Year : 2018

THREE ESSAYS ON CAPITAL STRUCTURE AND INTERFIRM RELATIONSHIPS

Prostakova Irina

UNIL | Université de Lausanne

FACULTÉ DES HAUTES ÉTUDES COMMERCIALES

DÉPARTEMENT DE FINANCE

THREE ESSAYS ON CAPITAL STRUCTURE AND INTERFIRM RELATIONSHIPS

THÈSE DE DOCTORAT

présentée à la

Faculté des Hautes Études Commerciales
de l'Université de Lausanne

pour l'obtention du grade de
Docteure ès Sciences Économiques, mention « Finance »

par

Irina PROSTAKOVA

Directeur de thèse
Prof. Norman Schürhoff

Co-directeur de thèse
Prof. Theodosios Dimopoulos

Jury

Prof. Olivier Cadot, Président
Prof. Boris Nikolov, expert interne
Prof. Stefano Sacchetto, expert externe
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La thèse est intitulée :

THREE ESSAYS ON CAPITAL STRUCTURE AND INTERFIRM RELATIONSHIPS

Lausanne, le 8 janvier 2018

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Acknowledgements

First and foremost, I would like to thank my advisor Norman Schürhoff for his trust in me, his intellectual guidance, and support that made my thesis work possible. I am very grateful to Theodosios Dimopoulos and Stefano Sacchetto for the insightful discussions and their encouragement. I would like to thank Boris Nikolov and Dmitry Livdan for their comments and advice, as well as for the inspiration that they provided.

Abstract

My dissertation consists of three papers on capital structure decisions in production networks and the relation between debt type and acquisitions activity.

The first paper explores the role of leverage in the interaction between non-financial industries. The current state of technology dictates the structure of customer-supplier links in the production network. I look at how industries make decisions about their capital structure, the size of the leverage, given this network connections. A theoretical setup illustrates the joint optimal capital structure choices of different industries depending on the intensity of input-output links and industries' characteristics. Based on these results, the empirical part of the paper demonstrates that, first, the more suppliers or customers an industry has, the higher its leverage becomes and, second, that industries with highly levered partners have a higher leverage themselves.

The second paper studies the relations between the leverage ratios of non-financial companies and their connections both along the supply chain and in product market competition. I show that the positioning of the firm in the trading network is important and that every new supply contract will on average lead to a drop of 0.1% in market leverage. The general insight of this empirical paper is that companies with numerous trading links tend to have higher leverage ratios.

In the third paper together with my co-authors, Theodosios Dimopoulos and Stefano Sacchetto, I explore the relation between capital structure policies and mergers and acquisitions activity. We find that the probability of becoming an acquirer is positively associated with the firms pre-acquisition deviation from target debt maturity. Moreover, we examine the implications of debt maturity for bidder and target returns, and for target selection and find that the average target size co-vary with long-term debt deficit.

Résumé

Ma thèse est constituée de trois articles sur les décisions relatives à la structure du capital dans les réseaux de production et sur la relation entre le type de dettes et l'activité d'acquisition.
Le premier article explore le rôle du levier financier dans les interactions entre industries non-financières. La partie théorique illustre comment les choix communs des industries envers une structure optimale du capital sont guidés par l'intensité des liens d'entrée-sortie et les caractéristiques des industries. La partie empirique, basée sur ces résultats, démontre que plus une industrie a de fournisseurs ou clients, plus son levier devient important et que par ailleurs les industries ayant des partenaires avec des leviers importants ont elles-mêmes de plus grands leviers.
Le deuxième article étudie la connexion entre les ratios de levier des entreprises non-financières ainsi que leurs liens pendant la chaîne logistique et leur relation de concurrence sur le marché des produits. Je démontre que le positionnement d'une entreprise dans un réseau commercial est important et que chaque nouveau contrat avec un fournisseur va diminuer en moyenne de 0,1% son levier financier. Cet article empirique montre que d'un point de vue général les entreprises avec de nombreux liens commerciaux ont tendance à avoir plus de levier.
Dans le troisième article nous explorons, mes co-auteurs Theodosios Dimopoulos et Stefano Sacchetto, et moi-même, la relation entre les politiques de structure du capital et l'activité de fusion et d'acquisition. Nous avons trouvé que la probabilité de devenir acquéreur d'une entreprise est associée positivement avec les déviations de la maturité de la dette prédite avant l'acquisition. De plus un examen de maturité de la dette sur les rendements des entreprises acquéreur et cible ainsi que de la sélection de cette cible montre que la taille moyenne de l'entreprise cible évolue conjointement à la maturité de la dette.

Contents

Chapter 1

Introduction

Capital structure describes the composition of a company's assets. The proportion in which the firm mixes common shares, preferred stocks, and bonds affects its cost of capital and its risk profile. The companies try to keep both these parameters low. In order to understand what is an ideal mix of their securities, companies look for their optimal capital structure. The extensive literature offers theoretical models and empirical evidence on how the optimal capital structure should be composed. However, several capital structure puzzles remain some of the major unresolved puzzles of corporate finance. The insight provided by the dominant trade-off theory does not fit the empirical evidence about capital structure. For example, contrary to the theory predictions, leverage ratios are found to be too low and debt-to-equity ratios of similar firms remain quite different.

My dissertation focuses on the capital structure and debt composition as an essential determinant of the interaction between economic agents.

In Chapter 2 "Capital Structure Decisions in Industry Networks" I explore the strategic role of leverage in the interaction between non-financial industries. I employ a network model of corporate capital structure decisions in which every industry (representing a node in the network) makes their capital structure decisions dependent on their trading links (representing the edges of the network) with other industries. I first develop a simple theoretical setup that illustrates the joint behavior of optimal capital structure depending on the intensity in input-output links and given firms' characteristics. Based on these results, I show in the empirical part of the paper that the position of an industry in the network affects its capital structure policy. The more suppliers or customers an industry has or the more connected to other industries they are, the higher its leverage becomes. My second empirical finding is a positive dependence between partner industries' leverages. Using a spatial-autoregressive model I show that industries with highly levered partners have a higher leverage themselves. This network effect supports the hypothesis that leverage is used as an instrument to improve a firm's bargaining position.

Chapter 3 "Leverage as a Commitment Tool in Product Market Networks" studies the connection between the leverage ratios of non-financial companies and their connections both along supply chain and in product market competition. I show that the positioning of the firm in the trading network is important and that every new supply contract will on average lead to a drop of 0.1% in market leverage. The effect does not disappear if I control for the proximity to the final consumer. I use novel data describing the product market network on several levels: supply chain flows and competition relation. I confirm that core firms, in terms of supply chain, demonstrate better economic performance. Peripheral firms, with regard to competition, tend to have higher leverage. The general insight of this empirical paper is that companies with numerous trading links tend to have higher leverage ratios.

In Chapter 4 “Debt Type and Acquisitions” my co-authors, Theodosios Dimopoulos and Stefano Sacchetto, and I explore the relation between capital structure policies and mergers and acquisitions activity. We study empirically how deviations from target debt maturity affect acquisition decisions. We find that the probability of becoming an acquirer is positively associated with the firm’s pre-acquisition deviation from target debt maturity. Moreover, we examine the implications of debt maturity for bidder and target returns, and for target selection. We find that the average target size co-vary with long-term debt deficit. We also investigate the potential of several economic theories to explain the link between debt maturity and acquisition policy.

Chapter 5 concludes and suggests the insights for future research.

Chapter 2

Capital Structure Decisions in the Supplier-Customer Network

We explore network effects in capital structure decision making. The economy is presented as a set of nodes (industries) and edges (trading links between them). First, we propose a simple theoretical setup which allows us to illustrate numerically joint dynamics of optimal capital structure choices with respect to agents' characteristics and the intensity of input-output links.We find that the position of an industry in the network affects its capital structure policy. The more suppliers or customers an industry has or the more connected to other industries it is, the higher its leverage becomes. Our second finding is a positive dependence between partner industries' leverages. It implies that industries with highly levered partners are prone to keep higher leverage. This result supports the theory that leverage is partly used as an instrument to improve an economic agent's bargaining position. The results are confirmed under multiple robustness checks.

2.1 Introduction

Economic agents do not make capital structure decisions in a vacuum. The default of one firm affects the credit risk of its partners and may cause contagion. Empirical studies show that both intra-industry (Leary and Roberts, 2014) and inter-industry (Kale and Shahrur, 2007) links affect an individual firm's capital structure policy. The nature of connections between companies varies with the roles which each one of them plays in the relationship. The firm could be a competitor, a supplier, and a customer simultaneously, but it chooses the role-specific behaviour as a response to its partners' observed characteristics. This multifunctionality allows us to consider the firm not only in the dimensions of competitive interaction or of upstream-downstream connections, but as an element of a network. The purpose of this paper is to empirically examine the role of cross-industry connections for capital structure choice, to explore through which channels this effect manifest itself, and to understand how economic agents depend on their surroundings. The novelty of the research question is in the focus on network effects rather than on pairwise connections.

In this paper an economy is presented as a network, in which each node is an industry. Every node has individual characteristics — average size, profitability, tangibility, market-to-book ratio, R&D expenditures — as well as capital structure decision characteristics — mean leverage ratio. The agents, i.e. industries, are expected to choose their actions, i.e. the level of debt load, not only based on their specific properties, but also as a response to adjacent nodes' actions. We use inter-industry input-output flows as a proxy for the customer-supplier connections between agents.

The flows are given by an input-out matrix. All firms in the economy are assigned to 107 sectors which provide a fraction of their yearly output as an input for other sectors' production process.

The effects we find are twofold. First, the position of an agent in the network affects the level of its leverage. Agents with more suppliers or more customers, who are important nodes in multi-link supplier-customer chains and are more exposed to economic interaction, tend to have higher leverage. Second, our estimations show that the industries tend to increase their leverage in response to a raise in their partners' leverage.

Our work mainly belongs to research areas of upstream-downstream relationships and peer network effects. The former can be discussed from a trade-off point of view. Hennessy and Livdan (2009) point out that the size of leverage is a trade-off between strengthening of a bargaining position and default costs. They found direct costs of default to be relatively low, while mainly indirect ones outbalance the leverage, such as costs of losing suppliers, customers, receivables. Thus, firms tend to decrease their leverage to strengthen their connections with partners. On the other hand, firms have an incentive to increase the leverage. A high leverage ratio deliberately raises the required minimum threshold in a bargaining game in a supplier-customer partnership. Hennessy and Livdan (2009) derive a theoretical model for optimal capital structure in the supplier-customer relationship framework, and show that leverage increases along with the bargaining power of supplier. Kale and Shahrur (2007) use an alternative approach of agency costs. According to this approach, the firm uses lower leverage to encourage their partners to undertake relationship-specific investments.

The second field of literature follows studies in social sciences and provides an effective methodology to control for spill-over effects throughout the network. To the best of our knowledge, Leary and Roberts (2014) were the first to use the peer network approach in corporate finance. They reveal the presence of within-industry peer effects in capital structure decision making. Moreover, they describe two sources from which a firm can receive a signal about an environmental shock: competitors' policies, i.e. capital structure decisions, and competitors' characteristics, i.e. profitability, sales, etc. Firms react mostly to their policies, not to other firms' characteristics. The manner in which firms absorb shocks depends also on the type of the firm. In Leary and Roberts (2014) model each agent can belong to one of the two groups: leaders or followers. The latter mimics the former, but not vice versa. Leary and Roberts (2014) use a linear-in-means empirical model. According to (Bramoullé, Djebbari, and Fortin, 2009), this class of models faces two challenges. Firstly, socially exogenous (individual characteristics), endogenous (peers' outcomes) effects, and correlated effects (common environment) should be identified and distinguished. The difficulty is to disentangle their effect. The second challenge is collinearity between average peers' outcome and average peers' characteristics. Leary and Roberts (2014) resolve both by estimating the spill-over effect by the instrumental variable approach. Alternatively, (Bramoullé, Djebbari, and Fortin, 2009) derive necessary and sufficient conditions for the identification of the model. It is worth noting that the peer network approach is not common in theoretical models.

Possible theoretical explanations of how intra-industry connections influence firms' decisions can be found in different fields.[1] Product market competition aspect was raised by

[1] We do not discuss a vast literature on industry effects on capital structure and how within-industry

Brander and Lewis (1986), they claim that the debt mimicking stems from competition reaction functions. Myers and Majluf (1984) developed an information asymmetry approach: managers signal to outside investors about the firm quality through the type of external financing. The most modern field is rational herding models. According to Devenow and Welch (1996) and Bikhchandani, Hirshleifer, and Welch (1998), firms use informational cascades: they rely on the decision of the firm with greater expertise department. Scharfstein and Stein (1990) propose another behavioural argument: sometimes similarity of decisions could be more rational than efficient.

Among many various techniques, we choose a production network setup, similar to Chu (2012) and Acemoglu et al. (2012) to construct our toy model. To introduce uncertainty, I follow Acemoglu et al. (2012) and model it though individual production to every industry. Chu (2012) demonstrates an alternative approach, where the uncertainty is driven by product prices. While at the first glance it seems quite rational, it has its hidden traps.

The rest of the paper is arranged as follows: Section 2.2 introduces a theoretical setup and illustrates numerically how characteristics of nodes neighbours and the node's connectedness in the network affect its capital structure. Section 2.3 describes the data used, Section 2.4 discusses regression specifications and presents results. Section 2.5 concludes, and Appendices contain details on the data, techniques and regressions.

2.2 Model

This section describes a theoretical model and its predictions. First, we introduce a setup of the economy. Then we discuss default boundaries. At the end of the section, we show how the solution of the model changes depending on its parameters.

2.2.1 Network Economy Setup

The economy consists of n industries. Every industry produces a unique product and uses other industries' goods in its production process. Industries trade with each other at a fixed price. If an agent ceases its economic activity — because of a default, for example, — its customers cannot switch to a different supplier. Thus, we identify the agents as industries.[2]

An adjacency matrix $W = \{w_{ij}\},\ w_{ij} \geq 0$, describes the supplier-customer relations in the economy and designates the share of good j in the total intermediate input use of firms in sector i. In particular, $w_{ij} = 0$ if sector i does not use good j as input for production. The matrix might be asymmetric: if an industry i is a client of an industry j, $w_{ij} > 0$, it does not imply that the industry i supplies the industry j at the same time, i.e. w_{ji} can be 0. For example, farmers supply the ketchup production with tomatoes, but they do not buy the ketchup to grow vegetables. The use of industry's own product as an input, w_{ii}, is defined according to the production function.[3] However, there exists a restriction that the

competition affects capital structure here, since our focus is inter-industries variation of leverage and we assume that firms' debt loads tend to be similar within the same industry.

[2]If we consider the case of nodes representing individual companies, we will have to model an option to switch between suppliers. When a company defaults, its customers are hit by a temporary supply shock before they find a replacement, as they bear search and switching costs. However this shock is not as severe as a permanent loss of supplier.

[3]According to BEA input-output matrix, in 2002 an average consumption by an industry of its own product is 13%. *Fish and other nonfarm animals* and *Transit and ground passenger transportation* are examples of sectors which do not consume its own product at all. *Aerospace products and parts*, in contrast,

agents, $j = 1, \ldots, n$, consume all the product that is produced in this period by the given industry i. Th market clearing condition is defined by an equation

$$\sum_{j=1}^{n} w_{ij} = 1.$$

The column vector $X = \{x_i\}, i \in \{1, 2, \ldots, n\}$, contains the magnitude of individual inputs, where x_i denotes how much industry i produces.

Every industry receives a production shock A_i . The shocks $A_i,\ i \in \{1, 2, \ldots, n\}$, are independent and uniformly disturbed with the base $[\check{A}_i, \hat{A}_i]$. The shocks distribution is common knowledge in the economy.

These components combine into a linear production function[4]

$$F_i(W_i, X) = A_i \sum_{j=1}^{n} w_{ij} x_j$$

or in the matrix form

$$F(W, X) = AIWX,$$

where $A = \{A_i\}, i \in \{1, 2, \ldots, n\}$, is a column vector of individual shocks and I is an n-by-n identity matrix.

All-equity case A cost of use of industry i's product is $k_i,\ i \in \{1, 2, \ldots, n\}$. The corporate tax rate is τ. Given this setup, the profit of an industry i — in the case when it is financed by equity completely is

$$\pi_i^U(x_1) = \big(A_i \sum_{j=1}^{n} w_{ij} x_j - \sum_{j=1}^{n} w_{ij} k_j x_j\big)(1 - \tau),$$

which for unlevered firm coincides with the cash flow to shareholders $CF_i^U = \big(A_i \sum_{j=1}^{n} w_{ij} x_j - \sum_{j=1}^{n} w_{ij} k_j x_j\big)(1 - \tau)$.

Debt-financing case Further, we assume that all industries have some debt load,[5] which is represented by a coupon payment c_i paid at the end of the period. Then the profit of a levered industry takes the following form:

$$\pi_i(x_1, c_i) = (A_i \sum_{j=1}^{n} w_{ij} x_j - \sum_{j=1}^{n} w_{ij} k_j x_j - c_i)(1 - \tau)$$

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consumes around 92% of its own output.

[4]This assumption makes all products in the economy perfect substitutes. In the combination with the assumption that an agent cannot switch its suppliers this feature allows the industries to absorb their production shocks but does not allow them to substitute a given supply good by the increased amount of any alternative input.
Chu (2012) uses a CES production function but with a constant elasticity of substitution across different agents and with no individual shocks.
At the same time the linearity of the function guarantees the uniqueness of the equilibrium.

[5]This assumption is quite realistic: in 1962 – 2011 among 119 industries, there are only 49 cases with zero industry-level debt.

and the cash flow to shareholders includes the tax shield $c_i\tau$

$$CF_i = \big(A_i \sum_{j=1}^{n} w_{ij}x_j - \sum_{j=1}^{n} w_{ij}k_jx_j - c_i\big)(1-\tau) + c_i\tau.$$

However, the shareholders of the agent i receive the entire cash flow only in the case when, first, its own shock was mild and, second, all industry's suppliers stay solvent. Default in this model means that an industry's net profit is not sufficient to cover coupon payments and that it does not deliver its output to its client/customer industries, $x_j = 0$. If an industry i defaults, its shareholders receive zero cash flow $CF_{i,D} = 0$.

The cash flow of the solvent industry with a number of failed suppliers reduces to

$$CF_{i,\xi_k} = \big(A_i \sum_{j=1, j\notin\xi_k}^{n} w_{ij}x_j - \sum_{j=1, j\notin\xi_k}^{n} w_{ij}k_jx_j - c_i\big)(1-\tau) + c_i\tau,$$

where ξ_k is a set of defaulted firms in the economy.

The outcome - defaulting, being hit by a shock, or staying completely solvent - depends on the distribution of the production shocks. Let us denote D_i a zone where the shocks outcome lead to a default of the industry i. D_{i,ξ_k} is a zone where the industry i stays solvent but does not receive all the inputs required by the production technology and thus receives only a "partial" cash flow. Finally, D stands for the zone where the industry i receives all its proper inputs.

Combining these three regions: where the industry i's shareholders receive *(a)* no profit, *(b)* "partial" profit, and *(c)* "entire" profit, we compute the value to the shareholders:

$$V_i(x_i, c_i) = \int\limits_{D_i}\cdots\int CF_{i,D}\, dA_1 \dots dA_n + \tag{2.1a}$$

$$+\sum_{k=1}^{n}\sum_{\xi_k} \int\limits_{D_{i,\xi_k}}\cdots\int CF_{i,\xi_k}\, dA_1 \dots dA_n + \tag{2.1b}$$

$$+\int\limits_{D}\cdots\int CF_i\, dA_1 \dots dA_n. \tag{2.1c}$$

In order to find the optimal reply functions, we need to define first order conditions:

$$\frac{\partial V_i}{\partial c_i} = 0 \;\Rightarrow\; c_i = c_i^*(x_k, \check{A}_k, \hat{A}_k) \tag{2.2}$$

and then embedding the optimal capital structure function $c_i^*(x_k, \check{A}_k, \hat{A}_k)$ function into the shareholders' value, find the optimal production plan

$$\frac{\partial V_i}{\partial x_i}\bigg|_{c_i = c_i^*(x_k, \check{A}_k, \hat{A}_k)} = 0 \;\Rightarrow\; x_i = x_i^*(\check{A}_k, \hat{A}_k).$$

Definition 1 *An equilibrium is a set of coupons (c_i) and production decisions (x_i) such that industries maximise their value to shareholders taking the network and spot market prices as given and market clearing condition holds.*

Below we focus on the optimal capital structure policy c_i and leave the discussion of the optimal output decision x_i out of focus of this paper.

2.2.2 Default zones

As it was partly covered in the previous section, to describe the first order condition (2.2) correctly, we pay closer attention to the mechanism of default. The model distinguish two types of defaults:

- *An independent default* happens because of the severity of the shock A_i, under the condition that all deliveries have been made properly.

  If the shock A_i is very severe, the earnings before interest are not sufficient to pay the coupon and the industry i defaults:

$$A_i \sum_{j=1}^{n} w_{ij} x_j - \sum_{j=1}^{n} w_{ij} k_j x_j < c_i$$

  The same threshold applies when agents defaulted independently of each other:

$$A_{i_1,\xi_0} \leq \frac{c_i + \sum\limits_{j=1}^{n} w_{ij} k_j x_j}{\sum\limits_{j=1}^{n} w_{ij} x_j},$$

  where ξ_k denotes the set of k defaulted counteragents.

- *A spillover default* happens because at least one of i's suppliers fails to deliver; the individual shock of the industry i is not strong enough to make it default but together with insufficient input, it brings the industry to the default.

$$A_i \sum_{j=1, j \notin \xi_k}^{n} w_{ij} x_j - \sum_{j=1, j \notin \xi_k}^{n} w_{ij} k_j x_j < c_i \quad \Rightarrow \quad A_{i,\xi_k} \leq \frac{c_i + \sum\limits_{j=1, j \notin \xi_k}^{n} w_{ij} k_j x_j}{\sum\limits_{j=1, j \notin \xi_k}^{n} w_{ij} x_j} \tag{2.3}$$

  Thus, every industry has a set of thresholds which monotonically increase along the number of defaulting counterparts:

$$\check{A}_i < A_{i_1,\xi_0} < A_{i_1,\xi_1} < \cdots < A_{i,\xi_{n-1}} < \hat{A}_i$$

At the same time, a good shock can rescue an industry from bankruptcy.[6] The higher the positive shock, the more resistant an industry is to the lack of pre-ordered inputs. For an extreme event, when all industries but one default, there is a threshold $A_{i,\xi_{n-1}}$. Then $[A_{i,\xi_{n-1}}, \hat{A}_i]$ is a safe interval. If industry i shock falls on it, the industry does not depend on lack of deliveries and survives.

Thus to describe a map of joint defaults and the three parts of value to shareholders (2.1), we define 3 zones with respect to cash flows of industry i :

- i defaults

$$D_i : \qquad A_i < A_{..}$$

$$\prod_{j \neq i, j \notin \xi_k} \frac{\hat{A}_j - A_{j,\xi_k}}{\hat{A}_j - \check{A}_j} \prod_{j \in \xi_k} \frac{A_{j,\xi_k} - \check{A}_j}{\hat{A}_j - \check{A}_j} \frac{1}{\hat{A}_i - \check{A}_i}$$

$$CF_{i,D} = 0$$

[6] In this paper we do not distinguish between bankruptcy and default. In our setup we do not specify that the industries are mutual debtholders and, thus, they do not recover any value of a bankrupt industry.

- k industries default defaults and i is not among them

$$D_{i,\xi_k}: \qquad \exists j \neq i \ A_j < A_{i1,\xi_k}$$
$$\prod_{j \neq i, j \notin \xi_k} \frac{\hat{A}_j - A_{j,\xi_k}}{\hat{A}_j - \check{A}_j} \prod_{j \in \xi_k} \frac{A_{j,\xi_k} - \check{A}_j}{\hat{A}_j - \check{A}_j} \frac{1}{\hat{A}_i - \check{A}_i}$$

$$CF_{i,\xi_k} = \big(A_i \sum_{j=1, j \notin \xi_k}^{n} w_{ij} x_i - \sum_{j=1, j \notin \xi_k}^{n} w_{ij} k_j x_i - c_i\big)(1-\tau) + c_i \tau$$

- no one defaults

$$D: \quad \forall j \ A_j > A_{i1,\xi_n}$$
$$\prod_{j \neq i} \frac{\hat{A}_j - A_{j,\xi_k}}{\hat{A}_j - \check{A}_j} \frac{1}{\hat{A}_i - \check{A}_i}$$

$$CF_i = \big(A_i \sum_{j=1}^{n} w_{ij} x_j - \sum_{j=1}^{n} w_{ij} k_j x_j - c_i\big)(1-\tau) + c_i \tau$$

Here we study the optimal capital structure changes in response to the change of parameters: weighting matrix W, distributions of production shocks $[\check{A}_i, \hat{A}_i]$, etc.

2.2.3 Model Timeline

The model is one-period and its timeline is split by the realisation of the production shocks into two parts: before and after shocks. Figure 2.1 illustrates it. Before the shocks the industries make their capital structure and then production decisions taking into account their counteragents' behaviour. After the shocks the economy realises which industries have to default and then solvent industries make payments to their stakeholders.

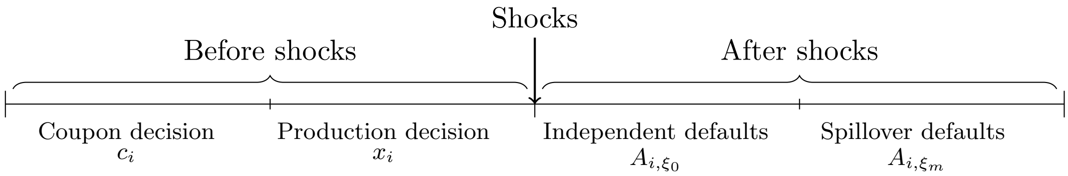


Figure 2.1: reports the timeline of the model. before the shocks: companies make their capital structure and production decisions, shocks are realised, after the shocks: the companies make payments. Before the shocks are realized, the agents, first, make their decisions about borrowing and then about output magnitude. After the shocks have been realised, the agents state their default or solvency independently and together with the other agents in the economy.

Even though the defaults happen simultaneously, once the industries learn the magnitude of the shocks in the economy, they still differ in nature (independent and spillover defaults). To understand the logic of the spillover mechanism we look at the more detailed timeline of the model.

Before shocks. Step 1: Industries choose their coupons in order to maximize the value of the firm (for the shareholders):

$$c_i = c_i^*(x_{kj}), \ k, j \in \{1, 2, \dots, n\}$$

Before shocks. Step 2: Given the optimal debt levels, the industries choose their inputs x_i and preorder them:

$$x_i = x_i^*(w_{kj}, A_k),\ k, j \in \{1, 2, \ldots, n\}$$

After shocks. Step 1: Production shocks happen and all industries learn which of them are going to default now. Only "independent" defaults are announced. This is the first wave of defaults.

After shocks. Step 2: Industries, which shocks were not high enough to default independently, realise whether they are going to default because of delivery failure. This is the second wave of defaults.

...

After shocks. Step k: Industries which have not defaulted after all waves of defaults produce, repay their coupons, and receive their profits. Payments to suppliers happen, only after a successful delivery. Thus, if the supplier failed to deliver the good, the customer does not bear the cost k_j of buying it.

2.2.4 Example of an economy consisting of three industries

For the sake of tractability, we consider an example with three agents and present numerical results. Figure 2.2 presents three networks of different structures: isolated agents in Panel 2.2a, linear/star-shaped economy in Panel 2.2b, and circular economy in Panel 2.2c. In the first case all industries are isolated and, thus, make their decisions independently; a shock that hits one of them does not affect the other nodes of the network. In the linear economy a central node is clearly seen: the node 2 as presented in the figure. The shock of the industry 1 never affects the industry 3 directly, only through a neighbour effect, i.e. through the node 2. In the circular economy all industries are interconnected, any production shock will hit every industry in the economy. Below we discuss how a position of an industry in the economy becomes a determinant of its capital structure.

Figure 2.3a reports conditional default zones for a fully interconnected economy. As there are three industries, they produce three default zones and one non-default zone. The shock of industry 1 moves along axis x, the shocks of industries 2 and 3 along axes y and z respectively. Red zone corresponds to an "independent" default of industry 1. Orange zone describes a conditional default of industry 1 when one and only one counteragent defaults. Yellow zone shows a zone of conditional default of industry 1 when both counterparties default. Transparent zone corresponds to the higher shock and describes the non-default zone for industry 1. We see that the red zone is a layer which covers the plane:

$$A_1 \in [\check{A}_1, A_{1,\xi_0}],\ A_2 \in [\check{A}_2, \hat{A}_2],\ A_3 \in [\check{A}_3, \hat{A}_3],$$

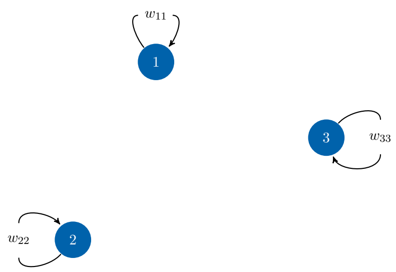
meaning that under any shocks for industries 2 and 3 industry 1 defaults, as its own shock is below an independent threshold.

The orange zone corresponds to two intersecting stripes:

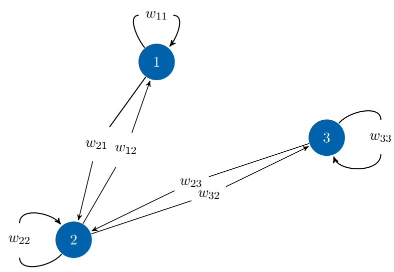
$$A_1 \in [A_{1,\xi_0}, A_{1,\xi_1}],\ A_2 \in [\check{A}_2, A_{2,\xi_0}],\ A_3 \in [\check{A}_3, \hat{A}_3],$$

and

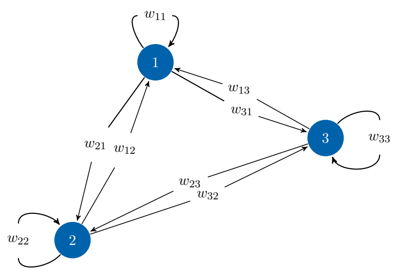
$$A_1 \in [A_{1,\xi_0}, A_{1,\xi_1}],\ A_2 \in [\check{A}_2, \hat{A}_2],\ A_3 \in [\check{A}_3, A_{3,\xi_0}],$$



(a) Isolated Industries

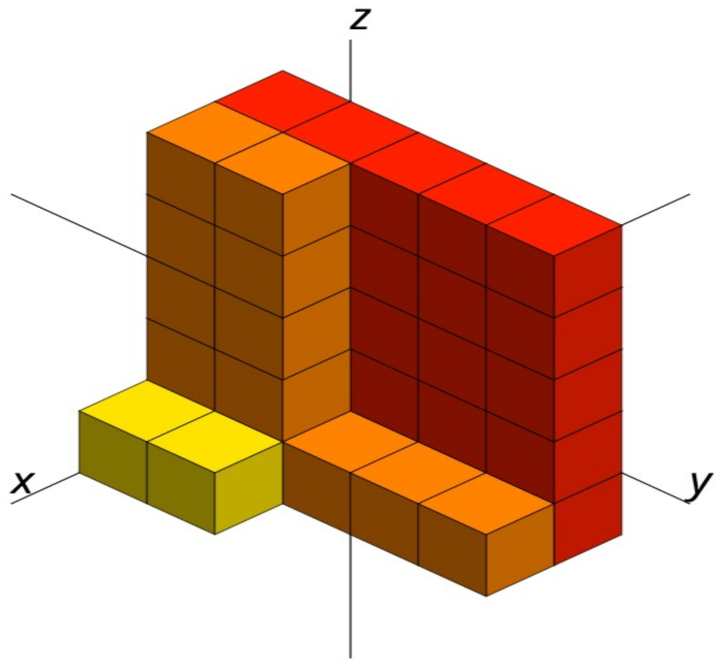


(b) Linear/Star-shaped Economy

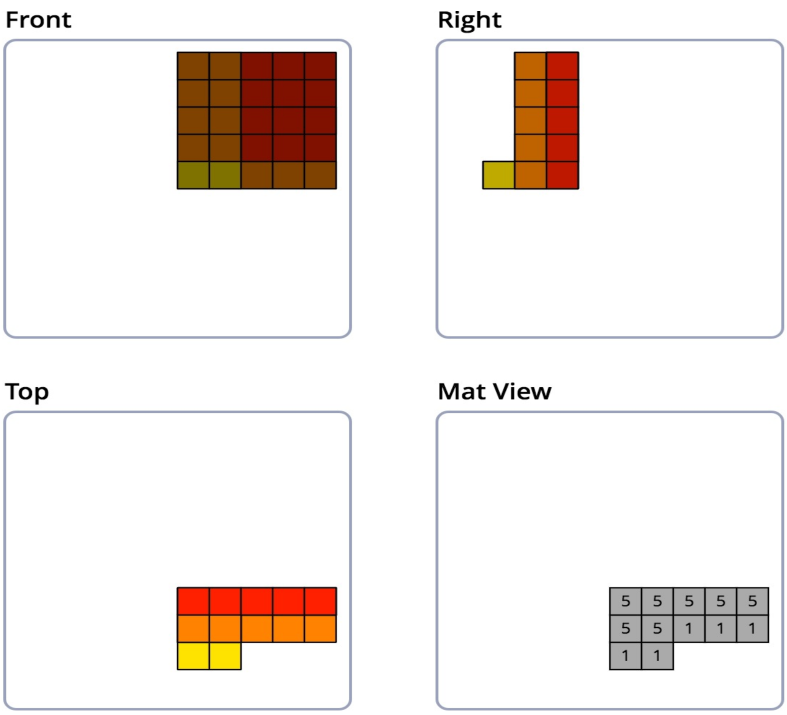


(c) Circular economy

Figure 2.2: demonstrates 3 potential shapes of three-industry economy. Panel 2.2a presents isolated industries. All industries are isolated and, thus, make their decisions independently; a shock that hits one of them does not affect the other nodes of the network. Panel 2.2b corresponds to a linear (or star-shaped)economy. In this type of the economy a central node is clearly seen: the node 2 as presented in the figure. The shock of the industry 1 never affects the industry 3 directly, only through a neighbour effect, i.e. through the node 2. Panel 2.2c depicts a circular economy. Here all industries are interconnected, any production shock will hit every industry in the economy.



(a)



(b)

Figure 2.3: illustrates 3 types of default of industry 1 with respect to production shocks of all three industries in a fully interconnected economy. The shock of industry 1 moves along axis x, the shocks of industries 2 and 3 along axes y and z respectively. Red zone corresponds to an "independent" default of industry 1. Orange zone describes a conditional default of industry 1 when one and only one counteragent defaults. Yellow zone shows a zone of conditional default of industry 1 when both counterparties default. Transparent zone corresponds to the higher shock and describes the non-default zone for industry 1.

meaning that a default of at least one counterparty will hit vulnerable industry 1 hard enough to default.

The yellow zone is described as follows:

$$A_1 \in [A_{1,\xi_2}, A_{1,\xi_2}],\ A_2 \in [\check{A}_2, A_{2,\xi_0}],\ A_3 \in [\check{A}_3, A_{3,\xi_0}].$$

It is worth noting that there is a part of an orange zone where both counteragents default as well. However, we distinguish the colours with respect to the degree of vulnerability of industry 1, not the number of defaulting industries.

The rest of the space that fills the parallelepiped up to the point $(\hat{A}_1, \hat{A}_2, \hat{A}_3)$ is transparent and describes the zone where industry 1 does not default under any circumstances.

Figure 2.3b presents the same default zones only presented in slice-by-slice.

Figure 2.4 reports dynamics of coupons for industries 1 and 2. The blue line depicts the dynamics of industry 1's coupon. The orange line depicts the dynamics of industry 2's coupon. The left hand side column reports the graphs for interconnected case: when industry 1 consumes product of industry 2. The right hand side column stands for an independent industry 1. The first row exhibits dynamics of optimal coupons (y-axis) over the cost of product 2 (x-axis). In the left column we see that as the use of product 2 becomes more expensive, industry 1 has less resources to pay out its debt and, thus, it prefers to reduce its optimal coupon. In the right column the cost of product 2 does not affect coupon 1 in any way, because it does not depend on supplies of product 2.

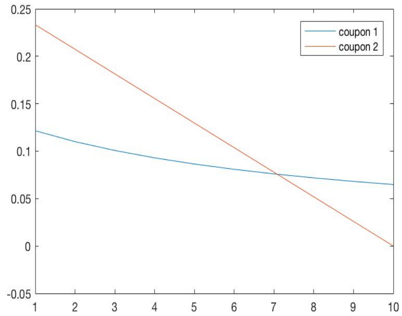
The second row reports dynamics of optimal coupons (y-axis) along the top limit of the production shock (x-axis). In the left column the optimal coupon 1 increases along the upper boundary of industry 2's product shock $\hat{A}_2$. As the next panel shows, the essential reason of this growth is the increase of the corresponding mean, $\bar{A}_2$. As expected, in the right column the coupon 1 is not affected by the change of parameters in industry 2.

The third row presents dynamics of optimal coupons (y-axis) along the volatility of production shock 2, its mean stays unchanged (x-axis). We see that in both columns the coupon 1 stays unchanged. It can be explained by the setup in which the volatility of a production shock does not affect coupon 1.

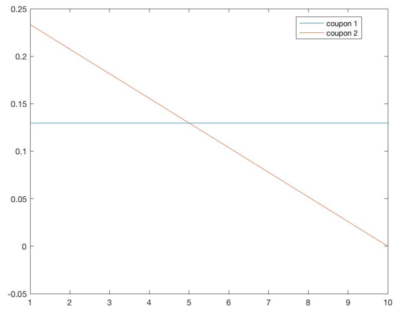
Figure 2.5 reports dynamics of coupons for industries 1, 2, and 3. The size of a coupon is measured along y-axis. Along x-axis grows the weight of product 2 as an input of industry 1 (w_{12}); w_{11} stays constant at the level of 10%; w_{13} is decreasing along x-axis. The blue line depicts the dynamics of industry 1's coupon. The orange line depicts the dynamics of industry 2's coupon. The yellow line depicts the dynamics of industry 3's coupon. Panel 2.5a reports the case when the distributions of production shocks in industry 2 and 3 are the same, however, the cost of product 3 is 10 times higher than the cost of product 2. Industries 2 and 3 are supplied by their own product completely. We notice the contrast between the level of coupons 2 and 3: product 3 is so expensive that industry 3 cannot issue any debt. The more industry 1 switches to product 2, the higher coupon industry 1 can afford.

Panel 2.5b reports the case when the proportion of costs remains unchanged: the cost of product 3 is 10 times higher than the cost of product 2, and the production shock interval of industry 3 shift upwards, i.e. both its bottom and top extremes are higher than in the previous case. The coupon 2 remained unchanged, as none of parameters of industry 2 have changed. Industry 3 issues coupon now, because its production shock is much higher.

Panel 2.5c show the setup identical in everything but inputs x_{12} and x_{13}, which are twice as higher as in Panel 2.5b. In this case the increasing dynamics of coupon 1 remains, however the pace of the growth changes due to the new weights.



(a)



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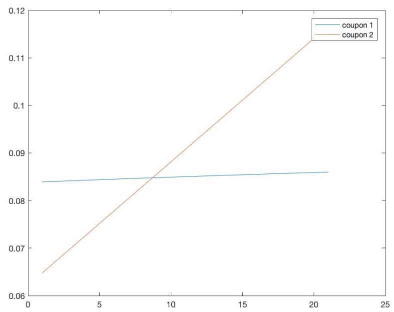
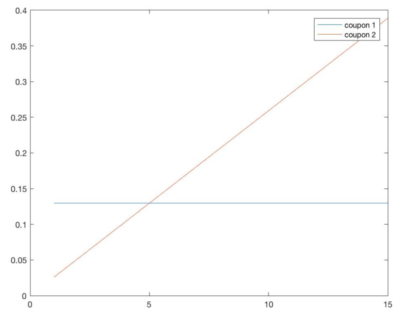
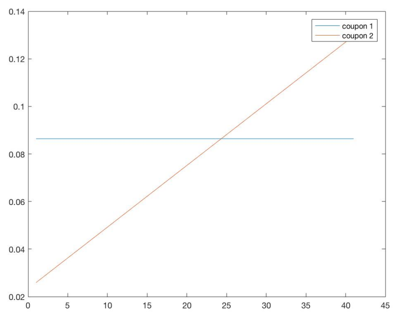


(c)



(d)



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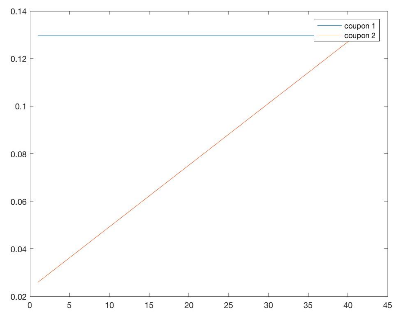
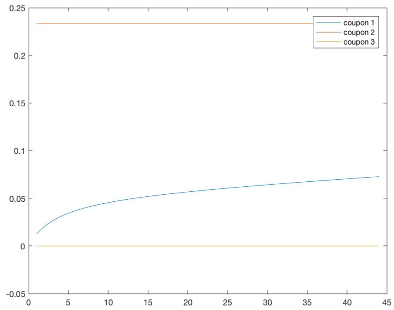
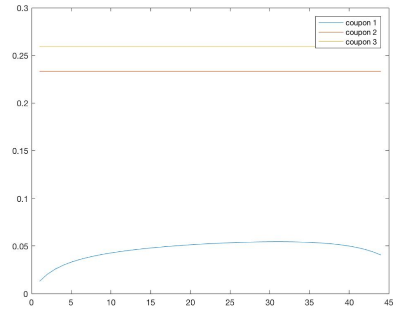


(f)

Figure 2.4: reports dynamics of coupons for industries 1 and 2. The blue line depicts the dynamics of industry 1's coupon. The orange line depicts the dynamics of industry 2's coupon. The left hand side column reports the graphs for interconnected case: when industry 1 consumes product of industry 2. The right hand side column stands for an independent industry 1. The first row exhibits dynamics of optimal coupons (y-axis) over the cost of product 2 (x-axis). The second row reports dynamics of optimal coupons (y-axis) along the top limit of the production shock (x-axis). The third row presents dynamics of optimal coupons (y-axis) along the volatility of production shock 2, its mean stays unchanged (x-axis).



(a)



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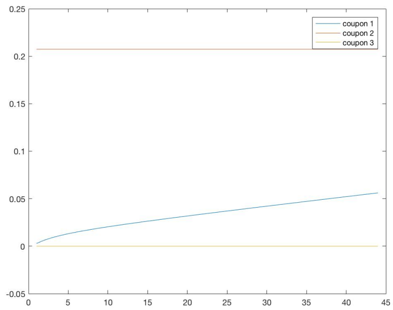
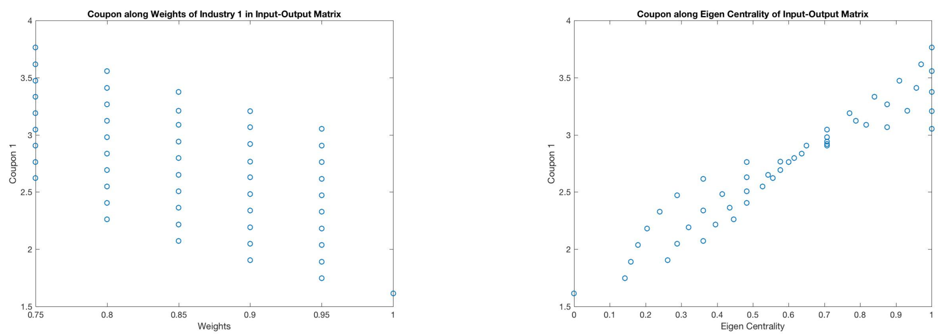


(c)

Figure 2.5: reports dynamics of coupons for industries 1, 2, and 3. The size of a coupon is measured along y-axis. Along x-axis grows the weight of product 2 as an input of industry 1 (w_{12}); w_{11} stays constant at the level of 10%; w_{13} is decreasing along x-axis. The blue line depicts the dynamics of industry 1's coupon. The orange line depicts the dynamics of industry 2's coupon. The yellow line depicts the dynamics of industry 3's coupon. Panel 2.5a reports the case when the distributions of production shocks in industry 2 and 3 are the same, however, the cost of product 3 is 10 times higher than the cost of product 2. Panel 2.5b reports the case when the proportion of costs remains unchanged: the cost of product 3 is 10 times higher than the cost of product 2, and the production shock interval of industry 3 shift upwards, i.e. both its bottom and top extremes are higher than in the previous case. Panel 2.5c show the setup identical in everything but inputs x_{12} and x_{13}, which are twice as higher as in Panel 2.5b.

In the above figures, there is no direct response by capital structure decision of one industry onto capital structure decision of an other one ($c_1 \neq c_1(c_2)$), rather the response is on the characteristics of the counteragent ($c_1 = c_1^*(k2, \check{A}_2, \hat{A}_2, ...)$). So it is a similar in spirit to spatial-error model rather than spatial-autoregressive model.

Figure 2.6 reports dynamics of coupons for the industry 1 along its measures of centrality. The size of a coupon is measured along y-axis. In Panel 2.6a long x-axis the weight of input of its own product grows. In other words, the points closer to the origin correspond to a more connected node and the weight equal to one stands for an isolated industry. This is reverse to the in-degree measure change, i.e., the weaker is isolation, the more counterparts an industry has and, thus, the higher the in-degree measure is. And an independent industry has zero trading connections and a zero in-degree measure. In Panel 2.6b the eigen centrality of industry 1 is measured along y-axis. The matrix of input-output weights provides a set of of eigenvalues and eigenvectors. The eigen centrality equals a corresponding coordinate in the eigenvector associated with the highest eigenvalue. The details of different centrality measures are discuused in Section 2.4.1. This figure illustrates the hypotheses, which are tested in the empirical part of the paper: the leverage of more connected industries is higher.



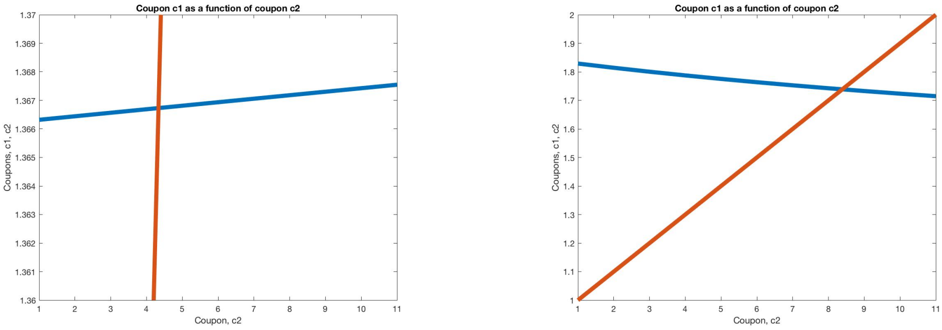
(a) (b)

Figure 2.6: reports dynamics of coupons for the industry 1 along its measures of centrality. The size of a coupon is measured along y-axis. In Panel 2.6a long x-axis the weight of input of its own product grows. In other words, the points closer to the origin correspond to a more connected node and the weight equal to one stands for an isolated industry. This is reverse to the in-degree measure change, i.e., the weaker is isolation, the more counterparts an industry has and, thus, the higher the in-degree measure is. And an independent industry has zero trading connections and a zero in-degree measure. In Panel 2.6b the eigen centrality of industry 1 is measured along y-axis. This figure illustrates the hypotheses, which are tested in the empirical part of the paper: the leverage of more connected industries is higher.

The spatial-autoregressive perspective is illustrated in Figure 2.7. Panels 2.7a and 2.7b demonstrates the contrast between two sets of parameters under which capital structure of industry 1 responds positively or negatively on the increase of industry 2's coupon. The comparative elasticity in these two figures shows that a negative response is more likely.

2.3 Data

The model in the previous section provides two predictions: the leverage of more connected industries is higher and industries are likely to decrease their leverage in response to the increase of counterpart's leverage.



(a) (b)

Figure 2.7: reports dynamics of coupons for industries 1 and 2. The size of a coupon is measured along y-axis. Along x-axis grows the coupon of industry 2 as an inputs of industry 1 (w_{11}); w_{12} stay constant at the level of 50%; w_{13} is zero. The blue line depicts the dynamics of industry 1's coupon. The orange line depicts the dynamics of industry 2's coupon. Panel 2.7a reports the case when the coupons of industry 1 and 2 co-move. Panel 2.7b reports the case when the coupon of industry 1 responds negatively to industry 2's capital structure.

2.3.1 Data selection.

We use annual data from a merged CRSP-Compustat database for companies with headquarters in the USA from 1962 to 2012. The time period is chosen to provide non-missing data on dependent and explanatory variables (listed in Section 5). The data sample includes 50,088 firm-year observations. We winsorize ratios at 1 and 99 percentile levels to prevent the outliers from affecting the analysis. We exclude financials ($NAICS$ starts with 52), utilities ($NAICS$ starts with 22), and government entities ($NAICS$ starts with letters). The former have specific capital structure regulations. The second are usually thoroughly monitored by the community and government, and thus are constrained in leverage decision making, and might be prevented from defaults due to the significance of their business to a population. The latter group may not be profit-oriented, so the principles of their functioning, and among others issuing debt, may be different.

2.3.2 Data Description.

The winsorized sample companies' market leverage ratios vary from 0 to 2.282 (though the 99 percentile corresponds to the market leverage level of 0.9) with a median market leverage of 0.170. The size of the company has a range from -6.908 to 12.98 (the negative value appears due to the construction of the ratio — firm size is the logarithm of its sales), the market-to-book ratio ranges from 0.0132 to 80.830, the profitability varies from -21.290 to 1.984, the asset tangibility varies from 0 to 0.999. The basic summary statistics for the data in levels is presented in the Table 2.1.

2.3.3 Industry Connections.

To describe the interactions between industries we use the input-output use matrix from the Bureau of Economic Analysis. Each cell in this matrix describes how much of the corresponding row industry's output the corresponding column industry consumes. The data is presented in producers' prices. The results in this paper are calculated with the

Table 2.1: **Descriptive Statistics for Leverage and Control Variables.** The sample consists of firms from the merged CRSP-Compustat database for companies with headquarters in the USA from 2003 to 2014 on the annual base. Financials (historical SIC or SIC between 4900 and 4949), utilities (historical SIC or SIC codes between 6000 and 6999), and government entities (NAICS starts with letters) are excluded from the sample. All variables are winsorised at 1% and 99%. Values are shown to three significant decimal places.

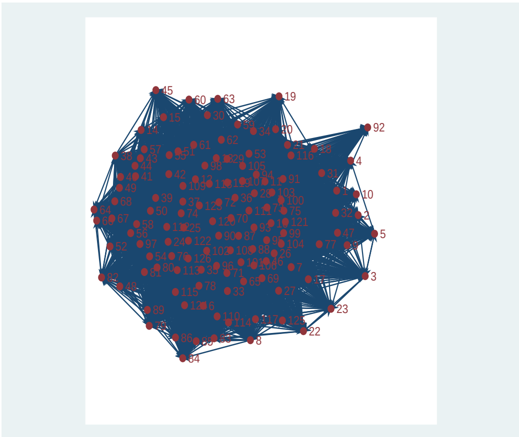
Centrality Measure	Mean	Median	s.d.	Min	Max
Book Leverage (Colla et al., 2013)	0.286	0.253	0.264	0.000	24.610
Book Leverage (Uysal, 2011)	0.552	0.512	0.463	0.009	62.720
Market Leverage (Colla et al., 2013)	0.293	0.238	0.239	0.000	0.998
Size	4.997	5.028	2.203	-7.034	12.620
Market-to-Book ratio	1.174	0.738	1.695	0.001	74.260
Profitability	0.075	0.119	0.280	-21.290	1.984
Assets Tangibility	0.323	0.269	0.229	0.000	1.000
R&D Dummy (Uysal, 2011)	0.549	1.000	0.498	0.000	1.000
R&D/Total Assets (Uysal, 2011)	0.040	0.000	0.120	0.000	7.796
Cash Holdings	0.119	0.056	0.161	0.000	0.993
Observations	88'595				

2002 matrix, in which industries (and corresponding output products) are split into 127 groups.

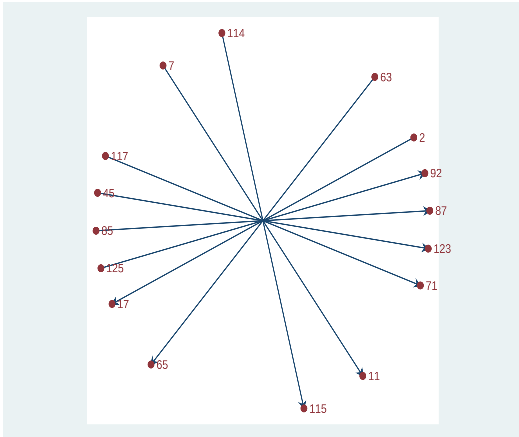
The position of an industry in the network is defined by the number of connections with other industries and the magnitude of each. The first property is described by an adjacency matrix. Its element is one if there exists a corresponding product-industry link and zero otherwise, the diagonal elements are set to be zeros. The second is described by the weighting matrix. Each cell in the weighting matrix is zero if the corresponding cell in the adjacency matrix is zero. All other cells are the magnitude of the connection. An alternative way to describe the strength of dependence between industries is a normalized weighting matrix. It is a weighting matrix each cell of which is divided by the row industry's total output.[7] Thus, the sum of a row in the normalized matrix is always one. This transformation ensures the ties between large and small industries are considered as equally important. For example, if a small industry supplies most of its output to another small industry, then they are linked tightly. Without this normalization, this link would be negligibly small in the presence of large industries. However, we are interested in the relative importance of the partner industries as well as in the absolute magnitude of inter-industry trading flows. The difference between the set of the industries with the strongest ties in relative and absolute terms is presented in Graphs 2.8b and 2.8c.

Formally, those characteristics can be presented in terms of centrality measures. Each of measure reflects different properties of a node. Out-degree, the average weight of a node's outgoing edges, shows the average magnitude of an industry's customers' consumption. In-degree, the average weight of a node's ingoing edges, shows the average magnitude of an industry's suppliers' input. Eigenvector centrality measures the importance of the industry in the economy network. The details of construction and interpretation of these and other

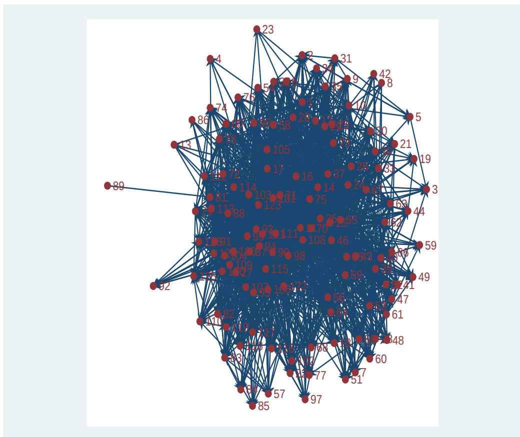
[7] Alternative methods of normalization were used to check the robustness of the results and will be discussed in Section 2.4.



(a) Entire network



(b) Network with 10% of the strongest ties shown



(c) Network with 10% of the most expensive trading ties shown

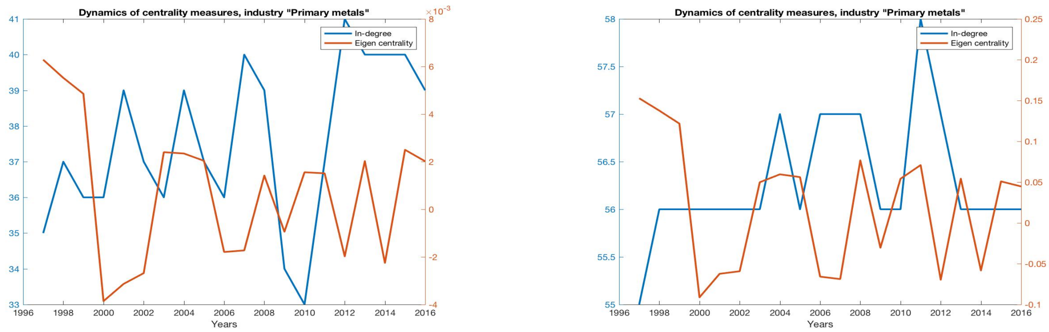
Figure 2.8: reports a network of trading relations between the U.S. industries in 2002. The top left sub-figure represents an entire network. The top right sub-figure depicts the ties corresponding to the top 10% of row-normalized weights. The bottom sub-figure describes the ties corresponding to the top 10% of non-normalized weights.

The sub-graphs 2.8b and 2.8c demonstrate the difference between structures of normalized weighting and non-normalized weighting matrices. Although the trading links can be large in absolute values — and thus can be included into the plot 2.8c, at the same time they can be out-balanced by other large flows — and thus become relatively less important and be excluded from the plot 2.8b. The matrix of relative values is used to analyze the local "neighbour-to-neighbour" connections, the matrix of absolute values is used for the global "throughout a network" relations.

measures can be found below (Section 2.4.1).

The data on companies was re-aggregated into 107 groups, corresponding to the columns of the input-output matrix. Some firms from CRSP-Compustat database belong to industries which are not described in the matrix and so are removed. The summary statistics for centrality measures can be found at Table 2.2.

Figure 2.9 illustrates the dynamics of in-degree and eigen centrality in 1997–2016. For the clarity of presentation only two industries are shown: “Apparel and leather and allied products” industry, which NAICS are 315000 and 316000, and “Primary metals” industry, which NAICS start with 331. However, the result holds for all industries. This figure also demonstrates that the chosen scale of an industry is optimal. Bigger industries — with more commodities per industry — would not show such a vivid dynamics and would not represent the change of technology and economic conditions. For smaller industries — with fewer commodities — it is impossible to find data of the same level of reliability.



(a) (b)

Figure 2.9: shows the dynamics of centrality measures: in-degree and eigen centrality. The left y-axis corresponds to the in-degree mesure, the right y-axis reflects the eigen centrality. Panel 2.9a stands for “Apparel and leather and allied products” industry (NAICS are 315000 and 316000). Panel 2.9b stands for “Primary metals” industry (NAICS start with 331).

According to different measures, the same industries can be at the same time core and peripheral. For instance, Tobacco products have high out-degree and eigenvector centralities and a low betweenness centrality. This fact can be explained in the following way: this industry has lots of direct customers and they, in their turn, are connected to many other industries, but it does not lie on the shortest paths between many industries, it is in the ”blind end” of this customer-supplier chain. The different types of core and peripheral industries are listed in Table 2.3. If we group the industries along a centrality measure, we observe the difference in the dynamics of these subsamples. The fact is illustrated in Figures 2.10a–2.10f and 2.11a–2.12d. They demonstrate the median leverage and industries’ median characteristics’ dynamics of three groups of industries: core, intermediate, and peripheral. In the left columns of plots the centrality groups are defined with respect to out-degree centrality and in the right columns they are assigned with respect to eigenvector centrality. The measures were chosen to underline the presence of a network effect. The out-degree centrality characterizes the node locally, because it is constructed on the ties to first-order neighbours. Roughly speaking, this approach is similar to consideration of each node with its partners separately. While the eigenvector centrality reports the importance of a node in the entire network. In this case we cannot consider the economy hub-by-hub, but only all nodes together. The peripheral industries with respect to both local (out-degree)

Table 2.2: **Summary statistics — Measures of Centrality**
Centrality measures are computed on the base of the BEA input-output use matrix. The matrix provides information on how much output of a row industry has been consumed by a column industry. The data is presented in producers' prices. Adjacency matrix' elements are 1's if there exist corresponding product-industry links and 0 otherwise, the diagonal elements are set to be zeros. Weighting matrix' 0 elements coincide with those of the adjacency matrix and 1's are replaced by the normalized magnitude of the connections. The normalization was made by dividing each cell by the sum of the row. Values are shown to three significant decimal places.

Adjacency matrix					
Out-degree	0.454	0.138	0.388	0.295	0.882
In-degree	0.676	0.013	0.674	0.656	0.729
Degree	1.126	0.144	1.060	0.959	1.562
Closeness	1.105	0.066	1.124	0.844	1.200
Betweenness	0.366	0.117	0.422	0.003	0.523
Eigenvector	0.049	0.013	0.043	0.031	0.091
Katz-Bonacich	0.036	0.014	0.043	-0.019	0.055
Weighting matrix					
Out-degree *weighted*	280.598	90.770	238.783	192.391	613.550
In-degree *weighted*	417.457	28.899	414.161	374.234	524.099
Degree *weighted*	703.960	115.298	672.471	581.162	1069.722
Closeness *weighted*	413.207	115.540	448.627	0.923	556.023
Betweenness *weighted*	0.446	0.152	0.514	0.015	0.656
Eigenvector *weighted*	0.037	0.006	0.034	0.031	0.058
Katz-Bonacich *weighted*	0.036	0.022	0.033	0.000	0.101
Normalized weighting matrix					
Out-degree *weighted,normalized*	6.766	2.523	7.242	-2.236	14.214
In-degree *weighted,normalized*	0.008	0.000	0.008	0.007	0.009
Degree *weighted,normalized*	0.012	0.002	0.012	0.011	0.017
Closeness *weighted,normalized*	10805.708	3162.548	9360.447	6130.257	20485.073
Betweenness *weighted,normalized*	8219.340	2900.568	9383.144	0.021	12014.487
Eigenvector *weighted,normalized*	0.034	0.004	0.032	0.030	0.052
Katz-Bonacich *weighted,normalized*	4.081	1.254	3.429	2.541	8.532
Observations	50088				

and global (eigenvector) centrality measures have in average higher leverage. Moreover, book leverages and industries' characteristics of core and peripheral sectors show different dynamics as well as different magnitudes.

Table 2.3: **The Core and the Peripheral Industries According to Different Measures of Centrality**

The table reports the list of core and peripheral industries with respect to out- and in-degree, closeness, betweenness, eigenvector, and Katz-Bonacich centrality measures computed on the base of adjacency, weighting, and normalized weighting matrix. Industries are included in the core (peripheral) group if the corresponding measure of centrality is in the top (bottom) 1% of all values of centrality measure.

	Adjacency	Weighting	Normalized Weighting
		Core	
out-degree	Tobacco products, Radio and television broadcasting	Tobacco products, Ordnance and accessories	Fish and other nonfarm animals, Household appliances
in-degree	Courier and messanger services, Insurance carriers and related services	Forestry and logging activities, Insurance carriers and related services	Forestry and logging activities, Insurance carriers and related services
closeness	Water, sewage and other systems, Rights to nonfinancial intangible assets	Electric lighting equipment, Other information services	Tobacco products, Hospital care
betweenness	Water, sewage and other systems, Rights to nonfinancial intangible assets	Water, sewage and other systems, Rights to nonfinancial intangible assets	Water transportation, Rights to nonfinancial intangible assets
eigenvector	New nonresidential construction, Tobacco products	Support activities for agriculture and forestry, Tobacco products	Support activities for agriculture and forestry, Mining support activities
Katz-Bonacich	Water, sewage and other systems, Transit and ground passanger transportation	Retail trade, Rail transportation	Support activities for agriculture and forestry, Tobacco products
		Peripheral	
out-degree	Water transportation, Rights to nonfinancial intangible assets	Maintenance and repair construction, Rail transportation	Mining support activities, Industrial machinery
in-degree	Support activities for agriculture and forestry, Natural gas distribution	Wholesale trade, Management of companies and enterprises	Retail trade, Social assistance
closeness	Hospital care, Nursing and residential care	Tobacco products, Nursing and residential care	Water, sewage and other systems, Water transportation
betweenness	Hospital care, Nursing and residential care	New residential construction, Tobacco products	New residential construction, Tobacco products
eigenvector	Water, sewage and other systems, Rights to nonfinancial intangible assets	Maintenance and repair construction, Water transportation	Audio, video, and communications equipment, Rights to nonfinancial intangible assets
Katz-Bonacich	New residential construction, Radio and television broadcasting	Tobacco products, Nursing and residential care	Water transportation, Rights to nonfinancial intangible assets

2.4 Empirical Evidence

We estimate the two network effects: first, whether and how much the position (centrality) of an industry in the network influences its capital structure and, second, whether the industry's leverage is affected by leverages of its suppliers and customers or their characteristics.

2.4.1 Network terminology

Out-degree gauges how connected the vertex is, how many flows (and of which magnitude — in weighted case) stem from it.
Out-degree is computed as a number (a sum — in weighted the case) of out-flows normalized by the maximum possible amount of outflows (the number of nodes in the network minus one).

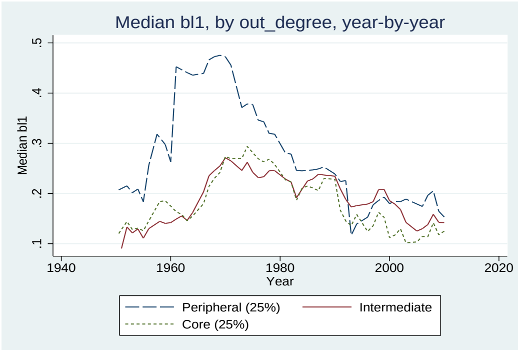
In-degree measures how connected the vertex is, how many flows (and of which magnitude — in weighted case) flow into it.
In-degree is computed as a number (a sum — in the weighted case) of in-flows normalized by the maximum possible amount of inflows (the number of nodes in the network minus one).

Betweenness characterizes the importance of the node's position in the network.
Betweenness of a vertex is computed as a sum over all nodes of the following ratios: in the numerator there is a number of the shortest paths linking two nodes of a network, different from the given vertex, routing via this vertex, in the denominator a number of all shortest paths linking the same two nodes, normalized by the maximum amount of paths a vertex could lie on between all pairs of other vertex.

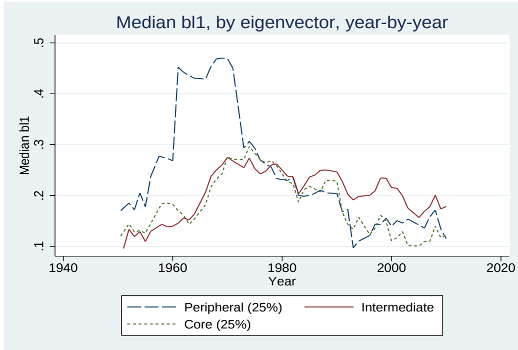
Closeness measures how close to the nodes of the reachable subnetwork the vertex is. The closer to other nodes the vertex is, the higher score it receives.
Closeness is a ratio of the maximum possible number of connections a node can have (the number of nodes in the network minus one) and the sum of distances from the vertex to all nodes of the reachable set.

Eigen centrality measures the importance of a vertex. It receives high scores if it has many neighbours, important neighbours, or both. The idea of this measure coincides with a concept of eigenvectors. There is the same characteristic on the left- and right-hand sides of the equation: the higher are the scores of a vertex's neighbours, the higher scores it has itself. An eigenvector is a vector of scores, a matrix is an adjacency matrix — thus the product of the matrix and the vector of the scores provides a summary of the neighbours' scores — and an eigenvalue is a scaling coefficient.Technically, eigenvector centrality of a vertex is the corresponding coordinate of the largest eigenvalue's eigenvector of an adjacency matrix.

Katz-Bonacich centrality was constructed with logic similar to eigenvector centrality, but it includes an intercept into the equation and thus guarantees that isolated vertices are assigned non-zero scores.



(a)



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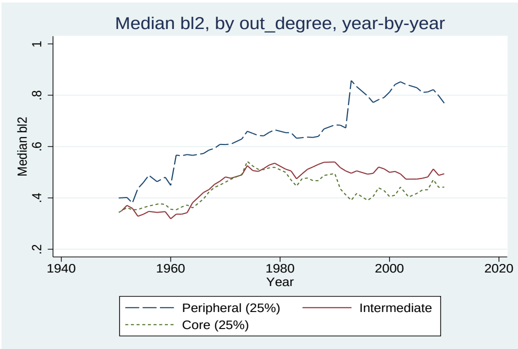
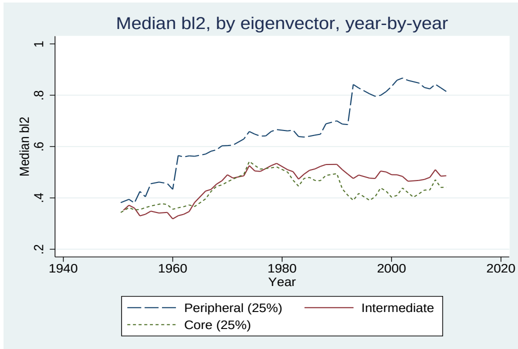


(c)



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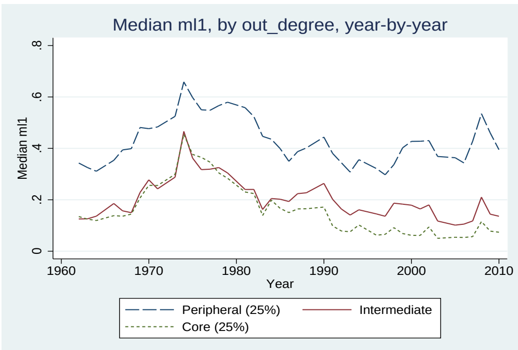

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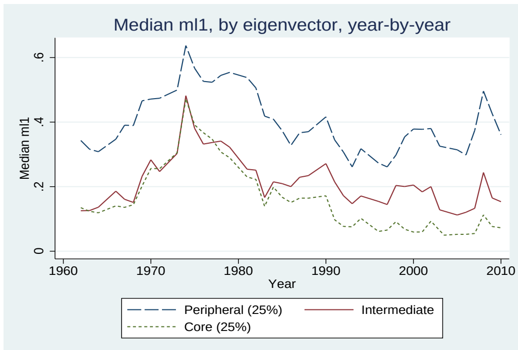
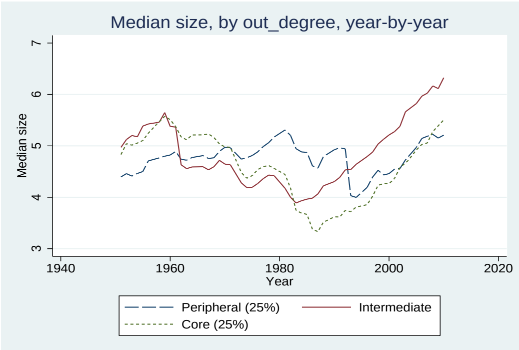
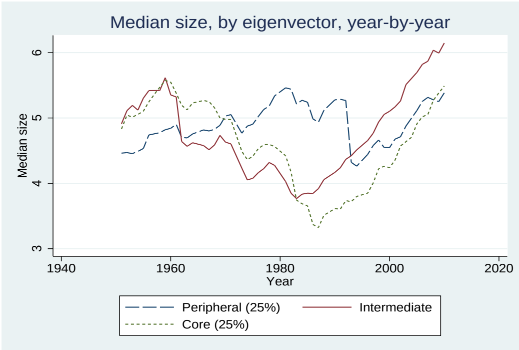


(f)

Figure 2.10: demonstrates the median leverage dynamics of three groups of industries: core, intermediate, and peripheral. The first row of pictures represents book leverage 1, the second book leverage 2, and the third market leverage 1. The industries in the figures in the left column are split with respect to out-degree centrality, and in the right column to eigenvector centrality. Industries are included in the core (peripheral) group if the corresponding measure of centrality is in the top (bottom) 25% of all values of centrality measure. The rest of the industries forms the intermediate group.
The peripheral industries with respect to local (out-degree) and global (eigenvector) centrality measures have on average higher leverage. Moreover, book leverages of industries of different centrality show different dynamics as well as different magnitudes.



(a)



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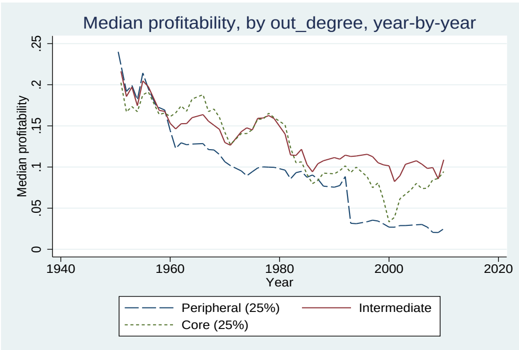

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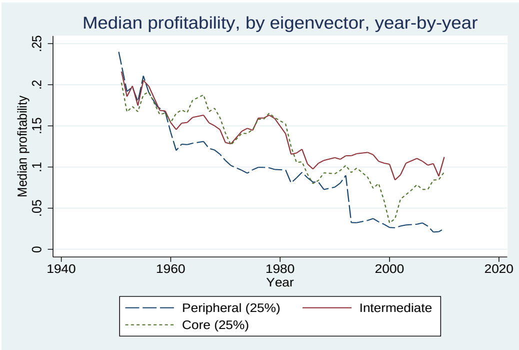
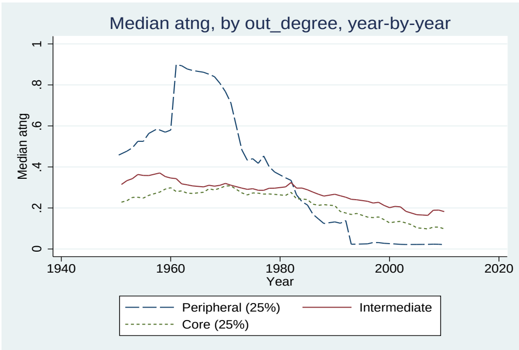
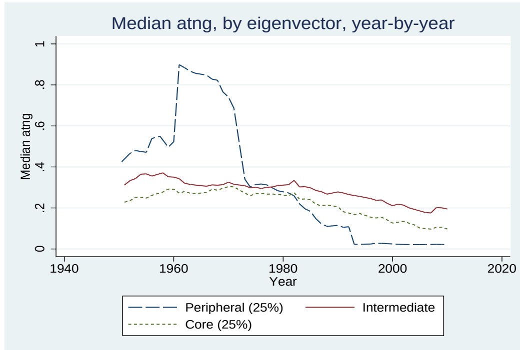


(d)

Figure 2.11: demonstrates the dynamics of the industries' characteristics for three groups of industries: core, intermediate, and peripheral. The first row of pictures represents size, the second profitability. The industries on the figures in the left column are split with respect to out-degree centrality, and in the right column to eigenvector centrality. Industries are included in the core (peripheral) group if the corresponding measure of centrality is in the top (bottom) 25% of all values of centrality measure. The rest of the industries forms the intermediate group.
The peripheral industries with respect to local (out-degree) and global (eigenvector) centrality measures show different dynamics as well as different magnitudes.



(a)



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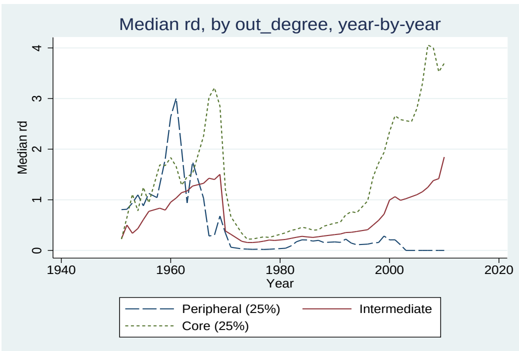

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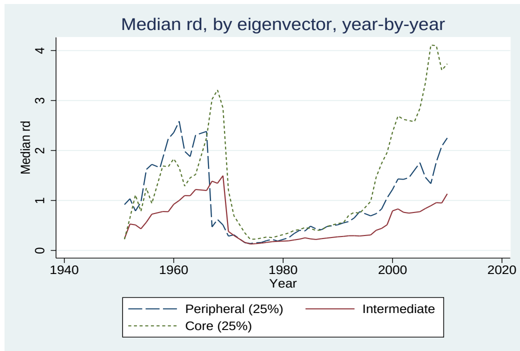


(d)

Figure 2.12: demonstrates the dynamics of the industries' characteristics for three groups of industries: core, intermediate, and peripheral. The first row of pictures represents asset tangibility, the second R&D expenditures. The industries on the figures in the left column are split with respect to out-degree centrality, and in the right column to eigenvector centrality. Industries are included in the core (peripheral) group if the corresponding measure of centrality is in the top (bottom) 25% of all values of centrality measure. The rest of the industries forms the intermediate group.
The peripheral industries with respect to local (out-degree) and global (eigenvector) centrality measures show different dynamics as well as different magnitudes.

2.4.2 Industry centrality

The first effect is estimated by a regression

$$y = \alpha + X\beta + C\gamma + \varepsilon,$$

where y is a measure of capital policy, X are capital structure determinants, C is one of the measures of centrality, ε is a vector of errors, and $(\alpha', \beta', \gamma)$ is a vector of parameters. We used four proxies for leverage ratio as dependent variables: a ratio of total debt to total book assets, a ratio of total liabilities to total book assets, and a ratio of total debt to market value of assets (calculated in two alternative ways). Capital structure determinants were chosen according to Leary and Roberts (2014), Frank and Goyal (2009), and Kale and Shahrur (2007): size, profitability, asset tangibility, market-to-book ratio, product uniqueness (R&D), cash holdings. As a proxy for industry competition and bargaining power a concentration variable was used. Plus we included a lagged dependent variable, since leverage is an inert ratio. We use this "standard" set of explanatory variables separately and with a measure of centrality. The latter included out-, in-degree, closeness, betweenness, eigenvector, Katz-Bonacich measures for adjacency, weighting, and normalized weighting matrices. A more detailed discussion of the explanatory variables can be found in Appendix (Section 5).

2.4.3 Interaction with the trading partners

The second effect can be split into two parts: partners' actions and determinants of their behaviour. We estimate the direct reaction on the partners' behaviour with a spatial-autoregressive model

$$y = \alpha + \lambda W y + X\beta + u,$$

where y is a measure of capital policy, W is the weighting matrix, X is the firm's characteristic matrix (including concentration), u is the error vector, and $(\alpha', \lambda, \beta')$ is a vector of parameters. The regression estimates the network effect by the $\lambda W y$ term. The parameter λ captures the reaction of industries on their partners' capital structure decisions. If it is positive, then on average industries tend to increase their leverage along those of their neighbours. A negative coefficient suggests that they reduce their debt load in response to the growth of their partners' leverage. The inclusion of a dependent variable into the right-hand side of the regression creates a threat of spill-overs. We will describe how we treat them below, in the Method subsection.

A spatial approach is appropriate here, because unlike in a traditional econometric model, observations can be dependent. In a spatial terminology, a unit can affect the behaviour or characteristics of the nearby regions through the common border. If we consider customers and suppliers as neighbours, the nodes which are linked by the common edge, we observe the same effect. The observations are no longer independent, their characteristics and decisions can change the actions of the other industries.

According the procedure of spatial model estimation, the weighting matrix must be exogenous to the units' characteristics. We use a matrix of trading connections between agents. It is perfectly legitimate, as it comes from an economic dimension, while the capital structure decision is made in a financial dimension. Although there exists literature[8] on how intra-industry competition affects capital structure, it is not a concern here, since we focus the inter-industry connections.

[8] Brander and Lewis (1986), Leary and Roberts (2014), Zhdanov (2007).

In order to ensure the input-output matrix is a valid weighting matrix, we must normalize it. The basic approach is a row normalization: each element is divided by the sum of its corresponding row. We also use two alternative techniques: spectral and minmax. Spectral normalization means that each element of the matrix is divided by the absolute value of the largest eigenvalue of the matrix. In the minmax normalization procedure each element is divided by the minimum between the maximum of row sums and the maximum of column sums. The row normalization equalizes large and small industries. Each connection becomes as strong, as important it is for the current industry. Thus the regressions with a row-normalized matrix better describe the local network effect. On the contrary, spectral and minmax normalizations scale the whole matrix with the same numbers, preserving all existing proportions. These normalizations provide more similar to each other results (as it can be seen in Figures 2.13a–2.13p) and describe the global network effect.

Figure 2.13: demonstrates the dynamics of spatial models' coefficients.The top two rows of pictures represent Spatial-Autoregressive Model (book leverages in the first row, market leverages in the second row), the bottom two rows show Spatial-Error Model (book leverages in the third row, market leverages in the fourth row). Two left columns correspond to the estimations in levels, two right columns report estimates in differences. Three different lines in each sub-figure report the results for three ways of normalization of the weighting matrix: row, minmax, and spectral.
The SAR block in levels is the most sensitive to the choice of the normalization method.

The direct reaction to the changes in leverages of customers and suppliers seems to be the most obvious channel. But industry's partners can experience shocks in their characteristics and environment, and through these affect the industry in question, while maintaining a constant leverage. To estimate this shock transmission channel, we use a spatial-error model:

$$\begin{cases} y = \alpha + X\beta + u, \\ u = \rho W u + v. \end{cases}$$

The notation is the same as before; v denotes an error vector and ρ is a coefficient to estimate. Here the network structure is imposed upon the errors of the regression. It does not specify how the shock is carried through the network. But paired with the previous regression, it can shed light on how active non-leverage channels are.

2.4.4 Method

Spatial models have a challenge of collinearity between average peers' outcome and average peers' characteristics. The estimation in this paper was made under the condition that the difference of an identity matrix and a product of a spatial coefficient and a weighting matrix is invertible.[9]

2.4.5 Results

Industry centrality. The first model was estimated by three methods: as a panel regression with fixed (Table 2.4) and random[10] effects and by Fama-MacBeth procedure (Table 2.5) in levels. The comparison of the results lets us conclude that they are robust to the method of estimation. The inclusion of the measures of centrality does not cause a significant change in the estimates of other coefficients. We observe this effect due to correlations between the explanatory variables (which can be found in Table 2.6). In case of *in-degree* centrality measure, it explains the previously unexplained variation of leverage without affecting the explanatory power of the other determinants. The principal component statistics (Table 2.7 and Figures 2.14b and 2.14a) supports our inference.

[9] For details, see Drukker et al. (2011).

[10] As the sample covers the major U.S. industries, the model with fixed effects is more legitimate here. The estimation with random effects was made to check the robustness of the results, the results are unreported.

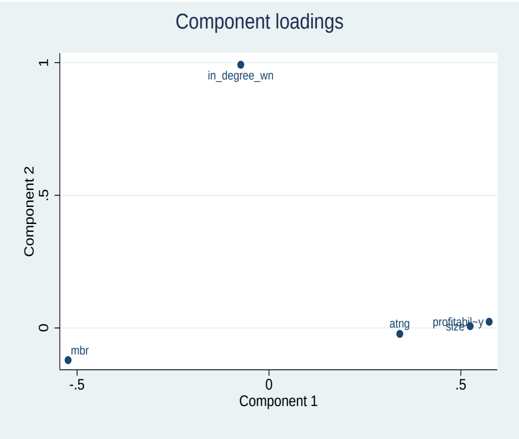
Table 2.4: **Panel (fixed effects) — Market Leverage**

The table reports the results of panel estimation with fixed industry effects. The first column reports a regression with conventional explanatory variables: size, market-to-book ratio, profitability ratio, asset tangibility, and lagged dependent variable. The columns (2)–(7) correspond to regressions with a conventional set of explanatory variables plus a measure of centrality - the corresponding measure is indcated at the top of each column. Standard errors in parentheses: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

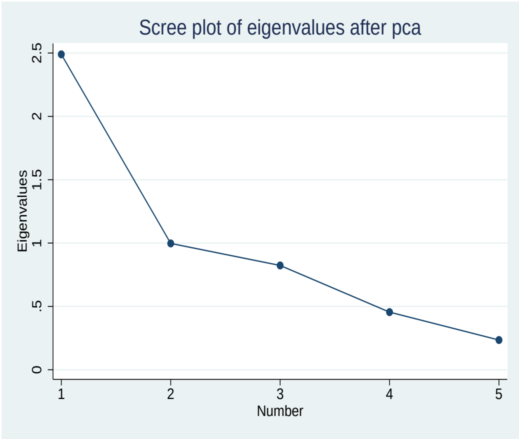
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		out_degree	in_degree	closeness	betweenness	eigenvector	KB
Size	0.019***	0.010***	0.002	0.003*	0.011***	0.009***	0.013***
	(0.0011)	(0.0014)	(0.0014)	(0.0014)	(0.0012)	(0.0014)	(0.0012)
Market-to-Book ratio	-0.027***	-0.032***	-0.037***	-0.037***	-0.033***	-0.032***	-0.031***
	(0.0015)	(0.0015)	(0.0015)	(0.0015)	(0.0015)	(0.0015)	(0.0015)
Profitability	-0.086***	-0.064***	-0.038*	-0.038**	-0.055***	-0.062***	-0.063***
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Assets Tangibility	0.442***	0.385***	0.306***	0.304***	0.348***	0.379***	0.371***
	(0.0139)	(0.0148)	(0.0155)	(0.0155)	(0.0149)	(0.0148)	(0.0147)
Market Leverage$_{lagged}$	0.237***	0.204***	0.161***	0.162***	0.189***	0.199***	0.203***
	(0.0134)	(0.0137)	(0.0137)	(0.0137)	(0.0135)	(0.0137)	(0.0135)
Out-degree		0.190***					
		(0.0181)					
In-degree			0.275***				
			(0.0156)				
Closeness				0.166***			
				(0.00930)			
Betweenness					0.310***		
					(0.0205)		
Eigen centrality						1.942***	
						(0.172)	
Katz-Bonacich							2.331***
							(0.175)
Constant	0.017***	0.009**	-0.004	-0.005	0.001	0.008*	0.004
	(0.0034)	(0.0033)	(0.0034)	(0.0034)	(0.0034)	(0.0033)	(0.0034)
N	5'123	5'123	5'123	5'123	5'123	5'123	5'123

Table 2.5: **Fama-MacBeth — Market Leverage**
The table reports the results of panel estimation by Fama-MacBeth procedure. The first column reports a regression with conventional explanatory variables: size, market-to-book ratio, profitability ratio, asset tangibility, lagged dependent variable, and time-invariant concentration variable. The columns (2)–(7) correspond to regressions with a conventional set of explanatory variables plus a measure of centrality - the corresponding measure is indcated at the top of each column. Standard errors in parentheses: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		out_degree	in_degree	closeness	betweenness	eigenvector	KB
Size	0.034***	0.029***	0.016***	0.019***	0.031***	0.028***	0.032***
	(0.00345)	(0.0034)	(0.0038)	(0.0037)	(0.0035)	(0.0034)	(0.0035)
Market-to-Book ratio	-0.035***	-0.040***	-0.059***	-0.056***	-0.041***	-0.042***	-0.039***
	(0.0059)	(0.0059)	(0.0064)	(0.0062)	(0.0057)	(0.0058)	(0.0057)
Profitability	-0.320***	-0.347***	-0.374***	-0.368***	-0.323***	-0.346***	-0.317***
	(0.0641)	(0.0679)	(0.0819)	(0.0798)	(0.0669)	(0.0678)	(0.0652)
Assets Tangibility	0.226***	0.226***	0.162***	0.156***	0.189***	0.224***	0.199***
	(0.0198)	(0.0197)	(0.0170)	(0.0173)	(0.0193)	(0.0195)	(0.0196)
Concentration	1.026**	0.996**	0.312	0.188	0.612	1.030**	0.784*
	(0.334)	(0.329)	(0.322)	(0.328)	(0.331)	(0.328)	(0.326)
Market Leverage$_{lagged}$	0.334***	0.325***	0.256***	0.263***	0.309***	0.320***	0.319***
	(0.0238)	(0.0237)	(0.0223)	(0.0221)	(0.0231)	(0.0236)	(0.0234)
Out-degree		0.086***					
		(0.0212)					
In-degree			0.303***				
			(0.0361)				
Closeness				0.168***			
				(0.0192)			
Betweenness					0.152***		
					(0.0174)		
Eigen centrality						1.009***	
						(0.215)	
Katz-Bonacich							1.073***
							(0.137)
Constant	0.025***	0.021***	0.001***	0.003***	0.016***	0.020***	0.019***
	(0.0031)	(0.0024)	(0.0002)	(0.0006)	(0.0024)	(0.0023)	(0.0026)
N	5'123	5'123	5'123	5'123	5'123	5'123	5'123



(a) Component loadings



(b) Eigenvalues

Figure 2.14: demonstrates the results of Principle Component Analysis. The left sub-figure is a loading plot and the right one is a scree plot of the eigenvalues of a correlation matrix.

On the example of in-degree variable, we see that a position of an agent in the network (characterized by a centrality measure) explains previously unexplained variation of leverage without affecting the explanatory power of other determinants.

Table 2.6: **Cross-Correlation for Dependent and Explanatory Variables**
The table reports cross-correlation for the main industry characteristics and centrality measures.

Variables	bl1	size	mbr	profit-y	ebitic	in_d	close-s	out_d_wn	in_d_wn	d_wn	rd	ch	bl1_l
Book Leverage (Colla et al.)	1.000												
Size	0.168	1.000											
Market-to-book	-0.350	-0.438	1.000										
Profitability	0.086	0.675	-0.344	1.000									
Assets Tangibility	0.549	0.236	-0.358	0.321	1.000								
In-degree	-0.317	0.012	-0.097	-0.052	-0.141	1.000							
Closeness	-0.188	-0.170	-0.044	0.033	0.045	0.080	1.000						
Out_degree_wn	-0.151	-0.072	0.110	-0.107	-0.083	0.099	0.420	1.000					
In-degree_wn	-0.135	-0.005	-0.094	0.011	0.036	0.405	-0.229	-0.222	1.000				
Degree_wn	-0.028	0.148	-0.025	-0.049	-0.128	0.445	-0.771	-0.123	0.589	1.000			
R&D	-0.116	0.366	0.126	0.017	-0.207	0.011	-0.203	-0.024	0.055	0.225	1.000		
Cash	0.137	0.477	0.056	0.131	0.011	-0.068	-0.303	-0.048	0.096	0.267	0.545	1.000	
Book Leevrage_lagged	0.698	0.282	-0.042	0.371	0.533	-0.235	-0.047	-0.095	-0.147	-0.133	-0.153	0.113	1.000

Table 2.7: **Principle Component Analysis — Component Loadings**
The leading eigenvectors from the eigen decomposition of the correlation matrix of the variables. On the example of in-degree variable, we see that a position of an agent in the network (characterized by a centrality measure) explains previously unexplained variation of leverage without affecting the explanatory power of other determinants.

	e(L)				
	Comp1	Comp2	Comp3	Comp4	Comp5
Size	.5243369	.0068677	-.3522992	.572729	-.5223892
Market-to-Book	-.5236009	-.1213801	.0328925	.7836154	.3097966
Profitability	.5738385	.0233254	-.18803	.0816039	.7925597
Assets Tangibility	.3409109	-.0223675	.9156713	.2057039	-.0501143
In-degree$_{weighted\ normalized}$	-.0734993	.9920561	.0315296	.0946313	.0217559

The positive coefficient before in- and out-degrees[11] suggests that the more in- and out-connections an industry has, the higher its leverage tends to be. The direction of causality is not clear from this regression. Either the industry which acquires new suppliers chooses to increase its debt-to-assets ratio, or after the industry raises its leverage, it feels more free to interact with a higher number of suppliers. In either case we do not know anything about the structure of these supply ties: they could be homogeneous, or they could vary considerably across partners. The regression with weighted measures of centrality partially answers these questions. The interpretation of a positive coefficient here is more clear: the more singular suppliers or customers with strong ties the industry has, the larger its debt load tends to be. The interpretation of coefficients for other measures of centrality are similar. For betweenness, the more important link in a several-industries-long upstream-downstream chain an industry is, the higher its leverage tends to be. For eigenvector, the higher the amount of the neighbours of an industry and the bigger these neighbours are, the larger leverage the industry is prone to have.

Interaction with the trading partners. The model is estimated cross-sectionally, in levels, year-by-year. The average, across time, coefficients are reported in Table 2.8. The dynamics of the coefficients is shown in Figures 2.13a–2.13p.The parameter corresponding to the autoregressive component is positive in line with our hypothesis of leverage as an instrument to improve an industry's bargaining position.

Bronars and Deere (1991) demonstrate the use of debt as a negotiating tool between firms (in the role of customers) and employees (in the role of labour suppliers). They argue that when firms issue more debt, then they reduce the proportion of surplus that a workers' union can extract. In their paper the optimal structure is obtained through a trade-off between wealth gain from the reduction in the union's part of surplus and the firms's bankruptcy costs. Maksimovic and Titman (1991) derive a consequence of this mechanism. They show that higher levered firms are less likely to invest in its reputation and produce high-quality products. This effect is an illustration that using debt as a bargaining tool is a substitute to its use as a commitment instrument. In the latter case a firm would be interested in investing in its own reputation to encourage its suppliers to undertake firm-specific investment.

The spatial-autoregressive model confirms the hypothesis that firms react directly to

[11] The unreported results for different capital policy proxies and centrality measures support the positive relation.

Table 2.8: **Coefficients - Dynamic Spatial Models**
The table reports average over time dimension coefficients of cross-sectionally estimated year-by-year Spatial-Autoregressive and Spatial-Error Models. The time period is from 1969 till 2011.

	Spatial-Autoregressive Models			Spatial-Error Models		
	λ_{row}	λ_{minmax}	$\lambda_{spectral}$	ρ_{row}	ρ_{minmax}	$\rho_{spectral}$
			In levels			
Book Leverage 1	.02735777	.0098585	.01508651	.0098585	.01675604	.01508651
Book Leverage 2	.03091664	.02359696	.02920189	.02359696	.0318319	.02920189
Market Leverage 1	.02479033	.01856751	.02253783	.01856751	.02410329	.02253783
Market Leverage 2	.02621361	.01813967	.02260352	.01813967	.02349898	.02260352
			In differences			
Book Leverage 1	-.00102788	-.00124657	-.00211773	-.00124657	-.00102334	-.00211773
Book Leverage 2	-.0045568	-.00434462	-.00553487	-.00434463	-.00492667	-.00553487
Market Leverage 1	.0005835	.00021272	-.00032128	.00021272	-.00036233	-.00032128
Market Leverage 2	.00009513	-.00029905	-.00085159	-.00029935	-.00094283	-.00085159

the leverage of their partners. Alternative channels of shock transmission require further research.

2.5 Conclusion

The main result of the paper is that a significant network effect in capital structure decision making was found. There are two main components of it. The first is the dependence of industry's capital structure policy on its position in the network. The less diversified industry's suppliers or customer are, the lower its leverage tends to be. The second is the dependence of industry's capital structure policy on its partner industries' decisions. The relation is positive, meaning that the industries are prone to raise their own leverage in the response to the increase of their partners' leverage. This conclusion supports the theory that leverage is partly used as an instrument to improve agent's bargaining power.

Our numerical results reinforce intuitive predictions about capital structure decisions in an interconnected economy. In the future research we will focus on developing a more elaborate model and addressing to the contrasts of industry-level and individual firm-level product network.

Chapter 3

Leverage as a Commitment Tool in Product Market Networks

Does the position of a firm in the product market network affect its capital structure? I show that every new supply contract will on average lead to a drop of 0.1% in market leverage and the "strategic" positioning of the firm in the trading network is important. The effect does not disappear if I control for the proximity to the final consumer. I use novel data describing the product market network on three levels: supply chain flows, competition relation, and partnership connections. I confirm that more central firms demonstrate better economic performance. Peripheral, in terms of competition, firms tend to have higher leverage. Several statistical tests make the interpretation of Partner network as a mild form of supplier-customer network plausible.

3.1 Introduction

3.1.1 Motivation

The idea that firms make their decisions in active interaction with other economic agents rather than in isolation has gained a lot of popularity recently. Capital structure policy have not been an exception. Researchers have approached this topic from various angles. There are multiple papers showing that CEOs and directors sitting on different companies' boards who attended the same school, shared an office once, or play golf at the same club will likely follow similar financial policies (Bouwman (2011), Fracassi (2013), Gygax, Hazledine, and Spencer (2016)). Under these circumstances, objective characteristics of a company such as the size of its assets, its profitability, the proportion of tangible assets, etc. become of secondary importance.

An alternative facet of active inter-company interaction is vertical integration. Some papers show that group-affiliated companies tend to have higher leverage than their isolated counterparts (Manos, Murinde, and Green (2007)).

All these papers seem to agree that the more central firms (either in terms of connections of their managers and directors or in the terms of in- and out-source manufacturing) tend to make less idiosyncratic decisions and tend to ignore the fundamentals. These findings can help to resolve the empirical capital structure puzzle.

One of the most important forms of inter-firm communication is their interaction in product market. Companies trade supplies, produce their goods, and deliver to their customers. During production cycles a natural disaster, a strike, or unexpected change in regulation can happen. It might disorganise delivery process and require time to recover the supply chain. We see that in reality companies are quite sensitive to supply shocks, irrelevant of what was the reason for the shock. Here is a quote of how Johnson&Johnson raise their concern in their annual report, form 10-K, 2016[1]:

> Some important factors that could cause the Company's actual results to differ materially from those expressed or implied in the Company's forward-looking statements are as follows:
> ...
> Financial distress and bankruptcies experienced by significant customers and suppliers that could impair their ability, as the case may be, to purchase the Company's products, pay for products previously purchased or meet their obligations to the Company under supply arrangements;
> ...

Such concerns make companies very cautious while selecting suppliers. Once the contract is signed, both parties have good incentives to commit to the agreement. One of the reasons being charges for the preliminary ending of a contract. Another is search and switching costs, which can be quite large sometimes. For example, up to August 2016, the US Food and Drug Administration prescribed pharmaceutical companies to apply for a prior approval supplement (PAS) if they wanted to switch to an alternative supplier of hard gelatin capsules used for proper dosage of drugs. Since then the regulation has been softened: now pharmaceuticals have to request for an approval only if the capsules differ from the original ones.[2] Obviously such regulation imposes extra legal and time switching costs on companies.

Firms try to remove the necessity of nonvolunteer replacement of its trading partner. They try to guarantee the execution of the delivery contract. For this purpose they impose fees, offer access to new markets, adjust their pricing, etc.

All the measures discussed are applied to reinforce already existing connections. Strategically, however, a company can apply the same criteria to itself. In other words, it should understand how easily its supplier or its customer can replace a link between them. Johnson&Johnson describe the perceived potential threats to their relations with suppliers and customers as follows:[3]:

> Interruptions and delays in manufacturing operations could adversely affect the Company's business, sales and reputation. The Company's manufacture of products requires the timely delivery of sufficient amounts of complex, high-quality components and materials. These subsidiaries operate 119 manufacturing facilities as well as sourcing from hundreds of suppliers around the world. The Company has in the past, and may in the future, face unanticipated interruptions and delays in manufacturing through its internal or external supply chain. Manufacturing disruptions can occur for many reasons including regulatory action, production quality deviations or safety issues, labor disputes, site-specific

[1] `http://www.investor.jnj.com/secfiling.cfm?filingID=200406-16-71&CIK=200406`

[2] "US FDA changes policy on switching hard gel capsule suppliers" by Gareth MacDonald for in-Pharma Technologist, 16-Aug-2016, `http://www.in-pharmatechnologist.com/Drug-Delivery/US-FDA-changes-policy-on-switching-hard-gel-capsule-suppliers`.

[3] `http://www.investor.jnj.com/secfiling.cfm?filingID=200406-17-6&CIK=200406`

> incidents (such as fires), natural disasters, raw material shortages, political unrest and terrorist attacks. Such delays and difficulties in manufacturing can result in product shortages, declines in sales and reputational impact as well as significant remediation and related costs associated with addressing the shortage.

More generally, companies are afraid of the risks which their trading partners run. While many of them are impossible to eliminate either by the initiative of the given company or simply in short-term period, a company might switch its attention to manageable risks. One of them will be a default risk which is regulated by company's capital structure decisions. The higher company's leverage is — given its size, growth opportunity, economic performance, etc. — the more risky this company is considered to be by an outsider (including a potential supplier or a potential customer). This paper is going to explore how firms embedded in a product market network employ leverage as a commitment mechanism.

I study the influence of the structure of the network, the position of a company in the network, and various company's characteristics on its capital structure decision. Publicly traded US companies are nodes or vertices of the network. The edges connecting the nodes are of four types: competitive rivalry, partnership agreements, and customer and supplier trading links. Two companies are neighbours in the corresponding network if at least one of them mentions the connection between them in its public reports. The structure of the network defines whether a company takes into consideration its neighbours' leverage ratios explicitly while making a capital structure decision. The position of a firm can vary from core to peripheral. The core nodes are better incorporated in the network. The peripheral nodes are relatively more isolated and if removed from the network, will not disturb its structure much.

3.1.2 Literature and Hypotheses

Even though classical works on capital structure (Mogdiliani and Miller, 1958, Myers, 1984, Frank and Goyal, 2009) ignore firm interactions, there are models showing that the inter-firm relations matter for different financial aspects (Herskovic, 2017, Dai, Ng and Zaiats, 2017). More generally, there are three well-established strands of literature that relate to this paper. The first one explores how the competition in a product market affects leverage. The second strand examines the trading links along a supply chain and under vertical integration. The third domain is less homogeneous; it studies networks in their different aspects: social, trading, bank inter-lending, etc.

Product market competition. The seminal theoretical paper of Brander and Lewis (1986) gave a rise to an entire new branch of research: capital structure in a product market competition. Their prediction is that taking more leverage incites more aggressive competitive behaviour from the companies, which encourages firms to use more leverage. Zhdanov (2008) finds a set-up in which "follower" firms copy the "incumbent" agents and have relatively higher leverage which brings them to their earlier default. Using network terms, I define the "follower" firms as peripheral nodes, because they are the last to join the network and have not had enough time to form as many edges as the core "incumbent" companies. Thus, I expect them to copy capital structure decisions of core companies.

Leary and Roberts (2011) confirm this theoretical insight. However, they identify the competitors through one- to three- digit SIC codes. Hobert and Phillips (2011) raise their concern about the accuracy of the classic SIC and NAICS typologies. They reconstruct the connections between firms using textual analysis of the product description in 10-K statements filed yearly with the Securities and Exchange Commission. I use the information from the same reports concerning specifically competitors. That is, while aforementioned methodology reconstructs the competitors, I use the companies that have been named the competitors explicitly.

Hypothesis 1 *On the competitor level, peripheral companies copy the behaviour of more central ones, have higher leverage.*

Supplier-customer leverage. The literature on upstream-downstream connections is extensive as well. There is a lot of evidence in favour of debt being used as a bargaining tool in customer-supplier negotiations. Kale and Shahrur (2007) find a positive relation between a firm's debt and the concentration rate of its customer or supplier industry. Chu and Wang (2014) claim that the positive relation between the company's and its customer's leverage is stronger when the customer industry concentration is higher. Jochem and Peters (2016) confirm the direction of influence as they study how optimism in terms of EPS forecast spreads from the managers of customer companies to the managers of their suppliers. They find the short-term waves of optimistic forecast in leverage as well. This might be partly explained by the finding of Hertzel et al. (2008): distress of a customer creates a significant negative price shock on the suppliers and thus, creates negative wealth effect. However, they do not investigate leverage in detail.

Hypothesis 2 *The capital structure decisions spread from customer to supplier.*

Chu (2012) studies the opposite direction from a theoretical point of view. He explores how a customer's leverage depends on suppliers' bargaining power, expressed through the elasticity of substitution between suppliers.

Charoenwong (2016) finds that the proximity of a company in a processing chain to the final consumer matters for the level of leverage. It tends to increase closer to the consumer.

Hypothesis 3 *Upstream and downstream positions matter but do not eliminate the influence of the centrality measure.*

Networks. There are two relatively recent strands of literature that emerged in parallel: social and production networks. Among numerous papers on the influence of social networks of top managers and members of director boards on financial policies of the companies, Gygax et al. (2017) find that the companies with the same directors tend to take similar capital structure decisions. However, this aspect of networks is not going to be the focus of this paper.

Production networks literature studies the complexity of production processes which varies not only across industries but often across competing companies. Some of them can involve hundreds of suppliers, some can buy inputs from only dozens. The specificity of the product defines how easily a company can switch between suppliers and thus how independent of the exact shipping agreements it can be. The levels at which companies interact are manifold: they can not only directly provide supplies but also license out their technologies, outsource jobs, and so on.

Acemoglu et al. (2012) study how the structure of trading networks on an industry level affects the profitability of the industries and find that core companies show better economic performance. However, there is a lack of research on how the market product networks affect leverage.

Another branch of network literature concerns bank inter-lending. Gornall and Strebulaev (2017) develop a theoretical model which shows that banks have higher leverage compared to industrial firms. The reason is banks' low asset volatility and their supply chain position. The potential to take high leverage makes them ideal intermediaries.

Hypothesis 4 *In product market network core industries have higher leverage.*

The last domain of network literature covers graph theory.

Galeotti et al. (2010) construct a model under realistic conditions of incomplete information — every node is aware only of the part of the network. Their paper shows that network nodes can perform several roles: depending on the network structure and their positions in the network, the vertices can undertake substituting or complementing actions. Applied to the problem of capital structure decision, the model takes a form of a network economy where companies (nodes) issue debt (carry out actions). The substituting nature of actions implies that when a company increases its debt, its trading partners (network neighbours) shrink theirs. This is an example of using leverage as a commitment tool. It happens when companies balance their risks very carefully. A set of risks is one of the individual firm's characteristics. There are plenty of risks a firm is subjected to: production risks, delivery risk, regulatory risks, currency risk, default risk, and so on. Once one of them surges, risk managers try to offset it, rebalance and reduce the rest of risk portfolio. So if a trading partner of a firm suddenly increases its own leverage — the counterparty risk of the firm-in-question rises automatically — the reaction of the firm's risk management team is to outbalance the new risk. If a model limits a set of the firm's actions to increasing or decreasing debt, the natural reaction is to diminish firm's leverage.

In contrast, when the nature of the actions is complementary, the firm raises its leverage in response to the increase of its neighbouring node's leverage. This comovement is motivated by a bargaining process. The trading partners might increase their leverage in order to receive negotiate better deal conditions for itself.

Kale and Shahrur (2007) found that firms use leverage as a bargaining tool in supplier-customer pairs. My insight is that network structure of connections can reveal an alternative nature of leverage.

Hypothesis 5 *Firms use leverage as a commitment device to encourage their counterparts to enter firm specific relation.*

Relation between partner firms is not as explicit as other types of connections. There is no evident upstream-downstream "subordination" like in supply chain, no easily identifiable rivalry like between competitors in a product market. Partner networks can rather be viewed as a part of vertical integration research phenomenon, i.e., a mild form of supplier-customer relations.

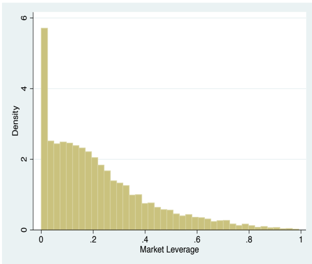
Hypothesis 6 *Partner networks are a part of vertical integration relation.*

3.2 Sample

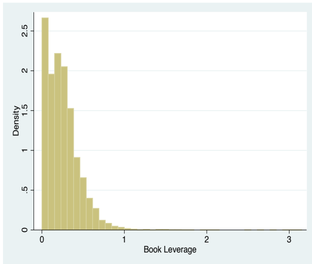
3.2.1 Data

The data come from two main sources: CRSP-Compustat dataset for firm fundamental characteristics and Factset Revere for connections between firms.

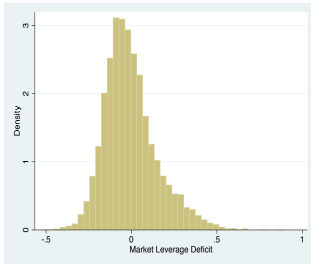
Individual firm characteristics. Individual firms characteristics come from CRSP-Compustat Annual Fundamentals dataset. The utilities, the firms with historical SIC or SIC codes between 6000 and 6999, and financials, with historical SIC or SIC between 4900 and 4949, are not in the sample. The sample describes the publicly traded companies incorporated and headquartered in the USA and traded in US dollars. I impose several filters on the data to fix the recording errors and balance the sample, eliminating firms with time gaps in their time-series, with total assets and total debt negative or missing, with missing information on tangible assets, or with the sales which fell at least once below $10mln within the observation period. I do not restrict the stock exchange where the shares are traded. Monetary variables are discounted to 1990 and winsorised at 1%. Profitability and stock returns are winsorised at 2%. The detailed description of the variables is presented in Table A1, summary statistics are in Table 3.1 and in Figures 3.1 and 3.5 – 3.8.



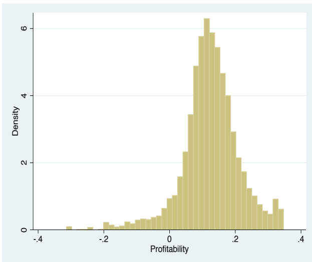
(a) Market Leverage



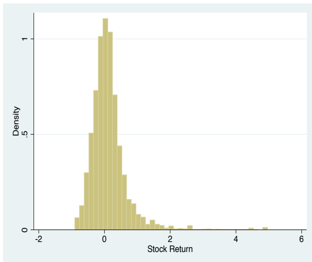
(b) Book Leverage



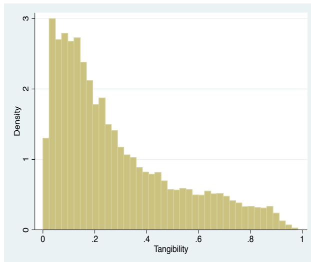
(c) Market Leverage Deficit



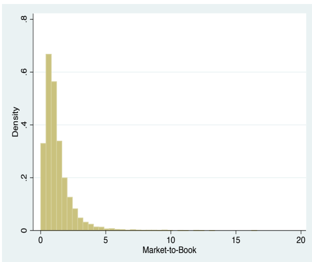
(d) Profitability



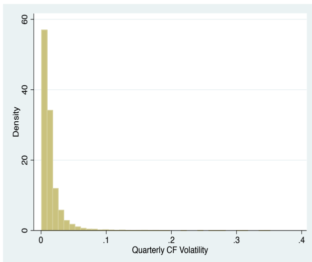
(e) Stock Return



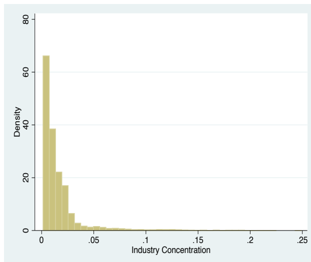
(f) Asset Tangibility



(g) Market-to-Book Ratio

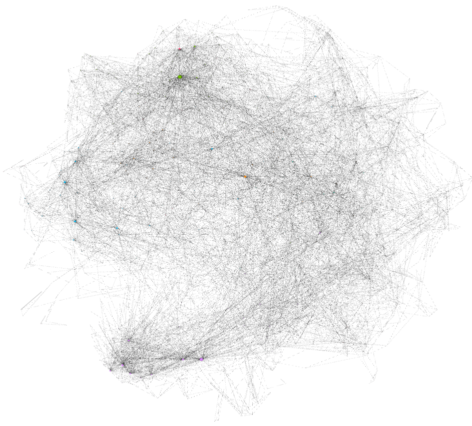


(h) CF Volatility

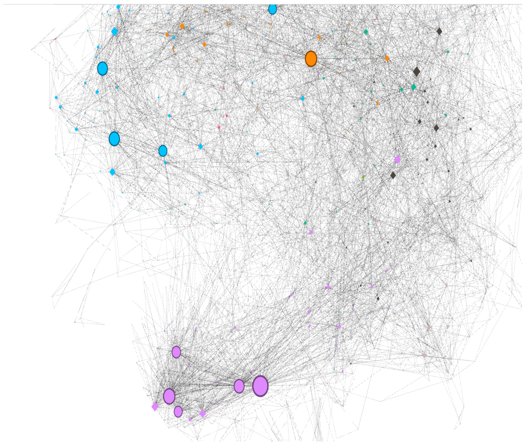


(i) Industry Sales Concentration

Figure 3.1: **Histograms of Leverage Measures and Explanatory Variables.** Individual Firms Characteristics come form CRSP-Compustat Annual Fundamentals dataset. The sample consists of publicly traded US firms. Monetary variables are discounted to 1990. All variables are winsorised at 1% and 99%, except for *Profitability* and *Stock Return* which are winsorised at 2% and 98%.

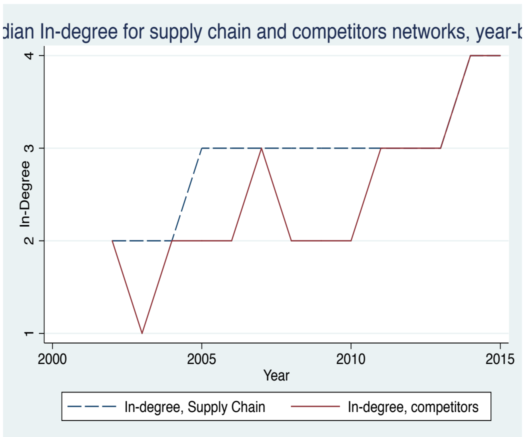


(a) Zoom Out

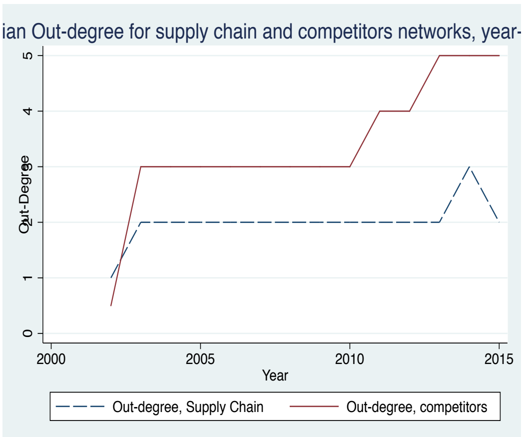


(b) Zoom In

Figure 3.2: **Competitor Network in 2007.** The figure presents an example of competitor network. Only the links active in 2007 are shown. The size of the nodes indicates the degree of a vertex — the number of neighbours — and the colour indicates modularity.

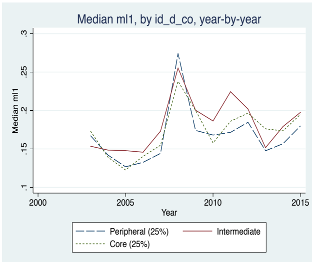


(a) In-Degree

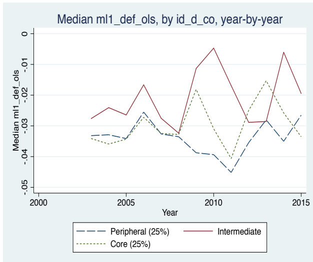


(b) Out-Degree

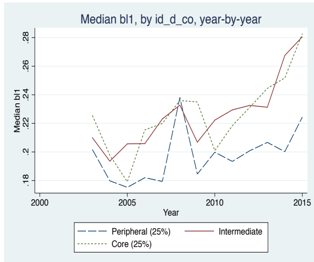
Figure 3.3: **Dynamics of Suppliers and Competitor Networks' Centrality Measures.** The figure reports the dynamics of two pairs of centrality measures along the time axis. Panel 3.3a shows the dynamics of in-degree centrality measure for supply chain (dash-line) network and competitor (solid line) network. Panel 3.3b shows the dynamics of out-degree centrality measure for supply chain (dash-line) network and competitor (solid line) network.



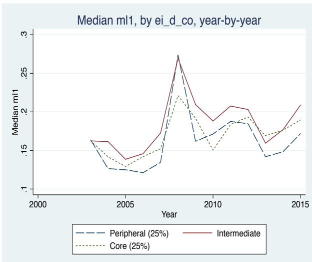
(a) Market Leverage — In-degree



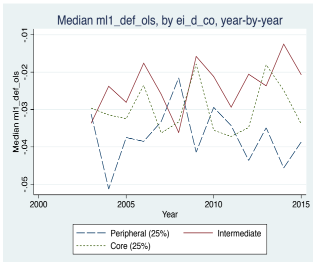
(b) Market Leverage Deficit — In-degree



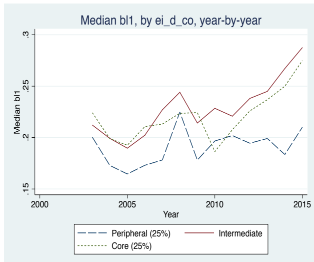
(c) Book Leverage — In-Degree



(d) Market Leverage — Eigen

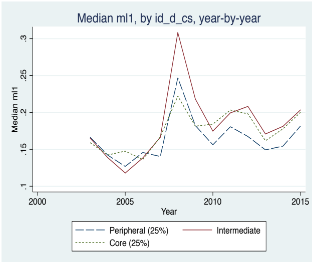


(e) Market Leverage Deficit — Eigen

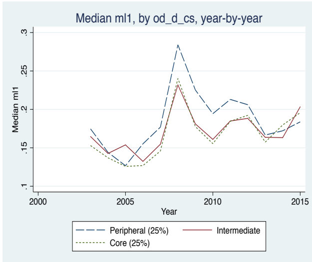


(f) Book Leverage — Eigen

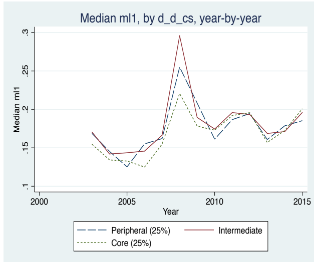
Figure 3.4: **Dynamics of average Market Leverage, Market Leverage Deficit, and Book Leverage across the economy split with respect to In-degree and Eigen centrality measures. Competitor Network.** The core industries are defined as a top quartile with respect to a centrality measure. The peripheral industries correspond to the bottom quartile.



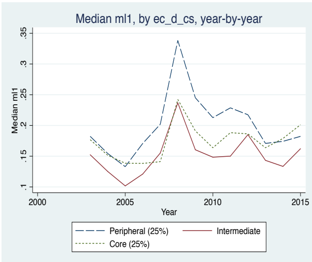
(a) In-degree



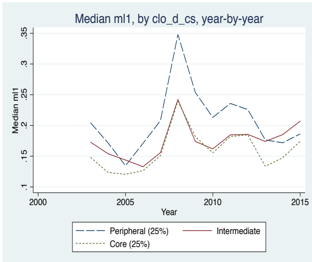
(b) Out-degree



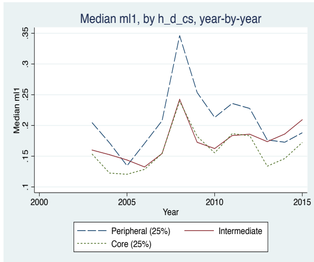
(c) Degree



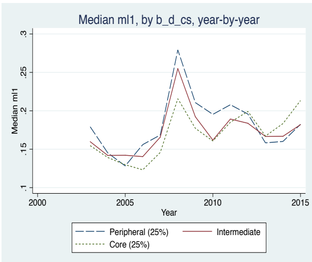
(d) Eccentricity



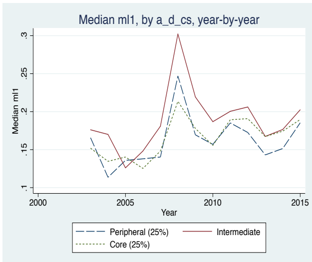
(e) Closeness



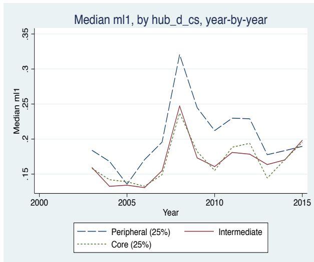
(f) Harmonic Closeness



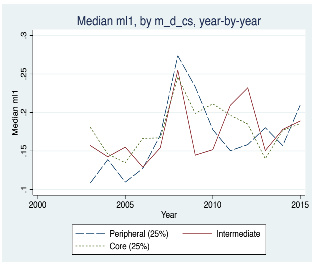
(g) Betweenness



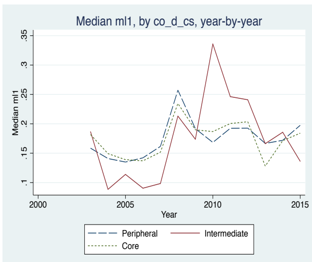
(h) Authority



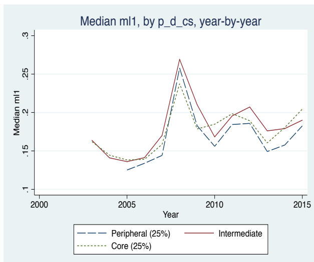
(i) Hub



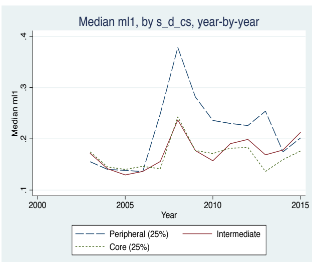
(j) Modularity class



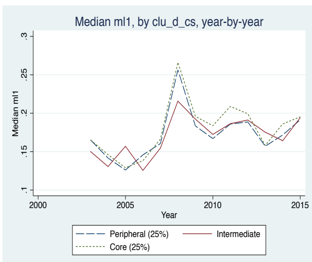
(k) Component Number



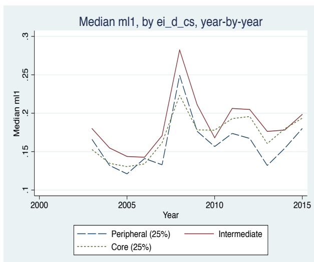
(l) Pageranks



(m) Strong Component Number

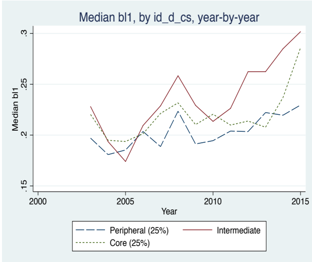


(n) Clustering

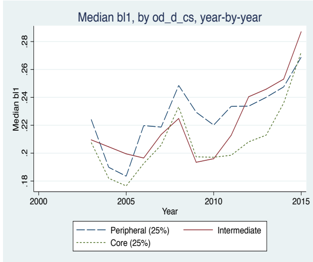


(o) Eigen

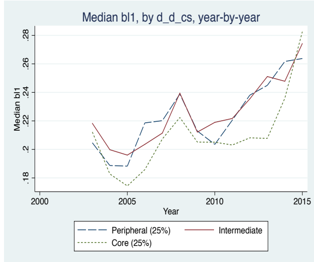
Figure 3.5: **Dynamics of average market leverage across the economy split with respect to centrality measures.** For all measures, except component number and string component number, the core industries are defined as a top quartile with respect to a centrality measure. The peripheral industries correspond to the bottom quartile. Due to the particularities of the definition, strong component number has thresholds at 99% and 1%. For component number, its maximum ($co = 10$) defines the core companies and the minimum ($co = 0$) defines the peripheral ones. Panels (3.5a) – (3.5c) report the distributions of the measures based on the number of edges incoming, outgoing, or passing via a vertex. Panels (3.5o) and (3.5l) show the distributions computed using eigenvectors. Panels (3.5h) and (3.5i) describe the distributions of a dual measure.



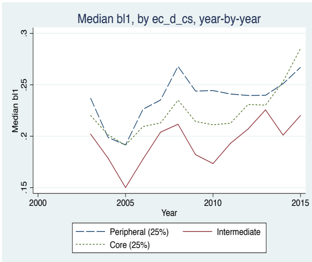
(a) In-degree



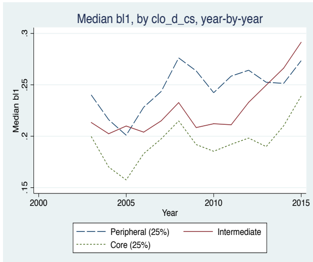
(b) Out-degree



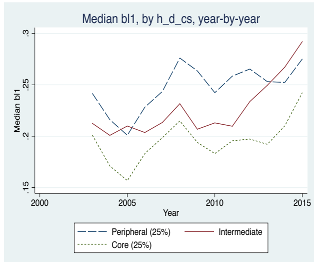
(c) Degree



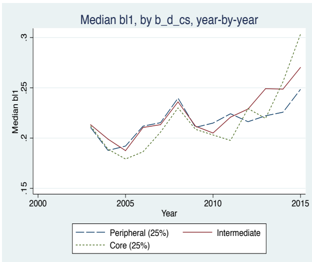
(d) Eccentricity



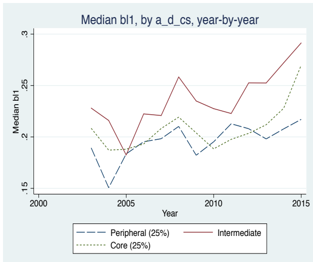
(e) Closeness



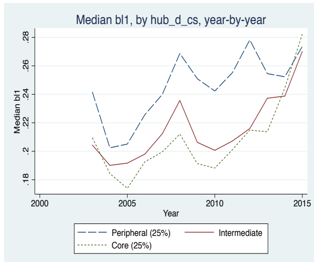
(f) Harmonic Closeness



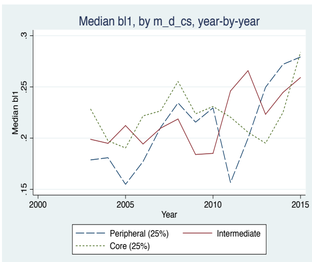
(g) Betweenness



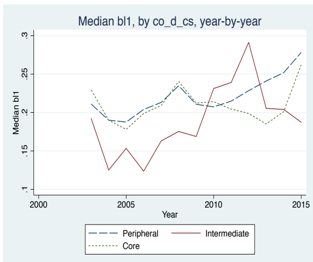
(h) Authority



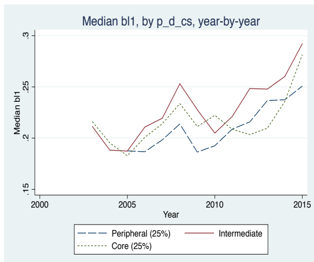
(i) Hub



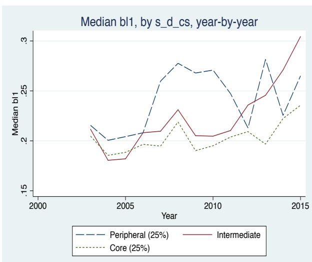
(j) Modularity class



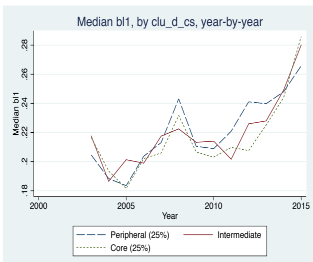
(k) Component Number



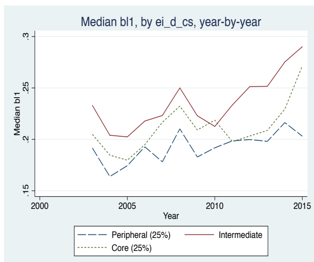
(l) Pageranks



(m) Strong Component Number

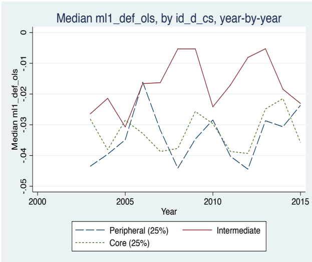


(n) Clustering

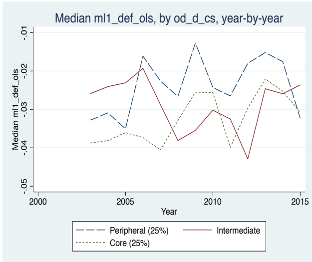


(o) Eigen

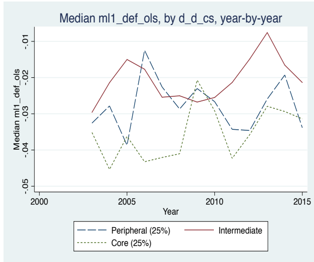
Figure 3.6: **Dynamics of average book leverage across the economy split with respect to centrality measures.** For all measures, except component number and string component number, the core industries are defined as a top quartile with respect to a centrality measure. The peripheral industries correspond to the bottom quartile. Due to the particularities of the definition, strong component number has thresholds at 99% and 1%. For component number, its maximum ($co = 10$) defines the core companies and the minimum ($co = 0$) defines the peripheral ones. Panels (3.6a) – (3.6c) report the distributions of the measures based on the number of edges incoming, outgoing, or passing via a vertex. Panels (3.6o) and (3.6l) show the distributions computed using eigenvectors. Panels (3.6h) and (3.6i) describe the distributions of a dual measure.



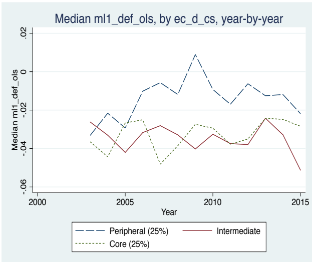
(a) In-degree



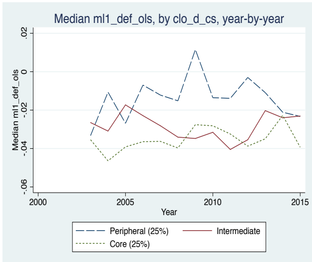
(b) Out-degree



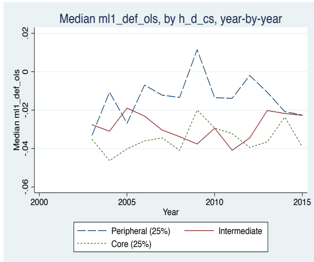
(c) Degree



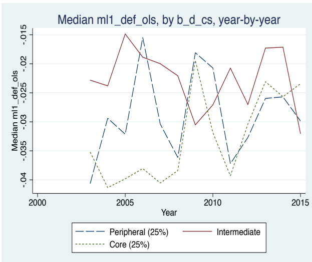
(d) Eccentricity



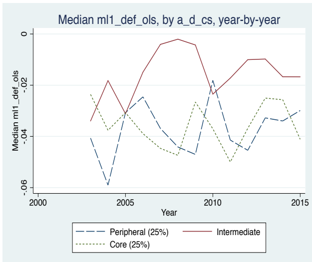
(e) Closeness



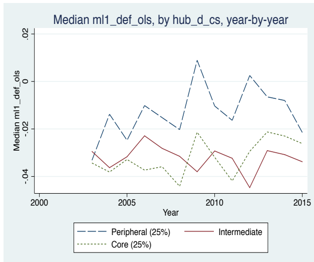
(f) Harmonic Closeness



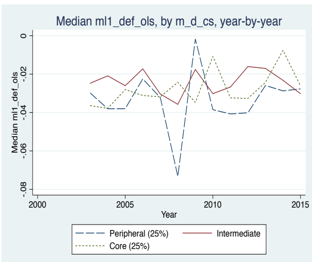
(g) Betweenness



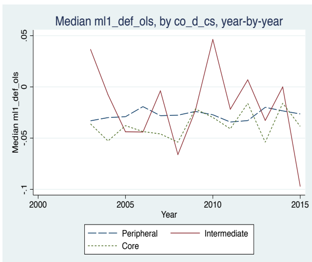
(h) Authority



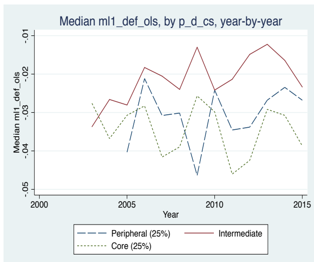
(i) Hub



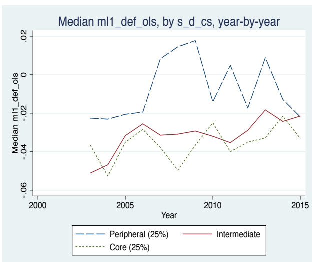
(j) Modularity class



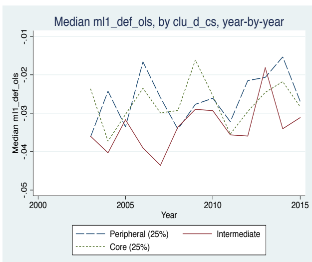
(k) Component Number



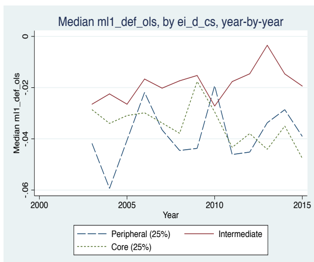
(l) Pageranks



(m) Strong Component Number

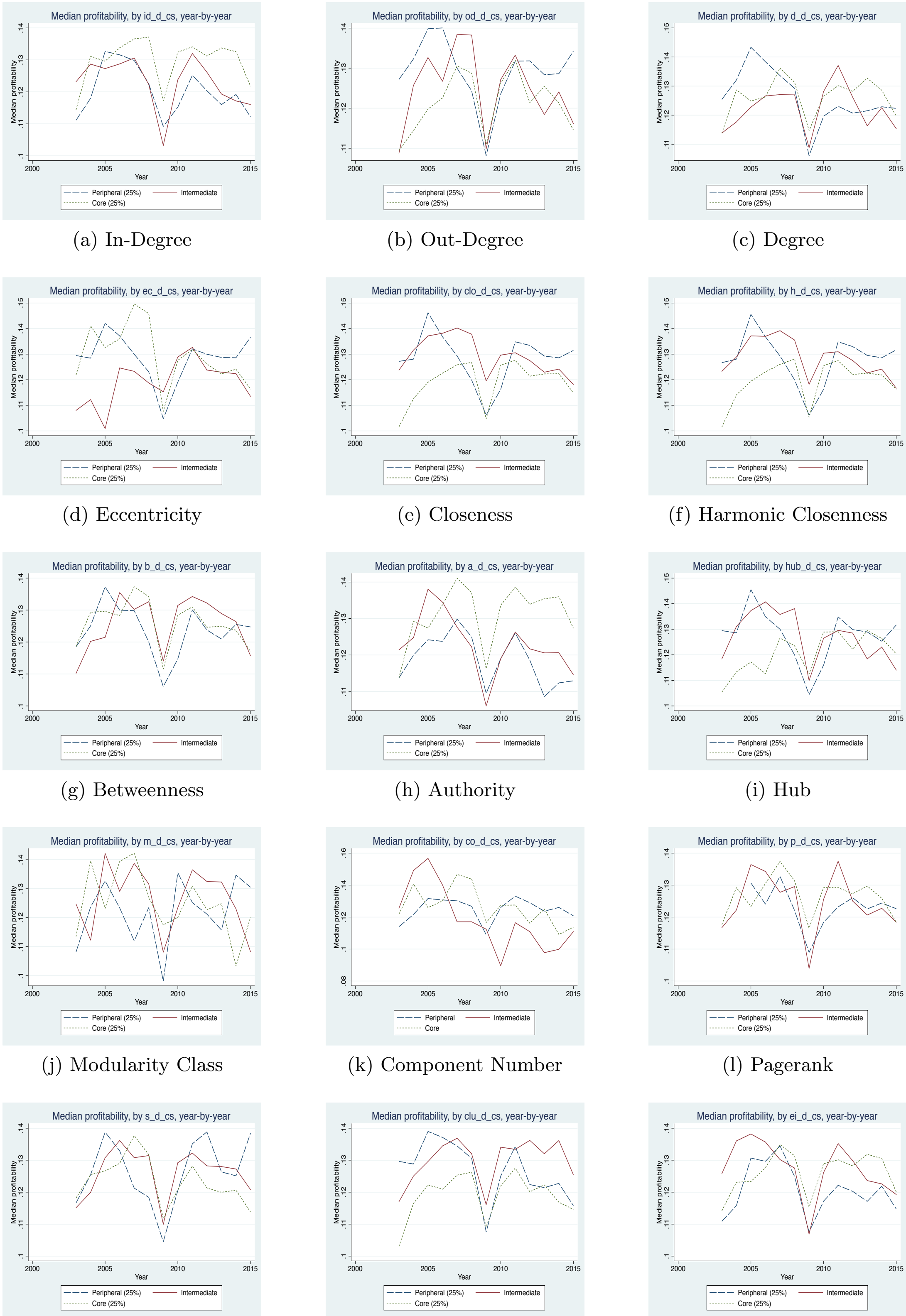


(n) Clustering



(o) Eigen

Figure 3.7: **Dynamics of average market leverage deficit across the economy split with respect to centrality measures.** For all measures, except component number and string component number, the core industries are defined as a top quartile with respect to a centrality measure. The peripheral industries correspond to the bottom quartile. Due to the particularities of the definition, strong component number has thresholds at 99% and 1%. For component number, its maximum ($co = 10$) defines the core companies and the minimum ($co = 0$) defines the peripheral ones. Panels (3.7a) – (3.7c) report the distributions of the measures based on the number of edges incoming, outgoing, or passing via a vertex. Panels (3.7o) and (3.7l) show the distributions computed using eigenvectors. Panels (3.7h) and (3.7i) describe the distributions of a dual measure.



(a) In-Degree

(b) Out-Degree

(c) Degree

(d) Eccentricity

(e) Closeness

(f) Harmonic Closenness

(g) Betweenness

(h) Authority

(i) Hub

(j) Modularity Class

(k) Component Number

(l) Pagerank

(m) Strong Component Number

(n) Clustering

(o) Eigen

Figure 3.8: **Dynamics of average profitability across the economy split with respect to centrality measures.** For all measures, except component number and string component number, the core industries are defined as a top quartile with respect to a centrality measure. The peripheral industries correspond to the bottom quartile. Due to the particularities of the definition, strong component number has thresholds at 99% and 1%. For component number, its maximum ($co = 10$) defines the core companies and the minimum ($co = 0$) defines the peripheral ones. Panels (3.8a) – (3.8c) report the distributions of the measures based on the number of edges incoming, outgoing, or passing via a vertex. Panels (3.8o) and (3.8l) show the distributions computed using eigenvectors. Panels (3.8h) and (3.8i) describe the distributions of a dual measure.

Connections between firms. The data on connections between firms come from the Factset Revere database. It comprises a list of source and target firm pairs with details of the relationship. The source company is the one which provides information in its SEC 10-K annual filings, press releases, presentations, and so on. The target firm is the company mentioned in those sources as a counterpart. The use of word "target" does not narrow down the nature of relationship between the mentioned companies. This relation can be of four major types: customers, suppliers, competitors, and partners. Each of the big categories in turn consists of subtypes. Customers include firms that have been disclosed as customers or entities to which the source company out-licenses technologies, patents, etc. and receives payment in return. Suppliers are the disclosed suppliers, entities from which the source company licenses technologies, patents, and so on, distributors, entities which promote or manufacture the source company product or service. Competitor is an entity which the source company mentioned as a competitor. Finally, partner category includes a number of cases: entities which own a stake in the source company or in which the source company has its stake, which own jointly with the source company a stake in a third entity. Partner category also covers the cases of joint research, manufacturing, and unspecified partnership.

To merge the data from the two databases I use CUSIP identifiers and match the Factset Revere contract dates with the report date from CRSP-Compustat.

In the next section I introduce centrality measures used in the paper. I discuss the final sample in detail in Section 3.2.3.

3.2.2 Centrality Measures

Network theory produced numerous measures which can gauge the importance of a vertex in the network. The quantity of these measures can be explained by different aspects of importance: how many neighbours a vertex has, how critical its position is to maintain the current structure of the network, how influential its status is, and so on. Every aspect can be differentiated from a technical, computational point of view as well. Some measures are calculated as a number of edges connecting the vertex with its neighbours, some involve consideration of paths with different characteristics passing through the given vertex, some are based on matrix computations. Below I cover the measures used in the paper.

Degree. In-degree is the number of incoming edges — the number of suppliers in economic terms. Out-degree is the number of outgoing edges — the number of customers. Degree is the total number of incoming and outgoing edges — the total number of suppliers and customers.

Betweenness Centrality. Betweenness Centrality is the number of shortest paths between every two vertices in the network going through the given node.

Closeness Centrality. Closeness Centrality is the ratio of one over the sum of lengths of the shortest paths between the given node and all other vertices of the network.

Harmonic Closeness Centrality. Harmonic Closeness Centrality is the sum over all vertices of the network of the ratios of one over the length of the shortest path between the given node and a corresponding vertex.

Eigen Centrality. Eigen Centrality is the measure of influence of a node on the network described by the respective entry of the eigenvector corresponding to the greatest eigenvalue.

Pagerank. Pagerank is measured by left-hand side eigenvector and scaled by the number of the immediate neighbours.

Katz-Bonacich Centrality. Katz-Bonacich Centrality is similar to Eigen Centrality but penalises remote connections with a "fee" α.

Authority and Hub Scores. The authority score of a vertex is proportional to the sum of the hub scores of the vertices on the incoming ties and the hub score is proportional to the authority scores of the vertices on the outgoing ties.

Eccentricity. Eccentricity is the maximum distance between the given node and any other vertex of the network.

Modularity. Modularity is the difference between the ratio of the actual edges of the group and the expected ratio if the connections were assigned randomly.

Component Number. Component Number in an undirected network is the number of nodes in the greatest set of nodes such that every pair of them is connected by a path.[4]

Strong Component Number. Strong Component Number in a directed network is the number of nodes in the greatest set of nodes such that every pair of them is connected by a path.

Clustering. Clustering is the ratio of actual connected pairs of the given node's neighbours over all possible connected pairs of the given node's neighbours.

3.2.3 The final sample

Below I continue the discussion started in Section 3.2.1. The final sample covers the period of 2003–2015, as the earliest contract description available dates back to April 3, 2003. The sample includes 1'657 unique firms and 387'043 observations. Tables 3.2 and 3.3 contain summary statistics of the data. Table 3.4 lists core firms according to different definitions of centrality.

[4] `https://www.sci.unich.it/~francesc/teaching/network/components.html`

Table 3.1: **Descriptive Statistics for Leverage and Control Variables.** The sample consists of firms from the merged CRSP-Compustat database for companies with headquarters in the USA from 2003 to 2014 on the annual base. Financials (historical SIC or SIC between 4900 and 4949), utilities (historical SIC or SIC codes between 6000 and 6999), and government entities (NAICS starts with letters) are excluded from the sample. All variables are winsorised at 1% and 99%. Values are shown to three significant decimal places.

Centrality Measure	Mean	Median	s.d.	Min	Max
Firm Size (log of sales)	6.552	6.518	1.744	2.310	12.62
Market-to-Book	1.248	0.968	1.078	0.00630	16.61
Profitability	0.125	0.125	0.0872	-0.314	0.347
Tangibility	0.281	0.207	0.230	0.0000754	0.983
Industry Concentration	0.0163	0.00933	0.0218	0.00129	0.249
Book Leverage	0.249	0.219	0.206	0.00000207	3.151
Market Leverage	0.221	0.173	0.195	0.00000133	0.991
Market Leverage Deficit	-0.00531	-0.0279	0.153	-0.519	0.889
Stock Return	0.131	0.0548	0.571	-0.902	4.961
Quarterly CF Volatility	0.0143	0.00946	0.0175	0.000704	0.351
Observations	13219				

Table 3.2: **Descriptive Statistics for Centrality Measures.** Centrality measures are computed on the base of the Factset Revere database. It provides information on suppliers and customers that contribute at least 10% of consolidated revenue in any period reported.

Centrality Measure	N	Mean	s.d.	Min	Max
		indegree			
Supply Chain, Dynamic	18869	20.39	47.70	0	600
Supply Chain	18742	20.34	47.62	0	599
Competitor, Dynamic	16850	4.789	11.68	0	195
Competitor	18866	12.53	29.12	0	394
Partner, Dynamic	14369	7.104	27.32	0	514
Partner	13031	7.722	28.47	0	511

Table 3.3: **Centrality Percentiles.** Centrality measures are computed on the base of the Factset Revere database. It provides information on suppliers and customers that contribute at least 10% of consolidated revenue in any period reported.

Centrality Measure	p1	p5	p10	p25	p50	p75	p90	p95	p99
					indegree				
Supply Chain, Dynamic	0	0	1	3	7	18	43	71	275
Supply Chain	0	0	1	3	7	18	42	71	275
Competitor, Dynamic	0	0	0	1	2	5	10	17	57
Competitor	0	0	1	2	6	12	25	41	136
Partner, Dynamic	0	0	0	1	2	4	11	26	109
Partner	0	0	0	1	2	5	12	29	109
					eigen centrality				
Supply Chain, Dynamic	0.000	0.000	0.000	0.001	0.011	0.058	0.170	0.271	0.614
Supply Chain	0.000	0.000	0.001	0.005	0.026	0.071	0.178	0.268	0.596
Competitor, Dynamic	0.000	0.000	0.000	0.001	0.005	0.017	0.056	0.111	0.370
Competitor	0.000	0.001	0.001	0.003	0.010	0.029	0.080	0.129	0.456
Partner, Dynamic	0.000	0.000	0.000	0.000	0.002	0.007	0.037	0.090	0.425
Partner	0.000	0.000	0.000	0.000	0.002	0.007	0.036	0.087	0.279

Table 3.4: **The Core Firms According to Different Centrality Measures.** The table lists core firms with respect to some centrality measures to provide some intuition for what the different measures represent. The table contains the maximum value of the corresponding centrality measure applied to supply chain, competitor, or partner networks. The listed firms' corresponding measure of centrality achieves maximum in the listed years.

	Customers	Competitors	Partners
In-Degree	General Electric Co, 2003–2013	Microsoft Corp, 2014	Microsoft Corp, 2009-2014
	600	188	514
Out-Degree	General Electric Co, 2003–2013	Honeywell International Inc, 2008-2009	General Electric Co, 2003–2013
	360	71	82
Degree	General Electric Co, 2003–2013	Microsoft Corp, 2014	Microsoft Corp, 2009-2014
	960	212	556
Betweenness	General Electric Co, 2003–2013	General Electric Co, 2013	General Electric Co, 2003–2013
	5937464	1510385	2737323
Eccentricity	National Healthcare Corp, 2003, 2010–2013	Neenah Paper Inc, 2007	Coeur Mining Inc, 2003, 2004, 2010–2013; NVR Inc, 2003, 2004, 2007–2013; MGP Ingredients Inc, 2004–2013; Conagra Brands Inc, 20052–013; Boyd Gaming Corp, 2007-2013; Salix Pharmaceuticals LTD, 2008-2013; ACCO Brands Corp, 2008-2013
	12	32	17
Modularity	Digital Ally Inc, 2011-2013	Lennar Corp, 2004; KB Home, 2004; Beazer Homes USA Inc, 2004; MDC Holdings Inc, 2004; Pultegroup Inc, 2004; Toll Brothers Inc, 2004; NVR Inc, 2004	Invacare Corp, 2003-2005, 2008
	27	66	122
Component	Digital Ally Inc, 2011-2013	Cash America Intl Inc, 2004	Invacare Corp, 2003-2005, 2008
	10	48	107
Strong	Digital Ally Inc, 2011-2013	Century Aluminum Co, 2012	Exar Corp, 2008, 2013
	5000	3176	3319

There are two types of contracts: of a fixed duration and without an expiration date. The average duration of supply contracts for one-time contracts is 907 days (or 2.5 years), for repeated contracts — 810 days (or 2 years and 2.5 months). The average for the total duration of contract links (in one long contract or in multiple short contracts) is 2190 days (or 6 years). The average number of contracts per pair is 2, the maximum is 17.

The dataset can be well-characterised by looking at the reciprocity of the connections. 20'736 pairs of firms report each other as counteragents (source and target companies' IDs and start and end dates of the contract correspond). However, different parties report the same contracts differently. In other words, there are not twice as few relations as repeated pairs (10'368 pairs). Among them: 5'524 firms (2'762 pairs) claim each as competitors, 567 agree on the customer-supplier connection. There are 1'237 pairs where one of the parties considers the other a competitor and the second claims to be customer (224 cases), supplier (209 cases), or partner (the rest). 108 companies are customers of one another, 134 are suppliers of one another.

Some companies register the same ties under several labels, for example, Nintendo Co Ltd reports Interplay Entertainment Corp as a competitor during the period April 3–13, 2003, while Interplay Entertainment Corp reports Nintendo Co Ltd as a competitor, supplier, and licensing partner. I do not correct or reconstruct the asymmetry of reported links.

It is important to remember that the dataset is unbalanced. For example, a contract is mentioned in a year when it contributes 10% and more to consolidated revenue of a company and it is registered as a long-term agreement. Its contribution can change, or/and the two firms can decide to end the contract for the following reasons: due to unexpected new charges in the contract[5], new regulation,[6] or natural disasters and their consequences.[7]

Dynamics of centrality measures through the years are presented in Figure 3.3. The average number of suppliers increases over the years. It is important to remember of the 10% compulsory reporting threshold, as it can affect the interpretation of this increase. This effect could be explained by the fact that the firms chose to be more transparent with time, or by the fluctuations in sales, the suppliers can trespass the contribution threshold of 10%, and thus appear or disappear as a component of the graph.

It is worth noting that the network of connections can be quite volatile — in terms of links between two particular companies rather than on average. For example, Johnson&Johnson report having a wholesaler distributing their products for all three segments that represented approximately 11.0% of the total consolidated revenues in 2014. However, in 2013 and 2012, they did not have a customer that represented 10% or more of total consolidated revenues.[8] The threshold of 10% can be easily overcome in either direction due to potential shocks of various nature.

Nowadays regulators scrutinise reporting standards to promote responsible business bahaviour. The European Union have approved draft regulations which prohibit sourcing minerals from conflict areas like Democratic Republic of Congo, Rwanda, and Burundi. The planned date of introduction of these regulations is 2021. Although in the United States such regulations and their approval are suspended — to a large extent because of

[5] `http://www.msn.com/en-us/money/companies/wal-mart-to-impose-charges-on-suppliers-as-its-costs-mount/ar-AAc0XCt`

[6] `http://www.reuters.com/article/us-tin-supply-chain-idUSKBN17N0DJ`

[7] Toyata reorganised its supply chain in "earthquake resistant" way. They did not manage to exclude all suppliers situated in risky locations but even if a disaster hits, the supply chain must recover within two weeks. `http://www.reuters.com/article/toyota-supply-chain-idUSL4E8E21ZJ20120302`

[8] `http://www.investor.jnj.com/secfiling.cfm?filingID=200406-15-4&CIK=200406`

the recent presidential campaign and the new political course for cutting business costs — companies which decide to be transparent and responsible appear to be more frequent.[9] This behaviour does not have to be driven by sentiment or by purely brand building practice. Partly, it is a protection against future demand shocks.[10] Final consumers do not usually trace how a product has been produced. Nevertheless, when the information which is not congruent with their ethical norms about their retailers is released, they fleed. In the past 5 years, the supply scandals happened to a number of clothes chains: Marks & Spencer, H&M, Uniqlo, Zara, and Nike were allegedly using child labour in South-East Asia and South America[11] ; and in food retailer industry: horsemeat sold as beef was found in the UK supermarkets.

These shocks are not long-term, however, they have affected transparency policies of all the above companies.

3.3 Testing the hypotheses

3.3.1 Target Leverage

Before testing the hypotheses, I compute target level of leverage. I exploit the list of classical determinants (Frank, Goyal, 2009):

$$y_t = \alpha + X_{t-1}^{target}\beta + Industry\ FE + \epsilon_t, \tag{3.1}$$

where y_t is market leverage and X_{t-1} includes a classical set of firm-specific characteristics, which will be discussed in detail below, and industry fixed effects. ϵ is the error vector, and (α', β') is the vector of parameters. I apply the Fama-MacBeth procedure to estimate the equation. I run regressions year-by-year on the period 1990-2014; there are 1'467 – 1'921 firm-observation per year and 36'145 observation in total. Then I find the average for every coefficient. The standard errors are computed by definition. R-squared is an average of yearly Rs-squared. Table 3.5 reports the results of the regression. All the coefficients are significant except for Abnormal earnings. The R-squared is 0.38. There are 49 industries defined according to Fama and French.

Following numerous works in capital structure determinants (Titman and Wessels, 1988, Frank and Goyal 2009, Johnson 2003) I pick a set of explanatory variables. I use natural logarithm of sales as a proxy for company's size. The logarithmic transformation assigns higher weight to smaller firms. The coefficient, corresponding to it, is positive which can be interpreted as: the larger firms can afford to raise more leverage, as they tend to be less prone to default — because of business diversification or being more mature and having more stable earnings (I control for the volatility of cash flows separately). Market-to-book ratio is a proxy to growth opportunities; the corresponding coefficient is negative, as expected, as the opportunities for growth increase the market value of capital but cannot be collateralised. In other words, an increase in growth opportunities affects the denominator of the leverage ratio in a positive way and the numerator stays mostly unaffected. An interproduct of Market-to-Book ratio and Maturity has a positive coefficient. That is, given the growth opportunities, having lower makes a company more likely to increase the

[9] Top management and owners of Chopard visit golden mines, which supply the metal to their production units.

[10] http://www.reuters.com/article/us-tin-supply-chain-idUSKBN17N0DJ

[11] https://www.theguardian.com/sustainable-business/supply-chain-transparency-relationships-suppliers

Table 3.5: **Target Leverage.** The table reports the results for the yearly regressions of *Market Leverage* onto a classical set of explanatory variables. Signs of the coefficients correspond to the trade-off theory prediction. The residuals of this regression are used in the paper to denote *Market Leverage Deficit*. Industry fixed effects are included.

Variable	Coef	s.d.
Market-to-Book$_{t-1}$	-0.082 ***	0.005
Market-to-Book × Maturity$_{t-1}$	0.001 ***	0.000
Tangibility$_{t-1}$	0.104 ***	0.009
Profitability$_{t-1}$	-0.127 ***	0.027
Sales$_{t-1}$	0.004 ***	0.001
R&D ratio$_{t-1}$	-0.235 ***	0.052
CF Volatility$_{t-1}$	-0.092	0.061
Investment Tax Credit$_{t-1}$	-0.048 ***	0.008
Net Operational Loss Carryforward$_{t-1}$	0.045 ***	0.003
Abnormal Earnings$_{t-1}$	0.001	0.007
Observations	36'145	
R-Squared	0.38	

leverage ratio in the next period. Tangibility is a proxy for collateral; the higher it is, the more leverage a company can take. Profitability has a negative coefficient: the operating income increases the market value of the company but does not encourage it to issue more debt. This coefficient is consistent with the pecking order theory by Donaldson (1961). R&D ratio, which is the ratio of R&D expenditures to total assets, reflects the uniqueness of the firm. As it has been shown by Titman and Wessels (1988), R&D ratio is negatively correlated with non-debt tax shields and with collateral value, so the negative coefficient in the regression for Market Leverage is expected. The volatility of Operating Income Before Depreciation must have a negative effect on the leverage ratio, since the less predictable the cash flows are, the lower leverage a company can afford without exposing itself to high default risks. Investment Tax Credit is the amount that a firm can legally subtract from their tax payments due to reinvestment. I use it as a proxy for non-debt tax shield. The negative coefficient can be interpreted as follows: the higher non-debt tax shield, the lower the necessity of debt tax shield, hence, no need to issue more debt. Net Operating Loss Carryforward is a dummy for non-zero Tax Loss Carry Forward. It corresponds positively to the leverage: if a company suffers losses and plans to reduce tax liability in the next period, the company is likely to increase its leverage. The coefficient corresponding to Abnormal Earnings is not significant. The detailed definitions of the variables can be found in Table A1.

I consider the Market Leverage predicted by the model (Market Leverage Fitted) an "optimal", target, level. The residuals of this regression stand for deviation of actual values from the "optimal" capital structure and form Market Leverage Deficit variable. The existence of a target level for leverage is both widely supported (Titman and Tsyplakov, 2004, Leary and Roberts, 2005) and criticised (Shyam-Sunder and Myers, 1999, Graham and Harvey, 2001, Chang and Dasgupta, 2009). However, it has not been rejected by its opponents entirely. It is the well-established fact that capital structure levels stay quite stable over decades (Lemmon, Roberts, and Zender, 2008). In this paper I attempt to explain the time-varying deviation from this level with properties of inter-firm connections.

3.3.2 Competitor Network

The literature on intra-industry capital structure is extensive and the exploration of competitor network is not the main focus of this paper. I use it to test representativeness of the new dataset. To do so, I verify the well-established hypothesis according to which peripheral companies tend to have higher leverage. This idea has been explored by Zhdanov (2008). Leary and Roberts (2011) have confirmed empirically it using the standard CRSP-Compustat data and SIC codes to define the competitors.

I consider peripheral companies as "new comers" or "followers" in terms of product market competition terminology. They are the last to enter the market and they have not had enough time to form multiple connections: to gain a status of competitor by their rivals. Statistically, these companies are younger firms with lower expertise (R&D expenditures). That is to say, they lack experience and knowledge to make an educated capital structure decision. Considering that, the peripheral firms choose to copy observable decisions of more experienced and successful "incumbents", or core firms.

The novelty of the result originates from the usage of the dataset where companies name their competitors by themselves. This is the principal difference with the classical approach, which defines whether firms compete or not by standard industry codes. Thus, a large company has to choose a single industry code and "reject" an opportunity to be classified as a competitor within its second, third, and so on largest sectors.

Example 1 *Proctor and Gamble has SIC 2840. Leary and Roberts (2011) identified competitors by three-digit SIC code. See Table 3.6 for the details. According to the traditional identification, P&G has 147 competitors, along the entire period of 2002-2015, from 3 sectors: SOAP, DETERGENTS, CLEANG PREPARATIONS, PERFUMES, COSMETICS (SIC 2840); SPECIALTY CLEANING, POLISHING AND SANITATION PREPARATIONS (SIC 2842); and PERFUMES, COSMETICS & OTHER TOILET PREPARATIONS (SIC 2844). In its 10-K form annual report, P&G has identified 19 competitors and has been identified 144 times by the firms from 21 industry, including ELECTRIC HOUSEWARES & FANS (SIC 3634). If we compare the companies which are present in both lists the one formed according to SIC codes and the one collected from 10-K reports — , we can see that the numbers of observations does not coincide. It means that the competition might have been not essential in same years.*

This example demonstrates that the traditional way of identifying competitors might mention extra companies and omit real rivals. This particularity can lead to biased results. To confirm that there is no "slicing" by SIC levels, I look at the network of the competitors in, say, 2007. In Figure 3.2 we see no separate clouds, i.e., the competition strictly within SIC or NAICS-codes industries, where the firms would have no chance to compete having very different codes.

At the next step, I turn to examining the hypothesis 1 that peripheral firms should have higher leverage. I pick two centrality measures, In-degree and Eigen Centrality, to assign companies to core or peripheral groups. In-degree measure tells us how many firms identify the given vertex as their competitor, which they see as a threat. In contrast, Out-degree would be less appropriate here. The companies with the potentially higher Out-degree — huge companies acting in several industries and expectedly behaving in a more aggressive way — do not report long lists of their competitors. The second measure, Eigen Centrality, gauges the overall importance of the node in the undirected network of competitors. Figure 3.4 shows no clear support for the hypothesis and reports mixed

Table 3.6: **Comparison of three-digit SIC and Factset Revere links as identification methods for competitors.**

Three-digit SIC		
Company Name	SIC	Frequency
CCA INDUSTRIES INC	2844	12
CHURCH & DWIGHT INC	2840	13
CLOROX CO/DE	2842	12
COLGATE-PALMOLIVE CO	2844	10
CPAC INC	2842	3
DEL LABORATORIES INC	2844	1
ECOLAB INC0	2842	10
ELIZABETH ARDEN INC	2844	10
LAUDER (ESTEE) COS IN	2844	12
STEPAN CO	2840	12
ZEP INC	2842	4
Total	3 codes	99
Factset Revere		
Company Name	SIC	Frequency
ACUITY BRANDS INC	3640	1
AMGEN INC	2836	3
APPLICA INC	3634	1
CCA INDUSTRIES INC	2844	12
CHURCH & DWIGHT INC	2840	13
CLEARWATER PAPER CORP	2621	4
COFFEE HOLDING CO INC	5140	1
COLGATE-PALMOLIVE CO	2844	6
CPAC INC	2842	2
DEL LABORATORIES INC	2844	1
FARMER BROS CO	2090	2
HAIN CELESTIAL GROUP	2000	4
INTL FLAVORS & FRAGRA	2860	1
INVENTURE FOODS INC	2030	5
KIMBERLY-CLARK CORP	2621	1
LAUDER (ESTEE) COS IN	2844	12
LITTELFUSE INC	3613	1
MONDELEZ INTERNATIONA	2000	2
NUTRACEUTICAL INTL CO	2833	3
ORCHIDS PAPER PRODUCT	2670	1
PEPSICO INC	2080	5
PRESTIGE BRANDS HOLDI	5122	8
SALIX PHARMACEUTICALS	2834	2
SANTARUS INC	2834	2
ULTRALIFE CORP	3690	1
VIVUS INC	2834	5
WATER PIK TECHNOLOGIE	3569	2
YOUNG INNOVATIONS INC	3843	6
ZEP INC	2842	4
Total	21 codes	147

evidence for either of the measures and for all three variables: Market Leverage, Market Leverage Deficit, and Book Leverage.

To verify the hypothesis more accurately I run a regression:

$$y_t = \alpha + X_{t-1}^{competitor}\beta + Industry\ FE + Year\ FE + \epsilon_t,$$

where y is the measure of capital structure and $X^{competitor}$ is the firm's characteristic matrix, ϵ is the error vector, and (α', β') is the vector of parameters. The results are reported in Table 3.7. There is a panel for every leverage proxy: Market Leverage, Market Leverage Deficit and Book Leverage. First three columns of the table show the coefficients for the entire sample, columns (4) – (6) report the results for peripheral firms, with respect to the corresponding measure, and finally, last three columns report estimates for core industries, with respect to the same measure.

Market and Book Leverage have expected coefficients for the standard explanatory variables. They correspond in signs to what I have discussed in Section 3.3.1. Market Leverage Deficit shows unusual in sign coefficients for size of a company and for Tangibility. This happens because the main drivers are already offset.

As for the coefficients corresponding to the centrality measures, they are negative when reported for the entire sample. This result confirms the hypothesis of a negative association between centrality of a company and its leverage. The peripheral firms, in terms of the In-degree and Eigen centrality, tend to be over-levered. The subsamples do not allow me to infer which group of firms drives the effect.

3.3.3 Production Network

For the production network I show that more central firms demonstrate better economic performance and lower leverage. The latter fact supports the hypothesis that companies use leverage as a commitment device.

A proxy for economic performance is Return-on-Assets (Profitability). To study the association with the centrality, I split the sample into three groups: core, intermediate, and peripheral companies. Figure 3.8 demonstrates that the core firms — in terms of several centrality measures — have prominent pattern of higher profitability over the span of 12 years. This supports the finding by Hertzel et al. (2008) and Acemoglu et al. (2012).

Figure 3.5 shows that core firms tend to have lower leverage, but very similar dynamics to peripheral ones, driven mostly by the stock prices. To diminish this effect, I construct similar graphs for Book Leverage. In Figure 3.6 the pattern is much more prominent. For Market Leverage Deficit (Figure 3.7) the dynamics of core and peripheral firms are quite different. To conduct a more accurate analysis, I run several regressions and estimate them with different methods.

The specification for production network is as follows:

$$y_t = \alpha + X_{t-1}^{supply\ chain}\beta + Industry\ FE + Year\ FE + \epsilon_t,$$

where y is the measure of capital structure and $X^{supply\ chain}$ is the firm's characteristic matrix, ϵ is the error vector, and (α', β') is the vector of parameters. I include the industry and the year fixed effects. The firm fixed effects and alternative specification of explanatory factors are discussed in Section 3.3.5.

Firms characteristics include — besides standard Size, Profitability, Tangibility, and Market-to-Book ratio — a proxy for bargaining power and a position in the supply chain. For the bargaining power I use R&D ratio and control for it for both the firm-in-question and

Table 3.7: **Pooled regression. Competitor Network.** Dependent variable heads the corresponding panel: Market Leverage, Market Leverage Deficit, and Book Leverage. Columns (1) – (3) report the results for the entire sample. Columns (4) – (6) do so for the subsample of peripheral firms. Columns (7) – (9) show the coefficients for the subsample of core firms. The core industries are defined as a top quartile with respect to a centrality measure. The peripheral industries correspond to the bottom quartile. The results for In-degree and Eigen centrality measures are reported. Estimated by the ordinary least squares method. Industry and year fixed effects. Standard errors are in parentheses as follows: *, ** and *** stand for 5%, 1% and 0.1% significance levels, respectively.

Market Leverage									
	Entire Sample			Peripheral Firms			Core Firms		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Firm Size (log of sales)	0.00536***	0.0114***	0.00939***	0.0221***	0.0232***	0.0233***	-0.00714***	-0.00552*	-0.0126***
	(0.000921)	(0.00117)	(0.00112)	(0.00288)	(0.00247)	(0.00297)	(0.00128)	(0.00234)	(0.00216)
Market-to-Book	-0.0776***	-0.0734***	-0.0732***	-0.0652***	-0.0738***	-0.0652***	-0.0845***	-0.0668***	-0.0735***
	(0.00163)	(0.00166)	(0.00167)	(0.00342)	(0.00299)	(0.00342)	(0.00281)	(0.00259)	(0.00286)
Profitability	-0.120***	-0.120***	-0.118***	-0.0846*	-0.0924**	-0.0849*	-0.0721*	-0.177***	-0.0459
	(0.0151)	(0.0156)	(0.0157)	(0.0343)	(0.0287)	(0.0343)	(0.0288)	(0.0296)	(0.0324)
Tangibility	0.104***	0.122***	0.122***	0.0989***	0.0894***	0.0996***	0.0711***	0.230***	0.164***
	(0.00913)	(0.00970)	(0.00971)	(0.0195)	(0.0162)	(0.0195)	(0.0151)	(0.0180)	(0.0187)
In-Degree		-0.00147***			-0.00802			-0.000504***	
		(0.000150)			(0.00594)			(0.000149)	
Eigen Centrality			-0.200***			-9.996			-0.0425
			(0.0246)			(5.935)			(0.0241)
Observations	12275	10838	10838	2730	3954	2730	4147	2809	2710
R^2	0.337	0.346	0.344	0.357	0.349	0.358	0.381	0.456	0.442

Market Leverage Deficit									
	Entire Sample			Peripheral Firms			Core Firms		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Firm Size (log of sales)	-0.00157	0.00355**	0.00187	0.0147***	0.0157***	0.0159***	-0.0134***	-0.0115***	-0.0172***
	(0.000884)	(0.00112)	(0.00107)	(0.00274)	(0.00235)	(0.00283)	(0.00126)	(0.00230)	(0.00215)
Market-to-Book	-0.00362*	0.000427	0.000542	0.00980**	0.00185	0.00982**	-0.00755**	0.00600*	0.00467
	(0.00156)	(0.00160)	(0.00160)	(0.00327)	(0.00284)	(0.00327)	(0.00277)	(0.00255)	(0.00284)
Profitability	-0.00351	-0.00245	-0.000396	-0.0277	-0.0316	-0.0280	0.0429	-0.0281	0.0605
	(0.0145)	(0.0150)	(0.0150)	(0.0327)	(0.0273)	(0.0327)	(0.0283)	(0.0292)	(0.0322)
Tangibility	-0.0429***	-0.0285**	-0.0286**	-0.0406*	-0.0503**	-0.0399*	-0.0746***	0.0708***	0.00437
	(0.00876)	(0.00931)	(0.00932)	(0.0186)	(0.0154)	(0.0186)	(0.0148)	(0.0178)	(0.0186)
In-Degree		-0.00123***			-0.00955			-0.000316*	
		(0.000144)			(0.00565)			(0.000147)	
Eigen Centrality			-0.166***			-9.824			-0.0267
			(0.0236)			(5.662)			(0.0239)
Observations	12275	10838	10838	2730	3954	2730	4147	2809	2710
R^2	0.009	0.016	0.014	0.055	0.040	0.056	0.072	0.152	0.158

Book Leverage									
	Entire Sample			Peripheral Firms			Core Firms		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Firm Size (log of sales)	0.00778***	0.0145***	0.0122***	0.0269***	0.0243***	0.0263***	-0.00701***	-0.0213***	-0.0249***
	(0.00110)	(0.00142)	(0.00135)	(0.00319)	(0.00263)	(0.00329)	(0.00151)	(0.00311)	(0.00278)
Market-to-Book	-0.0270***	-0.0244***	-0.0242***	-0.0256***	-0.0335***	-0.0256***	-0.0336***	-0.0297***	-0.0348***
	(0.00193)	(0.00201)	(0.00201)	(0.00380)	(0.00318)	(0.00380)	(0.00332)	(0.00345)	(0.00368)
Profitability	0.0522**	0.0588**	0.0618**	0.0406	0.0835**	0.0408	0.0871*	0.0270	0.202***
	(0.0180)	(0.0189)	(0.0189)	(0.0381)	(0.0306)	(0.0381)	(0.0340)	(0.0394)	(0.0417)
Tangibility	0.0910***	0.0965***	0.0963***	0.0552*	0.0775***	0.0548*	0.104***	0.212***	0.182***
	(0.0108)	(0.0117)	(0.0117)	(0.0216)	(0.0173)	(0.0216)	(0.0178)	(0.0240)	(0.0240)
In-Degree		-0.00179***			0.00102			-0.000352	
		(0.000182)			(0.00633)			(0.000198)	
Eigen Centrality			-0.247***			5.175			-0.00497
			(0.0297)			(6.587)			(0.0310)
Observations	12275	10838	10838	2730	3954	2730	4147	2809	2710
R^2	0.157	0.168	0.166	0.239	0.231	0.239	0.183	0.265	0.262

its counterparty. The regressions report (Tables 3.8 – 3.11) significant negative coefficients. The effect is expected be driven by the correlation between R&D ratio and non-debt tax credit, as it is discussed in Section 3.3.1. Controlling for the bargaining power of both sides is essential in these regressions. This way I can address the issue of the switching costs and of the uniqueness of a supplier or a customer.

Table 3.8: **Pooled regression. Supply chain. Market Leverage.** The table reports the results of regressions for a regression with no centrality measures in it (column (1)) and for regressions including on of the measures: In-degree ((2) – (4)), Out-degree ((5) – (7)), Degree ((8) – (10)), Eccentricity ((11) – (13)). The first column corresponding to the centrality measures is estimated on the entire sample. The second ones correspond to peripheral firms and the third correspond to core firms. Estimated by the ordinary least squares method. Industry and year fixed effects. Standard errors are in parentheses as follows: *, ** and *** stand for 5%, 1% and 0.1% significance levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Firm Size (log of sales)	0.00333**	0.0121***	0.0130***	-0.00393	0.00415***	0.0139***	-0.00611***	0.0116***	0.0119***	0.00184	0.00464***	0.0133***	-0.000247
	(0.00112)	(0.00134)	(0.00308)	(0.00264)	(0.00115)	(0.00232)	(0.00176)	(0.00134)	(0.00319)	(0.00236)	(0.00113)	(0.00283)	(0.00177)
Market-to-Book	-0.0756***	-0.0750***	-0.0651***	-0.0929***	-0.0756***	-0.0751***	-0.0853***	-0.0751***	-0.0669***	-0.0976***	-0.0751***	-0.0795***	-0.0647***
	(0.00195)	(0.00193)	(0.00383)	(0.00381)	(0.00194)	(0.00352)	(0.00363)	(0.00193)	(0.00424)	(0.00395)	(0.00194)	(0.00420)	(0.00284)
Profitability	-0.152***	-0.166***	-0.117**	-0.135***	-0.153***	-0.161***	0.0305	-0.164***	-0.132**	-0.0593	-0.156***	-0.196***	-0.175***
	(0.0178)	(0.0178)	(0.0357)	(0.0353)	(0.0179)	(0.0358)	(0.0352)	(0.0178)	(0.0414)	(0.0457)	(0.0178)	(0.0429)	(0.0237)
Tangibility	0.100***	0.106***	0.0330	0.204***	0.0989***	0.0838***	0.119***	0.103***	0.0341	0.194***	0.103***	0.0727***	0.0929***
	(0.0109)	(0.0108)	(0.0199)	(0.0208)	(0.0109)	(0.0178)	(0.0201)	(0.0108)	(0.0214)	(0.0202)	(0.0109)	(0.0218)	(0.0174)
R&D ratio	-0.191***	-0.172***	-0.213**	-0.184	-0.184***	-0.267*	-0.120*	-0.166***	-0.399**	-0.208*	-0.182***	-0.0866	-0.175**
	(0.0393)	(0.0390)	(0.0759)	(0.103)	(0.0393)	(0.132)	(0.0497)	(0.0391)	(0.135)	(0.0853)	(0.0392)	(0.125)	(0.0583)
Counterpart R&D ratio	-0.134**	-0.107*	-0.0818	0.00164	-0.126**	-0.247*	0.0179	-0.0995*	-0.151	0.0350	-0.117*	-0.383**	-0.139
	(0.0465)	(0.0462)	(0.101)	(0.0742)	(0.0465)	(0.105)	(0.0604)	(0.0463)	(0.115)	(0.0694)	(0.0464)	(0.133)	(0.0802)
R&D * Counter R&D	0.517***	0.471***	0.625	0.294	0.498***	1.366***	0.0990	0.453***	1.342**	0.343	0.494***	0.987***	0.434**
	(0.0854)	(0.0849)	(0.335)	(0.207)	(0.0856)	(0.408)	(0.110)	(0.0850)	(0.437)	(0.234)	(0.0852)	(0.234)	(0.145)
Upstream	-0.0228***	-0.0219***	-0.0735	0	-0.0208***	-0.0336*	-0.0352***	-0.0188**	-0.0217*	-0.0467***	-0.0164**	-0.0680**	-0.00402
	(0.00578)	(0.00574)	(0.0480)	(.)	(0.00582)	(0.0141)	(0.00853)	(0.00576)	(0.0101)	(0.0128)	(0.00584)	(0.0244)	(0.00816)
Downstream	-0.0135*	-0.0230***	-0.0000815	-0.0224*	-0.0169**	-0.0291***	-0.0327	-0.0265***	-0.00237	-0.0302*	-0.0253***	-0.0240**	-0.0319**
	(0.00569)	(0.00571)	(0.0108)	(0.0111)	(0.00578)	(0.00775)	(0.0286)	(0.00577)	(0.00983)	(0.0132)	(0.00592)	(0.00891)	(0.0120)
In-Degree		-0.00140***	-0.0615	-0.000791***									
		(0.000121)	(0.0481)	(0.000145)									
Out-Degree					-0.000702**	-0.0267***	-0.000301						
					(0.000215)	(0.00649)	(0.000270)						
Degree								-0.00110***	0.00304	-0.000771***			
								(0.0000994)	(0.00466)	(0.000121)			
Eccentricity											-0.00261***	0.0202*	0.00364
											(0.000371)	(0.00979)	(0.00228)
Observations	8958	8946	2472	2519	8946	3550	2716	8946	2236	2647	8946	2631	3262
R^2	0.363	0.372	0.333	0.464	0.363	0.385	0.394	0.371	0.372	0.453	0.366	0.399	0.351

Table 3.9: **Pooled regression. Supply chain. Market Leverage.** The table reports the results of regressions for Authority (columns (1) – (3)) and Hub (columns (4) – (6)), Pagerank (columns (7) – (9)), Storing Component (columns (10) – (12)), Eigen Centrality (columns (13) – (15)). The first column corresponding to the centrality measures is estimated on the entire sample. The second ones correspond to peripheral firms and the third correspond to core firms. Estimated by the ordinary least squares method. Industry and year fixed effects. Standard errors are in parentheses as follows: *, ** and *** stand for 5%, 1% and 0.1% significance levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Firm Size (log of sales)	0.00994***	0.0164***	-0.00787***	0.00356**	0.0155***	-0.000434	0.00556***	0.0108**	-0.000555	0.00297**	0.00763***	0.0138***	0.00615***	0.0151***	-0.00263
	(0.00127)	(0.00340)	(0.00237)	(0.00112)	(0.00301)	(0.00195)	(0.00118)	(0.00370)	(0.00195)	(0.00112)	(0.00230)	(0.00338)	(0.00119)	(0.00375)	(0.00194)
Market-to-Book	-0.0748***	-0.0648***	-0.0908***	-0.0756***	-0.0814***	-0.104***	-0.0755***	-0.0663***	-0.0865***	-0.0757***	-0.0944***	-0.0623***	-0.0756***	-0.0635***	-0.0930***
	(0.00193)	(0.00429)	(0.00388)	(0.00195)	(0.00453)	(0.00421)	(0.00194)	(0.00435)	(0.00369)	(0.00194)	(0.00408)	(0.00418)	(0.00194)	(0.00460)	(0.00384)
Profitability	-0.163***	-0.161***	0.0173	-0.152***	-0.182***	0.0860	-0.158***	-0.175***	-0.174***	-0.151***	-0.0365	-0.191***	-0.160***	-0.184***	-0.0713*
	(0.0178)	(0.0380)	(0.0424)	(0.0179)	(0.0459)	(0.0439)	(0.0179)	(0.0415)	(0.0311)	(0.0179)	(0.0396)	(0.0423)	(0.0178)	(0.0433)	(0.0344)
Tangibility	0.106***	0.0761***	0.197***	0.0992***	0.0688**	0.108***	0.100***	0.0482*	0.186***	0.100***	0.114***	0.0780**	0.0958***	0.0663**	0.130***
	(0.0108)	(0.0221)	(0.0212)	(0.0109)	(0.0225)	(0.0222)	(0.0109)	(0.0242)	(0.0214)	(0.0109)	(0.0216)	(0.0238)	(0.0109)	(0.0254)	(0.0213)
R&D ratio	-0.176***	-0.234**	-0.268***	-0.188***	-0.162	-0.125*	-0.188***	-0.182*	-0.0481	-0.190***	-0.115	-0.244**	-0.185***	-0.283**	-0.0731
	(0.0390)	(0.0807)	(0.0767)	(0.0393)	(0.171)	(0.0604)	(0.0392)	(0.0723)	(0.109)	(0.0392)	(0.0984)	(0.0841)	(0.0392)	(0.104)	(0.108)
Counterpart R&D ratio	-0.112*	-0.0136	0.0893	-0.127**	-0.365**	0.0811	-0.133**	0.117	-0.316**	-0.132**	-0.201*	0.0545	-0.122**	0.0827	-0.270*
	(0.0462)	(0.130)	(0.0722)	(0.0466)	(0.141)	(0.0671)	(0.0464)	(0.124)	(0.115)	(0.0465)	(0.0953)	(0.123)	(0.0464)	(0.138)	(0.111)
R&D * Counter R&D	0.479***	0.585	0.245*	0.505***	0.989	0.0992	0.514***	-0.110	0.523**	0.512***	0.825***	0.443	0.496***	0.900	0.433*
	(0.0850)	(0.301)	(0.120)	(0.0856)	(0.584)	(0.116)	(0.0853)	(0.312)	(0.201)	(0.0854)	(0.204)	(0.413)	(0.0852)	(0.694)	(0.194)
Upstream	-0.0203***	-0.0163	-0.117	-0.0219***	0.00334	-0.0193*	-0.0246***	-0.0329**	0	-0.0101	-0.0308	-0.00722	-0.0255***	-0.0854	0
	(0.00575)	(0.00938)	(0.140)	(0.00580)	(0.0346)	(0.00920)	(0.00578)	(0.0124)	(.)	(0.00663)	(0.0478)	(0.00905)	(0.00578)	(0.0538)	(.)
Downstream	-0.0202***	0.00130	-0.0141	-0.0150**	-0.0225*	-0.0479	-0.0184**	-0.0194	-0.0610***	-0.00949	-0.0106	-0.000176	-0.0205***	0.0212	-0.0231
	(0.00569)	(0.0173)	(0.0107)	(0.00574)	(0.00936)	(0.0541)	(0.00574)	(0.0126)	(0.0156)	(0.00577)	(0.0113)	(0.0120)	(0.00576)	(0.0144)	(0.0164)
Authority	-0.712***	-244.0	-0.204**												
	(0.0665)	(365.9)	(0.0747)												
Hub				-0.158*	0	-0.0104									
				(0.0788)	(.)	(0.113)									
Pageranks							-7.856***	-552.4	-6.047***						
							(1.350)	(382.0)	(1.537)						
Strong Component Number										-0.0000186***	-0.0000774**	-0.00000269			
										(0.00000471)	(0.0000252)	(0.00000963)			
Eigen Centrality													-0.115***	-78.67	-0.109***
													(0.0165)	(48.66)	(0.0212)
Observations	8946	1802	2474	8946	2364	2340	8946	1750	2596	8946	2592	1745	8946	1628	2614
R^2	0.371	0.359	0.446	0.363	0.392	0.412	0.365	0.338	0.434	0.364	0.447	0.334	0.366	0.339	0.470

Table 3.10: **Pooled regression. Supply chain. Market Leverage Deficit.** The table reports the results of regressions for a regression with no centrality measures in it (column (1)) and for regressions including on of the measures: In-degree ((2) – (4)), Out-degree ((5) – (7)), Degree ((8) – (10)), Eccentricity ((11) – (13)). The first column corresponding to the centrality measures is estimated on the entire sample. The second ones correspond to peripheral firms and the third correspond to core firms. Estimated by the ordinary least squares method. Industry and year fixed effects. Standard errors are in parentheses as follows: *, ** and *** stand for 5%, 1% and 0.1% significance levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Firm Size (log of sales)	-0.00297**	0.00504***	0.00603*	-0.0101***	-0.00225*	0.00565*	-0.0107***	0.00452***	0.00383	-0.00464*	-0.00171	0.00487	-0.00574***
	(0.00107)	(0.00129)	(0.00292)	(0.00260)	(0.00110)	(0.00222)	(0.00171)	(0.00129)	(0.00303)	(0.00231)	(0.00108)	(0.00271)	(0.00170)
Market-to-Book	-0.00253	-0.00193	0.00457	-0.0167***	-0.00254	-0.00330	-0.00835*	-0.00207	0.00497	-0.0199***	-0.00200	-0.00982*	0.00378
	(0.00187)	(0.00186)	(0.00362)	(0.00375)	(0.00187)	(0.00337)	(0.00353)	(0.00186)	(0.00403)	(0.00387)	(0.00186)	(0.00402)	(0.00272)
Profitability	-0.0248	-0.0372*	0.0334	-0.0216	-0.0255	0.00572	0.105**	-0.0357*	0.0262	0.0254	-0.0287	-0.0176	-0.0339
	(0.0171)	(0.0171)	(0.0338)	(0.0348)	(0.0171)	(0.0343)	(0.0343)	(0.0171)	(0.0393)	(0.0448)	(0.0171)	(0.0411)	(0.0227)
Tangibility	-0.0492***	-0.0434***	-0.119***	0.0419*	-0.0502***	-0.0618***	-0.0294	-0.0466***	-0.114***	0.0441*	-0.0468***	-0.0719***	-0.0630***
	(0.0105)	(0.0104)	(0.0188)	(0.0205)	(0.0105)	(0.0171)	(0.0196)	(0.0104)	(0.0203)	(0.0198)	(0.0104)	(0.0209)	(0.0167)
R&D ratio	-0.117**	-0.100**	-0.141	-0.139	-0.111**	-0.0697	-0.0985*	-0.0951*	-0.222	-0.216**	-0.108**	0.0939	-0.0947
	(0.0377)	(0.0375)	(0.0719)	(0.102)	(0.0377)	(0.127)	(0.0483)	(0.0375)	(0.128)	(0.0836)	(0.0376)	(0.120)	(0.0559)
Counterpart R&D ratio	-0.121**	-0.0968*	-0.0760	0.0108	-0.114*	-0.300**	0.0305	-0.0898*	-0.160	0.0472	-0.105*	-0.401**	-0.109
	(0.0446)	(0.0444)	(0.0958)	(0.0730)	(0.0447)	(0.100)	(0.0587)	(0.0445)	(0.109)	(0.0680)	(0.0446)	(0.127)	(0.0769)
R&D * Counter R&D	0.409***	0.368***	0.558	0.185	0.393***	1.198**	0.0810	0.352***	1.106**	0.370	0.388***	0.876***	0.306*
	(0.0820)	(0.0815)	(0.317)	(0.203)	(0.0821)	(0.391)	(0.107)	(0.0817)	(0.415)	(0.229)	(0.0818)	(0.224)	(0.139)
Upstream	-0.0227***	-0.0219***	-0.0870	0	-0.0210***	-0.0361**	-0.0334***	-0.0191***	-0.0253**	-0.0470***	-0.0166**	-0.0648**	-0.00399
	(0.00555)	(0.00552)	(0.0454)	(.)	(0.00558)	(0.0135)	(0.00829)	(0.00553)	(0.00957)	(0.0125)	(0.00561)	(0.0233)	(0.00783)
Downstream	-0.0152**	-0.0239***	-0.00602	-0.0188	-0.0182**	-0.0281***	-0.0382	-0.0270***	-0.00535	-0.0285*	-0.0265***	-0.0238**	-0.0326**
	(0.00546)	(0.00548)	(0.0102)	(0.0110)	(0.00555)	(0.00742)	(0.0278)	(0.00554)	(0.00934)	(0.0130)	(0.00568)	(0.00853)	(0.0115)
In-Degree		-0.00127***	-0.0729	-0.000703***									
		(0.000116)	(0.0455)	(0.000142)									
Out-Degree					-0.000605**	-0.0230***	-0.000336						
					(0.000206)	(0.00622)	(0.000263)						
Degree								-0.000994***	0.00332	-0.000658***			
								(0.0000955)	(0.00442)	(0.000118)			
Eccentricity											-0.00248***	0.0233*	0.00277
											(0.000356)	(0.00937)	(0.00219)
Observations	8958	8946	2472	2519	8946	3550	2716	8946	2236	2647	8946	2631	3262
R^2	0.024	0.037	0.079	0.154	0.025	0.060	0.103	0.036	0.075	0.130	0.029	0.076	0.042

Table 3.11: **Pooled regression. Supply chain. Market Leverage Deficit.** The table reports the results of regressions for Authority (columns (1) – (3)) and Hub (columns (4) – (6)), Pagerank (columns (7) – (9)), Storing Component (columns (10) – (12)), Eigen Centrality (columns (13) – (15)). The first column corresponding to the centrality measures is estimated on the entire sample. The second ones correspond to peripheral firms and the third correspond to core firms. Estimated by the ordinary least squares method. Industry and year fixed effects. Standard errors are in parentheses as follows: *, ** and *** stand for 5%, 1% and 0.1% significance levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Firm Size (log of sales)	0.00292*	0.00780*	-0.0141***	-0.00278**	0.00690*	-0.00561**	-0.000947	0.00530	-0.00632***	-0.00330**	0.00130	0.00718*	-0.000415	0.00818*	-0.00832***
	(0.00122)	(0.00320)	(0.00236)	(0.00108)	(0.00289)	(0.00188)	(0.00113)	(0.00351)	(0.00189)	(0.00107)	(0.00223)	(0.00324)	(0.00114)	(0.00352)	(0.00189)
Market-to-Book	-0.00177	0.00563	-0.00968*	-0.00255	-0.0128**	-0.0239***	-0.00238	-0.000848	-0.0118***	-0.00256	-0.0179***	0.00239	-0.00247	0.00210	-0.0161***
	(0.00186)	(0.00404)	(0.00385)	(0.00187)	(0.00435)	(0.00407)	(0.00186)	(0.00413)	(0.00358)	(0.00187)	(0.00395)	(0.00400)	(0.00186)	(0.00432)	(0.00375)
Profitability	-0.0344*	-0.000850	0.0788	-0.0249	-0.00508	0.128**	-0.0299	0.0164	-0.0747*	-0.0237	0.00378	0.00575	-0.0314	-0.00254	0.0406
	(0.0171)	(0.0358)	(0.0421)	(0.0171)	(0.0441)	(0.0424)	(0.0171)	(0.0393)	(0.0301)	(0.0171)	(0.0383)	(0.0404)	(0.0171)	(0.0407)	(0.0336)
Tangibility	-0.0438***	-0.0846***	0.0401	-0.0499***	-0.0781***	-0.0270	-0.0491***	-0.117***	0.0343	-0.0489***	-0.0255	-0.0843***	-0.0531***	-0.0984***	-0.0153
	(0.0104)	(0.0208)	(0.0211)	(0.0105)	(0.0215)	(0.0215)	(0.0104)	(0.0230)	(0.0208)	(0.0105)	(0.0209)	(0.0227)	(0.0105)	(0.0238)	(0.0208)
R&D ratio	-0.104**	-0.163*	-0.240**	-0.115**	-0.0691	-0.117*	-0.115**	-0.123	0.00664	-0.117**	-0.0599	-0.177*	-0.112**	-0.197*	0.00289
	(0.0375)	(0.0760)	(0.0762)	(0.0377)	(0.164)	(0.0583)	(0.0376)	(0.0686)	(0.105)	(0.0377)	(0.0953)	(0.0804)	(0.0376)	(0.0978)	(0.105)
Counterpart R&D ratio	-0.101*	-0.0233	0.0850	-0.116**	-0.366**	0.0990	-0.120**	0.0321	-0.290**	-0.119**	-0.193*	-0.00580	-0.110*	0.0344	-0.250*
	(0.0444)	(0.122)	(0.0717)	(0.0447)	(0.135)	(0.0648)	(0.0446)	(0.117)	(0.111)	(0.0446)	(0.0923)	(0.117)	(0.0446)	(0.130)	(0.108)
R&D * Counter R&D	0.376***	0.433	0.231	0.401***	1.155*	0.0816	0.407***	0.0511	0.319	0.405***	0.757***	0.602	0.392***	0.864	0.253
	(0.0816)	(0.284)	(0.119)	(0.0821)	(0.560)	(0.112)	(0.0819)	(0.296)	(0.195)	(0.0819)	(0.198)	(0.395)	(0.0819)	(0.652)	(0.189)
Upstream	-0.0205***	-0.0203*	-0.0921	-0.0220***	0.00841	-0.0198*	-0.0244***	-0.0259*	0	-0.0107	-0.0324	-0.00666	-0.0251***	-0.0994*	0
	(0.00553)	(0.00884)	(0.139)	(0.00557)	(0.0331)	(0.00888)	(0.00555)	(0.0117)	(.)	(0.00636)	(0.0463)	(0.00865)	(0.00555)	(0.0505)	(.)
Downstream	-0.0213***	-0.00581	-0.00983	-0.0164**	-0.0226*	-0.0591	-0.0197***	-0.0185	-0.0645***	-0.0115*	-0.0114	-0.00788	-0.0216***	0.00603	-0.0241
	(0.00546)	(0.0163)	(0.0106)	(0.00551)	(0.00898)	(0.0522)	(0.00551)	(0.0119)	(0.0151)	(0.00554)	(0.0109)	(0.0115)	(0.00553)	(0.0135)	(0.0160)
Authority	-0.634***	-279.1	-0.143												
	(0.0639)	(344.5)	(0.0742)												
Hub				-0.125	0	0.0417									
				(0.0757)	(.)	(0.109)									
Pageranks							-7.100***	-430.0	-5.698***						
							(1.296)	(362.4)	(1.490)						
Strong Component Number										-0.0000175***	-0.0000739**	-0.000000268			
										(0.00000452)	(0.0000244)	(0.00000920)			
Eigen Centrality													-0.104***	-87.80	-0.0956***
													(0.0159)	(45.70)	(0.0207)
Observations	8946	1802	2474	8946	2364	2340	8946	1750	2596	8946	2592	1745	8946	1628	2614
R^2	0.035	0.087	0.111	0.024	0.070	0.082	0.027	0.079	0.108	0.026	0.079	0.060	0.029	0.087	0.114

Following the logic of Charoenwong (2016), I split the sample into three groups according to their proximity to the final consumer: downstream, midstream, and upstream firms. The upstream are the ones who have no suppliers. The downstream are those who have no business customers. We expect upstream firms to have less leverage. However, the results I observe tend to be the opposite: all supply chain position coefficients are negative and the coefficients corresponding to upstream firms are lower in magnitude. Thus, the leverage for upstream firms is higher on average.

The Market Leverage is countercyclical to all centrality measures.[12] It means that whether a company has more trading partners (represented by In-degree, Out-degree, and Degree), is situated in a more important network location (Authority and Hub), or is considered more influential (Eigen Centrality), it will tend to have lower leverage. This gives us an insight that leverage is used as a commitment device.

Panels for the core and peripheral firms show that for different centrality measures, either core or peripheral companies could drive the effect.

To exploit the structure of the data in a more efficient way, I proceed with the Fama-Macbeth procedure. Tables 3.12 – 3.13 show the result. I apply the same empirical model as in pooled regression and the results stay unchanged.

[12] The centrality measures that are not reported here — closeness, harmonic closeness, betweenness, modularity, and component number – have not shown significant results.

Table 3.12: **Fama-MacBeth. Supply chain. Market Leverage.** The table reports the results of panel estimation by Fama-MacBeth procedure. The first column reports a regression with conventional explanatory variables: size, market-to-book ratio, profitability ratio, asset tangibility, lagged dependent variable, and time-invariant concentration variable. The columns (2)–(13) correspond to regressions with a conventional set of explanatory variables plus a measure of centrality. The first column corresponding to the centrality measures is estimated on the entire sample. The second ones correspond to peripheral firms and the third correspond to core firms. Industry fixed effects. Standard errors are in parentheses as follows: *, ** and *** stand for 5%, 1% and 0.1% significance levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Firm Size (log of sales)	0.00490***	0.0204***	0.0209***	0.0180***	0.00778***	0.0113***	0.00651***	0.0177***	0.0173***	0.0159***	0.00636***	0.00341	0.00642**
	(0.00106)	(0.00377)	(0.00347)	(0.00405)	(0.00141)	(0.00188)	(0.00103)	(0.00215)	(0.00344)	(0.00226)	(0.00106)	(0.00350)	(0.00167)
Market-to-Book	-0.0567***	-0.0565***	-0.0659***	-0.0567***	-0.0492***	-0.0652***	-0.0540***	-0.0535***	-0.0648***	-0.0583***	-0.0547***	-0.0783***	-0.0512***
	(0.00500)	(0.00471)	(0.0114)	(0.00499)	(0.0109)	(0.0109)	(0.00673)	(0.00676)	(0.0110)	(0.00705)	(0.00556)	(0.0121)	(0.00482)
Profitability	-0.376***	-0.400***	-0.335***	-0.488***	-0.381***	-0.487***	-0.374***	-0.399***	-0.405***	-0.405***	-0.381***	-0.326***	-0.398***
	(0.0360)	(0.0376)	(0.0391)	(0.0479)	(0.0359)	(0.0458)	(0.0407)	(0.0372)	(0.0449)	(0.0410)	(0.0360)	(0.0459)	(0.0380)
Tangibility	0.110***	0.115***	0.0624***	0.172***	0.109***	0.105***	0.122***	0.112***	0.0689**	0.159***	0.113***	0.0985***	0.0886***
	(0.0126)	(0.0131)	(0.0129)	(0.0190)	(0.0123)	(0.0172)	(0.0145)	(0.0127)	(0.0186)	(0.0170)	(0.0132)	(0.0168)	(0.0194)
R&D ratio	1.340**	1.073*	0.153	2.194*	1.323**	3.921**	0.431	1.118*	1.515	0.725	1.368**	3.753***	0.108
	(0.440)	(0.433)	(0.949)	(0.804)	(0.428)	(0.934)	(0.497)	(0.420)	(0.779)	(0.723)	(0.425)	(0.767)	(0.518)
Counterpart R&D ratio	0.0341	-0.0156	-0.0859	-0.511*	0.0369	0.265	-0.177	0.0174	0.161	-0.337	0.0761	0.237	-0.108
	(0.161)	(0.151)	(0.169)	(0.197)	(0.159)	(0.214)	(0.155)	(0.158)	(0.188)	(0.243)	(0.157)	(0.302)	(0.145)
R&D * Count R&D	1.870	0.581	7.309*	9.161	1.607	-9.038	11.47	0.515	-0.193	8.938**	1.502	-8.357	12.66**
	(3.571)	(3.269)	(3.145)	(9.293)	(3.489)	(8.026)	(8.317)	(3.268)	(3.876)	(2.850)	(3.445)	(8.640)	(4.149)
Upstream	-0.0213***	-0.0201***	-0.0252**	0	-0.0186***	-0.0159*	-0.00620	-0.0169***	-0.00878	-0.0245**	-0.0146**	-0.0227*	-0.00416
	(0.00387)	(0.00386)	(0.00661)	(.)	(0.00367)	(0.00683)	(0.00650)	(0.00360)	(0.00536)	(0.00673)	(0.00401)	(0.00784)	(0.00690)
Downstream	-0.0167*	-0.0263***	-0.0180***	-0.0380***	-0.0211**	-0.0358***	-0.0266*	-0.0298***	-0.0176***	-0.0466***	-0.0284***	-0.0306***	-0.0240*
	(0.00558)	(0.00583)	(0.00365)	(0.00767)	(0.00527)	(0.00510)	(0.0117)	(0.00579)	(0.00388)	(0.0106)	(0.00650)	(0.00585)	(0.0109)
In-Degree		-0.00291*	-0.00719*	-0.00272*									
		(0.00116)	(0.00264)	(0.00117)									
Out-Degree					-0.00220	-0.0142***	-0.000515						
					(0.00117)	(0.00267)	(0.000292)						
Degree								-0.00166***	-0.00325**	-0.00152***			
								(0.000344)	(0.000932)	(0.000357)			
Eccentricity											-0.00531*	-0.00778***	0.00377
											(0.00220)	(0.00176)	(0.00286)
Observations	9117	9105	4542	5496	9105	4674	5412	9105	4335	5270	9105	5419	5338

Table 3.13: **Fama-MacBeth. Supply chain. Market Leverage.** The table reports the results of panel estimation by Fama-MacBeth procedure. Columns report a regression with conventional explanatory variables: size, market-to-book ratio, profitability ratio, asset tangibility, lagged dependent variable, and time-invariant concentration variable, — plus a measure of centrality. The first column corresponding to the centrality measures is estimated on the entire sample. The second ones correspond to peripheral firms and the third correspond to core firms. Standard errors are in parentheses as follows: *, ** and *** stand for 5%, 1% and 0.1% significance levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Firm Size (log of sales)	0.0127***	0.0267***	0.00640**	0.00546***	0.00342	0.00535***	0.00838***	0.0145**	0.00621***	0.00468***	0.00464***	0.00582***	0.00890***	0.0174***	0.00477**
	(0.00161)	(0.00363)	(0.00191)	(0.00112)	(0.00422)	(0.00107)	(0.00132)	(0.00350)	(0.00121)	(0.000970)	(0.00107)	(0.00118)	(0.00126)	(0.00264)	(0.00143)
Market-to-Book	-0.0560***	-0.0522***	-0.0617***	-0.0569***	-0.0765***	-0.0537***	-0.0568***	-0.0619***	-0.0589***	-0.0566***	-0.0548***	-0.0527***	-0.0561***	-0.0709***	-0.0574***
	(0.00494)	(0.00499)	(0.00702)	(0.00505)	(0.0143)	(0.00565)	(0.00502)	(0.00556)	(0.00540)	(0.00510)	(0.00472)	(0.00608)	(0.00546)	(0.0106)	(0.00583)
Profitability	-0.392***	-0.399***	-0.379***	-0.377***	-0.424***	-0.338***	-0.386***	-0.311***	-0.455***	-0.375***	-0.406***	-0.365***	-0.387***	-0.317***	-0.430***
	(0.0370)	(0.0361)	(0.0494)	(0.0359)	(0.0489)	(0.0421)	(0.0359)	(0.0440)	(0.0430)	(0.0358)	(0.0392)	(0.0350)	(0.0362)	(0.0343)	(0.0414)
Tangibility	0.116***	0.0708**	0.158***	0.109***	0.103***	0.125***	0.112***	0.0862***	0.137***	0.111***	0.137***	0.113***	0.106***	0.0656***	0.135***
	(0.0134)	(0.0177)	(0.0189)	(0.0124)	(0.0134)	(0.0198)	(0.0127)	(0.0132)	(0.0158)	(0.0127)	(0.0169)	(0.0151)	(0.0124)	(0.0136)	(0.0205)
R&D ratio	1.235*	-1.180	2.816**	1.325**	4.429**	0.649	1.142*	1.531	1.157	1.353**	1.669**	0.592	1.184*	-0.0292	1.582
	(0.435)	(1.177)	(0.888)	(0.430)	(1.107)	(0.496)	(0.429)	(1.083)	(1.006)	(0.429)	(0.510)	(0.388)	(0.436)	(0.794)	(0.838)
Counterpart R&D ratio	0.0120	-0.109	-0.0946	0.0538	-0.225	-0.102	-0.0118	-0.0494	-0.433	0.0522	0.113	-0.0225	-0.0285	-0.243	-0.0199
	(0.154)	(0.139)	(0.181)	(0.161)	(0.281)	(0.173)	(0.160)	(0.205)	(0.213)	(0.156)	(0.208)	(0.135)	(0.159)	(0.220)	(0.253)
R&D * Count R&D	0.260	12.46***	12.32	1.782	-4.932	24.23**	2.023	11.37	10.40	1.504	-2.445	8.342*	2.097	15.45	7.791
	(3.437)	(2.933)	(10.26)	(3.564)	(9.810)	(6.416)	(3.426)	(8.370)	(8.372)	(3.579)	(4.096)	(3.668)	(3.518)	(8.016)	(7.807)
Authority	-0.779***	0.466	-0.573***												
	(0.0759)	(4.476)	(0.0665)												
Upstream	-0.0183***	-0.0140	-0.0252	-0.0196***	-0.0247	-0.00677	-0.0234***	-0.00630	0	-0.00653	-0.0372	-0.0174**	-0.0235***	-0.0133	-0.00536
	(0.00386)	(0.00711)	(0.0167)	(0.00363)	(0.0118)	(0.00774)	(0.00396)	(0.00525)	(.)	(0.00426)	(0.0183)	(0.00438)	(0.00391)	(0.00635)	(0.00536)
Downstream	-0.0238**	-0.0221**	-0.0177*	-0.0192**	-0.0343***	-0.0196	-0.0229**	-0.00398	-0.0434**	-0.0128*	-0.0276***	-0.0117	-0.0243**	-0.0200**	-0.0256*
	(0.00579)	(0.00636)	(0.00708)	(0.00560)	(0.00564)	(0.0162)	(0.00592)	(0.00547)	(0.0135)	(0.00538)	(0.00652)	(0.00750)	(0.00577)	(0.00570)	(0.0116)
Hub				-0.277***	-11.90*	0.0684									
				(0.0481)	(3.998)	(0.0435)									
Pageranks							-10.38***	71.87	-9.979***						
							(1.320)	(52.81)	(1.330)						
Strong Component Number										0.000155	0.0000185	0.000688			
										(0.000179)	(0.000146)	(0.000678)			
Eigen Centrality													-0.140***	-0.248	-0.127***
													(0.0168)	(0.683)	(0.0156)
Observations	9105	4194	4924	9105	4466	4651	9105	3894	5217	9105	6583	7016	9105	3959	5153

Further, I test the direction of the influence: to the previous setting I add a lagged trading partner's leverage. For the firms which have customers it will be a customer leverage. For the firms which have suppliers I add supplier's leverage. Table 3.14 shows significant influence by the lagged leverage ratio of both a customer and a supplier. Thus, I cannot exclude upstream or downstream directions of influence of capital structure policy spread.

Table 3.14: **Market Leverage as a response to Customer/Supplier Market Leverage.** The table reports the results of regressions with inclusion of two customer/supplier characteristics: lagged leverage and R&D ratio. The columns with odd numbers correspond to suppliers sample and their reaction to customers' leverage and R&D. The columns with even numbers correspond to customers sample and their reaction to suppliers' leverage and R&D. Industry fixed effects. Standard errors are in parentheses as follows: *, ** and *** stand for 5%, 1% and 0.1% significance levels, respectively.

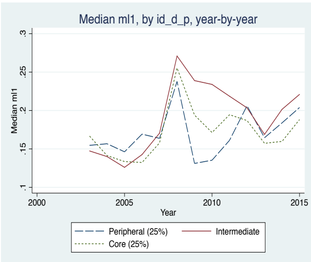
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cust/Sup Market Leverage	0.664***	0.622***	0.655***	0.615***	0.663***	0.621***	0.655***	0.615***
	(0.0125)	(0.0111)	(0.0125)	(0.0111)	(0.0125)	(0.0111)	(0.0125)	(0.0111)
Firm Size (log of sales)	0.00277**	0.00166	0.00845***	0.00736***	0.00311**	0.00197*	0.00776***	0.00659***
	(0.000934)	(0.000918)	(0.00115)	(0.00112)	(0.000954)	(0.000937)	(0.00113)	(0.00110)
Market-to-Book	-0.0468***	-0.0453***	-0.0467***	-0.0451***	-0.0469***	-0.0454***	-0.0469***	-0.0453***
	(0.00169)	(0.00166)	(0.00169)	(0.00166)	(0.00169)	(0.00166)	(0.00169)	(0.00166)
Profitability	-0.0886***	-0.0797***	-0.0989***	-0.0899***	-0.0890***	-0.0803***	-0.0971***	-0.0881***
	(0.0153)	(0.0151)	(0.0153)	(0.0151)	(0.0154)	(0.0151)	(0.0153)	(0.0151)
Tangibility	0.0578***	0.0682***	0.0616***	0.0721***	0.0573***	0.0677***	0.0591***	0.0696***
	(0.00994)	(0.00970)	(0.00992)	(0.00968)	(0.00996)	(0.00972)	(0.00992)	(0.00968)
Cust/Sup R&D ratio	-0.337***	-0.313***	-0.324***	-0.305***	-0.332***	-0.308***	-0.318***	-0.297***
	(0.0350)	(0.0333)	(0.0349)	(0.0332)	(0.0351)	(0.0334)	(0.0350)	(0.0333)
R&D ratio	0.274***	0.317***	0.273***	0.330***	0.273***	0.316***	0.272***	0.324***
	(0.0364)	(0.0406)	(0.0363)	(0.0405)	(0.0364)	(0.0407)	(0.0363)	(0.0405)
R&D * C/S R&D	0.196***	0.123*	0.184***	0.105*	0.191***	0.119*	0.177***	0.100
	(0.0530)	(0.0526)	(0.0528)	(0.0525)	(0.0531)	(0.0527)	(0.0529)	(0.0525)
In-Degree			-0.000899***	-0.000917***				
			(0.000105)	(0.000103)				
Out-Degree					-0.000351	-0.000327		
					(0.000184)	(0.000181)		
Degree							-0.000679***	-0.000683***
							(0.0000861)	(0.0000843)
Observations	8606	8777	8595	8766	8595	8766	8595	8766
R^2	0.520	0.531	0.524	0.535	0.520	0.531	0.523	0.534

3.3.4 Partner Firms' Network

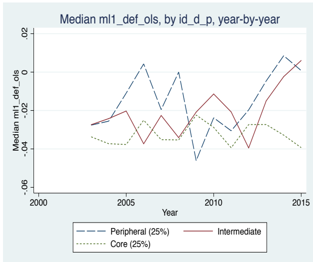
The partners relations are more similar in nature to supply chains than to a competition. They are regulated by a formal agreement. The difference is that the regulation is not as strict: delivery payments usually do not have to be made in advance and some types of partnership do not have an immediate effect on company's output.

Figure 3.9 show no clear evidence of higher or lower leverage for core or peripheral firms.

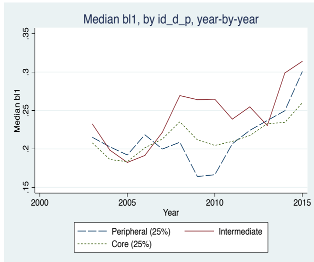
I introduce two alternative definitions of partnership, which are two sub-types of partners set: partner-investors (with equity cross-holdings or joint investment into a third company) and partner-manufacturers (joint production, research, licensing, etc.) and test the following model with three different definitions of partners:



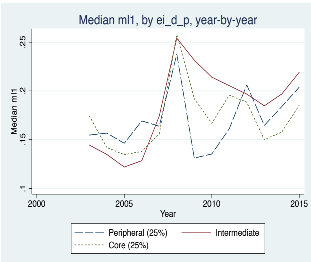
(a) Market Leverage — In-degree



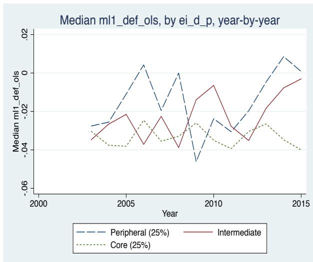
(b) Market Leverage Deficit — In-degree



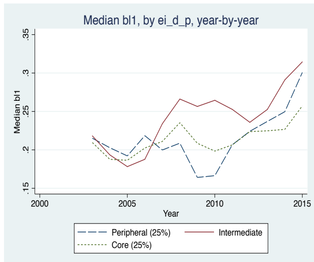
(c) Book Leverage — In-degree



(d) Market Leverage — Eigen Centrality



(e) Market Leverage Deficit — Eigen Centrality



(f) Book Leverage — Eigen Centrality

Figure 3.9: **Dynamics of average Market Leverage, Market Leverage Deficit, and Book Leverage across the economy split with respect to In-degree and Eigen centrality measures. Partner Network.** The core industries are defined as a top quartile with respect to a centrality measure. The peripheral industries correspond to the bottom quartile.

$$y_t = \alpha + X_{t-1}^{partner}\beta + Industry\ FE + Year\ FE + \epsilon_t,$$

where y is the measure of capital structure and $X^{partner}$ is the firm's characteristic matrix, ϵ is the error vector, and (α', β') is the vector of parameters. Tables 3.15 – 3.16 show the results. The centrality measures which have significant coefficients both in production and in partner networks keep their negative association. However, Closeness and Harmonic Closeness which were insignificant in supply chain regressions have positive coefficients. However, as it is the only two measures, which are similar in nature, balanced out by 6 other measures, I tend infer that partner network can be viewed as a mild form of the production network and partner network has a particular structure. Some nodes can have only a few links to the key vertices, i.e., a few connections with its own neighbours but stay linked by shorts paths with the other nodes of the network. Under these conditions some nodes would expose low In-degree, Out-degree, and Degree and high Closeness and Harmonic Closeness.

Table 3.15: **Pooled regression. Partners. Market Leverage.** The table reports the results of ordinary least squares regression. Column (1) reports the estimates for a specification without any centrality measure. The following columns go by blocks of 3, every block corresponds to a centrality measure: In-degree, Out-degree, Degree, and Betweenness. Columns (2), (5), (8), and (11) correspond to the identification of a partner of any type. Columns (3), (6), (9), and (12) correspond to a partner-investor type, i.e, a partner either holds stocks of the source company, or the source company owns the partner's stocks, or they jointly own stocks of the third company. Columns (4), (7), (10), and (13) correspond to a partner-manufacturer type, i.e, the source and the partner companies either manufacture a product together, or hold a joint license, or one of them licences a technology to the other, or they have a joint research department. The logic of using leverage as a commitment mechanism holds here. Industry and year fixed effects. Standard errors are in parentheses as follows: *, ** and *** stand for 5%, 1% and 0.1% significance levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Firm Size (log of sales)	0.00390***	0.00538***	0.00524***	0.00524***	0.00483***	0.00499***	0.00491***	0.00570***	0.00551***	0.00571***	0.00576***	0.00577***	0.00579***
	(0.00103)	(0.00111)	(0.00110)	(0.00110)	(0.00108)	(0.00111)	(0.00107)	(0.00112)	(0.00112)	(0.00112)	(0.00109)	(0.00109)	(0.00109)
Market-to-Book	-0.0749***	-0.0748***	-0.0748***	-0.0748***	-0.0748***	-0.0748***	-0.0748***	-0.0748***	-0.0748***	-0.0748***	-0.0750***	-0.0751***	-0.0750***
	(0.00187)	(0.00187)	(0.00187)	(0.00187)	(0.00187)	(0.00187)	(0.00187)	(0.00187)	(0.00187)	(0.00187)	(0.00187)	(0.00187)	(0.00187)
Profitability	-0.153***	-0.152***	-0.152***	-0.152***	-0.156***	-0.156***	-0.156***	-0.154***	-0.154***	-0.154***	-0.155***	-0.154***	-0.155***
	(0.0175)	(0.0175)	(0.0175)	(0.0175)	(0.0175)	(0.0175)	(0.0175)	(0.0175)	(0.0175)	(0.0175)	(0.0175)	(0.0175)	(0.0175)
Tangibility	0.0971***	0.0975***	0.0976***	0.0976***	0.0973***	0.0981***	0.0970***	0.0976***	0.0979***	0.0975***	0.0972***	0.0973***	0.0973***
	(0.0104)	(0.0104)	(0.0104)	(0.0104)	(0.0104)	(0.0104)	(0.0104)	(0.0104)	(0.0104)	(0.0104)	(0.0104)	(0.0104)	(0.0104)
R&D ratio	-0.187***	-0.182***	-0.183***	-0.183***	-0.179***	-0.183***	-0.177***	-0.179***	-0.182***	-0.178***	-0.182***	-0.183***	-0.181***
	(0.0382)	(0.0382)	(0.0382)	(0.0382)	(0.0383)	(0.0382)	(0.0383)	(0.0382)	(0.0382)	(0.0382)	(0.0381)	(0.0381)	(0.0381)
Counterpart R&D ratio	-0.143**	-0.131**	-0.133**	-0.133**	-0.130**	-0.138**	-0.127**	-0.126**	-0.132**	-0.125**	-0.126**	-0.128**	-0.126**
	(0.0456)	(0.0457)	(0.0457)	(0.0457)	(0.0458)	(0.0456)	(0.0458)	(0.0458)	(0.0457)	(0.0458)	(0.0457)	(0.0456)	(0.0457)
R&D * Counter R&D	0.525***	0.505***	0.510***	0.510***	0.503***	0.516***	0.497***	0.498***	0.508***	0.495***	0.500***	0.504***	0.499***
	(0.0851)	(0.0852)	(0.0851)	(0.0851)	(0.0853)	(0.0851)	(0.0854)	(0.0853)	(0.0851)	(0.0853)	(0.0851)	(0.0850)	(0.0851)
In-Degree		-0.000783***	-0.000758***	-0.000758***									
		(0.000211)	(0.000214)	(0.000214)									
Out-Degree					-0.00174**	-0.00200**	-0.00204***						
					(0.000577)	(0.000709)	(0.000580)						
Degree								-0.000738***	-0.000694***	-0.000770***			
								(0.000180)	(0.000184)	(0.000178)			
Betweenness											-0.00000142***	-0.00000148***	-0.00000146***
											(0.000000269)	(0.000000274)	(0.000000270)
Observations	9751	9742	9745	9745	9742	9745	9746	9742	9745	9746	9742	9745	9746
R^2	0.355	0.356	0.356	0.356	0.355	0.355	0.356	0.356	0.356	0.356	0.357	0.357	0.357

Table 3.16: **Pooled regression. Partners. Market Leverage Deficit.** The table reports the results of ordinary least squares regression. Columns go by blocks of 3, every block corresponds to a centrality measure: Closeness, Harmonic Closeness, Authority and Hub, and Eigen Centrality. Columns (1), (4), (7), (10), and (13) correspond to the identification of a partner of any type. Columns (2), (5), (8), (11), and (14) correspond to a partner-investor type, i.e, a partner either holds stocks of the source company, or the source company owns the partner's stocks, or they jointly own stocks of the third company. Columns (3), (6), (9), (12), and (15) correspond to a partner-manufacturer type, i.e, the source and the partner companies either manufacture a product together, or hold a joint license, or one of them licenses a technology to the other, or they have a joint research department. The logic of using leverage as a commitment mechanism holds for Hub and Eigen Centrality measures. Closeness and Harmonic Closeness support an alternative hypothesis of leverage being used as a bargaining tool. Industry and year fixed effects. Standard errors are in parentheses as follows: *, ** and *** stand for 5%, 1% and 0.1% significance levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Firm Size (log of sales)	-0.00312**	-0.00318**	-0.00266**	-0.00315**	-0.00321**	-0.00264**	-0.00232*	-0.00238*	-0.00230*	-0.00210*	-0.00216*	-0.00209*	-0.00117	-0.00132	-0.00119
	(0.00100)	(0.00101)	(0.00100)	(0.00100)	(0.00101)	(0.00100)	(0.00102)	(0.00101)	(0.00101)	(0.000996)	(0.00101)	(0.000996)	(0.00104)	(0.00104)	(0.00104)
Market-to-Book	-0.00201	-0.00200	-0.00192	-0.00201	-0.00200	-0.00191	-0.00185	-0.00185	-0.00185	-0.00184	-0.00183	-0.00184	-0.00175	-0.00178	-0.00176
	(0.00180)	(0.00180)	(0.00180)	(0.00180)	(0.00180)	(0.00180)	(0.00180)	(0.00180)	(0.00180)	(0.00180)	(0.00180)	(0.00180)	(0.00180)	(0.00180)	(0.00180)
Profitability	-0.0204	-0.0203	-0.0238	-0.0202	-0.0202	-0.0239	-0.0231	-0.0233	-0.0239	-0.0244	-0.0243	-0.0249	-0.0241	-0.0240	-0.0246
	(0.0168)	(0.0168)	(0.0168)	(0.0168)	(0.0168)	(0.0168)	(0.0168)	(0.0168)	(0.0168)	(0.0167)	(0.0168)	(0.0167)	(0.0167)	(0.0167)	(0.0167)
Tangibility	-0.0536***	-0.0542***	-0.0525***	-0.0536***	-0.0542***	-0.0526***	-0.0526***	-0.0526***	-0.0525***	-0.0530***	-0.0522***	-0.0530***	-0.0521***	-0.0519***	-0.0520***
	(0.00996)	(0.00997)	(0.00997)	(0.00996)	(0.00997)	(0.00997)	(0.00996)	(0.00996)	(0.00996)	(0.00995)	(0.00996)	(0.00995)	(0.00995)	(0.00996)	(0.00995)
R&D ratio	-0.113**	-0.111**	-0.114**	-0.113**	-0.111**	-0.113**	-0.112**	-0.113**	-0.112**	-0.109**	-0.112**	-0.109**	-0.107**	-0.109**	-0.107**
	(0.0366)	(0.0366)	(0.0366)	(0.0366)	(0.0366)	(0.0366)	(0.0366)	(0.0366)	(0.0366)	(0.0366)	(0.0366)	(0.0366)	(0.0366)	(0.0366)	(0.0366)
Counterpart R&D ratio	-0.127**	-0.123**	-0.130**	-0.127**	-0.123**	-0.129**	-0.125**	-0.126**	-0.127**	-0.114**	-0.126**	-0.115**	-0.118**	-0.121**	-0.119**
	(0.0437)	(0.0437)	(0.0438)	(0.0437)	(0.0438)	(0.0438)	(0.0438)	(0.0438)	(0.0438)	(0.0439)	(0.0437)	(0.0438)	(0.0438)	(0.0437)	(0.0438)
R&D * Counter R&D	0.415***	0.411***	0.418***	0.417***	0.411***	0.417***	0.412***	0.414***	0.413***	0.396***	0.413***	0.396***	0.399***	0.404***	0.399***
	(0.0815)	(0.0816)	(0.0816)	(0.0816)	(0.0816)	(0.0817)	(0.0817)	(0.0816)	(0.0817)	(0.0817)	(0.0816)	(0.0817)	(0.0816)	(0.0816)	(0.0816)
Closenness	0.0176***	0.0166**	0.00420												
	(0.00467)	(0.00515)	(0.00664)												
Harmonic Closenness				0.0169***	0.0160**	0.00278									
				(0.00463)	(0.00508)	(0.00652)									
Authority							-0.0568	-0.0453	-0.0580						
							(0.0482)	(0.0492)	(0.0482)						
Hub										-0.376***	-0.287*	-0.378***			
										(0.0899)	(0.124)	(0.0903)			
Eigen Centrality													-0.111***	-0.106***	-0.110***
													(0.0252)	(0.0259)	(0.0252)
Observations	9742	9745	9746	9742	9745	9746	9742	9745	9746	9742	9745	9746	9742	9745	9746
R^2	0.020	0.020	0.019	0.020	0.020	0.019	0.019	0.019	0.019	0.020	0.019	0.020	0.021	0.020	0.021

3.3.5 Robustness Checks

To verify the robustness of my results, I run all tests for 4 variables: Book, Gross Market, and Net Market Leverage, and Market Leverage Deficit. I do not report all results, because the coefficients for Book and Market Leverages are very similar in sign, magnitude, and significance. Although I do not use panel estimations with random effects in the main analysis, I employ it as a robustness check for panel estimations with fixed effects and the Fama-MacBeth procedure estimations. I also run spatial regressions and even though the spatial effect per se is not confirmed, the results support all my findings in competitor and supply chain networks. The regressions with alternative proxies for bargaining power, namely, industry Herfindahl-Hirschmann Index of sales and a yearly concentration of a firm's sales in the total industry sales show similar results.

Throughout the paper I do not include firm fixed effects into regressions. Firm fixed effects increase R-squared by 40-60 p.p.. However, they do not add anything to the explanatory power of the model. They do establish that fact that a firm is unique but do not explain why.

3.4 Conclusion

In order to test my main hypothesis about the role of leverage as a commitment tool, I verify the representativeness of my novel dataset. For the competitor network, I confirm the result of Zhdanov (2008) and Leary and Roberts (2011): peripheral companies have higher leverage (hypothesis 1). There is a significant influence of the lagged leverage ratio of a customer on the leverage ratio of the supplier. However, supplier's leverage affects positively and significantly its customer's leverage too (hypothesis 2). My results are robust to inclusion of upstream and downstream positions dummies (hypothesis 3). In contrast to Gonrall and Strebulaev (2017), core industries tend to have lower leverage (hypothesis 4 is rejected). The leverage shows properties of a commitment device, as core industries tend to have lower leverage. At the same time I repeat the result of Kale and Shahrur (2007), showing that leverage is used as a bargaining tool: customer's leverage positively associated with supplier's R&D expenditures (hypothesis 5 cannot be rejected). Partner network can be interpreted as a mild form of supplier chain network (hypothesis 6).

One of the potential extensions to the present study is to increase the representativeness of the network by combining the properties of the industry and firm level data and by simulations. Another potential extension is to study sub-groups of relations: joint R&D or cross stake holding for partners. For competitors, my minor finding encourages to follow Hoberg and Phillips (2011) and explore the particularities of market competition on the network-like grid.

Chapter 4

Debt Type and Acquisitions

with Theodosios Dimopoulos[1] and Stefano Sacchetto [2]

In this paper, we study empirically how deviations from target debt maturity affect acquisition decisions. We find that the probability of becoming an acquirer is positively associated with the firm's pre-acquisition deviation from target debt maturity. Moreover, we examine the implications of debt maturity for bidder and target returns, and for target selection. We also investigate the potential of several economic theories to explain the link between debt maturity and acquisition policy.

4.1 Introduction

What is the effect of debt maturity on corporate acquisitions? While recent evidence by Uysal (2011) and Harford, Klasa, and Walcott (2009) show that leverage affects the likelihood that a firm becomes an acquirer and how it finances its bid, the relation between debt maturity and acquisition policies remains unexplored. Answering this question allows us to better understand which types of financing frictions drive corporate investment.

Several theories study the interaction between debt maturity and investment. Myers (1977) suggests that short-term debt is a solution to the debt overhang problem.[3] He argues that, even if a firm has a positive net-present-value investment opportunity, shareholders may not want to invest in it to avoid sharing the benefits with the debt holders in the event of default. However, short term debt allows equity holders to exercise their investment option after debt repayment, thus avoiding sharing the investment returns with debt holders. Ceteris paribus, the probability that a firm engages in large investments, such as acquisitions, should be negatively related to its debt maturity. Other theories argue that long-term debt can be beneficial, since it avoids short-term refinancing costs. These costs reflect debt holdup problems (Diamond (1991)), or transaction costs in debt rollover (Titman and Tsyplakov (2007), Kuehn and Schmid (2014) and Poeschl (2017)). Hence, ceteris paribus, firms with a longer debt maturity are more likely to engage in acquisitions.

In this chapter, we study empirically how deviations from target debt maturity affect acquisition decisions. We find that the probability of becoming an acquirer is positively associated with the firm's pre-acquisition deviation from target debt maturity. Moreover,

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[3]Compared to this classical result, Diamond and He (2014) present a dynamic model and show that, depending on the timing of investment opportunities, short-term debt can generate a higher debt overhang problem.

we examine the implications of debt maturity for bidder and target returns, and for target selection. We also investigate the potential of several economic theories to explain the link between debt maturity and acquisition policy.

Since target levels of capital structure are unobservable, we employ a two-stage estimation procedure to estimate the effects of deviations from target leverage and maturity of debt. In the first stage, we use the simultaneous-equation system proposed by Johnson (2003) to jointly determine leverage and debt maturity targets of firms. This step allows capital structure targets to vary according to firm size, growth opportunities, profitability, tangibility, cash flow volatility, asset maturity, investment tax credits and loss carryforwards. In the second stage, we perform a probit regression of the probability of becoming an acquirer on the leverage and debt maturity deficits obtained from the first stage, and other controls. We perform our analysis on a large sample of mergers and acquisitions for public U.S. companies using data from Compustat and SDC Platinum for the period 1991 to 2013.

The main finding of our paper is that a positive deviation from target debt maturity in a period, i.e. a current ratio of long-term-debt to total debt higher than the predicted target, is positively associated with the probability that a firm becomes an acquirer in the next period. This effect is significantly both statistically and economically: moving from the bottom to the top decile of maturity deficit increases the likelihood of becoming an acquirer from 10% to 16%. This result reflects a positive effect of debt maturity on both asset- and firm acquisitions. These results are consistent with theories of costly debt rollover (Titman and Tsyplakov (2007), Kuehn and Schmid (2014) and Poeschl (2017)) and dynamic debt overhang (Diamond and He (2014)), but not with static debt overhang (Myers (1977)).

Next, we investigate the potential of dynamic debt overhang to explain the link between debt maturity and acquisition likelihood. Diamond and He (2014) provide a formal analysis of the effect of debt maturity structure on real investment. They show that Myers' (1977) intuitive analysis, which suggests that debt overhang increases with debt maturity, does deserve merit, but it also faces limitations. In their analysis, Diamond and He (2014) highlight the importance of sequential investment opportunities. Firms invest in projects not only because of the direct cash flows they generate, but also because of the future investment projects that they bring.[4] The argument of Diamond and He (2014) is that short-term debt increases the likelihood of default and the risk that future investment projects are lost. In turn, this means that short-term debt decreases the marginal profitability of current investment and accentuates the debt overhang problem.

From an empirical perspective, the theory of Diamond and He (2014) implies that in good times, i.e. when firms have high growth opportunities, short-term debt can hurt investment more than long-term debt. Controlling for leverage, the deviation of long-term debt from target, when interacted with proxies for growth opportunities, should yield a positive effect on the likelihood that the firm is an acquirer. Using three proxies for growth opportunities—the firm's market-to-book ratio, the cash-flow-to-assets ratio, and an indicator variable for years outside of recession—we do not find statistical evidence in favor of the Diamond and He (2014) hypothesis. Thus, we conclude that the positive association between debt maturity and acquisition likelihood does not lend support to either the static or the dynamic debt overhang theory.

When we study the effects of debt maturity on value creation, we do not find any

[4]This consideration is especially important when considering investment in the form of acquisition expenditure, since Fuller, Netter, and Stegemoller (2002) find that more than a third of all the large, nonfinancial, nonutility takeovers are undertaken by serial acquirers.

evidence that the maturity structure significantly affects the acquirer's cumulative abnormal returns (CARs) or the target premium. However, consistent with the idea that short-term debt accentuates financing constraints, we find that deviations from maturity targets are positively associated with the size of the target firms.[5] Overall, we conclude that debt maturity affects the total deal volume, but not the average deal quality.

The analysis in this chapter is most closely related to empirical studies that investigate the dynamics of leverage around mergers and acquisitions. Uysal (2011) shows that deviations from target leverage have a significant effect on the probability that a firm becomes an acquirer: firms with leverage above target have a lower probability of becoming acquirers and of using cash as a means of payment in their offers. Harford, Klasa, and Walcott (2009) study how deviations from target leverage affect the means of financing in M&As, finding that over-levered bidders are less likely to finance acquisitions with further debt. Our contribution is to show that not only the level, but also the maturity of debt affects firms' acquisition decisions.

In general, this chapter contributes to the literature that examines deviations from capital structure targets and their implications on corporate financing and investment choices. In particular, our study relates to Hovakimian, Opler, and Titman (2001), Fama and French (2002), and Flannery and Rangan (2006), who focus on the effect of capital structure deviations from target for security issuance. Finally, our study also builds on the empirical literature that studies the determinants of debt maturity choice (see, for example, Barclay and Smith, 1995; Guedes and Opler, 1996; and Johnson, 2003) to define target debt maturity at the firm level.

The chapter proceeds as follows, in the next section we describe our dataset, Section 4.3 explains how we construct target values for leverage and long-term debt. Section 4.4 covers our findings on the relation between long-term debt deficit and M&A activity. In Section 4.5 we show how long-term deficit affects acquisition deal parameters and Section 4.6 concludes.

4.2 Data

Our sample covers 1988–2014 and is based on the dataset reported by CRSP-Compustat database. Exact definitions of variables are provided in Section 5. To ensure consistency with the existing research (Uysal (2011), Colla, Ippolito, and Li (2013)), we apply several filters.

First, to maintain similar reporting standards, we keep only firms incorporated and having headquarters in the USA, traded on Amex, Nasdaq, or NYSE in USD. This amounts to 77,647 firm-year observations and 7,155 unique firms.

Second, we discard industries exposed to specific regulation: financials and utilitties, — and at the same time clean the dataset of the observations with supposed errors in reporting. Eliminating financials and utilities, on the basis of historical and current SIC codes, leaves 57,724 observations. We drop observations if total assets and total debt are missing, negative, or zero. We eliminate observations if a company has zero tangible assets. We drop firms if their sales are below $10 million, in 1990 dollars, at least once; which results in a sample of 42,574 firm-year observations. Finally, we drop companies whose debt in current liabilities (**dlc**) is less than debt due in the first year (**dd1**). Our sample consists of 42,570 observations.

[5] We also find that overlevered firms acquire smaller target companies, confirming the result in Uysal (2011).

We merge the resulting sample with a sample of takeovers, obtained from Thompson Reuters SDC database. Our takeover information includes information on announcement dates, information about acquiring and target firms, types of takeovers, and transaction values. We apply several filters before merging the datasets. First, we only keep completed takeovers. Second, following Uysal (2011), we keep deals for which the form reported in SDC is "merger", "acquisition of majority interest", "asset acquisition", or "acquisition of certain assets". Third, we keep only cases in which the acquirer seeks to buy more than 50% of the target, and owns more than 50% at completion. Finally, we eliminate deals in which the target is bankrupt or there is a debt restructuring.

In the merged sample, the announcement date of a deal matches the latest closed firm-year observation. The outcome is following: firms which have not participated in M&A activities in a given year remain in the sample as a single firm-year observation. If a firm has participated in a number of M&A activities, it is represented by the corresponding number of firm-year observations with the same fundamental data and different data on every M&A deal involved. We also assign takeovers into two subsamples: firm and asset acquisitions. Firm acquisitions are the deals for which the form reported in SDC is "merger" or "acquisition of majority interest". Asset acquisitions include deals classified as "asset acquisition" or "acquisition of certain assets".

Thus, we are left with 49,176 observations or, as before, 42,570 unique firm-year observations. At this point we apply the last filter: we remove observations if a relative size of the deal (a ratio of the value of the deal to the total assets of bidder) is less than 1% (47,959 observations, 42,142 unique firm-year pairs, 4,324 unique firms). It is worth noting that as the source of fundamental information on firms is Compustat, a database covering publicly traded companies only, we do not cover the statistics for private targets.

Table 4.1 reports the descriptive statistics for our sample. Panel A summarises the fundamental characteristics of the sample. Average *Total Assets* are \$2,312mln in 1990 dollars, varying from \$1.606mln to \$198'104mln. *Market Leverage* averages 23.6% and varies from 0 to 99.2%. *Market-to-Book* ratio has an average of 1.804, a minimum of 0.291 and a maximum of 38.49. *Profitability* averages 0.125 and has extremes of −5.149 and 1.389. *Tangibility* has an average of 0.312 over a unit interval. *Sales* have an average of 5.984, a minimum of −1.911 and a maximum of 12.56. All the variables are winsorised at 1% and 99% levels, except *Profitability* which is winsorised at 2% and 98%. Overall, the statistics for fundamentals are consistent with the literature (Betton, Eckbo, and Thorburn (2008)).

Panel B reports the statistics for M&A activity. 32.4% of firms interest our sample make at least one acquisition. Most of them (25.3% of the whole sample) acquired assets and only about 7% of the entire sample participated in Mergers and Majority interest acquisitions. On average, firms make an acquisition per year; however, the majority of firms in the sample have make no acquisitions and a few firms make up to 30 per year. This statistics is consistent with the finding of Fuller, Netter, and Stegemoller (2002) that the companies who acquired five or more firms within a short period of time contribute more than a third of large, nonfinancial, nonutility takeovers in the United States.

The relative size of target which is measured by the ratio of the deal transaction value over the acquirer's total assets has an average of 21%.

The relatively low rate of M&A activity and the large size of the targets is explained by the fact that our sample does not include the information on private targets while in reality the majority of the acquisitions involve private firms.

Table 4.1: **Summary statistics.** Panel A reports the statistics for the sample of firms from a merged CRSP-Compustat database for companies with headquarters in the USA from 1991 to 2013 on the annual base. Financials (historical SIC or SIC between 4900 and 4949), utilities (historical SIC or SIC codes between 6000 and 6999) are excluded from the sample. All variables are winsorised at 1% and 99%, except *Stock Return* which winsorised at 2% and 98%. Values are shown to two decimal places.
Panel B: summarizes the statistics for the merged CRSP-Compustat and SDC dataset.

Panel A: Firm Characteristics

Variable	Mean	Median	S.d.	Minimum	Maximum
Total Assets	3041.35	419.48	10319.78	1.61	198103.81
Market-to-Book	1.82	1.50	1.24	0.29	38.49
Profitability	0.13	0.13	0.11	-5.15	1.39
Tangibility	0.31	0.24	0.23	0.00	1.00
Sales	6.18	6.08	1.80	0.13	12.56
Asset Maturity	4.21	2.75	5.78	-15.20	633.77
Net Operating Loss Carryforward	0.65	1.00	0.48	0.00	1.00
CF Volatility	0.02	0.01	0.02	0.00	1.28
Abnormal Returns	0.03	0.00	2.03	-147.50	347.80
Investment Tax Credit	0.02	0.00	0.13	0.00	1.00
Market Leverage	0.23	0.18	0.21	0.00	0.99
Cost of Debt	0.11	0.07	0.25	0.00	4.96
Stock Return	0.17	0.02	1.57	-0.99	134.60
Observations	37500				

Panel B: M&A Deals Characteristics

Variable	Mean	Median	S.d.	Minimum	Maximum
Ratio of Acquirers	0.33	0.00	0.47	0.00	1.00
Ratio of Asset Acquirers	0.26	0.00	0.44	0.00	1.00
Ratio of Firm Acquirers	0.07	0.00	0.26	0.00	1.00
Number of Acquisitions	0.97	0.00	2.27	0.00	30.00
Number of Asset Acquisitions	0.79	0.00	2.01	0.00	28.00
Number of Firm Acquisitions	0.18	0.00	0.59	0.00	10.00
Relative Size	0.20	0.06	0.45	0.00	9.48
All Cash	0.72	1.00	0.45	0.00	1.00
Competed	0.00	0.00	0.06	0.00	1.00
Hostile	0.00	0.00	0.03	0.00	1.00
Observations	37500				

4.3 Target Leverage and long-term debt

According to the trade-off theory of capital structure, there is an optimal level of leverage which depends on company's fundamental characteristics. Frank and Goyal (2009) elaborate the list of these fundamentals, study which parameters have significant influence on the leverage ratio and choose the main factors: market-to-book ratio, tangible assets, profitability, etc. We use these factors as explanatory variables and interpret the predictions of this empirical model as *Target Market Leverage.* If an actual value of firm's *Market Leverage* exceeds it, we call this firm over-levered. If the actual value of *Market Leverage* is lower, then the firms are categorised as under-levered. Similar logic applies to the fraction of total debt that is long-term. We define as long-term debt that is due more than three years from the company's reporting date.

Following Johnson (2003), we model the joint dynamics of *Market Leverage* and *Long-Term Debt* by the system of simultaneous equations

$$\begin{cases} ML_t = LTD_t + \beta_{ML} X_{t-1}^{ML} + industry\ FE + \varepsilon_t, \\ LTD_t = ML_t + \beta_{LTD} X_{t-1}^{LTD} + industry\ FE + \varepsilon_t, \end{cases}$$

where ML_t is a market leverage, LTD_t is a percentage of long-term debt in total debt. The set of explanatory variables for *Market Leverage*, X^{ML}, includes *Market-to-Book ratio*, interproduct of *Market-to-Book ratio* and *Assets Maturity*, *Tangibility* of assets,*Profitability*, logarithm of *Sales*, volatility of quarterly Cash Flows, *Investment Tax Credit*, *Net Operating Loss Carryforward* and *Abnormal Earnings.* All variables are measured with one year lag.

The pool of the explanatory variables for the *Long-Term Debt*, X^{LTD}, includes *Market-to-Book ratio*, *Assets Maturity*, logarithm of *Sales*, squared logarithm of *Sales*, volatility of quarterly Cash Flows, *Investment Tax Credit*, *Net Operating Loss Carryforward* and *Abnormal Earnings.* All variables are measured with one year lag.

We use three-stage least squares estimation for systems of simultaneous equations.

Johnson (2003) addresses exclusion restrictions by handpicking some coefficients in the system of equations. To guard against the possibility that the exclusion restrictions are violated, we run a robustness check, in which targets for leverage and maturity are pinned down by means of single equation Fama-MacBeth regressions. We run singles equations year-by-year from 1991 to 2013 and then find an average of the year-by-year coefficients. The results of the entire study hold under this alternative specification.

Table 4.2 reports the results of simultaneous equations regression. Significant coefficients meet our expectations. The increase in the percentage of *Long-Term Debt* leads to the increase of *Market Leverage*, which is consistent with Johnson (2003). Growth opportunities which we measure by Market-to-Book ratio relate negatively to the Market Leverage; traditionally it is interpreted as growth opportunities increase firm market value but do not affect the book debt of a company. An interproduct of growth opportunities with Asset Maturity has a negative coefficient: between two companies with the same growth opportunities the one with the lower Asset Maturity will have a higher leverage. *Tangibility* impact is positive, firms having more tangible assets can provide collateral for their potential new debt. *Probability* has a negative coefficient, as expected, this interaction is usually interpreted in a way that fastly growing operating income increases the market value of assets and does not have direct influence on the magnitude of book debt. A negative relation with the firm size means that smaller firms prefer to issue relatively more debt than big firms do. It can happen due to the comparatively higher costs of equity issuing. *Investment Tax Credit* and *Net Operating Loss Carry-forward* are proxies for non-debt tax shields. *In-*

vestment Tax Credit takes value one when a firm gets a tax credit for reinvestment. *Net Operating Loss Carry-forward* is a dummy for non-zero tax loss carry-forward. Both have positive coefficients, which is surprising, as we expect alternative tax shields to reduce the attractiveness of leverage. Abnormal Returns do not have a significant impact on either leverage, or maturity.

The coefficient of Market Leverage over Long-term maturity is not significant. Contrary to the predictions by Myers (1977) we find a positive association between firm's growth opportunity and long-term maturity. We will address the relation between the maturity and acquisitions as a growth opportunity in Section 4.4.2. Both Sales and Sales squared are in positive relation to the long-term maturity, which means that larger firms prefer longer maturity and this preference is non-linear over the natural logarithm of net sales. While there is no significant relation between Market Leverage and volatility of cash flows, we find a positive coefficient for volatility in the maturity estimates. The firms with volatile earnings might prefer to have less short-term debt because they are uncertain about being able to repay it. Positive coefficients correspond to both, *Investment Tax Credit* and *Net Operating Loss Carry-forward*, which means that the higher is the tax credit, the bigger fraction of debt becomes long-term. Asset Maturity and Long-Term Debt percentage relate positively. According to Myers (1977) firms try to match the maturities of their assets and liabilities to decrease under-investment problems.

We assume that this empirical model calibrated at our sample predicts *optimal* leverage and maturity structure. Under this assumption, deviations from predicted, target, values of *Market Leverage* and percentage of *Long-Term Debt* take a form of deficit. The *Market Leverage* deficit is positive when the firm is over-levered and negative when it does not issue enough debt. The *Long-Term Debt* percentage deficit is positive when there proportion of long-term debt over short-term debt is excessive and negative when this proportion is too low.

In the context of this paper, the levels of "inefficiency" have more intricate explanatory power than the levels of the corresponding variables.

4.4 Deviation from optimal Capital structure and Acquisition Activity

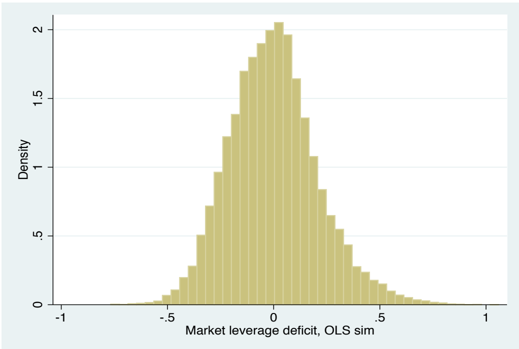
In this section we explore how leverage and maturity deficits affect M&A activity of a company. We assign a dummy variable to every company who has made an acquisition in a given year. An average over the entire sample gauges likelihood of becoming an acquirer. To get an insight about the relation of acquisition activity and inefficiency of capital structure policy, we split the sample along the *Market Leverage Deficit* and *Long-Term Debt Deficit* variables and compute the probability of becoming an acquirer decile-by-decile. Figure 4.1 reports the results. Panel 4.1b shows an inverted U-shape curve for the probability of being an acquirer along *Market Leverage Deficit* deciles, which is in line with the result by Uysal (2011). Panel 4.1d shows a positive slope line along maturity deciles. The observation holds through different types of acquisitions: the blue line presents all deals, the red line presents asset acquisitions and the green line reports majority interest acquisitions.

4.4.1 Likelihood of being an Acquirer

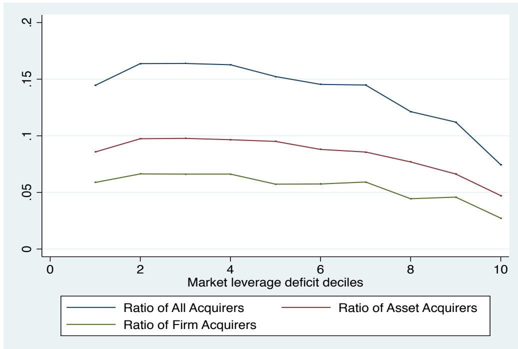
We expect that over-levered firms will show lower M&A activity in comparison with their under-levered counterparts and that companies with relatively long maturity will be more

Table 4.2: **Target Debt Structure Regressions.** The table reports the time series means of the coefficient estimates from the year-by-year (1991-2013) regressions of target leverage ratio (second column) and long-term debt ratio (third column) over key financial measures in the literature. The dependent variable is displayed in the corresponding column. All the explanatory factors – except Market Leverage and Long-Term Debt – are one-year lagged. t-statistics are reported in paretheses. Variable definitions are in the Appendix. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

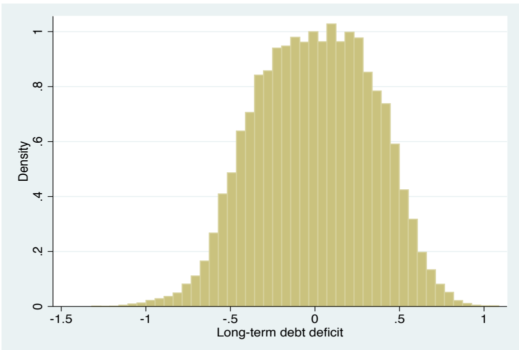
	Market Leverage Ratio	Long-Term Debt Ratio
Market Leverage		-0.033
		(0.024)
Long-Term Debt Ratio	0.475***	
	(0.025)	
Market-to-Book	-0.053***	0.068**
	(0.004)	(0.028)
Market-to-Book∗Maturity	-0.001***	
	(0.000)	
Tangibility	0.079***	
	(0.008)	
Profitability	-0.174***	
	(0.020)	
Sales	-0.020***	0.076***
	(0.002)	(0.019)
Sales Squarred		0.067***
		(0.021)
CF volatility	0.058	0.040*
	(0.091)	(0.021)
Investment Tax Credit	0.032***	0.058**
	(0.010)	(0.026)
Net opearting loss carryforward	0.046***	0.279***
	(0.004)	(0.060)
Abnormal Earnings	0.004	0.019
	(0.007)	(0.016)
Asset Maturity		0.117***
		(0.023)
Industry FE	Yes	Yes
R^2	-0.076	0.129



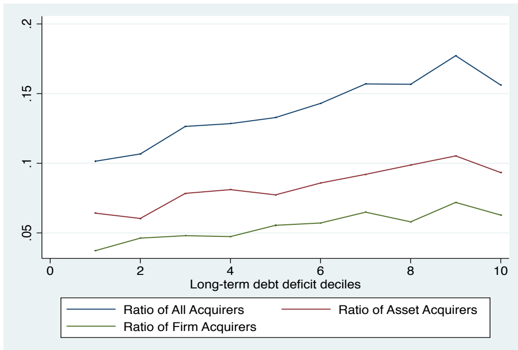
(a) Market leverage deficit, OLS, simultaneous equations



(b) Ratio of acquirers over market leverage deficit deciles



(c) Long-term debt percentage deficit, OLS, simultaneous equations



(d) Ratio of acquirers over long-term debt, in %, deficit deciles

Figure 4.1: **Probability of being an acquirer against market leverage and long-term debt deficits.** The panels (4.1a) and (4.1c) report the distributions of market leverage and long-term debt deficits, respectively. The deficits are computed as deviations of an actual leverage and of an actual long-term debt measure from the values forecasted by an empirical model. It is set by a pair of simultaneous equations, estimated by the 3-stage OLS method. The panels (4.1b) and (4.1d) show ratio of all, firm and asset acquirers against market leverage and long-term debt deficit deciles.

frequent acquirers. Table 4.3 confirms this insight. It reports the coefficients of probit regressions where the dependent variable is a dummy for a company undertaking an acquisition in a given year. The negative coefficients corresponding to *Market Leverage Deficit* and the positive coefficients before *Long-Term Debt Percentage Deficit* support our intuition. The results also show that bigger, more profitable firms are more likely to become an acquirer. The growth opportunities (*Market-to-Book* ratio) and *Stock Return* are also positively associated with the probability of acquiring a company.

The regressions run on the subsample of Firm Acquisitions (Table 4.4) confirm the results of the entire sample regressions. Firm Acquisitions coefficients are greater in magnitude and seem to be the main drivers of the effect. The regressions run on the subsample of Asset acquisitions (Table 4.5) exhibit lower, in absolute values, coefficients than both the entire sample and Firm Acquisitions subsample. One can see as well that the growth opportunities for asset acquisitions have a negative effect.

As a robustness check we also add square terms to prove the presence of the concave curve and our hypothesis is confirmed. For the coefficients see Table 4.6. In the unreported robustness checks we use specifications with and without control for cost of debt, measured by the ratio of interest expenses to total debt. The results hold under both specifications.

4.4.2 Debt Overhang Theories. Investments and Acquisition Activity

Debt overhang theory suggested by Myers (1977) describes how conflicts between equity- and debt-holders bring a company to inefficient investments. The companies with high leverage do not invest as much as they would do if the debt holders did not own such a considerate part of the company. We test three variants of the theory: by Myers (1977), by Smith and Warner (1979), and by Diamond and He (2014). We regress the ratio of investment activity both onto the deficit levels and with the predicted levels.

Myers (1977) suggests that a short-term debt might be a solution to the debt overhang problem. Among two firms with the same leverage the one with less long-term debt will have less severe underinvestment.

In our specification it would mean: first, the higher the leverage is the lower the bidder ratio must be. It corresponds to a negative coefficients before *Market Leverage Deficit* and to *Theoretical Market Leverage* in Table 4.7, column (7). Furthermore, more long-term debt is supposed to result in lower bidder ratio. According to Myers (1977), taking more long-term debt aggravates debt-overhang problem: its association with the likelihood of investments, undertaking a takeover in our case, must be negative. We find no confirmation to this effect in our sample. The positive coefficients before *Long-term debt percentile deficit* and *Theoretical Long-term debt percentile* contradict the debt overhang theory. They suggest that having more long-term debt increases the probability of investment, the probability of becoming an acquirer.

This is why we investigate further and look at the alternative factors that could alleviate the debt overhang problem. For this we turn to dynamic debt overhang theories by Smith and Warner (1979) and Diamond and He (2014) which suggest that the timing of issuing short-term debt can make underinvestment problem either more or less severe. Smith and Warner, 1979, suggest that debt covenants can mitigate the underinvestment problem. The covenants are supposed to protect debt-holders in case of the default. Cautious of that equity-holders are going to invest more efficiently. We use Altman's Z-score as a proxy for likelihood of default. By construction, it is should alert of default proximity when the score falls below 1.8 and indicate financial stability when it overgrows the threshold of 3.3.

Table 4.3: **Probability of being an Acquirer. All acquisitions.** The table reports the coefficients of probit regressions. The dependent variable is a dummy that equals one when the company undertakes an acquisition in a given year. The *Deficit* and *Fitted* variables for *Market Leverage* and *Long-Term Debt Percentage* are the results of the system of simultaneous equations. The negative coefficients corresponding to *Market Leverage Deficit* imply that relatively over-levered firms are less likely to be acquirers. The positive coefficients before *Long-Term Debt Percentage Deficit* mean that firms having longer maturity leverage are more likely to be acquirers. Industry fixed effects and Year fixed effects included. t-statistics are reported in brackets. *, ** and *** stand for 5%, 1% and 0.1% significance levels, respectively.

	(1) Acquirer	(2) Acquirer	(3) Acquirer	(4) Acquirer
Acquirer				
LT Debt Deficit			0.417***	0.485***
			(6.24)	(6.96)
LT Debt Fitted				0.283***
				(3.57)
Mrkt Lev Deficit	-0.441***	-0.525***	-0.160*	-0.320***
	(-10.26)	(-9.55)	(-2.00)	(-3.48)
Mrkt Lev Fitted		-0.165*	-0.603***	-0.876***
		(-2.46)	(-6.20)	(-7.08)
Sales	0.172***	0.173***	0.175***	0.161***
	(31.39)	(31.48)	(31.88)	(23.30)
Cost of Debt	-0.0745*	-0.0896*	-0.0768*	-0.0725*
	(-2.12)	(-2.51)	(-2.15)	(-2.03)
Stock Return	0.0335*	0.0368*	0.0505**	0.0609***
	(2.11)	(2.30)	(3.14)	(3.72)
Market-to-Book	0.0483***	0.0383***	0.0171	0.00597
	(4.79)	(3.52)	(1.50)	(0.50)
Profitability	1.202***	1.159***	1.072***	1.043***
	(10.67)	(10.16)	(9.34)	(9.06)
Industry M&A Liquidity	0.275*	0.272*	0.258*	0.241*
	(2.37)	(2.35)	(2.23)	(2.07)
HHI Sales	-2.398	-2.333	-2.417	-2.588
	(-0.32)	(-0.31)	(-0.32)	(-0.34)
Observations	30677	30677	30677	30677
Pseudo R^2	0.106	0.106	0.107	0.108

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4.4: **Probability of being an Acquirer. Firm acquisitions.** The table reports the coefficients of probit regressions. The dependent variable is a dummy that equals one when the company undertakes an acquisition in the form of Majority Interest Acquisition or a Merger in a given year. The *Deficit* and *Fitted* variables for *Market Leverage* and *Long-Term Debt Percentage* are the results of the system of simultaneous equations. The negative coefficients corresponding to *Market Leverage Deficit* imply that relatively over-levered firms are less likely to be acquirers. The positive coefficients before *Long-Term Debt Percentage Deficit* mean that firms having longer maturity leverage are more likely to be acquirers. The regressions run on the subsample of Firm Acquisitions confirms the results of entire sample regressions. Firm Acquisitions coefficients are greater in magnitude. Industry fixed effects and Year fixed effects included. t-statistics are reported in brackets. *, ** and *** stand for 5%, 1% and 0.1% significance levels, respectively.

	(1) FAcquirer	(2) FAcquirer	(3) FAcquirer	(4) FAcquirer
FAcquirer				
LT Debt Deficit			0.435***	0.497***
			(4.67)	(5.19)
LT Debt Fitted				0.304**
				(2.81)
Mrkt Lev Deficit	-0.481***	-0.574***	-0.194	-0.374**
	(-7.78)	(-7.09)	(-1.69)	(-2.83)
Mrkt Lev Fitted		-0.173	-0.630***	-0.913***
		(-1.80)	(-4.59)	(-5.36)
Sales	0.151***	0.152***	0.154***	0.139***
	(20.56)	(20.62)	(20.91)	(15.16)
Cost of Debt	0.00133	-0.0139	-0.000862	0.00324
	(0.03)	(-0.30)	(-0.02)	(0.07)
Stock Return	0.0547**	0.0581**	0.0726***	0.0839***
	(2.59)	(2.73)	(3.39)	(3.86)
Market-to-Book	0.0895***	0.0803***	0.0595***	0.0484***
	(7.34)	(6.07)	(4.25)	(3.32)
Profitability	0.481**	0.436**	0.344*	0.313*
	(3.23)	(2.89)	(2.27)	(2.06)
Industry M&A Liquidity	0.520***	0.518***	0.503***	0.486***
	(3.64)	(3.63)	(3.51)	(3.39)
HHI Sales	-23.91*	-23.82*	-24.16*	-24.54*
	(-2.29)	(-2.28)	(-2.31)	(-2.35)
Observations	30677	30677	30677	30677
Pseudo R^2	0.096	0.097	0.098	0.099

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4.5: **Probability of being an Acquirer. Asset acquisitions.** The table reports the coefficients of probit regressions. The dependent variable is a dummy that equals one when the company undertakes an acquisition in a form of Asset acquisition in a given year. The *Deficit* and *Fitted* variables for *Market Leverage* and *Long-Term Debt Percentage* are the results of the system of simultaneous equations. The negative coefficients corresponding to *Market Leverage Deficit* imply that relatively over-levered firms are less likely to be acquirers. The positive coefficients before *Long-Term Debt Percentage Deficit* mean that firms having longer maturity leverage are more likely to be acquirers. The regressions run on the subsample of Asset acquisitions confirms the results of entire sample regressions. Asset acquisitions exhibit lower in absolute values coefficients than both entire sample and Firm Acquisitions subsample. Industry fixed effects and Year fixed effects included. t-statistics are reported in brackets. *, ** and *** stand for 5%, 1% and 0.1% significance levels, respectively.

	(1) AAcquirer	(2) AAcquirer	(3) AAcquirer	(4) AAcquirer
AAcquirer				
LT Debt Deficit			0.388***	0.453***
			(5.55)	(6.22)
LT Debt Fitted				0.267**
				(3.22)
Mrkt Lev Deficit	-0.376***	-0.448***	-0.110	-0.258**
	(-8.36)	(-7.80)	(-1.31)	(-2.69)
Mrkt Lev Fitted		-0.143*	-0.551***	-0.810***
		(-2.04)	(-5.41)	(-6.24)
Sales	0.164***	0.165***	0.167***	0.153***
	(28.80)	(28.88)	(29.23)	(21.41)
Cost of Debt	-0.0830*	-0.0962*	-0.0837*	-0.0797*
	(-2.23)	(-2.54)	(-2.21)	(-2.11)
Stock Return	0.0421*	0.0448**	0.0574***	0.0671***
	(2.53)	(2.68)	(3.41)	(3.92)
Market-to-Book	0.0142	0.00544	-0.0143	-0.0250*
	(1.32)	(0.47)	(-1.18)	(-1.98)
Profitability	1.249***	1.212***	1.131***	1.104***
	(10.33)	(9.91)	(9.19)	(8.94)
Industry M&A Liquidity	0.0884	0.0862	0.0734	0.0570
	(0.73)	(0.71)	(0.60)	(0.47)
HHI Sales	3.679	3.741	3.702	3.526
	(0.47)	(0.47)	(0.47)	(0.45)
Observations	30677	30677	30677	30677
Pseudo R^2	0.097	0.097	0.098	0.098

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4.6: **Robustness Check. Probability of being an Acquirer. All acquisitions.** The table reports the coefficients of probit regressions. The dependent variable is a dummy that equals one when the company undertakes an acquisition in a given year. The Deficit and Fitted variables for Market Leverage and Long-Term Debt Percentage are the results of the system of simultaneous equations. The negative coefficients corresponding to Market Leverage Deficit imply that relatively over-levered firms are less likely to be acquirers. The positive coefficients before Long-Term Debt Percentage Deficit mean that firms having longer maturity leverage are more likely to be acquirers. Industry fixed effects and Year fixed effects included. t-statistics are reported in brackets. *, ** and *** stand for 5%, 1% and 0.1% significance levels, respectively.

	(1) Acquirer	(2) Acquirer	(3) Acquirer	(4) Acquirer
Acquirer				
Mrkt Lev Deficit	-0.413***	-0.477***	-0.109	-0.268**
	(-9.64)	(-8.64)	(-1.37)	(-2.93)
Mrkt Lev Deficit Sq.	-0.546***	-0.491***	-0.524***	-0.523***
	(-3.79)	(-3.34)	(-3.56)	(-3.55)
Mrkt Lev Fitted		-0.121	-0.563***	-0.828***
		(-1.84)	(-5.90)	(-6.85)
LT Debt Deficit			0.419***	0.482***
			(6.41)	(7.12)
LT Debt Fitted				0.276***
				(3.57)
Sales	0.172***	0.173***	0.176***	0.161***
	(31.93)	(31.94)	(32.32)	(23.69)
Stock Return	0.0307*	0.0331*	0.0474**	0.0578***
	(1.97)	(2.12)	(3.01)	(3.61)
Market-to-Book	0.0446***	0.0371***	0.0162	0.00558
	(4.65)	(3.57)	(1.49)	(0.49)
Profitability	1.168***	1.140***	1.050***	1.021***
	(10.78)	(10.42)	(9.54)	(9.24)
Industry M&A Liquidity	0.269*	0.268*	0.253*	0.236*
	(2.40)	(2.39)	(2.25)	(2.10)
HHI Sales	-0.375	-0.368	-0.600	-0.761
	(-0.05)	(-0.05)	(-0.08)	(-0.10)
Observations	31916	31916	31916	31916
Pseudo R^2	0.106	0.106	0.107	0.107

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4.7: **Debt Overhang Theories.** The table presents the test of three Debt Overhang Theories. Columns from (1) to (6) cover *Diamond and He (2014)* hypothesis that depending on the timing of investment opportunities, short-term debt can generate a higher debt overhang problem. The variables *Boom* (as defined by the BEA), *CF over Total Assets* and *Market-to-Book ratio* characterise how favorable the time period is for an investment. Column (7) tests classical *Myers (1977)* hypothesis. Columns (8) and (9) report the test of *Smith, Warner(1979)* and verify whether covenants can alleviate the problem. The proxy for this effect is an interproduct of leverage and maturity measures and *Altman's Z-score.* Both negative coefficients corresponding to *Market Leverage Deficit* and to *Theoretical Market Leverage* reveal the debt overhang problem. The positive coefficients before *Long-Term Debt Deficit* and *Long-Term Debt Percentile, predicted* contradict the debt overhang theory. They suggest that having more long-term debt increases the probability of becoming an acquirer. Industry fixed effects and Year fixed effects included. *, ** and *** stand for 5%, 1% and 0.1% significance levels, respectively.

	(1) Diamond He	(2) Diamond He	(3) Diamond He	(4) Diamond He	(5) Diamond He	(6) Diamond He	(7) Myers	(8) Myers	(9) Smith Warner	(10) Smith Warner
Acquirer										
LT Debt Deficit	0.486***	0.444***	0.437***	0.386***	0.439***	0.641***	0.447***	0.447***	0.466***	0.504***
	(5.77)	(4.58)	(6.08)	(5.21)	(5.34)	(5.54)	(6.32)	(6.32)	(6.22)	(5.88)
LT Debt Fitted	0.257**	0.257**	0.221**	0.211**	0.261**	0.290***	0.261**	0.261**	0.215**	0.227**
	(3.18)	(3.17)	(2.72)	(2.58)	(3.23)	(3.54)	(3.23)	(3.23)	(2.63)	(2.74)
Mrkt Lev Deficit	-0.236*	-0.318*	-0.151	-0.208*	-0.247**	0.0870	-0.246**	-0.246**	-0.183	-0.135
	(-2.51)	(-2.41)	(-1.60)	(-2.14)	(-2.64)	(0.53)	(-2.64)	(-2.64)	(-1.90)	(-1.23)
Mrkt Lev Fitted	-0.804***	-0.805***	-0.643***	-0.592***	-0.798***	-0.879***	-0.797***	-0.797***	-0.706***	-0.736***
	(-6.36)	(-6.36)	(-5.00)	(-4.56)	(-6.32)	(-6.73)	(-6.32)	(-6.32)	(-5.47)	(-5.52)
LT Debt Deficit*Boom	-0.0485	0.0220								
	(-0.87)	(0.23)								
Booming Economy	-0.0519	-0.0508								
	(-0.78)	(-0.76)								
Mrkt Lev Deficit*Boom		0.140								
		(0.88)								
LT Debt Deficit* CF/Tot.As.			-0.472	0.733						
			(-1.60)	(1.43)						
CF/Tot.As.			0.942***	0.939***						
			(6.79)	(6.75)						
Mrkt Lev Deficit* CF/Tot.As.				2.605**						
				(2.86)						
LT Debt Deficit*MtB ratio					0.00427	-0.0973*				
					(0.19)	(-2.07)				
Mark.Lev. Deficit*MtB ratio						-0.212*				
						(-2.48)				
LT Debt Deficit*Z-score									-0.00847	-0.0203
									(-1.23)	(-1.39)
Altman's z-score									0.0135***	0.0125**
									(3.35)	(2.98)
Mark.Lev. Deficit*Z-score										-0.0250
										(-0.92)
Sales Lagged	0.158***	0.158***	0.156***	0.157***	0.158***	0.157***	0.158***	0.158***	0.164***	0.163***
	(22.48)	(22.48)	(22.23)	(22.25)	(22.47)	(22.23)	(22.47)	(22.47)	(22.85)	(22.78)
Stock Return	0.0643***	0.0647***	0.0519**	0.0501**	0.0638***	0.0619***	0.0640***	0.0640***	0.0687***	0.0681***
	(3.84)	(3.86)	(3.07)	(2.96)	(3.81)	(3.69)	(3.82)	(3.82)	(4.06)	(4.02)
Market-to-Book	-0.0254*	-0.0253*	-0.0180	-0.0176	-0.0252*	-0.0275*	-0.0252*	-0.0252*	-0.0508***	-0.0496***
	(-2.11)	(-2.10)	(-1.48)	(-1.45)	(-2.09)	(-2.28)	(-2.10)	(-2.10)	(-3.68)	(-3.58)
Profitability	1.095***	1.095***	0.440**	0.480**	1.098***	1.097***	1.097***	1.097***	1.063***	1.060***
	(9.23)	(9.24)	(2.86)	(3.10)	(9.26)	(9.25)	(9.25)	(9.25)	(8.64)	(8.62)
Industry M&A Liquidity	0.0796	0.0795	0.0829	0.0838	0.0803	0.0823	0.0804	0.0804	0.0874	0.0889
	(0.67)	(0.67)	(0.70)	(0.71)	(0.68)	(0.70)	(0.68)	(0.68)	(0.74)	(0.75)
HHI Sales	7.165	7.139	6.859	6.913	7.131	7.087	7.137	7.137	7.328	7.338
	(0.94)	(0.94)	(0.90)	(0.90)	(0.93)	(0.93)	(0.93)	(0.93)	(0.95)	(0.96)
Observations	31916	31916	31916	31916	31916	31916	31916	31916	31489	31489
Pseudo R^2	0.098	0.099	0.100	0.100	0.098	0.099	0.098	0.098	0.100	0.101

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

For the test of the hypothesis that covenants can alleviate debt overhang problem, we use an interprodcut of maturity deficit and Z-score. Columns (8) and (9) in Table 4.7 report the results of the test. While having a one point higher Z-score is likely to increase the probability of becoming an acquirer, there is no significant interaction between the score and the maturity characteristics.

The third theory by Diamond and He (2014) predicts that inappropriate timing of short-term debt issuing can aggravate the debt overhang. We use three proxies for timing: Boom time, as it is described by the Bureau of Economic Analysis, Cash Flows over Total Assets and Market-to-Book ratio. Boom is the time between the bottom of the business cycle and its peak. The ratio of Cash Flows over Total Assets gauges profitability of the firm. As we discussed above, Market-to-Book ratio is a proxy for growth opportunities of a firm, it measures how much the market values firm's assets in comparison with their book value. All three variables stand for the time at which an immediate investment together with short-term debt can decrease debt overhang. However, in "bad" times, when return on investments is low, short-term debt, in contrast, increases the problem. In this context, we expect to find negative coefficients for interproducts of long-term maturity measures and favourable for investment time proxies. In columns (1) to (6) of the Table 4.7 there are no significant coefficients either to support the theory. We see though that Cash Flow over Total Assets ratio is positively associated with the likelihood of undertaking acquisition. It is interesting to note that, given Cash Flow over Total Assets, Market Leverage covaries with the dependent variable and, given Market-to-Book ratio, it has a negative relation.

Thus positive association between long-term maturity measures and probability of being an acquirer provides support for neither static, nor dynamic debt overhang theories. However, we find that the deviation of leverage from target level has a bigger effect on the likelihood of becoming an acquirer the more profitable the firm is and the less growth opportunities it has.

4.5 Debt Maturity and Value Creation

The previous sections covered how pre-acquisition deviation from target maturity structure associated with likelihood of becoming an acquirer. To complete the analysis, we examine the implications of debt maturity policy for characteristics of takeover deals and for bidder and target returns.

4.5.1 Average Size of Target Firm

First, we look at an average size of a target, which we define as a ratio of the total dollar volume of all acquisitions made by the firm during a year to the number of these acquisitions. Table 4.8 demonstrates that the average target size is increasing in maturity deficit and decreasing in its level. The more short-term debt oriented the firm is, the higher is going to be the average dollar value of its target However, if a firm deviates downwards from its target maturity policy, i.e., if it takes more short-term debt than it should according to its optimal maturity, the lower its acquisitions target size will become. Thus, bidders with optimally short maturity who "non-optimally" increased their maturity are more likely to acquirer the biggest targets. Leverage deficit has a negative association with the average target size. Sales and Profitability have a negative association as well. Market-to-Book and Stock Return relate positively. So the optimistic evaluation at the market increases the potential size of a target while sales and earnings decrease it.

Table 4.8: **Average Size of a Target. All acquisitions.** The table reports the coefficients of regressions for an average size of a target. We define it as a ratio of the total dollar volume of all acquisitions made by the firm during a year to the number of these acquisitions. The average target size is increasing in maturity deficit and decreasing in its level. The more short-term debt oriented the firm is, the higher is going to be the average dollar value of its target However, if a firm deviates downwards from its target maturity policy, i.e., if it takes more short-term debt than it should according to its optimal maturity, the lower its acquisitions target size will become. Thus, bidders with optimally short maturity who "non-optimally" increased their maturity are more likely to acquirer the biggest targets. Leverage deficit has a negative association with the average target size. Sales and Profitability have a negative association as well. Market-to-Book and Stock Return relate positively. So the optimistic evaluation at the market increases the potential size of a target while sales and earnings decrease it.

	(1)	(2)	(3)	(4)
Average Target Size				
LT Debt Deficit	0.191***	0.192***	0.190***	0.191***
	(5.09)	(5.12)	(5.07)	(5.09)
LT Debt Fitted			-0.383**	-0.366*
			(-2.61)	(-2.47)
Mrkt Lev Deficit	-0.258**	-0.275**	-0.247**	-0.258**
	(-2.93)	(-3.07)	(-2.79)	(-2.87)
Mrkt Lev Fitted		-0.226		-0.140
		(-1.09)		(-0.67)
Sales	-0.0303***	-0.0283***	-0.0117	-0.0112
	(-3.96)	(-3.60)	(-1.12)	(-1.07)
Stock Return	0.0957***	0.104***	0.0939***	0.0989***
	(3.79)	(3.94)	(3.72)	(3.75)
Market-to-Book	0.0611***	0.0505**	0.0588***	0.0523**
	(4.33)	(2.95)	(4.17)	(3.05)
Profitability	-0.684***	-0.730***	-0.714***	-0.741***
	(-3.71)	(-3.86)	(-3.86)	(-3.91)
Industry M&A Liquidity	0.261	0.252	0.271	0.265
	(1.38)	(1.33)	(1.43)	(1.40)
HHI Sales	-11.82	-12.02	-12.02	-12.13
	(-1.53)	(-1.56)	(-1.56)	(-1.57)
Observations	13034	13034	13034	13034
Pseudo R^2	0.086	0.086	0.086	0.086

4.5.2 Abnormal Returns

To study how the market reacts to acquisition announcements we compute Cumulative Abnormal Returns (CARs). We compute them on the basis of Fama-French three-factor model. Table 4.9 reports descriptive statistics for bidders CARs split over leverage and maturity policies. The top panel reports the number of observations belonging to a respective intersect of leverage and maturity quartiles. One can see that firms tend to cluster at the diagonal. In other words, if a firm is in the second bottom quartile with respect to the leverage deficit, it is most likely in the corresponding, second bottom, quartile along maturity deficit. Overall, we report 13,612 bidders.

The second panel summarizes mean CARs. They are positive everywhere besides second quartile along leverage deficit and forth quartile with respect to maturity. There, it is 0.1. In the next panel we see that standard deviation tends to be higher in top quartiles with respect to either measures. The minimum and the maximum (reported in two bottom panels) are the same throughout all quartiles. The later effect appears because of winsorisation at the 1% and 99%.

To study Acquisition Premium or Target CAR, we construct a sample of 647 deals, for which we know firm characteristics for both bidder and target. We found no significant evidence about Acquisition Premium or Target CAR. Table 4.10 indicates that over-leveraged firms and firms with higher leverage maturity pay higher premiums relative to other firms but no effect is significant.

Table 4.11 reports coefficient estimates of acquirer returns which are calculated over a three-day event window (one day before and one day after the announcement date). The benchmark returns are the value-weighted index of returns including dividends for the combined New York Stock Exchange, American Stock Exchange and NASDAQ. The table indicates that CAR increases with leverage deficit. However, no significant or consistent association found.

We have tested alternative approaches: total gains and dollar gains instead of CARs, — and specifications: changing time window for CARs and applying Capital Gains Tax as an instrumental variable — none of them revealed any effect.

4.6 Conclusion

This paper examines the relation between deviations from target debt maturity and acquisition decisions. Since target levels of capital structure and debt maturity are unobservable, we use a two-stage estimation procedure to find the effects of deviations from target leverage and maturity of debt. In the first stage, we use the simultaneous-equation system proposed by Johnson (2003) to jointly determine leverage and debt maturity targets of firms. In the second stage, we perform a probit regression of the probability of becoming an acquirer on the leverage and debt maturity deficits obtained from the first stage, and other controls. We perform our analysis on a large sample of mergers and acquisitions for public U.S. companies using data from Compustat and SDC Platinum for the period 1991 to 2013.

We confirm the association between leverage deficit and M&A activity found in the previous research and find a positive relation between the percentage of long-term debt and the likelihood of being an acquirer. This result is robust to the type of acquisition: it shows on the entire sample as well as on firm or asset acquisitions subsamples. The negative association between leverage deficit and probability of investment encourages us to test Myers (1977) debt overhang theory. However, neither original static, nor dynamic

Table 4.9: **Descriptive Statistics for Bidder CARs.** The table reports the summary statistics for acquirers' Cumulative Abnormal Returns. The statistics is presented on the grid of *Market Leverage Deficit* and *Long-term debt percentile deficit* quartiles.

	Number of observations				
	Long-Term Debt Deficite, quartile				
Mkt.Lev.Def., quart.	1	2	3	4	Total
1	1,329.0	899.0	891.0	284.0	3,403.0
2	1,008.0	1,117.0	922.0	356.0	3,403.0
3	733.0	1,076.0	1,093.0	501.0	3,403.0
4	333.0	311.0	497.0	2,262.0	3,403.0
Total	3,403.0	3,403.0	3,403.0	3,403.0	13,612.0

	Mean				
	Long-Term Debt Deficite, quartile				
Mkt.Lev.Def., quart.	1	2	3	4	Total
1	0.7	0.5	0.0	1.4	0.5
2	0.7	0.4	0.4	-0.1	0.4
3	0.5	0.0	0.7	1.1	0.5
4	0.5	1.2	0.8	0.4	0.5
Total	0.6	0.4	0.4	0.5	0.5

	S.d.				
	Long-Term Debt Deficite, quartile				
Mkt.Lev.Def., quart.	1	2	3	4	Total
1	5.1	4.8	4.9	6.2	5.1
2	5.1	4.3	4.5	5.7	4.8
3	5.1	4.1	5.0	5.8	4.9
4	5.4	6.0	5.6	5.1	5.3
Total	5.1	4.6	5.0	5.4	5.0

	Minimum				
	Long-Term Debt Deficite, quartile				
Mkt.Lev.Def., quart.	1	2	3	4	Total
1	-14.5	-14.5	-14.5	-14.5	-14.5
2	-14.5	-14.5	-14.5	-14.5	-14.5
3	-14.5	-14.5	-14.5	-14.5	-14.5
4	-14.5	-14.5	-14.5	-14.5	-14.5
Total	-14.5	-14.5	-14.5	-14.5	-14.5

	Maximum				
	Long-Term Debt Deficite, quartile				
Mkt.Lev.Def., quart.	1	2	3	4	Total
1	18.9	18.9	18.9	18.9	18.9
2	18.9	18.9	18.9	18.9	18.9
3	18.9	18.9	18.9	18.9	18.9
4	18.9	18.9	18.9	18.9	18.9
Total	18.9	18.9	18.9	18.9	18.9

Table 4.10: **Regressions for Acquisition Premium and Target CAR.** The table reports regression estimates for *Acquisition Premium* and *Target CAR(-42,1)*. The table indicates that over-levered firms pay higher premiums relative to other firms. However, no significant association found. Variable definitions are in the Appendix. Industry fixed effects and Year fixed effects included.

	Acq Prm	Acq Prm	Target CAR(-42,1)	Target CAR(-42,1)
LT Debt Deficit		596.0		4.765
		(1.46)		(0.25)
LT Debt Fitted		191.2		-40.46
		(0.42)		(-1.86)
Mrkt Lev Deficit	797.2	1233.8	3.655	43.64
	(1.73)	(1.75)	(0.17)	(1.30)
Mrkt Lev Fitted	667.0	55.52	23.56	48.32
	(1.43)	(0.08)	(1.07)	(1.51)
Sales	32.89	27.18	2.118	3.603*
	(0.96)	(0.71)	(1.30)	(1.99)
Market-to-Book	13.52	-15.49	3.553	3.671
	(0.23)	(-0.25)	(1.28)	(1.26)
Profitability	49.13	-6.276	3.727	8.674
	(0.06)	(-0.01)	(0.10)	(0.23)
Stock Return	88.99	101.5	1.471	0.514
	(0.90)	(1.02)	(0.31)	(0.11)
Within Industry Acquisition	56.11	51.42	-0.590	0.241
	(0.50)	(0.46)	(-0.11)	(0.05)
All Cash	-460.7***	-469.6***	15.88**	15.93**
	(-3.94)	(-4.02)	(2.87)	(2.88)
Competed	84.35	93.11	11.23	8.959
	(0.32)	(0.35)	(0.90)	(0.72)
Hostile	-37.84	-32.54	-18.57	-18.10
	(-0.10)	(-0.09)	(-1.05)	(-1.02)
Industry M&A Liquidity	512.7	500.3	-33.29	-28.81
	(0.90)	(0.87)	(-1.23)	(-1.06)
Sales HHI	16127.8	19385.1	164.1	186.0
	(0.66)	(0.79)	(0.14)	(0.16)
Target M-t-B	-15.03	-16.24	-7.248**	-6.868**
	(-0.32)	(-0.34)	(-3.25)	(-3.07)
Target Profitability	-422.1	-402.6	-24.00	-23.72
	(-1.45)	(-1.38)	(-1.74)	(-1.72)
Target Stock Return	-22.87	-20.27	-5.009	-4.980
	(-0.29)	(-0.25)	(-1.32)	(-1.32)
Observations	647	647	648	648
R^2	0.043	0.047	0.058	0.064

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4.11: **Regression of Bidder CARs.** The table reports coefficient estimates of acquirer returns which are calculated over a three-day event window (one day before and one day after the announcement date). The benchmark returns are the value-weighted index of returns including dividends for the combined New York Stock Exchange, American Stock Exchange and NASDAQ. Variable definitions are in the Appendix. The table indicates that CAR increases with leverage deficit. However, no significant association found. Industry fixed effects and Year fixed effects included. *, ** and *** stand for 5%, 1% and 0.1% significance levels, respectively.

	All Acquisitions CAR(-2;1)	Firm Acquisitions CAR(-2;1)	Assets Acquisitions CAR(-2;1)
LT Debt Deficit	-0.765	0.361	-1.595*
	(-1.17)	(0.31)	(-1.99)
LT Debt Fitted	-0.944	0.0631	-1.817
	(-1.25)	(0.05)	(-1.96)
Mrkt Lev Deficit	1.260	4.146*	0.0785
	(1.44)	(2.34)	(0.08)
Mrkt Lev Fitted	3.115*	3.771	3.422*
	(2.57)	(1.79)	(2.27)
Sales Lagged	-0.270***	-0.324**	-0.256**
	(-4.05)	(-2.80)	(-3.11)
Market-to-Book	-0.175	-0.0254	-0.290*
	(-1.74)	(-0.16)	(-2.17)
Profitability	2.105	4.932*	0.716
	(1.79)	(2.44)	(0.49)
Stock Return	0.0850	0.158	0.0122
	(0.56)	(0.62)	(0.06)
Relative Size	0.622**	0.255	1.340***
	(2.83)	(0.83)	(3.82)
Public Target	-1.679***	-2.132***	3.764
	(-6.72)	(-4.57)	(1.20)
Private Target	-0.517**	-0.602	-0.660**
	(-2.81)	(-1.28)	(-3.25)
Within Industry Acquisition	-0.0725	0.119	-0.151
	(-0.43)	(0.39)	(-0.74)
All Cash	0.259	1.256***	-0.218
	(1.53)	(3.95)	(-1.09)
Competed	0.305	0.140	3.361
	(0.35)	(0.15)	(0.62)
Hostile	-0.0770	-0.0305	0
	(-0.05)	(-0.02)	(.)
Industry M&A Liquidity	0.0491	-2.146	1.922
	(0.04)	(-1.03)	(1.29)
HHI Sales	-38.12	-269.9**	83.63
	(-0.73)	(-2.77)	(1.34)
Observations	4994	1799	3195
R^2	0.053	0.106	0.057

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

variants (Diamond and He (2014)) find support in our study. Neither does debt overhang theory with covenants by Smith and Warner (1979). We show an interesting pattern of how average target firm size depend on different aspects of bidder's maturity policy. The size increases in maturity deficit and decreases in optimal maturity ratio. Yet, no significant value creation effects are found.

The potential research effort can be directed to further search of value creation effects, studying debt structure (for example, bank versus public debt, secured versus unsecured debt), and to the development of an appropriate model as an alternative to the debt overhang theory.

Chapter 5

Conclusions

My thesis studies the roles of capital structure and debt maturity in the interaction between individual companies and industries.

Chapters 2 reveals the role of leverage in the interaction between non-financial industries. The simple theoretical model and the empirical study show that, first, the more suppliers or customers an industry has, the higher its leverage becomes and, second, that industries with highly levered partners have a higher leverage themselves.

Chapter 3 studies the relations between the leverage ratios of non-financial companies. This empirical work supports the hypothesis that individual firms use their leverage as a commitment tool in a firm-specific relationship.

Chapter4 focuses on the relation between capital structure policies and mergers and acquisitions activity. My co-authors and I find that the probability of becoming an acquirer is positively associated with the firms pre-acquisition deviation from target debt maturity.

The surprising contrast between the results of Chapters 2 and 3 — the positive relation between the centrality of an industry and its average leverage ratio and the negative association between the centrality of an individual firm and its leverage — creates a promising potential for future research. A subsequent research would present a game theory model describing the mechanism of how economic agents can use leverage either as a commitment tool for firm-specific relationship, or as a tool to improve their bargaining power within an upstream-downstream negotiation depending on the parameters of the economy. The insight is that some agents' characteristics make them vulnerable and put them into an inflexible position in a production economy. For instance, a firm acting in a highly competitive industry can easily lose a customer or a supplier. Such an agent will search for the ways to encourage their trading counter-agents to enter and maintain a relation. While an agent feeling an opportunity for conducting negotiation — for example, because of the uniqueness of its product — will bargain over the total surplus using debt as a threat of default. Thus, applying a game theory framework I will show that depending on the characteristics of individual nodes, their clusters, and entire networks, such as market concentration, uniqueness of product, and sector regulation the strategic role of leverage can vary.

There is a potential to use a novel *Factset* dataset on firms' competitors to analyse intra-industry strategic use of leverage. I expect to find that the less reputed, poorer, and younger companies tend to copy their more successful and mature counterparts, as it is predicted by information-based theories and theories of capital structure in product market. The reason for this behavior being either an attempt to pretend to be a more profitable and mature company than it is in fact or a lack of resources to conduct a necessary research. I expect also to find similarities in the dynamics of capital structure within the same industry due to similar production shocks, regulation, as well as shocks to equity prices. The research could cover a comparative analysis of the traditional ways of identifying inter-firm relations, by industry codes, with self-identified connections reported in a form 10-K according to the reporting requirements, and Hoberg and Phillips (2016) textual analysis identification. In another of my future studies I would like to take a deeper look at the capital structure puzzle spreading my focus to cash holdings and trade credit. Similar to the principles which drive company's leverage and, thus, its financial flexibility, cash holdings, trade credit, and, moreover, the interaction of all three will provide a more sound ground to my findings. Currently, I use these parameters as controls but their use could be extended to an integral study. The *Factset* database also allows me to explore the dynamics of these policies along different stages of vertical integration. This provides an opportunity to take into account the intensity of inter-firm connections.

Another aspect of interaction between economic agents is spillover mechanisms. Corporate financing behavior must partly explain securities' returns and thus, the dynamics of liquidity in the market. I believe that combining a strategic component (debt and equity issuing from a corporate finance policies perspective) and a technical component (frictions in stock and bond markets) promises a good outcome for applied research. This can have an impact on stock and bond trading dynamics and formation of joint portfolio. Understanding the spillover mechanism will also reveal how shocks propagate through the inter-agent connections.

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Appendix. Data

Table A1: **Definition of variables.** The Compustat and my code notation is reported in parentheses. Non-ratio variables are discounted to 1990.

Variable	Definition
	I. Identifying Information. *Source: CRSP-Copmustat.*
Company Name (**conm**)	is the company name in characters.
Company Identifier (**gvkey**)	is the Standard and Poor's Identifier
Headquarter's Country (**loc**)	is the code that identifies the country where the company headquarters is located. The country codes are established by the International Standards Organization (ISO).
Industry (**naics** or **sic**)	Before 1987: Standard Industrial Classification (SIC) codes. After 1987: North American Industrial Classification System (NAICS).

continues

Variable	Definition
	II. Firm Characteristics. *Source: CRSP-Copmustat.*
Total Assets (**at**)	represent total assets/liabilities of a company at a point in time. Winsorised at 1% and 99%.
Debt in Current Liabilities (**dlc**)	represents total amount of short-term notes and the current portion of long-term debt (debt due in one year).
Total Long-Term Debt (**dltt**)	represents debt obligations due more than one year from the company's balance sheet date.
Total Debt (**td**)	is the sum of Debt in Current Liabilities (**dlc**) and Total Long-Term Debt (**dltt**).
Total liabilities (**tl**)	
is current liabilities plus long-term debt plus other noncurrent liabilities, including deferred taxes and investment tax credit.[7pt] *Total current liabilities* (**lct**)	is liabilities due within one year, including the current portion of long-term debt.

continues

Variable	Definition
Long-Term Debt (**ltd**)	is the Long-Term Debt Due in more than 3 years (4th Year and more) or the difference between Total Long-Term Debt (**dltt**) and Debt Due in 3rd Year (**dd3**) and Debt Due in 2nd Year (**dd2**). Winsorised at 1% and 99%.
Market Equity (**me**)	is the product of Annual Fiscal Price Close (**prcc_f**) and Common Shares Outstanding (**csho**).
Preferred Stock (**pstk**)	is the net number of preferred shares at year-end multiplied by the par or stated value per share as presented in the company's Balance Sheet.
Market Leverage (**ml**)	is the ratio of Total Debt (**td**) to the sum of Total Debt (**td**), Market Equity (**me**) and Preferred/Preference Stock (**pstk**). Winsorised at 1% and 99%.
Preferred Stock Value (**preferred_stock**)	is Preferred Stock Liquidating Value (**pstkl**). If it is missing, then Preferred Stock Redemption Value (**pstkrv**). In turn, if it is missing, then Preferred Stock (**pstk**).
Market Value (**mva**)	**prcc_f*cshpri+dltt+dlc+pstkl-txditc**is the sum of Total Liabilities (**lt**), Preferred Stock Value (**preferred_stock**), and Market Equity (**me**).
Market-to-Book ratio (**mtb**)	is the ratio of Market Value to Total Assets (**at**). Winsorised at 1% and 99%.
Profitability	is the ratio of Operating Income Before Depreciation(**oibdp**) to Total Assets (**at**). Winsorised at 1% and 99%.

continues

Variable	Definition
Tangibility (**tang**)	is the ratio of Net Property, Plant and Equipment (**ppent**) to Total Assets (**at**). Winsorised at 1% and 99%.
Producers Price Index (**PPI**)	is Producers' Price Index for All Commodities US, the average change over time in the selling prices received by domestic producers for their output.
CF Volatility (**cfv**)	is the ratio of standard deviation of Quarterly Operating Income (**oibdpq**) to Total Assets (**at**). Winsorised at 1% and 99%.
Reported Net Sales (**sale**)	is net sales as they are reported by a company.
Sales (**sales**)	is the natural logarithm of sales (**sale**). Winsorised at 1% and 99%.
R&D dummy (**rd**)	1 if R&D expenses (**xrd**) is missing, negative or zero, 0 otherwise
R&D ratio (**rd_ratio**)	R&D expenses (**xrd**)/Total Assets (**at**). Winsorised at 1%.
Fama-French Industry (**FInd**)	is an index assigned to an industry with respect to the Fama and French 49 Industries classification.
gvkey	CRSP-Compustat Identifier
Working Capital (**work_cap**)	is the difference between Current Assets (**act**) and Current Liabities (**dlc**).

continues

Variable	Definition
Retained Earnings (**re**)	represents the cumulative earnings of a company less total dividend distributions to shareholders.
Z-score	is Altman z-score and measures the likelihood of bankruptcy. It is defined as $(1.2*work\_cap+1.4*re+3.3*ebit)/at+0.6*me/book\_debt+sales/at$. If the z-score hits the threshold of 1.8, it is likely to file for bankruptcy. If it stays above 3, the company is unlikely to go bankrupt. Winsorised at 1% and 99%.
Stock Return	is the real return on Annual Fiscal Price Close (**prcc_f**). Winsorised at 2% and 98%.
Herfindahl-Hirschmann Index of Sales (**HHI_sales**)	is the sum of squares of the market shares of all firms having the same Fama-French Industry (**FInd**), in which share of the market is defined as the ratio of sales of a firm to the sum of sales of all firms within the industry.
Current Assets (**act**)	U.S. and Canadian GAAP Definition.
Cost of Goods Sold (**cogs**)	represents all costs directly allocated by the company to production, such as material, labor, and overhead.
Depreciation and Amortization (**dp**)	Depreciation is concerned with spreading the actual cost or other basic value of tangible capital assets over their estimated useful life is a systematic manner. Amortization is the process of cost allocation for intangible assets.
Asset Maturity	equals **act/(act+ppent)*act/cogs+ppent/(act+ppent)*ppent/dp**. Winsorised at 1% and 99%.

continues

Variable	Definition
Earnings Per Share from Operations (**opeps**)	reflects earnings per share figure, which excludes the effect of all nonrecurring events.
Abnormal earnings (**abearn**)	is defined as **(opeps_d-opeps_d[_n-1])/prcc_f_d[_n-1]**.
Investment tax credit (**inv_tax_credit**)	is the dummy for non-zero Investment Tax Credit (**itcb**).
Net opearting loss carryforward (**nol**)	is the dummy for non-zero Tax Loss Carry Forward (**tlcf**),
Boom	is defined according to `http://www.nber.org/cycles/cyclesmain.html`. It starts at the trough and ends at the peak of a business cycle, i.e., countercycles with recession. The recession is defined as a significant decline in business activity throughout the economy, lasting more than a few months and visible in macroeconomic parameters, including GDP.
Acquisition dummy (**acq_dummy**)	generated on the base of (**acq**) Compustat variable (represents cash outflow of funds used for and/or the costs relating to acquisition of a company in the current year or effects of an acquisition in a prior year carried over to the current year.

III. Connections Characteristics

continues

Variable	Definition
Degree	n-degree is the number of incoming edges. Number of suppliers in economic terms. Out-degree is the number of outgoing edges, number of customers. Degree is the total number of incoming and outgoing edges, total number of suppliers and customers, in other. Weighted there is the weight assigned to every edge. In the given case, weight is the absolute or relative amount of trade.
Betweenness Centrality	is the number of shortest paths between every two vertices in the network going through the given node.
Closeness Centrality	is the ratio of one over the sum of lengths of the shortest paths between the given node and all other vertices of the network.
Harmonic Closeness Centrality	is the sum over all vertices of the network of the ratios of one over the length of the shortest path between the given node and a corresponding vertex.
Eigen Centrality	is the measure of influence of a node on the network described by the respective entry of the eigenvector corresponding to the greatest eigenvalue.
Pageranks	is measured by left-hand side eigenvector and scaled by the number of the immediate neighbours.
Katz-Bonacich Centrality	is similar to Eigen Centrality but now there is the “fee” of α for having remote connections.
Authority and Hub Scores	The authority score of a vertex is therefore proportional to the sum of the hub scores of the vertices on the in-coming ties and the hub score is proportional to the authority scores of the vertices on the out-going ties.[1]

continues

[1] `http://www.analytictech.com/ucinet/help/hs4200.htm`

Variable	Definition
Eccentricity	is the maximum distance between the given node and any other vertex of the network.
Modularity	is the difference between a ratio of the actual edges of the group and an expected ratio if the connections were assigned randomly.
Component Number	in a undirected network is the number of the greatest set of nodes such that every pair of them is connected by a path.[2]
Strong Component Number	in a directed network is the number of the greatest set of nodes such that every pair of them is connected by a path.
Clustering	is the ratio of actual connected pairs of the given node's neighbours over all possible connected pairs of the given node's neighbours.

	IV. M&Acquisitions Characteristics
All Acquisitions	describes all domestic US acquisitions irrelative of the form of the transaction.
Asset Acquisitions	relates to acquisitions made in the form of Asset acquisition.
Firm Acquisitions	characterises acquisitions made in the form of Majority Interest Acquisition or Merger.

continues

[2] `https://www.sci.unich.it/~francesc/teaching/network/components.html`

Variable	Definition
Acquisition Premium (**acqprm**)	is a ratio of a value of transaction (**val**) to the Target Market Capitalization in millions of dollars 42 days before the date of announcement (**target_mktcap40**).
Cumulative Abnormal Return (**CAR**)	is sum of the differences between the expected return on a stock and the actual return.
Within Industry Acquisition	is a dummy for a deal which has been done within the same Fama-French Industry.
All Cash	is a dummy for 100% Percentage of consideration paid in cash: Value paid in cash divided by total value. Source: Thomson Reuters Financial Securities Data Company (SDC) Platinum.
Competing Bidder Flag (**compt**)	is Yes/No flag set to 'Y' where a third party launched an offer for the target while this original bid was pending. Challenging bids are covered under a separate record and deal number with challenger as Acquirer.
Hostile Acquisition (**hostile**)	is a dummy for a hostile Attitude of the Transaction.
Industry M&ALiquidity	is a ratio of industry value of transaction to Industry total assets.
Relative size	is a ratio of a Value of Transaction (**val**) to Total Assets (**at**) of the bidder.
Public Target	is a dummy variable equal to one for publicly traded target firms.

continues

Variable	Definition
Private Target	is a dummy variable equal to one for private target firms.
Time to Acquisition	is a variable which measures time to acquisition in years. It varies form -5 to 5 with 0 corresponding to the year of announcement. In case when there is less then 10 years between acquisitions, we assign negative values, i.e., we prefer to consider this being a time to acquisition rather than time after the previous one.
Deal value	Value of cash and all securities offered by the bidder to the target shareholders in constant year–2000 US dollars. The consumer price index from the Bureau of Labor Statistics (Series CUUR0000SA0) is used to account for inflation. Source: SDC Platinum.