Binding & Loosening: The Evolution of the Interlocking Directorate Network of Chinese Banks in the Republican Era

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PRELIMINARY WORK

Abstract

The domestic Chinese banking sector flourished during the Republican Era, especially in the Nanjing Government period of the 1930s. The unstable environment, however, led banks in this sector to cooperate strongly with each other, building a dense web of interlocking directorates between them. While the literature has addressed the impact of interlocking directorates on firm performance, not much attention has been paid on the evolution of such networks of connections in general. I investigate the development of the interlocking directorate network between domestic Chinese banks from 1933 to 1936 to understand how financial institutions structure cooperation within the sector in response to unstable external environments and weak property rights. This paper uses a dynamic network simulation approach to address the inflection problem between bank performance and network formation, illuminating what factors underlay the network evolution and shaped the structure of cooperation between Chinese banks.

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1 Introduction

Chinese banks patterned on western example saw a dramatic rise during the interwar Republican era (Kong and Ploeckl, 2018b). As this growth happened during a period of instability the sector reacted through a strong level of cooperation in the sector. This is seen institutionally through strong linkages of bank personal, which goes far beyond simple clique relationships (Sheehan, 2005). This paper investigates the business logic underlying the pattern of institutional ties between these Chinese banks during the last years of the Nanjing decade, the height of Chinese economic prosperity in the interwar period.

There is a large literature that focuses on the impact of institutional ties between companies on their economic performance. The most relevant such ties are interlocking directorates, the practice of directors or other executives exercising important roles in multiple companies at the same time. Such interlocking directorates have been shown to influence firms performance. This has been demonstrated in a wide range of settings, from modern firms (Larcker et al., 2013) to Victorian stock companies (Braggion and Moore 2011), Dutch Banks (Colvin et al., 2015), British interwar steel companies (Holmes and Ploeckl, 2014) to the nascent domestic banking sector of China's republican era (Kong and Ploeckl, 2018a). These studies however focus predominantly on the impact of these interlocks, financial and otherwise, but largely shy away from analysing the pattern and dynamics of the utilized networks between firms. This study fills this gap by quantitatively analysing the main drivers behind the evolution of the interlocking network between domestic Chinese banks during 1933 to 1936, the height of the Chinese Republican era.

The domestic banking sector arose with the end of the Imperial era and flourished throughout the Republican era until the Japanese invasion. By the mid 1930s more than 150 banks were active, eclipsing foreign banks as well as the traditional financial sector by controlling about 80% of bank capital in China. These banks formed an interest association, the Shanghai Bankers Association. One of its activities was the publication of an annual yearbook, which for a number of years contains extensive statistical information about these domestic Chinese banks. In particular for the years 1933 to 1936 a wide range of financial performance indicators like total assets, profits, and liquidity are available besides more general information like headquarter location, the number of cities served, the main focus of activities (real estate, etc) and the names of directors and executives. The latter allows the identification of directors in the employ of two or more banks, which I use to create a network of interlocking directorates between these banks

Mizruchi (1996) categories potential reasons for such a tie between firms as collusion, co-optation and monitoring, legitimacy, career advancement, and social cohesion. This paper focuses on the motives of the firm, rather than the individual director, therefore exploring in particular collusion and co-optation patterns between these banks.

The evolution of the network is analysed with a Stochastic Actor oriented Network model, the SIENA methodology. This approach specifies an objective function for each actor, so each bank, consisting of a set of mechanisms. Each mechanism models a particular factor that potentially could affect the formation or dissolution of particular ties. The estimation then simulates the evolution of the model using this objective function and through comparison of the simulation outcomes with the actual observed network evolution data derives a parameter value for each mechanism, including statistical significance of these parameters. The exact nature of these mechanisms is fairly unconstrained, from the usual independent covariates of regular regression setups to characteristics of the existing network to interactions between multiple covariates and network structures.

A particular aspect of this situation is that the success of the sector happened within an environment with weak contract enforcement and property rights. This leads to the question how the structure of the emerging banking sector developed. Weak contract enforcement could lead to a strong clustering and polarization effects with banks forming tight bonds to protect and insure each other within distinct groups, or ties could be widespread rather than clustered to facilitate more limited transactions over the whole sector rather than creating strongly competing groups of banks. This can be included through including mechanisms that reflect the effect of particular network structures like the tendency to form triplets or the impact of the number of existing ties on new ones.

Although the national government wasn't fully able to achieve strong institutions, including meaningful banking regulation, it nevertheless was involved in the banking sector through stakes and outright ownership of a number of important banks. As shown by Kong and Ploeckl (2018b), these public banks had a strong network of interlocking directorates with private institutions. I test whether the nature of certain institutions as public banks had a particular influence on the network development and contrast banks owned by the national government with municipal and provincial institutions. Further I test whether the potential role of national level public banks remained constant over the time or changed with the monetary reforms of 1935.

Results show that there were network effects, with a tendency to form triads and a decentralization effect due to a negative effect of the existing number of ties. A number of operational effects mattered, including the types and ages of two potential partner banks . Similarly, financial characteristics mattered, in particular the relative ratio of two banks' assets, while size on its own did not have an effect. The involvement of national public banks mattered, with the pattern showing a strong swing from positive to negative effect with the 1935 financial reforms. Finally, the bank's financial performance, its levels of RoE and RoE growth, mattered for its tendency to expand its interlocking directorate network.

An important issue for analyzing the impact of these interlocking directorates is the question of possible endogeneity between the network and the financial performance of the involved firms.This is explored through expanding the model with including the Return on Assets as a second dependent variable. This leads to modelling the co-evolution of networks (interlocking directorates) and behaviour (financial performance) within the same estimation and the inclusion of explicit interaction effects as mechanisms driving the two outcomes. Results confirm the results found in the network only estimation but do not support an impact of interlocking directorates on the financial performance of the banks. A short discussion why this difference from the existing literature, including the preceeding chapter, might be due to constraints of the estimation method is included as well.

2 The modern Chinese banking industry during the Nanjing Decade

This paper builds upon the data and historical information presented by Kong and Ploeckl (2018b), the following section, which introduces and describs the rise of the modern domestic Chinese banking sector, is therefore a lightly adapted version of the historical background presented by Kong and Ploeckl (2018b).

The first Chinese modern domestic bank was established in 1897, more than half a century after a British bank had set up its first branch in China. The number of banks slowly increased until the fall of the Qing Dynasty in 1911 and then accelerated during the period of the warlords. From 1912 to 1927, despite the political turbulence of this time, a total of 266 new banks opened for business, around eighteen each year. However, almost half as many went out of business during the same period shown in table 1. Although the historical statistics have sufficient details to illustrate trends, the exact numbers are somewhat uncertain as the source already was unable to determine exact founding or bankruptcy years for a certain number of banks.

The Nanjing decade (1927-37), China's "golden decade" of modernization, saw another period of strong growth in the number of banks established, though in contrast to the warlord era the number of bankruptcies remained considerably lower — total of 124 new modern-style Chinese banks was established and 23 liquidated from 1928 to 1937 according to the statistics of Young (1971, p. 264). Overall, I present the numerical development of Chinese modern banks from 1896 to 1937 in table 1. It clearly highlights periods, in which the banking business flourished. While the mid 1920s saw a high rate of bankruptcy, the number of failed institutions stay low during the Nanjing decade.

However, not only the number of modern Chinese banks increased. Total paid-up capital of Chinese banks rose from C$167 [1] million in 1927 to C$403 million in 1936. From 1927 to 1936, these banks more than doubled their capital and reserve funds, tripled their loans and total assets, and quadrupled their deposits as reported by Economic Research Office (1937) and Cheng (2003).

[1] C$= Chinese yuan

Table 1: Chinese modern bank statistics from 1896 to 1937

year	founded	bankrupt	net change	year	founded	bankrupt	net change
1894	1		1	1921	27	18	9
1902	1	1		1922	27	19	8
1905	1	1		1923	25	20	5
1906	2	2		1924	7	5	2
1907	3		3	1925	9	7	2
1908	4	3	1	1926	7	7	
1909	1	1		1927	2	1	1
1910	1		1	1928	16	5	11
1911	3	2	1	1929	11	3	8
1912	14	10	4	1930	18	6	12
1913	2	1	1	1931	16	6	10
1914	3	1	2	1932	13	4	9
1915	7	5	2	1933	15	3	12
1916	4	3	1	1934	22	4	18
1917	10	9	1	1935	18	15	3
1918	10	6	4	1936	5	7	-2
1919	16	9	7	1937	3	4	-1
1920	16	14	2	unknow	50	24	26
				Total	390	226	164

Source: The department of economic research of China: *Quanguo yinhang nianjian* (The national yearbook of banks[1937]), A7-A8, A24-A25.

The growth of the modern Chinese banks during this decade was unmatched by either traditional institutions or foreign banks and consequently the sector became the dominant player in China's "Three Kingdom " financial structure. As table 2 illustrates, by 1936 the total assets of modern Chinese banks surpassed those of native banks and foreign institutions combined.

Although the emerging modern Chinese banks differed from institutions in the other two sectors in its focus of operations, they followed their western counterparts by differentiating further along other dimensions. Following a contemporary classification from the *Bank Year Book 1936* the modern Chinese banking sector was comprised of the following subgroups of banks:

- Central banking group. These were large public banks under the direction and con-

Table 2: Capital power in the Chinese financial market (1936)

Name/Items	Chinese Banks		Foreign Banks		Native Institutions		
	Amount	%	Amount	%	Amount	%	Total
Note	1,946.7	87	284.7	13	0.0	0	2,231
Deposits	4,551.3	79	511.2	9	673.6	12	5,736
Capital	402.7	67	113.7	19	84.2	14	600.6
Total	6,900.7	81	909.6	11	757.8	9	8,568

Unit: C$ 1,000,000.
Source: Cheng (2003, P.78)

trol of the central government[2]. They only took on direct central banking functions as commonly understood with the "Fabi reforms" in 1935. There were four public banks forming the group, namely, the central Banks of China, the Bank of China, the Bank of Communications and the Farmer Bank of China.

- Commercial and saving banks. The daily operations of these banks covered commercial and general banking, including savings and investment business. These banks tended to have a wider branch network while having their headquarters in one of the major metropolitan areas. Banks in this category comprised the biggest proportion of modern Chinese banks.

- Province and city banks. These were established by local authorities as a consequence of political decentralization after the fall of Qing empire in 1911. Their autonomy from the central government varied with the degree of political control of the KMT over local governments. Main functions included, but were not limited to, handling and coordinating monetary transactions at a local level such as tax collection and the issuing of legal tender notes.

- Farmer and industry bank. Financial institutions categorized into this group were banks whose business focused on agricultural and industrial loans. The origins of many banks in this group had a government background, in same cases these had

[2]These institutions were not consistently fully owned by the governments before 1935 the currency reform, but it had always retained a substantial stake in them.

been established by local authorities with the express purpose of supporting the local economy.

- Specialized banks. Although the business spectrum of these banks overlapped with that of commercial and saving banks, they had a special focus on specific fields like silk, mining, or salt.

- Oversea Chinese banks. This refers to those banks, whose owners were ethnically Chinese, yet the headquarters were located outside of mainland China, in particular the British colony of Hong Kong. Given their position they also functioned as intermediaries between foreign and domestic Chinese banks.

Modern Chinese banks not only differed in their business model but also geographic locations. Nevertheless, they did show a strong geographic concentration, though some of them had extensive networks of branches covering substantially more location (Tamagna, 1942, p121). This becomes visible in table 3 which provides summary statistics about headquarters and corresponding capitalization. According to Tamagna (1942) Shanghai was by far the most prominent financial center of China; while Tianjin, a major part in proximity to Beijing, was the regional center in northern China and Chongqing a counterpart in the south-west. Hong Kong was a leading financial market in southern China, although it was not territorially part of China. Banks located in other metropolitan areas are classified into the ”Others” category.

Shanghai clearly dominated this banking sector with 80 banks having their operations headquartered there. The number was substantially greater than the regional centers in Tianjin, Chongqing and Hong Kong. The aggregate assets controlled by Shanghai banks were over 4 billion Chinese yuan, an amount almost tenfold greater than that held by banks in Tianjin, the most significant financial hub in Northern China. The average bank size in Shanghai was also relatively larger with average assets of C$ 76,149,984.

The table also demonstrates that the type of bank influenced the level of their geographic concentration. Three of four banks out of the central banking group were located in Shanghai, which despite not being the official capital was the dominant economic, commercial and population center. This is also reflected in the locations of Commercial bank

Table 3: Bank headquarters and capitalization distribution statistics in 1935

Bank Type	Bank Headquarters				
	Shanghai	Tianjin	Chongqing	Hongkong	others
Central and chartered banks	3	0	0	0	1
Commercial & Savings Bank	62	5	5	6	33
Province & City Bank	2	1	2	0	22
Farmers & Industry Bank	8	1	0	0	25
Specialized banks	5	3	3	0	4
Oversea-Chinese Bank	0	0	0	4	4
Total numbers:	80	10	10	10	89
Total assets (in million C$):	4,264.1 Mil	438.6 Mil	78.3 Mil	228 Mil	1,058 Mil
Avg. assets (in C$):	76,149,984	54,830,870	11,185,961	75,996,639	13,924,984

All figures are based on authors' calculation and summary.

headquarters, more than half of which were located in the city. Banks with a more focused agricultural or specialist focus were also more likely to be located there, but with shares of a third (Specialized banks) to a quarter (Farmers & Industry banks) the concentration was substantially less strong. However, none of the other major centers had anywhere as strong a concentration in any of these categories. This difference of strength in concentration points towards the importance of agglomeration forces in the banking sector. Banks with a predominantly financial focus were strongly clustered while banks with a specialized industry or agriculture focus followed their customers more strongly in terms of geographical location. Similarly, the Province & city banks clearly showed their origins and links to regional locations as they were spread all over different metropolitan areas, while Oversea-Chinese banks were primarily clustered in Hong Kong, the major foreign colony in China.

3 Bank network and characteristics

The interlocking directorate network between modern domestic Chinese banks has been shown to link a large section of the whole sector tightly together (Kong and Ploeckl, 2018b), to have a coordination effect with regard to policies (Kong, 2018) as well as affect the profitability of these firms (Kong and Ploeckl, 2018a). This study focuses on the evolution of that network and does so by utilizing the data presented of those three studies. Consequently, the following exposition of the utilized data is directly adapted from them as well.

The analysis of the network formation will be focused on banks as central actors rather than the involved individuals. This implies that there are two main data requirements, namely first the interlocking directorate network between the banks and second, characteristics of the actors, so characteristics of the involved banks.

I look at the last years of the Nanjing decade, in particular 1933 to 1936, which implies that the sector had been substantially established at that time, but is nevertheless still adjusting internal network structures over these years. This allows to illuminate the principles driving this network evolution by focusing on this time period.

3.1 Interlocking Directorate Network

As indicated above, this study focuses on modern Chinese banks in the period 1933-1936, the end of the Nanjing era before the Sino-Japanese war. This excludes traditional financial institutions as well as foreign banks. While a number of Chinese banks did interact with foreign financial institutions, the two banking sectors did remain clearly separated. This is similar to the clear distinction of these institutions from the traditional financial institutions. Besides, as I showed earlier in table 2 modern-style Chinese banks had risen to dominance by the 1930s with collective bank capital surpassing that of foreign and traditional institutions combined. Consequently, I only look at domestic Chinese financial institutions that were patterned on western banking institutions.

The main data source is *The National Yearbook of Banks*, which was published by the department of economic research of the Bank of China. The annual issues for the years from 1934 to 1937 contain summaries about the whole sector as well as accounting and operational data about individual banks including names and positions of their directors and managers. I construct the dataset of boardroom composition by extracting information from the summary descriptions of the sector as well as the included annual reports of individual banks.

This data, which includes names, positions, and branch locations, is used to identify interlocking directorates by matching names of listed directors of all included banks. Due to the structure of traditional Chinese names duplicate names are not a significant concern. Nevertheless I address this by complementing the basic information about individual directors with information on middle name, birthplace, and age from various biographies and other sources[3].

For a very small number of institutions the recorded data is substantially incomplete or inconsistent. I exclude these as they are very small, local institutions and account for only a minuscule proportion of the full dataset. Consequently, my final sample consists of an unbalanced panel of 628 bank-year observations for the four-year period from 1933 to 1936[4]. While the coverage is complete for interlocking directorates, some of the operational and other bank characteristics are missing for a small number of observations.

Table 4 presents annual counts of directors and banks involved in interlocking directorates. Despite the unbalanced nature of the panel being responsible for a substantial share of the fluctuations, a consistent picture emerges that a comparatively small number of directors were linking together a major share of the whole domestic Chinese banking sector.

Table 4: Summary statistics of connected directors and banks

Year	# Director		# Banks		avg. # busy dirs/bank
	connected	unconnected	connected	unconnected	
1933	148	1267	101	41	1.04
1934	199	1429	114	45	1.25
1935	243	1459	108	54	1.5
1936	169	1530	104	58	1.04

This table presents a summary statistic of the connected director and banks of the data. Directors are considered as connected if they affiliate with more than one bank. Column 5 and 6 reports the number of banks with connected and unconnected director, separately. Avg. # busy dirs/bank refers to the the number of connected directors each bank on average. See text for the detailed data source.

[3]The major data source is (Jiang, 2014).

[4]Specifically, the dataset includes board information of 142,159,164, and 163 banks from 1933 to 1936 respectively.

Furthermore, the average number of directors per bank involved in interlocking directorates is close to two, implying that many banks were linked in different directions rather than just by a single link[5]. This is confirmed by figure 1, which shows the number of links per bank in 1933. Although there is a substantial number of banks that are completely unconnected and some with a single link only, the majority of banks formed part of two or more interlocking directorates.

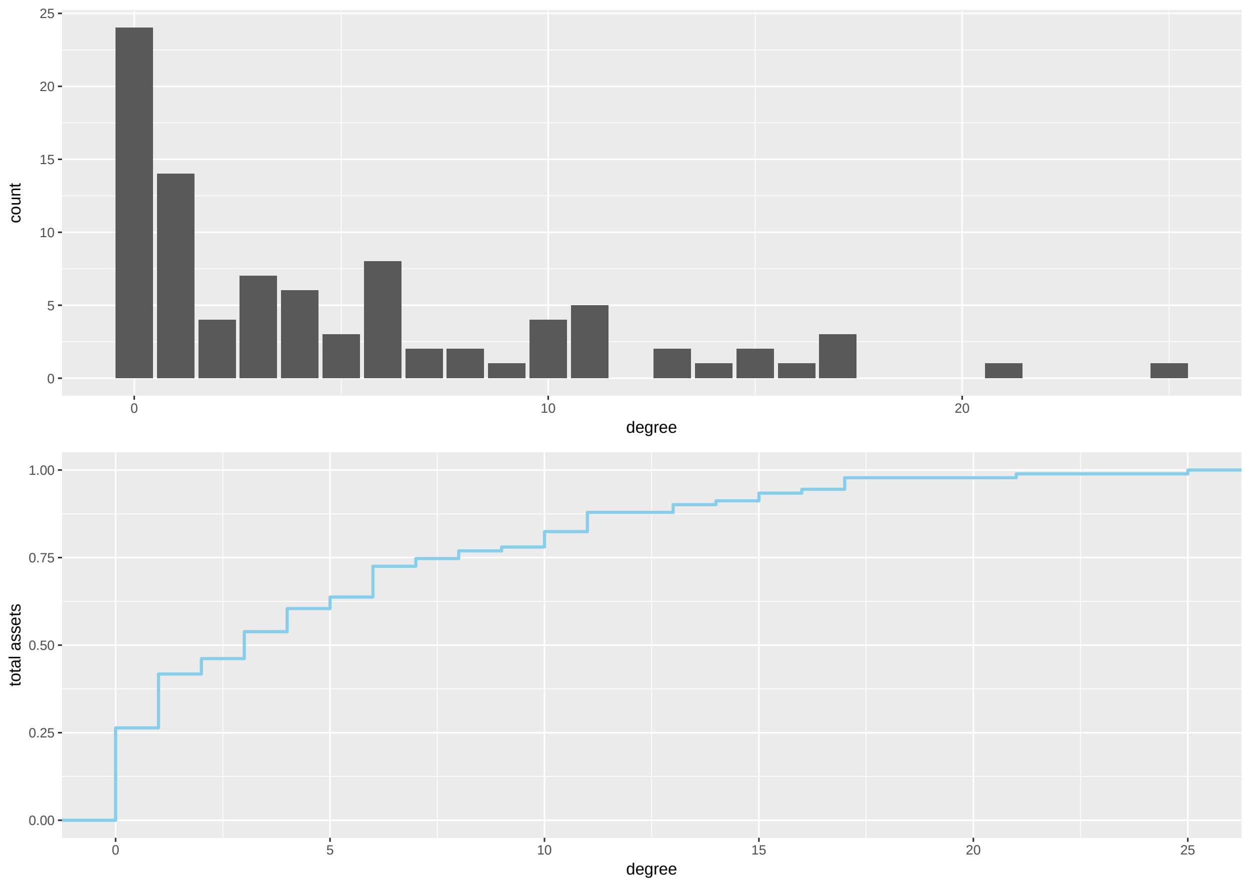

Figure 1: Bank network connection and assets cumulative distributions in 1933

As table 4 indicates the network of interlocking directorate was changing substantially over the four years. Although a certain amount is due to the unbalanced nature of the panel a good number of banks, according to table 5 about a quarter to a third, changed their board composition during the course of a year. As interlocking directorates are defined by board members, changes in board membership obviously has implications

[5]This also indicates that interlocking directorates are not just representing ownership and control.

for the persistence and stability of the interlocking directorate network. Consequently, the network was clearly not a static, inert structure but was continually adjusted and modified by the involved banks.

Table 5: Summary statistics of bank board composition change rate

Bank Type	1933	1934	1935	1936
All	base year	0.273	0.293	0.325
Central banking group	base year	0.410	0.155	0.221
Local official banking group	base year	0.256	0.432	0.438
Ordinary banking group	base year	0.272	0.264	0.301

3.2 Bank Characteristics

The source material for the ID network also contains information about a number of bank characteristics as shown in table 6

Table 6: Descriptive statistics of bank characteristics from 1933 to 1936

Statistic	N	Mean	St. Dev.	Min	Max
RoA	471	0.016	0.014	0.0002	0.108
net profit	471	305,933.000	1,177,183.000	15	17,095,868
total assets	471	42,129,680.000	155,148,552.000	58,271	1,803,048,120
#board members	470	12.736	4.701	1	39
#city	469	5.537	12.200	1	156
Age	360	10.211	7.423	1	29
#Staff	471	180.431	392.840	5	3,505
liquidity	431	0.212	0.368	0.004	4.755
investment in securities	413	4,282,349.000	16,276,276.000	28	252,904,406
leverage	470	0.642	0.467	0.032	7.160

4 Mechanisms and Simulations

Each interlocking directorate is a binary dyad between two actors. There are a number of standard regression approaches, most notably logistic regressions, that can be used to analyse binary data with each dyad, so each pair of banks, as an observation . There are, however, two main concerns in doing so. First, there is a potential endogeneity between an interlocking directorate and other characteristics of the banks involved. And second, there is potential violation of the independence between observations through a form of spatial dependence, as the formation of an interlocking directorate might have depended on the existing network links between other banks.

The main reasons that these two issues are of concern are that they distort the results and are an obstacle for identifying a clean direction of causality. In response to this I choose to utilise an approach that analyses the dynamic adjustment of the network, including the particular shape of a reciprocal influence and the impact of the wider network structure. Instead of correcting for endogeneity and dependence I essentially incorporate them as potential factors affecting the evolution of the network. To achieve this I use the SIENA methodology, which utilizes simulation methods to understand and identify factors driving the dynamic adjustment of network structures.

4.1 SIENA

The SIENA method has been recently developed in sociology, as illustrated by Steglich et al. (2010) and Snijders et al. (2010), and is slowly adopted in political science (Manger and Pickup, 2016) and economics (Esteves and Ploeckl, 2016). This section is directly based on the exposition of this method in Esteves and Ploeckl (2016), which directly builds upon the other mentioned works.

The method differs in its focus from standard regression approaches in three central ways, first the potential endogeneity between two characteristics, second the standard assumption of independence between network tie observations and third the appropriateness of modelling events as a series of regular spaced, discrete steps.

The finance literature on interlocking directorate network effects, including Kong and Ploeckl (2018a), argues that the relationship between interlocking directorates and a positive impact on financial profitability usually runs from the network to the financial outcomes, rather than in the opposite direction. The evidence base for that claim, however, is limited and usual approaches to account for this, for example the use of Instrumental Variables, are not really feasible due to absence of suitable instruments.

Secondly, explaining the pattern of interlocking directorates, rather than their impact, implies the use of ties, pairs of actors, as outcome variables. Network theoretic approaches can explain the status of ties conditional on the status of ties between other actors, but if the outcome depends on status of other bank dyads the independence assumption of the standard estimation approach is violated. There are some approaches to address this problem within standard econometric estimation approaches, for example Spatial Econometrics or Conley Standard errors. These approaches however have drawbacks,like the required a priori specification of a spatial weight matrix, which make them unsuitable here. In this context one exemplary point in this regard is that individual directors are members of multiple boards implies that interlocking directorates between specific bank pairs are directly related to each other.

Another conceptual issue is the the discrete nature of the observations used in the analysis. Similar to most empirical analyses, many firm level approaches in economic history use annual or even less frequent data points. This not only turns underlying continuous processes into discrete steps, losing information in the process and creating the, likely strongly misleading, impression that all changes within one period happened at the same time. The order in which links between banks are created, or dissolved, within the same year, might potentially contain substantial and relevant information lost through this standardization. Also the volative environments implies that there might be more than one change happening over a year, with network links forming and dissolving fairly rapidly. Similarly estimation usually requires discrete steps of equal length, potentially complicating the estimation even further.

The SIENA, Simulation Investigation for Empirical Network Analysis, methodology has been recently developed in response to these issues, see for example Steglich et al. (2010).[6] The main idea is to simulate the evolution of the network, or potentially the co-evolution of network and actor behaviour, like the financial profitability of banks, over time and use this to conduct statistical analysis of repeated observations of networks according to the Stochastic Actor-oriented Model.

The following describes the co-evolution of network and behaviour, however the net-

[6]The practical implementation is done with a software package in R labelled RSiena.

work side of the description is fully applicable to a network only analysis. The basic starting point is to incorporate a wide range of mechanisms into the formation and development of the network structure to identify their respective effects onto tie formation and dissolution. This is expanded by incorporating behaviour changes to the set-up which adds a potential mutual dependence between ties and behaviour. To address this endogeneity problem the approach shifts the conceptual model from a series of discrete choices to a continuous process whose state is observed at specific time points, with the recorded data taken as those observations. The network and the behaviour of involved actors are therefore taken as evolving continuously over the time period in question and their simultaneous modelling allows to account for mutual dependencies and multiple changes between the points of observations.

Structurally the modelling of mechanisms includes actor, dyadic and network structure covariates. The first are particular characteristics of the actors, for example the opening year or the number of branches of a bank, which makes them equivalent to regular explanatory variables in a standard regression setup. Dyadic covariates are characteristics of pairs of actors. These can be direct tie variables, for example whether the headquarters of two banks are located in the same location or they are the same type of bank, or interacted actor variables, for example the ratio of the assets of the two banks. Furthermore as pairs can be ordered these dyadic variables can be directed and therefore asymmetric. Network structure covariates are variables stating the structural position of the actor within the network, for example the number of other banks a bank is linked to through an intermediary bank only.

Changes in the network as well as the behavioural status of individual actors are modelled as the outcome of a two-step process comprising two sub-processes, the first governs when the possibility to change the network or behaviour arises for an actor while the second then consequently determines whether an actual change will happen once the opportunity is given. The first is governed by rate function while the second is determined by an evaluation function. The rate function is similar to a hazard rate function in a survival analysis set-up and determines the probability that the actor can make a change at any given point in time. Again similar to a hazard rate this function can vary over time, between countries and depend on covariates. Although they can be correlated due to this influence of covariates the rate functions for network changes and behavioural changes are independent of each other. Once the possibility of a change arises the evaluation function determines whether that change increases the utility of the actor and will consequently be implemented. As the rate functions are independent the opportunity to change a behaviour will never arise at exactly the same time point as the opportunity to change the network. This implies that the evaluation function in each case does take the state of network respective the behavioural values as given. Once the opportunity arises the evaluation function is used to derive a value for each possible action, with these values consequently used to determine relative probabilities for each option to be taken.

Practically the set-up consists of a set of actors which are potentially linked to each other in a binary network. The analysis can focus exclusively on the development of the network ties between the actors. Adding actor characteristics allows to focus on the development of these behavioural values as well as the joint development of the network and the behavioural characteristics. Finally it is also possible to extend the system to add further networks or behaviour characteristics. The further discussion focuses on the joint evolution of network and behaviour as it combines the two archetypical cases and represents the commonly utilized explanatory system.

Returning to the formal description the rate functions, which determine the waiting times until the next change opportunities, are modelled by an exponential distribution with the following distribution function

$$g_i(t) = \lambda e^{-\lambda t}, t > 0 \tag{1}$$

where $\lambda = \sum_i(\lambda_i^Z + \lambda_i^X)$ with λ_i^Z and λ_i^X as actor-and period-specific parameters for the behaviour rate respective network rate functions. This formulation implies that the probability that the next possible change actor i can make is a behavioural one is λ_i^Z/λ and for a tie change λ_i^X/λ.

Once an actor receives the opportunity to make a change the respective evaluation function determines if and if so what change is maximizing the utility of the actor. Starting with the network structure the actor has three possible types of actions, initiate a new tie, dissolve an existing tie or retain the existing network without making a change. If there are n actors then this implies n possible actions consisting of changes in $(n-1)$ ties to other actors as well as the retention of the existing structure. Formally the network evaluation function, which includes the mechanisms modelled by network structure, actor and dyadic covariates, is given by

$$f_i^X(\beta, \mathbf{x}, \mathbf{z}) = \sum_{\mathbf{k=1}}^{\mathbf{m_1}} \beta_k^X \mathbf{s}_{ik}^X(\mathbf{x}, \mathbf{z}) \tag{2}$$

Following generalized linear statistical models this function is assumed to be a linear combination of a set of *effects*, $s_{ik}(\mathbf{x}, \mathbf{z})$, which are functions defined on the state of the network and behavioural variables. Particular examples will be discussed in a later section. Statistical parameters β_k represent the importance of the respective effects so $f_i^X(\beta, \mathbf{x}, \mathbf{z})$ is the value of the evaluation function for actor i depending on the states $\mathbf{x}$ of the network and $\mathbf{z}$ of the behavioural variables. Additionally a random component is added to represent factors not modelled and general inherent randomness.

Similar to a multinomial logistic regression this allows to calculate the probability of any single tie change shifting the network status from $\mathbf{x}$ to $\mathbf{x}'$. Given the parameters of the evaluation functions this probability is:

$$P(x) = \frac{exp(f_i^X(\beta, \mathbf{x}', \mathbf{z})}{\sum_{x' \in C} exp(f_i^X(\beta, \mathbf{x}', \mathbf{z})} \tag{3}$$

This probability is for a directed network with a behavioural variable so tie x_{ij} can take the value 1 while x_{ji} is 0 (and vice versa). There are a number of possibilities to force the symmetry between x_{ij} and x_{ji} such that the network is undirected and ties are simple link between two actors. The options differ in their procedures about who proposes a change to a tie and whose consent is sufficient for creation or dissolution. One particular approach is 'unilateral initiative and reciprocal confirmation' where it is the decision by one actor (labelled as 'ego' in this case) to initiate a tie with another (labelled as 'alter) who then has to confirm the tie for it to be created. The probability that the tie is also in the interest of the alter is the following:

$$P(x) = \frac{exp(f_i^X(\beta, \mathbf{x}', \mathbf{z})}{exp(f_i^X(\beta, \mathbf{x}, \mathbf{z}) + \mathbf{exp}(\mathbf{f_i}^X(\beta, \mathbf{x}', \mathbf{z})} \tag{4}$$

This evaluation function only compares the value of the network with and without the potential change, it does not distinguish whether that change is a creation or dissolution of tie.

In case the potential change is to the behavioural value the actor has again the three types of choices, namely increase, decrease or retain the value. As the behavioural variable is required to be discrete the potential increase or decrease is limited to exactly one step up or down. This restriction to a single step change is similar to the restriction to a single tie change in the case of the network structure. Furthermore the network evaluation function is also equivalent in its components to its network counterpart:

$$f_i^Z(\beta, \mathbf{x}, \mathbf{z}) = \sum_{\mathbf{k=1}}^{\mathbf{m_2}} \beta_k^Z \mathbf{s}_{ik}^Z(\mathbf{x}, \mathbf{z}) \tag{5}$$

It is possible that the included effects s_{ik}^Z are the same as those in the network evaluation function, but this implies that the same covariates drive the change in network ties and behaviour values. This is clearly not a reasonable assumption so correspondingly the sets of included effects will normally differ between the evaluation functions. Although the included effects differ the probability for a particular change is formulated in the same way:

$$P(z) = \frac{exp(f_i^Z(\beta, \mathbf{x}, \mathbf{z}')}{\sum_{z' \in C} exp(f_i^Z(\beta, \mathbf{x}, \mathbf{z}')} \tag{6}$$

These functions are used in the simulation algorithm to execute the estimation. The idea is to sample parameter values with the goal of matching the characteristics of the simulated networks with those of the actual observed network. This estimation utilizes a Method of Moments approach, although alternatively a Maximum Likelihood as well as Bayesian approach are feasible as well. The algorithm results in an estimate for each parameter value and associated standard error as well as a t-statistic for its convergence. The latter provides a check whether the simulated values converged sufficiently close to the observed network values.

The sign of the parameter values and the standard error indicate the direction of the effect of the associated mechanism as well as the statistical significance of that effect. The estimated parameters for each effect should be interpreted as log-odds ratio. The explanatory covariate variables are centred on their mean, so if they are held at this rate the parameter values allow the calculation of an one-unit change in the mechanisms on the probability of an increase (or decrease) in the network (i.e. the number of ties) or the behavioural value.

This setup requires a number of assumptions to hold such that it is possible to interpret the results causally, especially with regard to influence and selection, i.e. endogeneity. Manger and Pickup (2016) summarizes them in the following:

- The observed network and behaviour are the outcomes of an underlying markov process in continuous time.
- The actors act conditionally independent of each other at any point in time conditional on the observed network, behaviour and covariates. This implies that there are no simultaneous changes in the network[7] or behaviour by two or more actors.
- The changes in the network are conditionally independent of the changes in behaviour, which implies there cannot be simultaneous changes in network ties and actor behaviour.
- At any given time only one single tie can be changed and similarly behaviour can only be increased or decreased by one unit.

The particular nature of the research questions in this paper fits extremely well within the structure of SIENA methodology.

4.2 Mechanisms and Influence factors

The mechanisms in the evaluation functions represent the factors whose influence on the evolution of the ID network is tested, similar to the role of independent observa-

[7] The requirement of reciprocal agreement to form a tie does not violate this assumption.

tions in a regression. To understand the evolution of the network I include a number of factors categorized into network variables, operational characteristics, government links, financial characteristics, and financial profitability. Some of these mechanisms are also included in the behavioural extension, which looks at the development of profitability as an additional outcome.

Network variables reflect the influence of the existing network structure on its evolution. Practically I use the following mechanisms:

- *Degree:* This measures the number of interlocking directorates a bank already has.
- *Transitive Triads:* This indicates whether a particular link closes a link triad with a third bank.
- *Number of actors at distance 2:* This counts the number of banks the bank is linked to only indirectly through a third bank.
- *Degree of alter:* The number of interlocking directorates of the potential link partner.
- *Assortativity:* This tests whether the relative distribution of all their IDs between the two potential partners matters.

Operational Characteristics contain variables that characterizes practical, operational (rather than financial) aspects of a bank's business. The mechanisms are specified such that it is the characteristic of the 'alter' that is included, so practical it is in the first instance not the characteristic of the bank that initiates the link but that of any potential partner. The type of mechanism varies, some are derived for the characteristics of one bank only while others use those of both banks involved in a potential interlocking directorate.

- *Co-Location:* This binary variable tests whether banks with headquarters in the same location are more likely to link up.
- *Same Bank Type:* This binary variable tests whether banks are more likely to form links with banks of the same type.
- *Bank Opening:* This variable contains the year the bank was established, consequently testing whether its age matters.

- *Bank Opening difference:* This test whether the difference in age between two banks matters.
- *Branches:* This variable contains the number of locations where the potential partner bank maintained at least one branch.
- *Staff:* This variable measures the total number of staff the potential link partner employs.
- *Execs:* This tests whether the number of executives a potential partner has matters for the likelihood of a link.
- *Assets per Executive* This variable contains the size of the assets per executive the potential partner bank had. This gives an indication of the extent of the responsibilities and experience of executives available for a potential link.

Government links are looking at the linkage between private and public banks.

- *Central Link* This variable indicates if a pair of banks contains one of the banks from the Central banking group. This variable is also interacted with time dummies to test whether its effect changed systematically over the included years.
- *Local Link* This variable indicates if a pair of banks contains one of the banks categorized as Province and city banks. This is used to contrast the reach of the national government with the engagement with local public banks.

Financial Characteristics contain mechanisms that build upon financial aspects of banks' operations and their strategic choices in that regard.

- *Asset ratio:* This is the ratio of two banks assets with the smaller divided by the larger (so 0.5 indicates one bank is twice the other, while 1 indicates equal size)
- *log Assets:* These is the logarithmic value of a potential partner bank's assets.
- *Leverage:* This measures how leveraged a potential partner is, calculated as (deposits all kind)/total assets.

- *Liquidity:* This measures how liquid a potential partner is, calculated as (reserve fund + cash on hand)/deposits all kind.

- *Bonds / Deposits:* This measures the ratio of a potential partner bank's investment in securities, notably bonds, and its total deposits. The bonds in question were usually government bonds issued by the national government

Profitability focuses on the financial results of banks, most importantly on their return on equity. Some of these are used as mechanisms only in the analysis focusing on the evolution of the network only and are not included in evaluation functions used to analyse behaviour and network co-evolution.

- *RoE ego:* This contains the return on equity the bank achieves in the current year.

- *RoE abs difference:* This measures the absolute difference between the RoE of the two partner banks.

- *RoE growth ego:* This contains the absolute growth of the return on equity the bank sees during the current year, so the difference in RoE between two years.

- *RoE growth abs difference:* This variable measures the difference in RoE growth between two banks in the current year.

4.2.1 Network and Behaviour co-evolution

The second part of the analysis focuses on the joint co-evolution of the Interlocking directorate network and the banks' RoE. This requires a change to the mechanisms used to explore the network evolution and the construction of mechanisms for the behaviour evolution.

The first difference is the introduction of a second outcome variable. Due to the constraints of the SIENA methodology it is currently not feasible to use RoE in its continuous form as such. Consequently, I introduce the *RoE band* variable, which categorizes RoE values into 6 bins, each assigned a corresponding value from 1 to 6. The categories are in

5% steps starting at zero with category 6 any RoE value above 25%. The simulations trace how banks change from one bin into others.

The choice of six categories is a compromise between fine RoE gradations to catch any impact and suitability of the data for the simulation. Shifting to a larger number of categories requires simulations to trace banks' movements through a large number of categories within a single period with larger RoE fluctuations, which creates substantial problems for the convergence of simulations run. The consequence of larger bins is that the results are much less likely to pick up smaller effects on RoE as they do not necessarily lead to a change in the observed outcome value. As a result of that necessary compromise the analysis is substantially more suitable for the network side than the behaviour side and the discussion of the results will take that into account.

Besides serving as an additional outcome variable, *RoE Band* is also included as a mechanism explaining the evolution of the interlocking directorate network. Additionally, *RoE band abs difference* is also included. This measures the difference between the Roe band variables of the two banks. When these two mechanisms are included, the variables *RoE ego* and *RoE abs difference* are dropped.

The modelling of the evolution of RoE also requires the inclusion of explanatory mechanisms for this outcome variable. The list of included factors resembles that for the network evolution with those mechanisms removed that were based on bank pair characteristics. Consequently, the following mechanisms are used.

- *Linear:* This is the value of the RoE band the bank is currently in
- *Squared:* This is the square of the value of the RoE band the bank is currently in.
- *Degree:* This is the number of IDs the bank has at that point
- *Average alter by Alter Assets:* This is the average RoE of all linked banks weighted by the assets of these banks
- *Bank Opening:* This is the year the bank did open.
- *Log Assets, leverage, liquidity, Bond / Deposits:* These are the same variables as above based on the bank in question.

- *Branches, Assets per Executive* Similarly, variables as above based on an individual bank.

5 Results

5.1 Network Development

Table 7 presents the results for the analysis of the network dynamics only, which indicate that there were a number of factors driving the evolution of the interlocking directorate network between modern Chinese banks.

In terms of network effects, the degree, so the number of IDs, of both potential partners matter, so the more IDs a bank already had the less likely it was to add another one. Similarly, the more IDs a bank already had, the less likely it was to be the target of a new partnership. If an ID closed a triad, the bank in question was 22% more likely to be selected as a partner than an otherwise identical bank that did not close a triad. Assortativity indicates that banks preferred a more even distribution of IDs between them.

Geographic proximity of headquarters has a strongly positive, however statistically insignificant effect. Changing the definition of what constitutes the extent of Shanghai, the core financial centre, might however change that. Banks were also 17% more likely to form a partnership with a bank of the same type over an otherwise identical bank of a different category. While the actual age did not seem to matter, the age gap did. Banks were actually more likely to form links with banks of a similar age, every year of the age gap reduced the likelihood by 1%. The size of bank staff had a negative effect, though it is very small with 100 additional employees reducing the relative probability by just 3%. In contrast, the number of branch locations had a positive effect with every additional location increasing the relative probability by a percentage point. While the number of executives didn't matter, the average size of assets each executive was responsible for, however, mattered.

While the total size of assets seemingly had no direct effect, did the ratio of the assets of the two potential partner banks have an effect. Comparing a 2:1 ratio to even size

Table 7: Evolution of the Interlocking Directorate Network

Degree (density)	-1.992	(0.390)	***	-1.659	(0.411)	***
Transitive triads	0.194	(0.027)	***	0.202	(0.025)	***
Distance 2 pairs	-0.001	(0.015)		0.202	(0.025)	
Degree of alter	-0.059	(0.019)	***	-0.049	(0.019)	***
Degree^(1/2) assortativity	0.096	(0.016)	***	0.089	(0.015)	***
Central Link	0.191	(0.119)		0.261	(0.124)	**
Central Link (period 2)	-0.862	(0.229)	***	-0.767	(0.227)	***
Central Link (period 3)	-0.380	(0.251)		-0.408	(0.261)	
Local Link	0.011	(0.048)		-0.062	(0.054)	
Asset ratio	0.302	(0.098)	***	0.274	(0.100)	***
Co-Location	0.061	(0.054)		0.050	(0.056)	
same Bank Type	0.180	(0.043)	***	0.177	(0.045)	***
Bank age alter	-0.001	(0.005)		-0.003	(0.005)	
Bank age difference	-0.007	(0.004)	*	-0.011	(0.004)	***
Staff alter	0.061	(0.172)		-0.139	(0.191)	
Execs alter	-0.016	(0.009)	*	-0.006	(0.010)	
Branches alter	0.005	(0.004)		0.005	(0.004)	
Asset/Execs alter	0.000	(0.001)		0.001	(0.001)	
log(Assets) alter	0.001	(0.015)		-0.006	(0.016)	
Leverage alter	0.066	(0.251)		-0.247	(0.289)	
Liquidity alter	0.109	(0.239)		0.182	(0.242)	
Bond.Deposits alter	-0.296	(0.306)		-0.372	(0.341)	
RoE ego				0.028	(0.007)	***
RoE abs. difference				-0.002	(0.001)	**
RoE_growth ego				0.055	(0.008)	***
RoE_growth abs. difference				-0.004	(0.002)	**
rate (period 1)	42.078	(6.926)		33.726	(5.208)	
rate (period 2)	10.594	(0.899)		10.790	(0.999)	
rate (period 3)	22.499	(2.997)		24.343	(2.747)	

Standard errors in parentheses, All variables have a convergence ratio below 0.1
The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.
ego refers to value of the proposing partner, *alter*— to that of the receiving partner

increases the relative probability by about 16%. The level of leverage and liquidity appear to not have had an effect, while banks with a larger investment in securities were less likely to be the target of an interlocking directorate.

The last set of factors concerns the impact of financial profitability in the form of return on equity on the likelihood to form interlocking directorates. The results for RoE and RoE growth indicate that more profitable firms as well as those with a higher profitability growth are forming interlocking directorates faster. The coefficients for the difference between two banks indicate that banks are slightly more likely to form interlocking directorates with other banks that looked like them in terms of profitability.

5.2 Network and Performance Co-evolution

The second part of the analysis takes into account the potential endogeneity between interlocking directorates and financial profitability of the banks. As Kong and Ploeckl (2018a) shows, interlocking directorates between Chinese banks were related to an increase in the banks' profits, consequently I extend the analysis to allow for the reciprocal influence of these two characteristics.

This is addressed by including RoE as a second outcome variable. The requirements of the simulation methods are such that the outcome can't be continuous but had to be an ordinal variable. Consequently, RoE is transformed into 6 categories of 5% steps. Each bin is then assigned a discrete integer value, ranging from 1 to 6 in ascending order of RoE. Besides requiring such a particular outcome format, the method also focuses on explaining changes in the outcome variable rather than its level. The simulation results therefore show whether factors are influencing that a bank's RoE moves from one bin into a neighbouring one, so crossing one of the 5% thresholds rather than explaining which bin a bank is in. The small number of bins, however, implies that the method is unlikely to pick up an effect of IDs on RoE if that effect is small in comparison to the 5% step size. Unfortunately, increasing the number of bins substantially creates problems for the estimation procedure, as substantial year to year fluctuations in RoE would require a large amount of changes to be captured by the simulation. Consequently, convergence of the simulation algorithm becomes problematic.

Table 8 contains the results for the analysis. The results for the network component of the analysis are very consistent with those of the network-only estimation discussed above. Noticeably, only the level of RoE growth and now the RoE bin mattered, while the differences between two banks no longer have statistically significant effects.

The results for the behaviour component, changes in RoE, show that as expected the effect of the number of IDs is statistically insignificant and close to zero. The only statistically signficant effect of other factors are the impact of age, younger banks were more likely to shift to higher RoE bands, while a higher share of investments into bonds was associated with a negative effect, so a shift down into lower bands.

6 Conclusion

While there is a large literature on the impact of interlocking directorates, not much attention has been paid to the factors shaping the dynamics of the network itself. This paper does so by in the context of modern Chinese banks during the Nanjing decade of the Chinese republic.

Simulating the evolution of the network reveals that there were a number of effects influencing the formation of links. These include network effects like triads, operational characteristics like the number of branches, financial factors like the ratio of assets of two banks, as well as the financial profitability of a bank. The relevance and impact of these factors confirm that domestic Chinese banks not only formed links based on cliques but clearly also due to business reasons.

An initial attempt is made to illuminate the endogeneity issue between interlocking directorates and bank profitability, though further investigation is necessary to understand whether the found result of no influence of directorates on RoE is due to method constraints or really reflecting the actual economic effect.

The current analysis is a first step in understanding the evolution of the interlocking directorate network. The flexibility of the utilized methodology allows, however, to further by incorporating multiple networks and behaviour outcomes. The main extension

Table 8: Co-evolution of the Interlocking Directorate Network and RoE levels

Network Dynamics			
Degree	-2.890	(0.775)	***
Transitive triads	0.258	(0.043)	***
Distance 2 pairs	0.007	(0.033)	
Degree of alter	-0.101	(0.036)	***
Degree^(1/2) assortativity	0.175	(0.026)	
Central Link	0.470	(0.202)	**
Central Link (period 2)	-1.408	(0.402)	***
Central Link (period 3)	-0.605	(0.442)	
Local Link	-0.122	(0.113)	
Asset ratio	0.490	(0.162)	***
Co-Location	0.143	(0.099)	
same Bank Type	0.297	(0.080)	***
Bank age alter	-0.004	(0.007)	
Bank age difference	-0.017	(0.007)	**
log_Assets alter	-0.018	(0.030)	
Asset / Exec alter	0.002	(0.002)	
Leverage alter	-0.290	(0.471)	
Liquidity alter	0.374	(0.400)	
Bond.Deposits alter	-0.616	(0.632)	
Staff alter	-0.476	(0.320)	
Execs alter	-0.005	(0.018)	
Branches alter	0.013	(0.006)	**
RoE_band ego	0.275	(0.063)	***
RoE_band difference	-0.014	(0.036)	
RoE growth ego	0.086	(0.025)	***
RoE growth difference	-0.014	(0.020)	
Behaviour Dynamics			
RoE_band linear shape	-0.591	(0.774)	
RoE_band quadratic shape	0.074	(0.039)	*
Degree	-0.000	(0.057)	
av. alters x alter's Assets	-0.553	(1.129)	
Bank age	0.024	(0.011)	**
Branches	-0.022	(0.030)	
Asset / Exec	0.013	(0.013)	
log_Assets	0.031	(0.030)	
Leverage	-0.836	(0.583)	
Liquidity	-0.638	(0.558)	
Bond.Deposits	-2.065	(1.106)	*

Standard errors in parentheses, All variables have a convergence ratio below 0.1
The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.
ego refers to value of the proposing partner, *alter*— to that of the receiving partner

possibilities are the inclusion of other linkage networks, in particular social, informal and clique networks as well as individual directors as actors. The evolution of the network can then be analysed not only in reference to the evolution of interlocking directorates between banks but also the careers of individual bankers and their links and relationships.

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