Emergence and maintenance of business transaction ties: The role of business and ownership connections

Introduction

Economic production happens through the interaction of firms in networks. Studying interfirm business transactions - firms buying or selling products or services to another firm - allow us to better understand production processes (Atalay et al. 2011), supply chain mechanisms (Arora and Brintrup 2021, Todo et al. 2016) or economic shock propagation (Inoue and Todo 2019, Diem et al. 2021).

Analyzing business networks is an emerging field, and it is tempting to use the mechanisms that are already well-known from social network analysis for this purpose. However, the mechanisms generating business transactions and social connections may be basically different. In general, social networks show a high level of transitivity, as friends of friends are likely to be friends; reciprocity, as social relations are highly reciprocated, and homophily, as similarity is an important mechanism driving social relations (Rivera et al. 2010, McPherson, et al 2001). In contrast, motivations behind business transactions are different. Firms produce different products and services, which can be understood by the mechanism of economies to scale and economies to scope (Tirole 1998), and buying products or services together is driven by the principle of substitution and complementarity. If products of firm A and B are *complements,* buyers of A's products will be likely to buy the products of B as well. This complementarity behind tie formation however results in a three-step closure, instead of a triad. In this sense, transaction networks are similar to functional networks, e.g. protein networks, with over-representation of even paths (Mattsson et al. 2021).

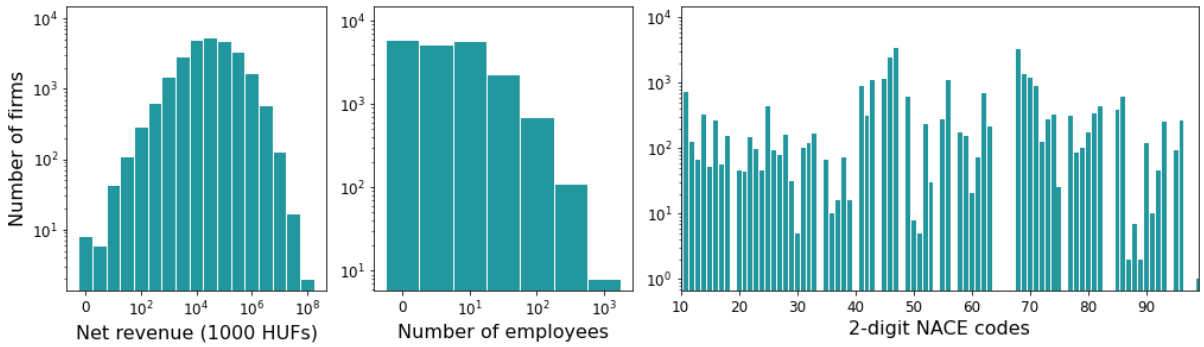
Beyond the above arguments on economic rationality, it also must be considered that economic activities are embodied in social relationships. From an economic point of view, the importance of trust is foremost, as it reduces uncertainty associated with business transactions (DiMaggio and Louch, 1998), and hinders opportunistic behavior and provides resources that are not available in arm's length relationships (Kale et al., 2000; Uzzi 1996). From the trust perspective, it is not only direct transaction relationships that convey information of trustworthiness of the partners, or offer opportunities for sanctioning opportunistic behavior, but other types of relationships (e.g. social relationships) matter too.
In the analysis we focus on one aspect of this multiplex structure, the relation between ownership and transaction networks, a specific social relation to determine the power it has over the formation and persistence of business transactions.

Data

To uncover the relationship between co-ownership and business transactions in a large-scale inter-firm network, we combine two key data sources. We get detailed information about the owners of companies operating in Hungary from the firm-level database, OPTEN. We define co-ownership ties as the two firms having the same personal owners listed in the dataset. We then restrict the analysis to firms registered in Hungary with any co-ownership connection to any other company in the period of 2016-2017.

We map the business transactions of firms through VAT reports collected by the National Tax and Customs Administration of Hungary. This dataset contains transaction links between Hungarian companies in case the tax content of their transactions exceeds 1 million HUF (ca. 3000 EUR) in the given year. The dataset is anonymized, but it is connected to firm-level panel balance sheet data on companies by the Data Bank of ELKH CERS. Figure 1 illustrates that our final sample is diverse both in terms of size and industries.

Figure 1 Properties of firms in 2016



Methods

To model the influence of network structural patterns on inter-firm business tie formation, we focus on a set of network motifs (Takes et al. 2018). These multi-level motifs and their relative frequencies are described in Table 1.

Table 1 Multi-level motifs to understand transaction tie formation

2016	2017	Motif name	Observed	Relative frequency
		Motifs behind tie creation		
		Direct ownership	17148	0.004%
		Indirect ownership	2022	0.001%
		Indirect transaction	234748	0.055%
		Indirect mixed	6949	0.002%
		Motifs behind tie persistence		
		Direct ownership	935	32.009%
		Indirect ownership	41	1.404%
		Indirect transaction	1115	17.939%
		Indirect mixed	524	17.939%

As our networks are relatively big (23602 nodes in 2016), estimation of standard statistical models on network formation, such as exponential random graph models or stochastic actor-oriented models are hardly feasible. Therefore, we opt to use simple dyad-level modelling approaches.

Our dependent variable is a binary variable $T_{ij,t+1}=1$, in case the business transaction tie between two firms (i and j) is present in time *t+1*, and $T_{ij,t+1}=0$ if it is not observed. We model tie creation and tie persistence separately and the following two equations illustrate our model settings.

$$pr(T_{ij,t+1} = 1 | T_{ijt} = 0) = \beta_1 SC_{ijt} + \beta_2 Rel_{ijt} + \beta_3 SI_{ijt} + \beta_4 O_{ijt} + \beta_5 OO_{ijt} + \beta_6 TT_{ijt} + \beta_7 OT_{ijt} + \beta_8 controls_{ijt} \quad (1)$$

$$pr(T_{ij,t+1} = 1 | T_{ijt} = 1) = \beta_1 SC_{ijt} + \beta_2 Rel_{ijt} + \beta_3 SI_{ijt} + \beta_4 O_{ijt} + \beta_5 OO_{ijt} + \beta_6 TT_{ijt} + \beta_7 OT_{ijt} + \beta_8 controls_{ijt} \quad (2)$$

where SC_{ijt} indicates whether firm *i* and *j* are in the same city, Rel_{ijt} represents the relatedness of firms *i* and *j*, and SI_{ijt} indicates whether firms operate in the same industry. O_{ijt} stands for the direct ownership connection between firm *i* and *j*, OO_{ijt} represents indirect ownership relations between firms, TT_{ijt} stands for indirect transaction ties and OT_{ijt} indicates whether firm *i* and *j* are connected through indirect, mixed ownership-transaction relations.

The model setting of equation (2) focuses on transaction ties that were present in the previous period. However, the estimation of equation (1) requires to consider all the potential connections between companies (more than 300 million possible connections). To make the estimation faster and easier, we propose theopt to use of log-linearuse log-linear models instead of the apparent logistic regression approach.

Results

We begin by focusing on new business tie formation and present a null model (Model 1 in Table 2) with variables only on the geographic proximity and industrial similarity of firms. next, we control for the influence of direct ownership ties between firms (Model 2), then we assess the importance of indirect connections on new direct business transactions (Model 3). Chi-square test of (Model 3) indicates that further effects are desirable to improve the predicting power of our model. Accordingly, we add all three-way interaction effects to the model (Model 4).

The two-way effects of “business tie creation” with all other variables describe the extent to which the presence of the motifs are associated with new business tie creation. These are the coefficients shown in Table 2 in terms of log-odds. Thus, the parameter of the same city variable in Model 4 indicates that the probability of new business tie creation is by $e^{3.758} = 42.9$ times increased, if two firms are located in the same city. Results indicate that operating in the same city and in related industries increase the probability of business tie creation. The variable same industry is also positive and significant in our best, final model (Model 4) on new business tie creation. This suggests that geographical proximate and technologically similar companies are more likely to form business ties over time.

Both direct and indirect ownership increase the probability of new business tie formation. This suggests that ownership ties are influential for business development. Furthermore, the effects of these motifs are higher by an order of magnitude than the effects of geography and industrial similarity.

Table 2 Key coefficients of log-linear models on new business tie creation

	Model (1)	Model (2)	Model (3)	Model (4)
Business tie creation X				
Same city	4.426***	2.721***	2.404***	3.758***
	(0.060)	(0.119)	(0.129)	(0.099)
Related industry	1.127***	0.948***	0.681***	0.814***
	(0.085)	(0.086)	(0.088)	(0.121)
Same industry	1.145***	0.282**	-0.023	0.746***
	(0.106)	(0.112)	(0.113)	(0.168)
Direct ownership		5.996***	5.862***	8.218***
		(0.131)	(0.147)	(0.141)
Indirect ownership			5.286***	7.186***
			(0.319)	(0.520)
Indirect transaction			5.711***	6.245***
			(0.070)	(0.076)
Indirect mixed			-2.483***	6.362***
			(0.129)	(0.286)
Model statistics				
Deviance	2.1E+09	1.76E+09	6362.0	173.0
d.f.	134	129	109	65
p value (LR test)		0.000	0.000	0.000
p value (Chi2 test)	0.000	0.000	0.000	0.000

Notes: Parameters of loglinear models, standard errors in parentheses, * p<0.1, ** p<0.05, *** p<0.01

Including three-way interactions to our final, preferred model enables us to evaluate the combination of effects on new business tie creation. These coefficients are listed in Table 3, where the diagonal repeats the two-way effects from Table 2 model 4, showing the individual impact of each variable. The non-diagonal cells include the three-way interactions. We see that all significant non-diagonal elements are negative, indicating a “diminishing return” on the examined effects. This suggests that the additional effect of a motif is always smaller, if another motif is already present compared to the case when it appears alone.

Table 3 Selected coefficients of the three-way interaction model on tie creation

	Same city	Related industry	Same industry	Direct ownership	Indirect ownership	Indirect transaction	Indirect mixed
Same city	3.758***	-0.175	-0.171	-3.030***	-2.948***	-1.217***	-0.812***
Related industry		0.814***	n/a	-0.256	-1.082	-0.201	-0.068
Same industry			0.746***	-0.632**	-1.597	-0.352	0.170
Direct ownership				8.218***	n/a	-3.115***	-4.493***
Indirect ownership					7.186***	-1.549**	-4.406***
Indirect transaction						6.245***	-3.209***
Indirect mixed							6.362***

Notes: The underlying model is presented in Table 5 model 4. * p<0.1, ** p<0.05, *** p<0.01

Coefficients from log-linear models on the persistence of business transaction ties are presented in Table 4. The structure of models is identical to our models on new tie creation.

The results indicate that firms in the same city are more likely to persist their business connections, while related or identical industry profiles do not significantly influence the maintenance of connections. Direct ownership ties between firms support the persistence of business transactions, but indirect ownership does not. This suggests that only direct control and influence through ownership support the maintenance of business ties. Coefficients for indirect transaction ties are positive and significant for all model settings, meaning that embeddedness in business transaction networks support tie persistence. Unlike in case of tie creation, indirect mixed ties increase the likelihood to maintain business connections between firms. It is important to note that effect sizes are much smaller than the ones observed in the context of business tie creation. The parameters are in the range of 0.6-0.7, which correspond to 1.8-2-fold increase in probabilities.

Table 4 Key coefficients of log-linear models on tie business tie creation

	Model (5)	Model (6)	Model (7)	Model (8)
Business tie X				
Same city	0.621***	0.261***	0.262***	0.677***
	(0.082)	(0.098)	(0.100)	(0.170)
Related industry	0.277**	0.272**	0.155	0.169
	(0.119)	(0.120)	(0.123)	(0.201)
Same industry	0.179	0.111	0.123	0.222
	(0.145)	(0.147)	(0.149)	(0.260)
Direct ownership		0.665***	0.677***	0.726***
		(0.098)	(0.101)	(0.174)
Indirect ownership			0.408	0.864
			(0.332)	(0.687)
Indirect transaction			0.591***	0.687***
			(0.082)	(0.117)
Indirect mixed			0.335***	0.605***
			(0.107)	(0.228)
Model statistics				
Deviance	5501	4514	186.5	100.9
d.f.	134	129	109	65
p value (LR test)	0.000	0.000	0.000	0.000
p value (Chi2 test)	0.000	0.000	0.000	0.003

Notes: Parameters of loglinear models, standard errors in parentheses, * p<0.1, ** p<0.05, *** p<0.01