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Original Paper

Japanese Network Economy-ERGM analysis of the "Big Six"

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Abstract

The paper analyses the network of relationships between large companies that defines the Japanese economy using ERGM (Exponential Random Graph Model) method. The Japanese economy, because of the presence of keiretsu groups and other corporate groups, is an excellent example of what can happen to a country's economy if large corporations and financial institutions in the market operate in a closely interconnected, highly centralized and dependent network. This is an important issue, because this economic practice is happening globally right now. Therefore, the interpretation of the Japanese network and the analysis of its economic performance also reflect the long-term negative and positive effects of this trend.

Keywords

Japanese economy, network economy, ERGM

1. Introduction

As the economy and economic actions are always embedded in society (Polányi, 1944, 2001), the functioning of different national economies, in addition to the global context, is always determined by the history, social relations and social network of the given culture. The economies of nation-states in the twenty-first century belong to the age of capitalist economies (Note 2), where the corporate and financial sectors are becoming more and more interdependent. Based on all this, it is worth looking at an economy like that of Japan's, operating in a close and dense network, (in which the engines of the economy are still based on a dense network of large corporations and banks), and analyzing the network factors that explain their operation.

The literature points to the collapse of Japan's bubble economy in the 1990s, followed by the long economic stagnation over the past 30 years. All of this was only exacerbated by the 2008 global

economic crisis, the catastrophic earthquake of 2011, and the tsunami that damaged northeastern Japan (Yoshino et al., 2014). Despite all this, the Japanese economy, of course, continues to be a leader among world economies, ranking third in the world in terms of GDP per capita (World Bank, 2020).

However, several studies point out that Japan's economic miracle and stagnation have the same components, viz., a strong bond between the corporate and banking sectors. The Japanese banking system is characterized by different types of banks: long-term credit banks, asset management banks, city banks, regional banks, secondary regional banks, and insurance companies (De Masi et al., 2011). These organizations and banks have a key role to play in the Japanese network economy. In each case, Japan's "big six" (Note 3) have an "internal bank" that is tied to the corporate group with multiple threads. Not only do these central financial institutions own more than 50% of the shares in firms (Agarwal & Elston, 2001), but in many cases, the chairs of supervisory boards are also bankers or bank-related actors who are part of corporate management. All this results in a classic merger of banking and market companies, analogous to the classical German banking system of the 19th century. Sterken and Tokutsu (2002) have shown that this connection encourages conglomerates to take out more favorable loans, and that the presence of a credit in itself attracts more loans from other banks. All this also results a number of phenomena that strengthen and distort the markets. There are long-term and close credit relationships between banks and large corporations, resulting in a highly hierarchical structure in which the central network positions are occupied by leading banks. However, this is accompanied by a strong asymmetric information problem in the market (De Masi et al., 2011). As Japanese firms operate in this system, they are heavily dependent on banks' funding, leading to the bankshaving much more information about the firms than their counterparts in other countries' credit markets (Spiegel & Yamori, 2003). In contrast, banks provide preferential credit terms, which are more lenient in terms of easier access to capital, bank debt settlement and the possibility of other preferential loan terms (De Masi et al., 2011). It follows from all this that in Japan, banks are steering firms towards low-risk investment decisions, which also implies that firms closely related to banks are less profitable than their other competitors (Ogawa et al., 2007). Ogawa et al. (2007) provided a detailed analysis of the evolution of the number of long-term debt ratios and the relationship between key indicators of the firms; the authors highlighted that although the largest firms have the most banking links, the number of links is positively correlated with solvency and R&D, but has a negative effect on the firms' liquidity.

Japanese financial institutions suffered heavy damage after the 1990 Bubble collapse due to the above-mentioned structural constraints. There has been a significant deterioration in the financial status of the Japanese banking system since 1992 (Brewer et al., 2003), with commercial banks recording a total loan loss of about Yen 83 trillion. These losses have reduced the capitalization of banks and led to the failure of three large banks. The precarious financial situation of these large banks affected the entire credit system, especially their weaker financial counterparts. In order to increase the financial stability of the system, Japanese regulators liquidated a city bank and nationalized two of the three

largest long-term credit banks (Brewer et al., 2003) in 1997. The failures of bank negatively affected the stock prices of the credit-related businesses as well (De Masi et al., 2011).

Therefore, a major financial transformation was implemented in Japan in the 2000s. The CRL (Commercial Rehabilitation Law) was enacted, which restructured the financing system's network-based connections, which lead to positive results by 2012. This was followed by further economic stimulus decisions by the government, decentralizing the system and removing the ties of market players. All this, in financial terms, has had positive results, as stock market prices have started to rise after a long stagnation (Chan-Lau, 2002). Of course, this result also required Japan to increase the share of foreign capital investment, compared to the national capital investments that had dominated the markets so far. All this has been recorded in literature, with many authors studying the FDI and its results like increased employment, output, and productivity (Driffield, 2001; Driffield & Girma, 2003; Driffield & Munday, 2000; Driffield & Taylor, 2000; Kimino et al., 2007).

Japan has taken a huge step towards tackling growth-restrictive corporate practices such as closed-loop sales, cartel-like behavior and entrenched agreements, which makes it more difficult for new entrants to compete for products, services and / or prices (Yoshino et al., 2014).

2. Zaibatsu and Keiretsu

It is important to note, however, that the afore said image captures only a part of the story. The development of this level of network hierarchy in the banking system is the result of a long social change leading all the way back to the operation of Edo-era family businesses. However, I would not interpret the whole economic history of Japan in this paper, but confine myself to the development of the capitalist economy.

Perhaps one of the most important internal engines of the development of Japanese capitalism (Showa era (1926-) was the Zaibatsu. Japan arrived in the global capitalist economic scenario relatively late, and even then, the process began due to external pressure (Imai, 1987). The engines of this economic transformation were the Zaibatsus, created to supplement the market imperfections of the changing economy. As a result, Zaibatsu firms, which have optimized their mutual returns within a strong hierarchical system, can be interpreted as a form of early-capitalist Japanese innovation through closely inter-related activities (Imai, 1987). These economic networks have created a strong control structure through asset-share ownership, human relationships, trust, and centralized purchase and marketing. The basic method of control was direct share ownership (Imai, 1987).

The close relationship between firms was reflected in the fact that executives held leadership roles in more than one company simultaneously, such that these organizations could "function as a monolithic whole" (Hadley, 2015). As a result, Zaibatsu has been able to bring success to several industries in the Japanese economy. This is how the Zaibatsu of 294 companies operating under Mitsui, the Zaibatsu of 241 companies under Mitsubishi, and that of 166 companies under Sumitomo emerged (Imai, 1987). This corporate transformation coincided with the transfer of technology from developed economies,

especially from Britain, to less developed economies, including Japan. The leaders of the successful Zaibatsu also had a missionary zeal in developing Japan as an industrial nation. Therefore, they opposed short-term gains and emphasized risk aversion, making strategic investments for industrialization (Imai, 1987). By the first half of the twentieth century, Zaibatsus became key players in bank subsidies, creating a close link and entanglement between the financial and corporate sectors (De Masi et al., 2011).

However, in World War II, these groups of companies opted for a strong political role, resulting in the economic cleansing announced in January 1947 after the capitulation of Japan. As is well known, senior executives of 245 large Japanese companies were removed. This was an epoch-making event, as it disrupted the Zaibatsus' networks-based transactions on personal attachment and changed the way decisions were made within the network groups. As a result, people in their forties who were at the level of department heads were appointed to the highest levels of governance, and they began to invest in innovative segments of the Japanese, economy, putting it on a turbulent trajectory. After the war, Japan thus became one of the fastest growing economies in the industrialized world.

This process also went hand- in- hand with the process of Keiretsu groups taking over the role of Zaibatsus. Yonekura's (1985) corporate graph typology (Figure 1) perfectly illustrates the differences between the two structures. Keiretsu groups show a more decentralized and reciprocal relationship structure, with a strong core that forms a reciprocal and decentralized network and a periphery made up of companies belonging to one of the core actors and with which they have a hierarchical and one-way relationship.

Figure 3. *Zaibatsu* vs. *Keirets*

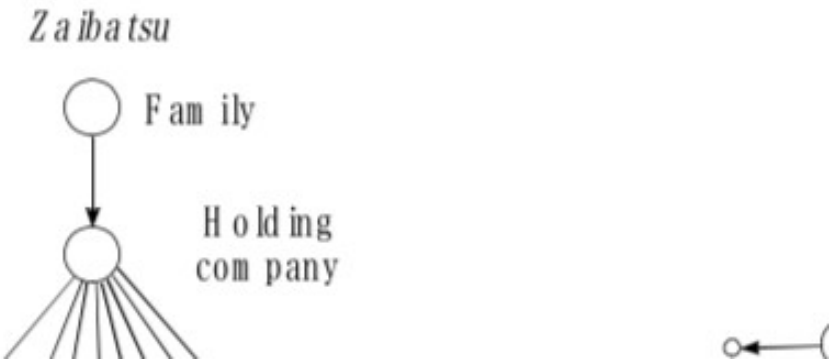


Figure 1. Schematic Graphs of the Zaibatsu and Keiretsu Groups

S. Yonekura (1985, p. 64).

One of the special features of the rapid growth of the Japanese corporate system was therefore the Keiretsu groups. Derived from the previous historical narrative, they cover a network of close and hierarchical corporate financial groups, in which banks have developed a close relationship of

dependence with companies. In many cases, the group's main bank also played the leading role in Keiretsu. There is also a stable internal cross-shareholding between the players in the Keiretsu group, similar to the Zaibatsu, with each company owning shares in the other companies in the group. Companies in Keiretsu usually do not sell their shares to outsiders. Additionally, the central bank usually owns the largest equity fund and is also the main creditor to the other members of the group (Chan-Lau, 2002).

Keiretsu groups are classified in Japan as the Big Six, viz., Sumitomo, Mitshubishi, Fuji, Sanwa, Mitsui and Daiichi Kangyo. Figure 2 shows the current group of big six and the most important companies belonging to them.

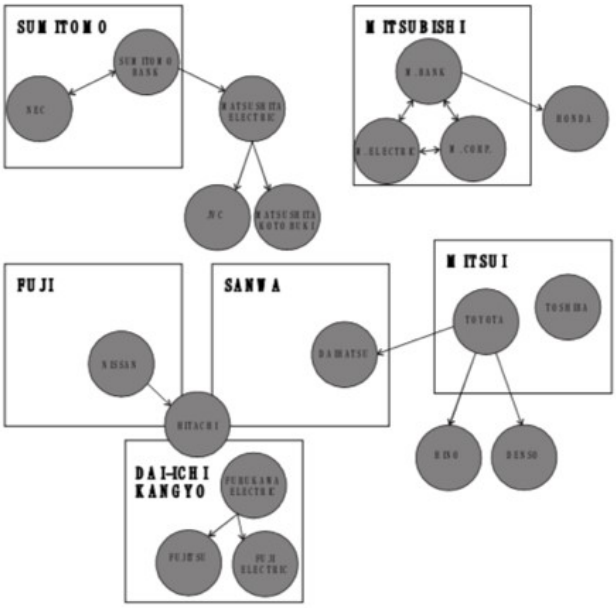


Figure 2. The Big Six and Their Leading Companies

Lincoln, 2004, 22.

This corporate governance system was one of the most important contributors to the success of the Japanese economy from the early 1950s to the late 1970s. However, downturns appeared in the central banking system by the mid-1970s, and the slow liberalization and regularization of the financial system began. Large and creditworthy companies began to reduce the use of bank loans as a major source of financing, as they were able to obtain cheaper finance in the securities markets. The concentration of bank loan portfolios began to shift towards medium-sized and smaller firms, which were in many cases independent of Keiretsu groups (Chan-Lau, 2002).

By the 1980s, although the Japanese economy was still on a turbulent trajectory, these downturns become stronger. An increasing problem which emerged by then was the corporate boards being were aligned better with creditors or banks than with employees or shareholders (Kanda, 1998), making

them more interested in strong bank support than in profit maximization (Morck &Nakamura, 1999). Further, other economic reforms also began in the 1980s, such as reducing the number of company executives and increasing focus on their performance, rather than on the length of their tenure in management positions., but this still wasn't enough that the dotcom burst don't drag down the Japanese economy with itself by the early 1990s, followed by a stagnant trajectory ever since (Chan-Lau, 2002).

2. Method

2.1 ERGM Network Analysis

Due to the strongly networked economic structure outlined above, a number of network studies have already been conducted about the Japanese economy, both descriptively and in a bipartite fashion (Peltomaki-Alava, 2006; Sneppen et al., 2004; Guillaume-Latapy, 2004). The main network analysis directions of the Japanese economy are the analysis of corporate debt and lending processes and network clusters (De Masi et al., 2011), in cross-sectional and longitudinal ways.

In my paper, however, I examine the Keiretsu groups based on ERGM (Exponential Random Graph Models) network analysis, a technique that can be classified as statistics- based network model building. ERGM allows the joint and controlled study of the effects of network parameters. In other words, ERGM models provide an opportunity to understand how and why network connections are formed.

Network connections are organized into patterns, and the presence of some connections (ties) promotes the appearance of others. The ERGM analyzes these endogenous effects, often referred to as "structural" effects. Thus, it interprets the internal processes of the network relationship system, complemented by the exogenous effects of the network, such as the effects of attributes associated with nodes (Lusher et al., 2013). Based on the findings of Watts (1999), ERGM modeling works with randomness and probabilistic random graph modeling. By incorporating randomness, ERGM models work with expected values, from which we can draw conclusions about whether the observed data are consistent with the theoretical (anticipated) data. During an ERGM modeling, we estimate the presence of network edges from several predictor variables and use model parameters to estimate their effect, direction, and significance in the studied network (Lusher et al., 2013).

For this reason, ERGM tries to model the network effects of edges, e.g. effect of transitive triads, k-star effect, effect of assertively (hemophilic, heterothallic relationships), effect of distributions, effect of degrees and effect of attribute variables. Further, it compares the models formed on the basis of the effects with the observed network and thus tries to reveal the causes of network edge formation.

In this paper, network descriptive statistical and morphological analyses were performed with Gephi 0.9.2v software, and ERGM analyses were created with the R software package and MPNet software (Wang et al., 2009).

2.2 Data used for Analysis

The data used for the ERGM model rely on a secondary data analysis from Lincoln et al. (2004). In their 1992 and 2004 works, Lincoln and co-authors performed network-based block modeling of

Japanese keiretsu groups, where networks were grouped based on the attributes of connections and nodes. In their longitudinal study, clusters of keiretsu groups from 1978 to 1997 were analyzed across the entire leading corporate population (258 firms). They used several variables to define the formation of the edges (ties), such as partial ownership, cross lending, capital, distribution of director positions. Then based on these, they formed the blocks using an algorithm called CONCOR (Note 1). Thus, clusters were created that contained closely or densely connected nodes (corporations).

I used the data of the 1997 keiretsu block model in my paper, and built the economic network based on this data. In the network, the companies are classified into six large Keiretsu groups and into two large economic blocks. One of the large economic blocks is the banking and finance block and the second is the industrial block. In addition, nodes also have an attribute indicating their economic sector.

If we consider the blocks, the financial block can be further divided into 5 clusters and the industrial block into 14 clusters. Based on the distributions in Table 1, it can be clearly seen that the companies belong to the industrial cluster have an overwhelming majority in the distribution of companies (81.01%), with a much smaller (18.99%) financial cluster

Table 1. Block Model of Keiretsu Groups (N = 258)

	Block and Cluster	
Blocks and Clusters	Frequency	%
Financial Block	49	18.99
City and Trust Banks	19	7.36
Mining	1	0.39
Mutual BKS and Securities	9	3.49
Regional banks and Insurance	16	6.20
Toyota	4	1.55
Industrial Block	209	81.01
DKB And Sanwa Group	17	6.59
DKB Group	15	5.81
Fuyo and Sanwa groups	15	5.81
Fuyo Group	16	6.20
Hitachi	7	2.71
Matsushita Group	13	5.04
Mitsubishi and DKB	14	5.43
Mitsubishi Group	18	6.98
Mitsui Group	33	12.79
Sanwa and DBK Group	12	4.65
Sanwa Group	13	5.04

Sumitomo Group	13	5.04
Toyota Group	11	4.26
Trading Companies	12	4.65
Grand Total	258	100.00

In order to interpret the ERGM data, it is also worth reviewing the distribution of nodes by Keiretsu groups (Table 2). The Table shows that the 6 large Keiretsu groups comprise about the same number of leading companies (6-10 percent of the total companies). It is also important to note that the share of independent companies (not part of any Keiretsu group) is quite high, at more than 55% of the total market.

Table 2. Distribution of Keiretsu Groups (N = 258)

Groups	Frequency	%
DKB	25	9.69
Fuyo	19	7.36
Independent(shacho-kai)	147	56.98
Mitsubishi	16	6.20
Mitsui	16	6.20
Sanwa	24	9.30
Sumitomo	11	4.26
Total	258	100.00

In addition to the above network edges, one more attribute parameter was included in the ERGM model, which indicated the economic sector of the companies. The distributions of this variable are summarized in Table 3.

Table 3. Distribution of Cooperation by Economic Sector (N = 258)

Sectors	Frequency	%
Automobile	17	6.59
Banking	49	18.99
Ceramics	8	3.10
Chemicals	28	10.85
Electronics	22	8.53
Fishing	4	1.55
Food	26	10.08
Forestry	1	0.39

Gen manuf	5	1.94
Heavy metal	15	5.81
Light metal	14	5.43
Machinery	13	5.04
Mining	2	0.78
Oil	8	3.10
Paper	7	2.71
Pharma	5	1.94
Precequip	2	0.78
Rubber	3	1.16
Shipyard	5	1.94
Textile	13	5.04
Trade	9	3.49
Transport	2	0.78
Grand Total	258	100.00

The Table shows that the leading companies in Japan are mostly in the financial / banking sector (18.99%), the chemical industry (10.85%), the food industry (10.08%) and electronics sector (8.53%).

3. Result

3.1 Network and ERGM Results

A 3a. and 3b. Figures show the network morphology of Kerietsu groups. Figure 3 shows the complete network in which we can see the Kerietsu groups' positions as also the positions of the blocks and clusters, while network Figure 3b depicts only the network of companies belonging to Kerietsu groups. Both networks are by definition unidirectional. Table 4 summarizes the basic network statistics for the two networks.

Figures 3 and 4 - Kerietsu groups and block model network and Kerietsu groups network

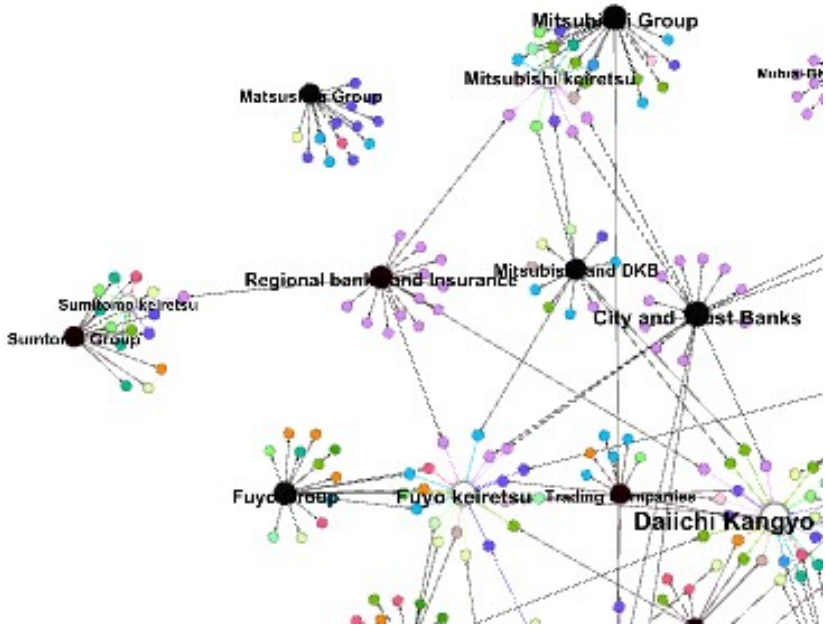
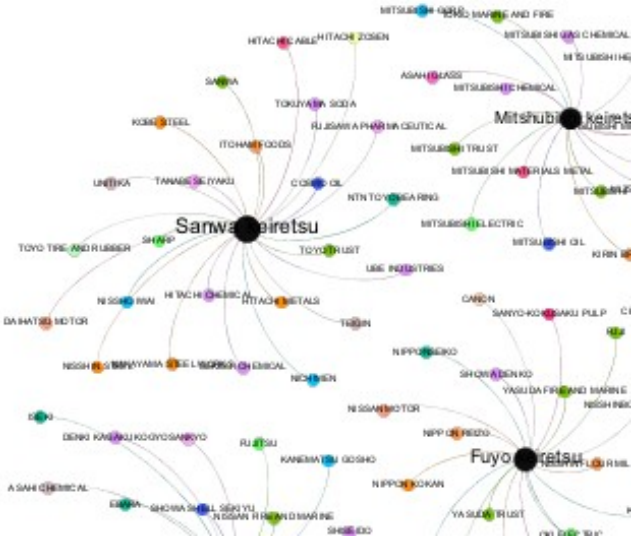


Figure 3. Kerietsu Groups and Block Model Network (N=283)



Figures 4. Kerietsu Groups Network (N=117)

Table 4. Network Statistics of the Two Networks

	Kerietsu groups and block model network (entire network)	Kerietsu groups network
Node number	283	117
Edge (tie) number	369	111
Average edge degree	1.304	0.949

Network density	0.009	0.016
Modularity	13	6
Average path	1	1
Number of components	1	6

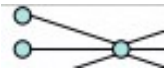
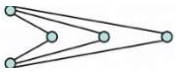
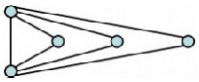
From the above statistics and morphology, it can be clearly seen that the six Kerietsu, which comprise a total of 117 leading Japanese companies, decompose into 6 well-separated components with high network density. Each Kerietsu encompasses companies from a very wide spectrum of economic sectors, from the banking system to heavy industry.

However, it is better to move on to an analysis of the entire network, which shows that Kerietsu networks play a much smaller role in the network of all leading companies. Statistics and morphology indicate that these corporate organizations are embedded in an economic network characterized by a much larger number of edges and a much lower network density. They form a completely connected network with 13 well-separable subgroups. An important result is that the role of Kerietsu corporate forms in the economic network has been taken over by Groups, in which members have an even less close network relationship with each other. Thus, it is not unlikely that the Mitsui Group has the highest degree (33) in the entire network. However, we still find Kerietsu groups in the most central positions like Daiichi Kangyo keiretsu (25) Sanwa keiretsu (24) and Fuyo keiretsu (19). We can find the City Central Banks (19) and other groups such as the Mitsubishi Group (18) and the DKB and Sanwa Group (17) in the most centric positions of the network.

Let us move on to the ERGM analysis itself, based on the Kerietsu groups and block model network. The network represents the entire network of connections between large Japanese corporations, in which organizations connect with each other for market dominance. ERGM analysis helps us to explore along which exogenous and endogenous variables this market network has evolved. There are many possible competing explanations for the evolution of the network structure, but if we examine only one process at a time, we may overestimate its role. With the help of ERGM, we can deduce the presence of an independent tendency for a particular configuration to appear, or the tendencies whose co-presence shapes the network.

The parameter estimates of the ERGM model were compared with 500 Markov Chain Monte Carlo (MCMC) network simulations. MCMC simulations created networks with the same number of nodes and densities as the observed network. In comparison, the MPnet software generated parameter estimates of the model, which indicate the strengths and direction of the network samples (endogenous and exogenous). Table 5 shows the parameter estimates for the Japanese economic network. Significant parameters are marked with an asterisk (*). A positive (negative) estimate indicates a larger (lesser) configuration than expected in the network, taking into account the other effects of the model. The magnitude of the parameter estimates cannot be compared directly along the different effects, because the scaling of the statistics is different.

Table 5. ERGM Parameter Estimates for the Japanese Economic Network

Network effects		Estimates - SE
Edge effect (Arc)		-0.091
2-Star (S2)		74.607*
3-Star (S3)		218.904*
4-Star (S3)		781.862*
5-Star (S3)		3320.958*
Triad effect		-1.692
4-Cycle		88.190*
Isolate		-5.393*
Hub		11.228*
Multiple 2-path		71.058*
Transitivity (Transitive Multiple 2-path)		-1.701
Alt-Edge-Triangle (AET)		-1.643
Attribute effects		
(exogenous - the blue circle indicates the node that can be characterized by the attribute)		
Homophily (econ. sector)		2.700

* = the parameter estimate is twice the absolute value of the standard error, which means that the effect is significant.

Based on the ERGM, the network can be characterized by a negative edge effect (-0.091); however, this effect is not significant. In other words, it is not the pair connections that play a decisive role in the structure of the network. What does play an important role in the formation of the network is whether or not the firm connects to the actors in the central positions, such as the Kerietsu groups and the block groups. We see this in the network-forming power of the 2, 3, 4, and even 5-star shapes, which in each case have positive and significant values. All this means that network centers play a crucial role in the formation of the network and are surrounded by a multitude of less inter-connected companies. The same result is supported by the hub effect, i.e., the positive and significant effect of the degree

distribution (11.228 *).

The strong centralization effect of the network is also supported by the negative and non-significant value of the triad effect, which means that the triple closed connections do not substantially shape the network. This is somewhat contradicted by the positive and significant role of quartet closed connections (88,190*), which can be explained by the fact that quadruple connections are formed quite often between hubs (groups, Kerietsu, blocks and clusters), which also indicates the strong network centralization.

The multiplied 2-way effect is also positive and significant, indicating that we find more 2-ways, due to the other effects of the model, in the measured network, than we might expect, i.e., connections with several central nodes forming the same companies are related with each other. However, the transitivity effect (transitive triad effect) is negative and not significant, suggesting that these 2-pathways do not close, but condense around specific nodes. We see the same lack of closure among the actors in the fact that we do not get a significant value in the case of alternative edge triangles either.

After the endogenous effects, let us move on to the exogenous effects, which in this case cover the attribute effect, i.e., the extent to which the economic sector influences the development of the network. We can see that the value is positive (thus influencing it in theory), but not significant, i.e., it does not play a decisive role with the other endogenous effects.

4. Discussion

I have analyzed the Japanese network economy in my paper, because in more and more countries, the system of relations between the leading market companies and financial institutions is constantly intensifying. In other words, we can see a tendency of monopolization in the capitalist economy. I have illuminated the effects of this trend through an economic system that has operated in a similar centralized relationship system for many decades. Starting with a review of the historical development of this economy, I have interpreted the available data with an ERGM network analysis.

From the ERGM analysis, we have seen that we can still analyze the network of large Japanese companies with highly endogenous effects resulting from network connections. This is not a coincidence, because, as has been raised several times in the historical part of my article, the Japanese economy relies heavily on resource transfers and on different corporate circles. All this means that the existence of a relationship of trust and dependency between corporate actors is decisive in the Japanese economy to this day, and this network effect is likely to persist for a long time due to the inertia of the system.

It can also be seen in the Keiretsu and group formations that the dominant relationships extend from the core - from the most important banks, commercial companies or heavy industry companies - to the extreme periphery, and we encounter less and less edge density, moving from the core to the periphery. While this will of course help to improve the quality of information flows, positioning the common market goals and speed up production and logistics processes, at the same time, as we have seen in the

Japanese economy, it can also lead to a decline in innovation and new entrants or independent entrants, not to mention that such a structure is beneficial primarily for companies located in the core, and as we move towards the periphery, this 'positive' impact diminishes.

As we have seen since the 2010s, Japan has decided that this economic structure, which is based on centralized market relations, will not make the country competitive in the global market in the long run, and we can also see that this systemic change has proved true. However, the anomalies of a multi-decade system can be changed over only extremely long decades. For all these reasons, it would be important for many national economies to consider the fact that a centralized and inter-dependent economic system cannot be sustainable in the long run in the current global economy.

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Notes

Note 1. CONCOR was a disaggregative clustering algorithm: it iteratively divided the population into several smaller sets.

Note 2. I use the terminology of capitalism as a collective term in my article. Of course, the majority of nation-states in the twentieth century can be placed in an extremely wide spectrum in this aspect, encompassing a wealth of forms from state-capitalist economies, through the monopoly-capitalist economy to the classical capitalist economies.

Note 3. The Big Six terminology is used to denote the leading groups of companies in the Japanese economy,namely Sumitomo, Mitshubishi, Fuji, Sanwa, Mitsui and Daiichi Kangyo Group of Companies.