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The Economics of Interfirm Networks

Tsutomu Watanabe • Ichiro Uesugi • Arito Ono
Editors

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 Springer

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¹ The workshop program and presentation materials are available at: <http://www.rieti.go.jp/en/events/12112901/info.html>.

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Needless to say, any remaining errors are our responsibility. The views expressed in this volume are those of the authors and do not necessarily reflect those of the institutions with which they are affiliated.

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Chapter 1

The Economics of Interfirm Networks: Main Issues

Tsutomu Watanabe, Iichiro Uesugi and Arito Ono

1.1 Introduction

Interfirm networks prevail in many facets of economic activity and are significantly influential across a range of economic phenomena from business cycles to knowledge spillovers. There is a growing concern in the policy arena relating to the vulnerability of such networks based on the casual observation that idiosyncratic shocks on firms can be amplified through interfirm connections and can lead to a systemic crisis. Typical examples are the manufacturing supply-chain networks in the automobile and electronics industries that propagated regionally concentrated shocks—such as the Great East Japan Earthquake and the floods in Thailand, both in 2011—into global ones. The recent global financial crisis has also shown that the failure of a large bank can have significant adverse effects on the economy as a whole via complex transaction networks.

There is growing interest among academic physicists and economists in network formation and functions. The standard economic model assumes that agents interact anonymously in centralized spot markets where transactions occur through independent decisions. However, many markets do not function as such, but rather involve many interactions through bilateral links. Hence, the notion of networks as a collection of nodes with links between them can be a useful tool for understanding a number of economic phenomena: there is an abundance of theoretical literature including Dutta and Jackson (2002), Jackson (2008), Goyal (2007), and Benhabib

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et al. (2011) on this concept. However, there are a limited number of empirical studies on interfirm networks.

It is against this background that we instigated the research project titled “Designing industrial and financial networks to achieve sustainable economic growth” under Japan’s Ministry of Education, Culture, Sports, Science and Technology program called “Promoting social science research aimed at solutions of near-future problems” in summer 2008. The main objective of the project is to examine the formation of interfirm networks and to investigate their impacts on a broad range of economic activities. The relevance of the research topic further increased in the face of subsequent massive shocks including the recent global financial crisis that erupted in late 2008 and the Great East Japan Earthquake that occurred in March 2011.

Having access to a comprehensive database on interfirm and firm-bank relationships was critical to the project success. For this purpose, we collaborated with the Teikoku Databank (TDB) Ltd.—the largest credit database company in Japan—and constructed a unique and massive transaction relationship database of approximately 400,000 Japanese firms. The TDB database provided details on firm attributes including their addresses (geographical location) and managerial performance and further providing information including their suppliers, customers, shareholders, and financial institutions. We augmented the database with variables from other sources including: information on firms’ domestic and foreign investment activities extracted from government statistics, information on financial institutions’ balance sheets obtained from other database companies, and information on the evolution of these networks based on our independent survey results. These database additions enabled us to examine a novel set of issues including the interaction between networks and economic agglomerations, and the impacts of interfirm transaction relationships and of firm-bank relationships on firms’ investment behavior.

The pertinent research issues were split into three categories: (1) the structure and evolution of interfirm networks and their relationship with macroeconomic fluctuations, (2) the impact of interfirm networks on economic geography and on firm activities, and (3) the interactions between bank-firm relationships and firm behavior. The project led to a number of research articles on interfirm networks and relationships—including those compiled in this volume—that fall under one of the three identified category headings. Section 1.2 summarizes our research achievements by mainly focusing on the 11 papers collected in this volume and by selectively referring to some of our related research articles. Section 1.3 discusses several unresolved issues that are left for future research.

1.2 Summary of the Volume

1.2.1 Structure and Evolution of Interfirm Networks

The four chapters in Part I empirically examine the structure and evolution of interfirm networks in Japan through the lens of network analysis. In Chap. 2, Takayuki Mizuno, Wataru Souma, and Tsutomu Watanabe examine whether micro shocks to individual

firms could diffuse widely to other firms through customer–supplier linkages and, ultimately, result in fluctuations in the economy as a whole. To this end, they start with a close look at the structure and evolution of customer–supplier networks in Japan from 2008 to 2012 using a unique dataset constructed from the TDB database. The authors present interesting empirical regularities in three aspects: (1) the cross-sectional attributes of the interfirm networks, (2) the evolution of interfirm networks, and (3) the interaction between the proximity of two firms in a network and the correlation of these firms’ managerial performance. Regarding the cross-sectional characteristics of the interfirm networks, the authors find a non-uniform distribution of the customer and supplier links across firms, in that there are many small firms that have a few interfirm transaction relationships while there are a few “hub” firms that have many interfirm relationships. Moreover, the authors suggest that firms tend to have stronger incentives to acquire customers than they do to acquire suppliers. Finally, the authors find that the shortest path length for a given pair of firms is, on average, 4.3 links, suggesting that firms are closely interconnected presumably because of the existence of hub firms. Regarding the evolution of customer–supplier networks, the authors find that the switching of customers and suppliers is relatively rare and that there is a close interconnectedness among firms. This finding suggests that a shock to a single firm can be easily propagated to an entire network since there is little substitution among potential transaction counterparts. Regarding the association between network structure and the correlation of firm performance, the authors report that the correlation in annual sales growth between two firms is greater when the shortest link path between the two firms further shortens. This suggests that a non-negligible portion of firm sale fluctuations stems from the propagation of an idiosyncratic shock to other firms that are closely linked to it via customer–supplier chains.

In Chap. 3, Takashi Iino and Hiroshi Iyetomi analyze the community structure of interfirm networks in Japan. They visualize both an overall network structure and the network structure of eight specific industrial sectors and show that the structure of these networks is highly heterogeneous. For example, construction firm networks have a highly hierarchical structure (contractors, sub-contractors, sub-subcontractors, etc.), while manufacturing firm networks are tightly connected and form a dense cluster. These results contrast with the conventional wisdom that the manufacturing industry has highly hierarchical connections, and the findings merit further investigation.

The authors formally identify communities in Japanese interfirm networks using modularity maximization. A community is defined as a group of tightly connected nodes, with the links between them being sparse. The modularity measures the difference between the actual link density within a network (community) subset and its expected value: the optimized division of a network yields the highest modularity values. Using this methodology, Iino and Iyetomi extracted 118 communities from a large firm-level database. Focusing on the characteristics of the 10 largest communities in terms of the number of constituent firms, they find that each community is strongly associated with its constituent firms’ characteristics with respect to regions and to industry sectors. The authors also detect sub-communities within

the 10 largest communities, because modularity optimization often fails to identify small but important communities embedded within large communities. They show that the 10 largest sub-communities within a given community are also characterized by the constituent firms' areal and industrial attributes. For example, the largest sub-community of the largest community (machinery manufacturers and wholesalers) contains major electrical appliance manufacturers, while the second largest sub-community contains an automobile manufacturing cluster led by Toyota Motor Corporation and its group firms. Overall, modularity maximization can detect clusters of firms, including those of automobile and electronics firms that are frequently taken as typical examples of industry agglomerations. Finally, the authors investigate the structure of inter-community relationships by measuring their "distances" and the directional features of their transactions.

In Chap. 4, Iichiro Uesugi focuses on several regional industrial agglomerations and examines the structure and evolution of their interfirm networks from a variety of perspectives including: the nature of interfirm transaction relationships as well as the developments in such relationships over time; firm participation in network activities other than supplier–customer transactions; and interactions between interfirm transaction relationships and other relationship types. To investigate these issues, the author used TDB database information in conjunction with the results of a unique firm-level survey. A questionnaire was distributed to over 14,000 manufacturing firms located in Japan's three major industry agglomerations: the Keihin, Higashi-Osaka, and Hamamatsu areas. Regarding the development of interfirm transaction relationships over time, Uesugi finds that their numbers tended to decrease rather than increase in the three major industry agglomerations over the past 10 years, especially in the case of small firms and transaction relationships involving local customers and suppliers. This coincides with a substantial decline in the number of manufacturing firms located in these agglomerations and indicates that these industry agglomerations may have experienced negative feedback from the declining number of interfirm connections. Regarding the second issue, the author indicates that apart from transaction relationships, many firms had established other interfirm link types and participated in group activities including those in industry associations and local chambers of commerce. This suggests that regional proximity and shared industry interests are important determinants of firm links. Regarding the third issue, the author suggests that bank-lending attitudes appear to be affected by the links among local firms. Specifically, hub customer firms for local suppliers are more likely to have their loan applications approved than hub supplier firms for local customers. A possible interpretation of this result is that banks perceive the externalities associated with hub firms that purchase from local firms to be greater than those associated with hub firms that sell to local firms, and hence are more accommodative in their lending attitudes toward the former. This suggests that banks internalize the externality associated with hub customer firms when making a loan decision. This idea is formally examined in Ogura et al. (2014): an important contribution arising from our research project. The authors examine the lending decision by banks when such banks take the borrowing firm's interfirm transaction network structure into account.

1.2.2 Networks, Economic Geography, and Firm Activities

Part II examines how interfirm networks and relationships are associated with economic geography and firm activities. In Chap. 5, Kentaro Nakajima provides an overview of the relevant recent literature. The author summarizes the studies that use aggregated data and refers to their limitations, and then reiterates the importance of using disaggregated interfirm transaction data. The author reviews the literature that uses two data sources: the interfirm transaction relationship data from TDB and from Tokyo Shoko Research Ltd. (TSR); and data from the Commodity Flow Survey (CFS) undertaken jointly by the U.S. Bureau of Transportation Statistics and the U.S. Census Bureau. Nakajima then examines the impacts of interfirm transaction networks on the following three aspects: the geographical concentration of firms, the geographical propagation of shocks, and corporate decision making. One of the reviewed studies—Nakajima et al. (2012)—focuses on the relationship between interfirm transaction networks and the geographical agglomeration of firms and is a notable research contribution of our project. The authors propose a methodology to measure the extent of the localization of interfirm transaction relationships in the spirit of the pairwise distance approach of Duranton and Overman (2005). The authors thus detect the localization of transaction relationships at the firm level by setting up counterfactual transaction counterparts. This powerful tool provided by Nakajima et al. (2012) enables researchers to examine the relationship between interfirm transaction networks and industry agglomeration.

In Chap. 6, Gilles Duranton shows how the information on economic activity networks is used to define geographical agglomerations. The author focuses on the labor market and proposes a simple but robust methodology to define metropolitan areas by an iterative aggregation of spatial units using the information on commuting flows between them. Essentially, a spatial unit A is aggregated to another spatial unit B if the share of the workers who work in B among all those that reside in A is above a given threshold. A further spatial unit C may next be aggregated to the union of A and B if, similarly, it sends a fraction of its commuters greater than the same threshold to this newly formed unit even though it may not have been possible to aggregate C directly to either A or B. This process of aggregation repeats until no further unit can be aggregated. Aside from its simplicity, the methodology has two advantages: transparency that avoids possible political pressures on the definition of metropolitan areas, and robustness on the threshold level of the ratio of commuters from one municipality to the other. The author studies the case of Colombia to find several empirical regularities. Duranton acknowledges that the methodology could be used to define another set of metropolitan areas using information on interfirm transaction networks. The author did not undertake this because of data limitations in Colombia; however, other researchers may apply the proposed methodology to countries where complete interfirm transaction network data are available. They may also examine how economic agglomerations that use the interconnectedness of the labor markets differ from those that use the interconnectedness of the goods and services markets.

In Chap. 7, Hiroyuki Okamuro and Kenta Ikeuchi examine the formation of interfirm and firm–bank transaction networks by start-up firms. Most start-up firms are vulnerable to failure because of a lack of internal business resources. External resources such as business and financial networks are essential for the survival and growth of such firms. These networks both provide start-up firms with access to external business resources and signal their trustworthiness to third parties. Several studies have shown that entrepreneurial networks contribute to start-up performance; however, few have examined the formation of business and financial networks by start-up firms. Against this background, the authors empirically explore the determinants of interfirm network formation by start-up firms at the early stage of their life cycle, focusing on the founders' characteristics. Based on the TDB database, the empirical results show that lengthy industry experience of 10 years or more on the part of the founder has a significant positive impact on the size of both business and financial networks, while having a university education positively affects both the size and quality of business and financial networks. Surprisingly, no distinct differences are detected between the determinants of business and financial networks. Moreover, in another important project research contribution Okamuro also examines the impact of interfirm transaction relationships on corporate performance (Okamuro and Nishimura 2013).

In Chap. 8, Yukiko Saito details the geographical propagation of shocks through interfirm networks. The author focuses on a single massive natural disaster—the Great East Japan Earthquake that occurred in March 2011—and studies the extent of the impact among firms that were located outside the earthquake-hit areas. In addition to affecting the firms located in areas directly hit by the earthquake, there is abundant anecdotal evidence suggesting that the earthquake indirectly damaged firms located outside the hit areas through supply-chain disruptions; however, there is limited empirical evidence on this. There are two different, although not mutually exclusive, mechanisms through which shocks are propagated: (1) when shocks are transmitted among transaction partners located in the physical proximity of the affected firm and (2) when a limited number of hub firms propagate shocks to the entire economy through a large number of transaction relationships. Using interfirm transaction data from approximately 800,000 firms in Japan, the author examines the extent of the latter propagation mechanism by studying how firms in the unaffected areas are linked to those in the affected areas. The result indicates that most firms in the unaffected areas have indirect relations with firms in the affected areas. Overall, the findings in Chap. 8 highlight the importance of firms being closely linked to each other even if they are geographically distant and emphasize that regional hub firms play a key role in spreading localized shocks.