Inter-Organisational Collaboration Networks in The Introduction Phase of Generative AI

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Abstract

The goal: This research is a preliminary report that analyses the inter-organisational collaboration networks related to generative AI (Artificial Intelligence), which has spread rapidly in recent years, and empirically clarifies the key players and their relationships in the business ecosystem during the introduction phase of the technology lifecycle. The methodology: Information on the collaborative relationships between organisations in the six months following the launch of Chat GPT4 in March 2023, which triggered the rapid expansion of the actual use of generative AI in companies, etc., was extracted from more than 100 major newspaper articles and press releases worldwide, and analysed using the method of social network analysis. The conclusion: The development and utilisation of generative AI is increasingly forming a business ecosystem with very diverse inter-organisational collaborations on applications and system devices, and each organisation is strategically positioning itself within the business ecosystem. The empirical analysis of the structure of the inter-organisational collaboration network has allowed an exploratory identification of various distinctive organisations in the business ecosystem.

Keywords: Inter-organisational collaboration, business ecosystem, social network analysis, introduction phase, generative AI
JEL classification: M15

Paper type: Research article
Received: 10 February 2024
Accepted: 28 August 2024

DOI: 10.54820/entrenova-2024-0037

Acknowledgments: This work was supported by JSPS KAKENHI Grant Number JP24K05126.

Introduction

This paper is a preliminary and exploratory research report to analyse how the inter-organisational relationships involved in the introduction phase of generative AI (Artificial intelligence). Artificial intelligence technologies have existed for some time, but since the release of generative AI, their use by ordinary companies and individuals has spread rapidly. Collecting and analysing real-time information on how the business and industrial structures of organisations change during the introduction of such new technologies is a valuable opportunity for research in business administration.

Businesses related to Artificial Intelligence are realised through the collaboration of diverse companies, the so-called ecosystem (Jacobides et al., 2021). One of the reasons for this is that artificial intelligence-related businesses require a huge amount of management resources. One of the main management resources is databases, and large amounts of high-quality data are the most important resource in artificial intelligence-related businesses. In addition, huge costs are required for software to analyse big data and hardware such as cloud servers to store the data. In order to collect huge amounts of high-quality data, it is preferable for many organisations to share the data rather than for each organisation to collect individual data. Therefore, the artificial intelligence business is characterised by economies of scale or network externalities that tend to be effective. Therefore, the formation and expansion of inter-organisational linkages is a goal of the growth strategy in the artificial intelligence business and can be considered an indicator to judge the success or failure of the artificial intelligence business. The skill of collaboration with other organisations is an important factor in determining the success or failure of an artificial intelligence business.

There are various patterns in the structure of inter-organisational collaboration, and the type of collaboration that is best depends on the characteristics of the product and industry. It also depends on the time in the product lifecycle. Therefore, in this study, the first research question is, which organisations are at the centre of inter-organisational collaboration in today's focus on generative AI. Secondly, what are the characteristics of the structure of collaboration between central organisations and other organisations? The aim of this study is to empirically clarify these two research questions. As described below, the study attempts to collect actual organisational information in a timely manner, from newspaper articles and press releases and to analyse them quantitatively using methods such as social network analysis. Please note that theoretical extension is not necessarily the goal of this report.

Previous research

In this study, the method of social network analysis was used to analyse the linkages between organisations. Social network analysis allows the structure of cooperation to be evaluated quantitatively. For example, one of the most prominent theories of social network analysis is the theory of weak tie of the network structure between nodes. According to Granovetter (1973), the strength of a weak network is access to novel information. The effect of the weak tie on innovation is also pointed out. On the other hand, some theories point to the strength of dense networks (e.g. Coleman, 1988) and suggest that strong relationships among a limited number of members are particularly likely to promote cooperation.

As well as network sparsity, there are also theories on positioning on the network. Burt (1992) refers to the degree to which different clusters of nodes are bridged as a structural hole, and points to the gains of the nodes in the bridging position. For example, bridging may facilitate innovation through new combinations. Also, one of

the main research themes in social network analysis is the degree of centrality of nodes in a network. Various studies have been conducted on node centrality, and network indices that represent different types of centralities, such as degree centrality, closeness centrality, betweenness centrality, and eigenvector centrality (Bonacich, 1972, etc.), have been developed.

Research analysing inter-organisational relations regarding generative AI, the topic of this study, using social network methods is still scarce. Dinh et al. (2024) conducted a network analysis of co-authorship relationships in research papers on generative AI. The analysis points out the characteristics of computer science bridging medicine, engineering and other fields. Cano-Marin (2024) and Mustapha et al. (2024) use text mining to analyse research papers and patents on generative AI and conduct a network analysis of the relationships between key words.

Research hypotheses

Based on the aforementioned survey of previous studies, the following research hypotheses were formulated. First, the hypothesis on network sparsity. Activities related to research, development and utilisation of generative AI are spreading across various industries and applications worldwide. If these activities are carried out in a disjointed manner, with limited cooperation with unspecified external organisations as required, then the relationships between the organisations carrying out these activities can be called sparse. The first hypothesis, which describes such a case, is as follows.

H1. the central organisation in the network of inter-organisational relations for generative AI forms a weak network with diverse organisations.

On the other hand, the opposite hypothesis could be the possibility of close collaboration between a limited number of organisations. Particularly in the early stages of research and development, it is necessary to proceed through a highly uncertain research and development process by trial and error. In order for such a process to be carried out in cooperation with various organisations, it is easier to succeed if there is a strong mutual trust and dense communication between the organisations. The second hypothesis, which describes such a situation, is as follows.

H2. the central organisations in the inter-organisational relationship network on generated AI form a dense network among a limited number of organisations.

There are also possible hypotheses concerning their position in the network. In research and development related to generative AI, as mentioned above, this is not achieved by a single organisation, but by collaboration between various organisations, such as hardware, software and services, for reasons such as the need for a large number of resources. Generative AI is also applied to a wide range of domains, and is utilised in connection with existing products, services and business processes in each of these domains. Previous studies on research papers on generative AI have pointed out that computer science in generative AI has a bridging role in various application domains. The central organisation in generative AI is assumed to be an inter-organisational network positioned to link R&D and utilisation in such diverse domains, leading to the following hypotheses

H3. the central organisation of the network of inter-organisational relationships in generative AI is positioned to bridge other organisations in the network.

In addition, the following hypotheses can be derived concerning the relationships between the central organisations. In the utilisation of AI, there is a debate as to whether the structure will continue to be concentrated on a few big techs, or whether the influence of specific factors such as industry characteristics will be strong and each will become more decentralised (Jacobides, et al., 2021). If the linkage relationship between central organisations is strong, it is assumed to be a centralised network

structure. Conversely, if the linkages between central organisations are weak, the network is assumed to be relatively decentralised, with each organisation building its own ecosystem. Generative AI is characterised by the large number of resources it requires, and at least in the initial stages, it is assumed to be centralised, with strong linkages between the respective big techs, such as hardware, software, etc.

H4. the central organisation in the inter-organisational relationship network for generative AI has strong collaborative relationships with other central organisations.

Analysis methods

Data

In this study, the partnerships between organisations were extracted based on information from newspaper articles and press releases. Newspaper articles are considered to be a convenient way to grasp new events that occur one after another around the world in a timely manner. However, as newspaper articles are selected and discarded according to the policy of the newspaper company, there is a possibility of listing bias among newspapers. This study uses the information source Lexis+, which enables the collection of textual information from more than 100 major newspapers around the world, increasing the comprehensiveness of the original data. It is further supplemented by adding press release information to the newspaper articles. As extraction conditions, Newspaper articles and press releases on generative AI that contain information on some kinds of cooperative inter-organisational relationship (partnership or alliance or cooperation or coordination or tie-up or collaboration) were extracted. The period covered was the nine months after 15 March 2023, when ChatGPT4 was released, and changes were analysed every three months. As the number of newspaper articles was large and the topics were diverse, the analysis was limited to articles related to electronics in order to focus the analysis.

Network Analysis

As an analysis method, first, network analysis is used to identify the organisation with the largest number of linked organisations as the central organisation. Secondly, network analysis is used to analyse the relationship between the number of organisations in each organisation that cooperate with each other and the network structure of the cooperative relationship. As a network index representing the network structure, we first used the ego-network density, which describes the sparseness of the network as described above. We also used the degree of constraint as the network index, which represents the number of structural holes around a node. In addition, eigenvector centrality was used as one of the network indices for the centrality of a node. This index is weighted by the degree to which a node is connected to more central nodes, rather than simply the degree to which a node is connected to other nodes. A similar index is used for assessing the importance of a website in internet searches.

Survey results

Basic statistics

The number of articles and press releases extracted, the number of organisations, the number of linkages between organisations and the average number of linkages per organisation are shown in the table 1. Note that Period 1 covers the three-month period from 15 March, Period 2 covers the three-month period from 15 June and

Period 3 covers the three-month period from 15 September. It can be seen that the number of linkages has increased over time.

Table 1
Number of data extracted

Item	Period 1	Period 2	Period 3
articles and press releases	200	315	464
organizations	282	562	777
collaborations between organizations	468	1,124	1,300
average number of collaborations	1.7	2.0	1.7

Source: Author's work

Central Organisation

Table 2 shows the organisations with the highest number of linkages for each period. These are the names of the ten organisations in descending order of the number of linkages and the number of linkages for each organisation. It was observed from the analysis that NVIDIA, the leading organisation in semiconductors for AI, is continuously expanding its collaboration one after another. OpenAI, the most powerful organisation in the development of generative AI, its partner Microsoft and its rival Google were also at the top of the list. In the so-called US Big Tech, Amazon is expanding its collaboration, while Apple, Meta and Tesla were not to be found. Elsewhere, we observed an expanding ecosystem of computer-related companies such as IBM and Intel, as well as tech ventures offering AI-related solutions.

Table 2
The organisations with the highest number of linkages

Period 1		Period 2		Period 3	
Organisation	**Size**	**Organisation**	**Size**	**Organisation**	**Size**
NVIDIA	41	Google	34	NVIDIA	41
Microsoft	23	Microsoft	34	Amazon	28
Google	14	NVIDIA	31	Microsoft	27
OpenAI	13	Skai	26	Google	21
Esperanto Technologies	7	OpenAI	22	Adastra	18
Arm	6	Alibaba	12	Intel	15
Amazon	5	Ayar Labs	12	IBM	13
IBM	5	Intel	11	Dell Technologies	11
Intel	5	Inworld AI	11	Cadence Design Systems	9
Axelera AI	4	SK Telecom	11	TSMC	9

Source: Author's work

Network structure

Next, the relationship between the structure of inter-organisational linkages and the number of linkages in each organisation was analysed. First, using the method of social network analysis, the structure of the cooperation network of each organisation was indexed. Then, a regression analysis was conducted using the obtained network index

as the explanatory variable and the number of linkages as the explained variable. In order to avoid the problem of multicollinearity between explanatory variables in the regression analysis, each explanatory variable was entered one by one. The results of the regression analysis for each period are summarised in a table 3.

Table 3
The relationship between network structure and the number of linkages

	Period 1		Period 2		Period 3	
network index	Regression coefficients	t value	Regression coefficients	t value	Regression coefficients	t value
density	-0.026	-1.352	-0.018	-1.957	-0.009	-1.163
Constraint	-7.982	-3.586**	-8.093	-7.421**	-6.12	-6.263**
Eigenvector	43.573	24.520**	44.289	16.467**	52.216	28.901**

Note[1]: the number of linkages as the explained variable
Note[2]: **: Significance level 0.01%
Source: Author's work

The results of the analysis show that no relationship with the number of linkages was observed for the value of Density. On the other hand, a strong relationship with the number of linkages was observed for the value of Constraint. The smaller the value of Constraint, the larger the structural void. A strong relationship with the number of linkages was observed for the value of Eigenvector. The more central the organisation, the more connected it is to other central organisations. No change in these trends was observed over the three time periods.

Discussion

Based on the results of the aforementioned analysis, each of the hypotheses set out is discussed. The first and second hypotheses concerned the sparseness or density of the network. The results of the analysis indicate that the sparseness or density of the network may not be related to the centrality of the network. In other words, central organisations do not necessarily form strong closed organisational groups, nor do they cooperate openly at all. Observing individual organisations, NVIDEA, for example, has an open network structure with a very large number of organisations in collaborative relationships. It can be inferred that organisations that develop and utilise generative AI are allied to NVIDEA for its superior devices. Google, Amazon and Microsoft also have a relatively open network structure of collaboration. In the research and development of generative AI, they seem to form some strong relationship groups, while collaborating with a wide range of organisations. They also seem to have a wide range of partnerships in development environments such as the cloud. On the other hand, it is observed that Intel and Dell, for example, work with several relatively strong relationship groups. With regard to the looseness of the networks, it can be inferred that there are different characteristics depending on the strategy and products of each organisation.

The third hypothesis concerned the positioning of the network. The results of the analysis showed that the more central an organisation is, the more bridging positioning it is likely to have. This is in line with the results of the co-authorship networks of the research papers in the previous studies. Currently, the central resource for generative AI is a huge pre-trained database, suggesting that a limited number of organisations

involved in the development of such a database and its utilisation in the cloud are central organisations. These include NVIDEA, Microsoft, Google, Amazon and OpenAI. On the other hand, there were a number of closed groups with relatively small network sizes. They are presumably utilising the huge resources offered by the big techs and catering to individual needs depending on industry, application, geography, etc. The central organisation acts as a platform, so to speak, linking many of these sub-groups. In other words, the character of the inter-organisational coordination network structure is not vertically integrated as in the traditional automotive industry.

Finally, the fourth hypothesis concerned the relationship between central organisations. From the results of the analysis, a strong relationship between central organisations was observed. In other words, it can be seen that the structure of the network is concentrated around some central organisations, the so-called big techs. For example, NIVIDEA has partnerships with almost all central organisations; Microsoft has a strong capital relationship with OpenAI. And among the other central organisations, there seems to be some kind of cooperation while competing on the one hand.

The characteristics of the network structure described above, including the face of the central organisations, changed little for three periods every three months for the period after the release of Chat GPT4. However, as generative AI is still in its introduction phase and new organisations are expected to enter the market one after another and new technologies and services will be created in the future, it is not necessarily true that the same structure will continue for a long time to come. For example, industry structures and industry standards have not yet been established. As the use of generative AI expands, there is a possibility that systems will be developed that are specialised for different industries and applications, and a decentralised network structure will emerge. Also, technologically, there is a possibility of a shift from the remote use of huge databases in the cloud to more sophisticated edge computing, leading to a distributed network structure. Future changes will be closely watched.

Conclusion

This study conducted an exploratory survey of the central organisations and the structure of their inter-organisational collaboration networks during the introduction phase of generative AI. The results of the survey revealed that companies developing generative AI and semiconductor manufacturers for AI are expanding their collaboration networks. Analysis of the characteristics of the structure of the inter-organisational cooperation network revealed that it is a centralised network structure in which some organisations act as bridges between multiple organisations.

As a future subject, I would like to continue to investigate the inter-organizational network structure related to generative AI. For example, research topics include whether the network structure will remain centralized or change to a decentralized structure, and what the influencing factors are.

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