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Exploring the Barriers and Mitigation Strategies in Digital Business Ecosystem Development: A Case Study from Engineering Material Supply Service Provider

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Abstract. At present, more and more companies are aware of and have the incentive to promote the construction and development of collaborative platforms, to improve collaboration to cope with many uncertainties such as market turmoil and increased competition. At the same time, with the emergence of emerging digital technologies, the concept of a digital business ecosystem is becoming more and more prominent. DBE development is a long-term evolutionary process, and there are many barriers in the practice. The current research on DBE is mainly conceptual and theoretical, and the barriers in the development process of DBE in the practice are still lack of exploration. Therefore, the purpose of this study is to summarize and analyze the key barriers in the practice of the enterprise through empirical investigation. According to the case companies' mitigation measures and related literature research, we proposed some relevant suggestions and research ideas to solve the barriers.

Keywords: digital business ecosystem development · collaborative platforms · mitigation strategies · case study

1 Introduction

The market turbulence and increased competition brought about by globalization have encouraged companies to engage in collaboration to gain flexibility and elasticity. With the advent of new organizations, platform structures, and enabling technologies, this trend provides an advantageous environment for business collaboration. A growing number of enterprises are aware of this trend and motivated to push forward the construction and development of collaborative platforms, and the concept of the digital business system is created gradually [1]. DBE can be understood as a social and technological environment composed of collaborative and competitive individuals, organizations, and digital technologies that jointly create value through Shared digital platforms [2]. The main characteristics of DBEs are platform, symbiosis, co-evolution, and self-organization [3]. The core of DBE is the platform.

DBE transcends the boundary of traditional industries by virtue of digital collaborative platforms and promotes more open collaboration and competition.

At present, the number of enterprises begins to pay attention to DBE development and actively build it of their own. The systematic architectural design is viewed as the means to improve their quality of service. Enterprises energetically promote the construction and development of collaborative platforms to build their own DBE. Commonly, the DBE platform is based on the transformation and upgrade of the traditional supply chain [4]. The traditional supply chain core enterprises gradually build the DBE through the development and operation collaboration platform, promoting collaboration among participants. In the existing researches of DBE, most scholars carry out relevant researches in the idealized state that the DBE has been constructed completely. In the literature on DBE development, [5] proposed a framework, at the theoretical level, for the formation and management of a DBE through a three-stage approach: creation, monitoring, and evaluation. [6] introduced the challenges of top-down and bottom-up DBE development through the comparison of DBE development cases between China and Germany. In practice, the development process of DBE is a complex system engineering, which has many barriers. Currently, the development process of DBE has not been discussed or paid enough attention in the literature.

Authors consider that it is vital to study the barriers in the development of DBE. Firstly, it is the basis of subsequent theoretical and conceptual studies. Besides, real enterprise case studies are more valuable and relevant to the practice of enterprises in the same field. Therefore, the purpose of this study is to analyze the development process of DBE in case enterprises through empirical research, focusing on the key barriers and mitigation strategies in the development process of DBE.

The following two research questions will be the core of the paper:

A: What are the key barriers for enterprises in DBE development?

B: What are the measures taken by the case enterprise to mitigate barriers during the DBE development?

We used the empirical method, through the collection and analysis of the interview data and text data of the relevant personnel of the case enterprise. We reviewed the process of DBE development of the case enterprise, and to summarize and analyze the key barriers in the process. We summarized and analyzed the barrier mitigation strategies of enterprises in the process of DBE development, and provides theoretical support for the corresponding strategies based on the relevant literature research.

The significance of this paper lies in: in practice, it can provide a reference for enterprises in the same field or other industries in DBE development, at the same time, in the academic field, it complements the relevant content of key barriers in DBE development, and provides a new practical perspective for the follow-up DBE related research.

The rest of the paper is organized as follows: the second section outlines the research methods of this paper, the third section summarizes and analyzes the key barriers and mitigation measures in the DBE development process, and the last section summarizes the full text and provides some future research.

2 Methods

2.1 Data Collection

Our research data are from China Railway Material Trade CO., Ltd. (hereinafter referred to as "MTC"), which was established in December 2010 and is a wholly-owned subsidiary of China Railway Group Limited and one of the world's top 500 enterprises. MTC is mainly responsible for the centralized procurement and supply management of materials for large engineering projects directly managed by the China railway. As a supply chain service provider, MTC has been taking "supply guarantee, quality guarantee, cost reduction" as the service target, serving the whole supply chain network.

In the early stage of its establishment, MTC mainly provided services for China railway's material supply chain, and gradually established second-level subsidiaries, including e-commerce companies and rail logistics companies, to continuously improve its professional services. With the suppliers and logistics providers participating in the service of engineering projects, MTC gradually attaches importance to its own supply chain upgrading and optimization. In 2015, MTC paid attention to the application of digital technology, built a business collaboration platform (BCP), made all offline businesses online, implemented the company's system and business management methods through the platform, and realized the internal control of MTC itself. In 2018, MTC valued the management of the entire supply chain and realized the management of the entire supply chain through the implementation of technologies such as data sharing and system interoperability. Starting from 2019, MTC builds its own supply chain intelligent collaborative service platform, hoping to become a demonstration enterprise of supply chain ecological services in China.

China Railway Group Limited is one of the world's top 100 enterprises and a leading enterprise in China's railway construction. It has more than 40 secondary subsidiaries and more than 150 tertiary subsidiaries. The whole China Railway Co., Ltd. has a huge ecological environment. This paper mainly introduces the DBE development process of China Railway products trade service provider-MTC. MTC has 10 subsidiaries and 3 branches. The ecology of China Railway Co., Ltd. is shown in Figure 1.

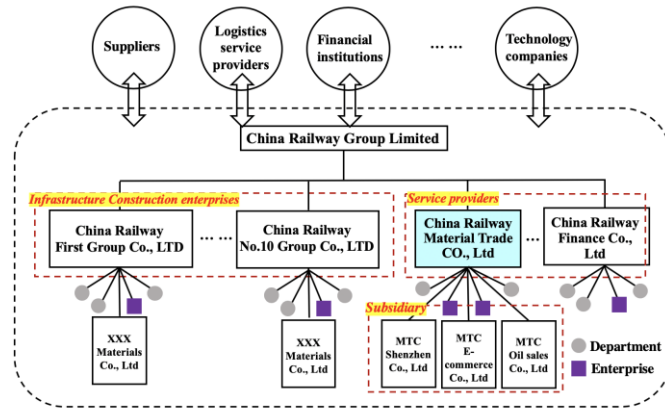


Fig. 1. China Railway Group Limited ecological map

To explore the key barriers in the development of DBE, it is necessary to understand the strategic planning of MTC from the perspective of the industry background, and further understand the barriers and solutions at various stages of its development. Since long-term tracking and multiple interviews are helpful to obtain relevant information, this paper takes deep rebound as the most important way to obtain data. In the current research on DBE, there is relatively little literatures on empirical research methods, which also encourage the use of empirical research methods to carry out DBE research[2], which proves the rationality of the selected method.

In view of the research problem, we conducted 6 semi-structured interviews on MTC including the technical developers of the commodity trade enterprises' BCP platform, the CEO of the commodity trade company, the business personnel of the two subsidiaries, and the relevant personnel of the commodity trade service bureau. Different managers, technicians, and business personnel from different departments were selected to systematically understand the BCP platform from various perspectives. The accumulation of years of practical experience helped them form their own unique understanding. They are all involved in the development, construction, and use of the platform within DBE, and have a relatively accurate grasp of some of the barriers. At the same time, we also collected a large number of text materials within MTC, and participated in two reports of MTC, so as to better understand the initial vision of the enterprise and the relevant strategic planning of the enterprise.

We maintain the flexibility of the conversation throughout the interview so that the interviewees can freely explain their experiences. We also take special care to ensure that there is no leading conversation [7]. The interview followed the semi-standard protocol [8], and questioning interviewees were based on interview design outline. At the same time, according to the respondent's answers and ideas, they were asked follow-up questions to obtain detailed information as far as possible and to avoid the bias of the evidence brought by the interviewees' mistakes or negligence.

Table 1. Types of Data Collected and Descriptions

Type of Data	Description
Onsite semi-structured interviews	17 hours of audio interview recordings with participants from different levels including the managing director, technology officer
Organizational documentation	(1) Approximately 450 pages of digital collaborative platform design report, feasibility report, planning ,etc. (2) Approximately 1300 pages of internal meeting summary, Risk Management Regulations, Business Management Approach, etc. (3) There are five ppt documents (120 pages) about logistics collaboration center design report, platform design report, which mainly include the functions, technologies and business strategies ,etc.

2.2 Data Analysis

We conduct data analysis from the perspective of interpretation, following the principle of interpretative research [9]. We followed the selective coding technique to code the number of interviews obtained. Data analysis and data collection is a continuous iterative process. When the data can be interpreted by literature, we will merge it into the theme model. When a new theme appears, but there is not enough literature data support, we will conduct follow-up interviews. Finally, the coded theme model was submitted to a group of scholars and enterprises for review, whose responsibility was to challenge the potential logic and data accuracy. Until the group agreed that the topic model was logical and accurate [9], we stopped coding.

To answer our first research question: what are the major barriers for enterprises in DBE development? we sorted out the answer records of different interviewees and identify some key factors.

The DBE development process of MTC can be divided into three stages. In the first stage, MTC focus on collaborative platform construction within the organization to achieve information sharing within the entire organization. In the second stage, MTC pays attention to collaboration platform construction among organizations in the supply chain environment to realize business collaboration among different organizations. In the third stage, MTC is building an ecological intelligent collaborative service platform, focusing on serving the whole ecology and realizes the value co-creation among organizations with the identity of the core enterprise. Therefore, this paper will mainly explore the main barriers in the process of DBE development from the following three stages.

Stage1: Business collaboration platform construction within the organization

Stage2: Business collaboration platform construction among the organizations

Stage3: Intelligent collaborative service platform construction in the ecosystem

According to the existing literature analysis, the barriers analyzed in this article are truly the challenges in front of the current research of DBE [2]. This article also sorts out some barriers that have not been mentioned in the literature and further research

the questions based on the interview records.

The second research question studies the strategies to overcome the barriers of DBE development. Firstly, starting from the innovative measures taken by the research objects MTC of this paper, we summarized the strategies taken by MTC to overcome the barriers in different DBE development stages. Then we identified the relevant literature to provide theoretical support for the corresponding strategies. Comparing the case study results with the literature, we proposed the mitigation strategies that organizations can adopt to alleviate the dilemma in DBE development.

3 Barriers and Mitigation Strategies in DBE Development

This section presents the findings of our qualitative research on the barriers and mitigation measures in DBE development. We discuss the barriers that MTC faces according to the different development stages. After identifying each barrier, we discuss the mitigation strategies implemented by MTC and suggest possible propositions based on relevant literature.

3.1 Stage 1: Business Collaboration Platform Construction within the Organization

According to the analysis of the interview data, we find that there are two key barriers in the first stage of the DBE development of MTC. On the one hand, MTC has a large number of independent systems, such as risk management system, e-commerce system, bidding system and so on. Due to the lack of data sharing, data re-entry and data accuracy lead to the complexity of the business and a lot of uncertainty. How to realize the system integration and data sharing in MTC organization becomes the key barrier in the first stage. On the other hand, one of the most important characteristics of construction industries is the existence of a large number of temporary project sites. [10] mentioned there is a time and space gap between the job site and the office that causes duplication of data and information, lack of data and information, and associated confusion. So, MTC is facing another key barrier is the management of the project sites.

The incompatibility of platform and system, and the different standards of data and information presentation, storage, exchange, processing, and communication have been the main obstacles in the process of enterprise collaboration [6]. Data standardization and system interoperability have always been key issues in the area of DBE [11]. According to the analysis of the interview data, MTC keeps trying to remove barriers in data sharing and process integration. MTC began to construct a business collaboration platform within the enterprise to solve the problem of data sharing by sharing a set of platform, and has achieved some progress.

The project site of the construction industry can be understood as an opportunity-driven temporary organization, which is difficult to be fixed and in a dynamic process. Because it is difficult to be controlled by the platform system, some scholars

describe it as shadow system or illegal system [12]. The Shadow System that exists outside the current legal system (BCP) can be understood as the network formed by people spontaneously. It is another network established by people outside the legal system (BCP) through informal channels. In practice, it can be understood that people or group are resistant to use the new platform and still deal with transactions according to the old habits, or the new platform has no practical help or pays no attention to their existence for people or group, and they still rely on traditional Excel or Database to deal with transactions or according to their own experience to deal with some things that the BCP will not record. For example, Different individuals and groups in construction make different messy evaluations of interacting events, which leads to them taking different actions [13]. This will lead to a lot of uncertainty outside the BCP control.

In the case of MTC, the Shadow System is mainly reflected in the construction site. There are still a lot of behaviors that are not recorded in BCP system. It is a key barrier for the development of the DBE platform that the existence of the Shadow Network supports or opposes the legal system, which needs to be paid attention to. At present, many researches have focused on the use of RFID and other technologies to achieve the implementation of data collection in the project site [10]. Through the investigation and research of a large number of the BCP users, MTC has begun to attach importance to the explicit of the shadow system, MTC are still mining more Shadow System forms in the organization and constantly made the Shadow Network explicit by using emerging technology, such as IoT, Blockchain and so on.

P1: Pay attention to the data sharing and system integration, and constantly mining Shadow System and make it explicit

3.2 Stage2: Interconnection Among Organizations in Ecosystem

In the process of building a collaborative platform within the organization, many businesses handled by BCP platform involve multiple participants in the supply chain. However, as the construction of BCP mainly serves the internal of the organization, MTC cannot provide services for external participants. As a result, MTC began to build a business collaboration platform among organizations, and the second phase of DBE development began.

Through the analysis of the interview data, we find that there are two main obstacles to MTC in the second stage of the development of disadvantaged commercial enterprises. On the one hand, with the increase of business participants, the business complexity behind system integration and data sharing is becoming increasingly prominent. On the other hand, the traditional collaborative process between organizations is connected by business processes. With the increase of business complexity, the collaborative process between organizations becomes a complex scenario, needs attention.

As mentioned above, heterogeneity has always been the focus of attention in the

collaborative process. In the second stage of DBE development, MTC is also trying to use various technologies to realize the system connection among organizations in the whole ecological network. With the increase of DBE participants in the business, including various organizations, personnel, processes, emerging technologies and other multi-party interaction and collaboration, the complexity of the business continues to increase, and the business gradually becomes a "black box". Traditional DBE platform developers have been looking at the complexity of business from a technical perspective, trying to solve business problems with emerging digital technologies, but the barriers have not been well solved. For example, MTC only has one material demand list, but it will be supplied by different suppliers, and multiple supply lists will be generated. Although all the lists can be recorded by the platform, the naming methods and data representation of goods by different enterprises will cause MTC to need a lot of manual understanding and refilling.

Therefore, in the process of collaborative, a lot of uncertainty and complexity come from collaborative business will be generated. With the rapid growth of collaboration business quantity, many problems cannot be solved only by data sharing. In a word, it is business barriers behind many technical problems. We need critical attention to the business-related issue since technology integration is not the biggest problem [11].

For the problem of data interoperability in collaborative networks, scholars have begun to pay attention to it. [14] proposed a systematic methodology and a set of mechanisms for the federation of four typical types of knowledge sources shared within CNs, to realize federation of varied knowledge sources in administrative CNs. Authors consider enterprises need to pay attention to the business complexity behind technology heterogeneity. Only by analyzing the complexity of the business, can we take appropriate technology to solve the corresponding barriers.

Digitally enable networks and ecosystem fuel complexity by fostering hyper-connection and mutual dependencies among human actors, technical artifacts, processes, organizations, and institutions [15]. Authors consider the collaboration of different organizations will bring a lot of uncertainty and complexity by means of a digital collaborative platform. It would be certain and manageable if the connection or collaboration is standard and controllable. In the integration process, the problem of the border crossing will be involved [16]. In the process of organization collaboration, there are many boundary conflicts. Including different organizational culture, information level does not match, data standards are not unified, and so on. Authors consider that the boundary is the carrier of complexity and uncertainty, so the boundary is not just a line, but a complex scenario that deserves attention.

Based on interviews with MTC personnel, MTC had sorted out several business scenarios including material demand, material procurement, material distribution, material handover and receipt, and reconciliation and settlement. Through scenario analysis, MTC focuses on a specific business and boundary conflicts involving multiple parties, and mitigate them.

P2: Pay attention to the business complexity behind the technology heterogeneity, and focus on the complexity and uncertainty in the organizational boundary during the business interaction between organizations.

3.3 Stage 3: Intelligent Collaborative Service Platform Construction-driven by Collaborative Scenario

Aiming to solve the two barriers (Stage 2) mentioned above, MTC began to promote the construction of intelligent collaborative service platforms driven by collaborative scenarios. The platform divides the key links in the business process into different collaborative scenarios for analysis and begins to pay attention to the business complexity and uncertainty in the collaborative scenarios analysis.

As mentioned above, as business complexity and uncertainty increase, business gradually becomes a black box. How to deconstruct the black box has become a major barrier in the construction of DBE development platform in Stage 3. According to the interview, MTC began to pay attention to business scenarios and proposed an intelligent collaborative service platform driven by collaborative scenarios in traditional business processes. The business process is divided into specific business scenarios, mainly from uncertainty and complexity to try to deconstruct the business "black box".

The business process is redefined as the concept of "Scene chain" when MTC studies business activities with scenario methods, so it is also necessary to pay attention to the transmission and cascade effect in the scene chain. [17] proposed a risk identification approach in collaborative networks, paying attention to the cascade effect of risk. [13] focus on knowledge transfer and information exchange in different construction projects. Each scenario involves flows that produce a response and generate a succession of multi-directional flows until a particular function is satisfied and specific issues are resolved. Cascading effect is an inevitable and sometimes unforeseen chain of events due to an act affecting a system [18]. In the process of focusing on scenarios, MTC needs to pay attention to the cascading effect in the whole ecosystem, which may include data ecological governance, knowledge interoperability, risk cascade, etc.

As described in the case introduction section above, MTC has 10 subsidiary companies and 3 branch companies. The establishment of early subsidiaries was mainly divided around different types and regions, such as steel, oil, etc. The business form of each subsidiary is relatively fixed. With the transformation and development of Luban e-commerce company, it began to be responsible for the overall bidding and procurement of various materials. With the establishment of Luban e-commerce digital platform, material bidding and procurement are standardized and unified. How to find their own positioning, how to carry out collaborative development between each other, and how to seek value co-creation have become important challenges in the future.

MTC has begun to pay attention to the whole ecological collaboration problem under its own complex organizational structure. It is trying to build an intelligent collaborative service platform driven by collaborative scenarios. Starting from the business scenario of multi-party collaboration, MTC starts to provide intelligent services and further excavates the value co-creation possibilities among participating subsidiaries.

According to the interview, the development of DBE of MTC is in the third stage, and the intelligent collaborative service platform driven by collaborative scenarios is

under development, and the specific obstacle solving measures have not been fully applied. Table 2 summarizes the main discussion in the third section.

P3: Pay attention to the uncertainty and complexity in the collaborative scenarios, and the cascading effect in the scenarios chain

Table 2. Barriers and measures in DBE development

DBE development stage	Barriers	Measures to overcome barriers	Corresponding proposition
Business collaboration platform construction within the organization	1. Data sharing and system interoperability 2. Shadow systems	1. Integration platform within the organization (BCP) 2. shadow system explicit	P1
Business collaborative platform construction among organizations	1. Business complexity behind technology heterogeneity 2. Boundary conflict of organizations collaboration	1. Focus on business (Business scenario) 2. Insights into organizational boundary scenario	P2
Intelligent collaborative service platform construction in ecosystem	1. Cascading effect 2. Collaborative value co-creation	1. Focus on cascading effect in the whole ecosystem 2. Intelligent collaborative service platform	P3

4. Conclusion

This research analyzes the barriers and mitigation strategies faced by DBE development. The conclusions are mainly the following three aspects.

First, this paper summarizes the key barriers in the three stages of the DBE development process through empirical research methods, and traces the source of the specific barriers and analyzes them in detail. through the analysis of the barriers, the research of related literature, and the related measures taken by the enterprises, the possible mitigation strategies for each type of barrier are proposed and presented in the form of propositions.

Secondly, in the field of practice, the development of DBE is a complex system project and a continuous long-term evolution process. The case company MTC is currently progressing to the third stage. Many companies may still stay in the first or second stage, or even a different evolution path. We only aim at case companies and provide references for the development of DBE in the field of construction engineering.

Thirdly, the existing DBE research is mainly at the theoretical level, so it calls for more empirical articles [2]. Empirical articles will bring more new research problems in the academic field. This article mainly discusses the key barriers and mitigation

measures companies face in the process of DBE development, supplements the literature in the field of DBE development, and puts forward new thinking and research questions on the related research of DBE in the form of propositions.

5. Future Research

The popularization and development of IoT technology provide new method for the solution of the shadow system. At present, in the construction industry, the solution to the problem of the shadow system is to collect behavior data with the help of some technologies, such as RFID [10]. The main solution is to use the digital method to show it on the platform. The project site is only a kind of shadow system which is concrete and obvious. There are many other shadow systems in the ecosystem. In the future, how to intelligently mine the shadow system and how to intelligently explicit the shadow system will become the key direction of collaborative platform optimization in the future.

As emphasized in the introduction of this paper, the development of DBE is a complex and systematic project, which is a long-term construction and operation process. DBE emphasizes the importance of digital technology, but according to MTC case study, some barriers cannot be solved by digital technology alone. It is necessary to return to the original business system and analyze the complexity and uncertainty of the business itself. Therefore, the future needs to carry out more empirical studies and accord real cases to explore more complex and uncertain situations in the construction industry business ecosystem.

The management method of complexity and uncertainty of the construction industry has always been the focus of scholars. [19] proposed a three-phase framework for the identification and categorization of uncertainty. And some scholars focus on lean management [20] or Soft Systems Methodology [13] to resolve the complexity of the construction industry. Taking the case of MTC as an example, the development of uncertainty and complexity analysis and manage methods has become the direction of future research.

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