding control right is simply unpractical. This is because in the presence of cross-shareholdings there exists an infinite number of ownership paths of different lengths. On the other hand, our proposed measures of ownership complexity fully take into account such means of enhancing control as non-pyramidal cross ownership links, where also the sizes of shareholdings and distances between
owners are explicitly accounted for. Hence, we consider these indicators as alternative measures of the separation of ownership and control rights. That is, the more complex the network of non-negligible relations is, the larger is the degree of control enhancement due to cross-shareholding links among firms. Therefore, also the difference between the control and the ownership stakes of primary owners in secondary owners is larger. The empirical results confirm this for the Czech banking sector, where the results are compared to the “weakest link” and “dominant shareholder” approaches of identifying control rights.

In reality, shareholdings are often silent (or partial) by their nature, meaning that they do not give control power for their owners. However, as partial cross ownership (PCO) results in commonality of interests of firms engaged in such shareholding interlocks, it is interesting to investigate what are the effects of PCO on the market performance and market power of the individual firms in an industry. This is the subject of study in Chapter 3. For this purpose we modify the well-known framework of the “structure-conduct-performance paradigm” for estimating firms’ market power and the degree of tacit collusion inherent to the market by considering both direct and indirect PCO holdings among firms. It is shown that, unlike in the no-PCO case, the link between firms’ price-cost margins and the degree of tacit collusion is nonlinear in the presence of PCO. Thus, if PCO is present, ignoring it will most likely lead to biased results due to model misspecification. The modified framework is applied to the Japanese banking sector in 2003. We find that Japanese banks compete in a modest collusive environment. If, however, PCO is neglected, the results indicate a Cournot oligopoly. Further, it is shown that banks with passive holdings in rivals exert a strictly larger market power than those without any PCO. In particular, city banks with many shareholdings are found to exercise a much larger market power than regional banks with none or few stockholdings. Hence, the hypothesis is confirmed that acquiring shares in rivals is one of the crucial means for a firm to enhance its market power.

Passive investments of firms in rivals were either granted a de facto exemption from antitrust liability or have gone unchallenged by antitrust agencies in recent cases. However, recently Gilo et al. (2006) showed that there are cases in which PCO arrangements can facilitate tacit collusion among rival firms, hence such a lenient approach towards passive investments in rivals may be misguided. However, Gilo et al. (2006) assumed that firms are symmetric and have the same marginal cost functions. Chapter 4 relaxes this assumption and examines the effect of PCO on the incentives of asymmetric firms to collude. Unlike Chapter 3, which studies some-
what similar issues in a one-period conjectural variations setting, Chapter 4 posits an infinitely repeated Bertrand oligopoly model. We first consider the case where only the most efficient firm in the industry invests in rivals. Since there are no other firms involved in partial ownership acquisition, we refer to this case as partial ownership (PO) case. (PCO, on the other hand, indicates that more than one firm are involved in stockholdings, thus could mutual shareholdings are possible.) It is shown that even unilateral partial ownership by this firm may facilitate a market-sharing scheme in which all firms charge the same collusive price and divide the market between them. Unlike the case where firms have the same marginal costs, here firms have different monopoly prices on which they wish to collude, and the collusive price is assumed to be a compromise between the monopoly prices of the different firms. We show that when the most efficient firm invests in rivals, the collusive price increases relative to the case where there are no PO arrangements.

Further, Chapter 4 shows that in the case of multilateral PCO arrangements an increase in the stake that firm \( r \) holds in firm \( s \) will never hinder collusion and it will strictly facilitate collusion if and only if (i) the industry maverick (the firm with the strongest incentive to deviate from a collusive agreement) has a direct or indirect stake in firm \( r \), and (ii) firm \( s \) is not the industry maverick. When either (i) or (ii) fails to hold, the increase in firm \( r \)'s stake in firm \( s \) does not affect tacit collusion. These results extend the earlier findings in Gilo et al. (2006) and show that the results for firms with symmetric cost functions generalize to the asymmetric costs case. Then Chapter 4 investigates the effect of a transfer of PCO between firms on tacit collusion, and shows that depending on the initial structure of shareholdings of firms directly involved in the ownership transfer, tacit collusion may be facilitated, be hindered, or remain unchanged.

### 1.3 The link to network economics and social network analysis

In the sociology literature, the problem of identifying the most important actors in social networks has been studied extensively, and still remains an essential topic of concern. In particular, within the field of Social Network Analysis a vast number of indicators, the so-called network centralities, have been proposed in order to identify key actors in networks. For example, the best-known and most often used measures are centralities of degree, closeness, betweenness, information, Katz status measure, and Bonacich centrality (see e.g., Wasserman and Faust, 1994, pp.
A similar problem from an economic perspective was first analyzed by Ballester et al. (2006), who introduce a network game, where actors’ payoffs depend on each other through network embeddedness. Players choose a level of activity in a game with negative global externalities (e.g., competition) and local positive externalities (e.g., learning, collaboration) that come through the network. Obviously, such system has feedback effects, which are taken into account in the Nash equilibrium activity levels that are dependent on the underlying network topology. The authors show that individual equilibrium levels of agents are proportional to their Katz-Bonacich centrality measures. Hence, they provide a behavioral foundation to the status measure of Katz (1953) and the network centrality measure of Bonacich (1987). However, these measures are not sufficient to identify a key player – the player with the largest impact on the overall equilibrium outcome. Hence, Ballester et al. (2006) propose a new measure of network centrality, named the intercentrality measure, that is derived from the planner’s optimization concern. Since it internalizes all the network payoff externalities of agents, the intercentrality measure identifies the key player.

Chapter 5 considers a more general setting of finding a key group in such network games, and also takes explicitly players’ ex ante heterogeneity into account. Similar to the key player definition, the key group is a group of players that exert the maximum possible impact on the overall equilibrium activity level of the network. It should be noted that the assumption of ex ante identical players in the search of a key player used in Ballester et al. (2006) is quite restrictive from a practical point of view, because in that case all observable differences between individuals are ignored. These heterogeneity factors include, for example, a player’s age, education, occupation, race, gender, parents education, or family size. We show that once this exogenous heterogeneity is accounted for, the results of the key player/group problem may change dramatically. In searching for the key group we make use of weighted and unweighted Katz-Bonachich (KB) centralities and group intercentrality measures, where the weights are the observable differences of the players.

Chapter 5 also endogenizes the size of the key group. The need for such endogenization arises because in reality targeting a certain set of players also incurs costs, next to benefits. In a majority of cases, these benefits and costs are directly related to the group size. As an example, suppose that a planner wants to maximally disrupt the functioning of a network of criminals in some location. It is obvious that
the larger the size of the key group of criminals is, the larger is the benefit in terms of reducing criminal activity in this society. However, there are costs involved in the “elimination” of criminals, such as costs related to gathering information, time, hiring people, and other costs for planning and implementation of such an annihilating aim. All these costs are generally higher for a larger key group. We show that within the class of network games studied in Ballester et al. (2006) the optimal size of the key group is determined by the minimal key group loss measure that depends on players’ weighted and unweighted KB centralities and key group intercentralities, and the costs of group targeting.

1.4 Interindustry economics and game theory

The key group problem within the network games discussed in the previous section has a close relation (at least, technically) to the problem of finding key sectors in the framework of input-output (IO) linkage analysis. Key sectors are the industries with the largest potential of spreading growth impulses throughout the economy. There are several methods for identifying key sectors in Interindustry Economics, but for our purposes we focus on the hypothetical extraction method (HEM) developed in the 1960s, which is extensively used in the IO literature. The HEM in identifying key sectors measures the importance of industries in terms of their contribution to the overall gross output of an economy by extracting them from the production structure. We show that this approach is similar to that of finding the key player in a social network in Network Economics and Social Network Analysis, where players are eliminated from the network of local interactions, which enables one to quantify these players’ marginal contribution to the overall activity level and/or network functioning.

The main contribution of Chapter 6 to the literature on key sectors identification from the HEM perspective is that it distinguishes between and explicitly formulates the optimization problems of finding a key sector and a key group of sectors, and derives analytical solutions for these problems in terms of simple measures called industries’ factor worths. The term “factor” refers to any indicator that is of interest in identifying the most important industries. This might be any social, environmental, and/or economic factor (e.g., employment, water use, GDP, etc.), or any combination of these factors. Our formal formulation of the HEM problems has several important implications, one of which is that the key group of \( k > 1 \) sectors is, in general, different from the set of top \( k \) sectors with the largest individual
contributions to the overall factor production/consumption. This is confirmed in the empirical application of the key sector and the key group problems to the Australian economy in case of water use and CO₂ emissions. This (expected) finding is important, since up to date, to the best of our knowledge, the linkage literature (implicitly) accepted the top k sectors (selected on the basis of the key sector problem) as the key group. Technically speaking, this incongruence is due to the fact that while the key sector problem looks for the effect of the (hypothetical) extraction of one sector, the key group problem considers the effect of a simultaneous extraction of k ≥ 2 sectors that takes differently into account the cross-contributions of the extracted industries to total factor arising within and outside the group. Its economic interpretation has to do with what sociologists call the redundancy principle (see e.g., Burt, 1992). In the IO framework, this means that sectors might be redundant with respect to each other if they have similar patterns of production linkages with other industries, and similar structures of final demand and factor generation capabilities. Hence, the optimal target should consist of rather nonredundant sectors that have different patterns of (significant) interindustry linkages and factor generation ability. Therefore, which sectors will be part of the key group is largely dependent on the (dis)similarity of the production linkage patterns of sectors to each other and of their final demand and factor generation structures. At this point we have to mention that the redundancy principle also plays an important role in identifying the key group of players within the network games that are discussed in detail in Chapter 5.

Revealing the connection of the HEM to the well-known fields of influence approach in the IO literature (Sonis and Hewings 1989, 1992) gives an alternative economic interpretation of the HEM problems in terms of the overall impact on aggregate factor generation due to an incremental change in sectors’ input self-dependencies. Further, we explore the related issues of finding the key region and the key group of regions in an interregional IO setting, and discuss the effect of netting out (nullifying) the intrasectoral transactions on industries’ (or regions’) factor worths. Also discussed in Chapter 6 is the link of the (generalized) HEM approach of finding the key sector to the coalitional game literature on fair allocation of gains from cooperation. In particular, the properties (axioms) of the well-known Shapley value are given, and it is elaborated whether these properties also hold for the industry’s factor worth. Hence, there is also a connection to Game Theory, and to measuring the power of players, in particular.
1.5 Outline of the study

A rough sketch of the present study is presented in Figure 1.1. As mentioned in the previous sections, the interdependencies that we are interested in are of three types, namely, cross ownership (or shareholding interlocks) of firms, social networks, and intersectoral relations. Obviously, since these interrelationships are different in their own nature, the analytical frameworks that are used in their analysis are also different. Hence, there are several well-established and seemingly independent fields of economics and sociology that are the focus of this study. As discussed in some detail in the previous sections these are Finance, Industrial Organization, Network Economics, Social Network Analysis, Interindustry Economics, and Game Theory.

It is worth noting, however, that all the issues considered in this work are closely related, because in the end the analysis boils down to focusing on all kinds of impacts due to the presence of the complex networks of linkages between firms, individuals, and/or sectors of an economy. Moreover, the mathematical techniques developed for one type of analysis (say, in Interindustry Economics) can be readily used to address related issues in the other fields (e.g., Industrial Organization, Network Economics). For example, the well-known open Leontief model in Input-Output Analysis, which is capable of quantifying both direct and indirect sectoral relations in an economy, is quite useful in modeling and analyzing cross ownership links of firms and easily allows to distinguish between the direct and indirect shareholdings. As will be discussed in the text this setting has important theoretical and practical implications. Similarly, our Lemmas 5.1 and 6.2 that are in fact mathematically equivalent, are the building blocks of the studies in Chapter 5 and Chapter 6. Thus, they directly connect the analysis of key players search in network games and key sectors identification in an input-output setting. Therefore, this thesis in fact shows that the above mentioned fields are not totally independent of each other, but are closely related, at least, when the focus is the analysis of interdependencies.

Some main issues of each chapter are also given Figure 1.1. For example, one of the main aims of Chapter 5 is the study of the problem of identifying key group of players in social networks, where the observable differences (or exogenous heterogeneity) of individuals are taken into account. This links our study to the Network Economics’ topics on network games. But since in the course of this analysis such important sociology notions as centrality measures and redundancy principle play a crucial role, there is also a close relation to the Social Network Analysis of
finding the most important actors in networks. Similarly, Chapter 6 extends the traditional hypothetical extraction method (HEM) in Interindustry Economics in finding a key sector with the maximum potential of spreading total output growth impulses throughout the economy to the problem of identifying a key group of sectors with the highest economy-wide impact on factor generation/consumption. This generalized HEM is then linked to another widely used approach in the same field, namely, the fields of influence method, which will be also discussed in detail in the chapter. The solutions of the HEM problems have direct connection to the intercentrality measures (discussed in Chapter 5) and the so-called Shapley value in the coalitional game literature. The Shapley value identifies the worth (or importance) of each participant of the coalition to its functioning. In this way, Chapter 6 also discusses briefly this link to Game Theory.

1.6 Some general notations

Due to the nature of our study, matrix algebra will be extensively used throughout the book. Therefore, it makes sense to introduce some important notations at this point.
Vectors and matrices. Adopting usual convention, matrices are given in bold, capital letters (e.g., $X$); vectors in bold, lower case letters (e.g., $x$); and scalars in italicized, lower case letters (e.g., $x$). Vectors are columns by definition, thus row vectors are obtained by transposition, indicated by a prime (e.g., $x'$). \( \hat{x} \) denotes the $n \times n$ diagonal matrix with the elements of the vector $x$ on its main diagonal and zeros elsewhere. The zero matrix and the zero vector are, respectively, denoted by $0$ and $0$. The summation vector $i$ consists of ones, i.e., $i' = (1 1 \cdots 1)$.

Matrix (and vector) inequalities. The following notation for inequalities between matrices (and vectors) is adopted.

- $X \leq Y$ means $x_{ij} \leq y_{ij}$ for all $i$ and all $j$;
- $X < Y$ means $X \leq Y$, but $X \neq Y$, i.e., $x_{ij} \leq y_{ij}$ for all $i, j$, with at least one strict inequality;
- $X \ll Y$ implies $x_{ij} < y_{ij}$ for all $i$ and all $j$. 