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Developing Digital Business Ecosystems to Create Collaborative Value in Supply-chain Finance

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Abstract. Although many enterprises have been launching the supply-chain finance (SCF) to help firms solve financing problems and increase collaborative performance, the formation process remains limited. The “digital business ecosystem (DBE)” is a sound guiding theory that we adopt to study the process of SCF networks formation, while SCF offers a suitable phenomenon to research how to integrate the business ecosystems and digital platforms to shape DBE and its logic of value. Guided by this lens, we conduct an in-depth case study of a super-large infrastructure enterprise in China. This study reveals a process model which consists of focal IT/IS enablers, dominant types of ecosystems, and forms of ecosystems. Our findings contribute to existing body of literature, in the field of SCF and DBEs. Core firms of ecosystems can use the model to design and develop DBEs to co-create value in SCF with rational deliberation and planning.

Keywords: Collaborative networks 4.0 · Value creation · Digital business ecosystems · Supply-chain finance · Process model · Case study.

1 Introduction

The existing research on collaborative networks (CN) is clarified into three stages that are defined as CN 1.0, 2.0 and 3.0. Specifically, CN 1.0 focus on goal-oriented networks such as virtual enterprises [1] and virtual organizations [2]. CN 2.0 focus on CN breeding environments [3] and CN 3.0 mainly discussed the interplay among multiple CNs (e.g., value system networks [4]). Research and development are now beginning to address the issues of CN 4.0, one of which is the formation of new business ecosystems focusing on collaborative value creation in the era of digital transformation.

Supply chain is a typical form of CN. With the growth of supply chains, a shortage of working capital faced by small and medium-sized enterprises (SMEs) always exists. Because of information asymmetry or financial risks (e.g., fake account receivable vouchers), SMEs’ good business performance does not always result in loans from financial institutions. To address this issue, SCF was created as a type of financial products/services that consists of a set of collaborative organizations that are interdependent to co-create and extend supply-chain value through the exchange of

services [5]. Simultaneously, SCF must be supported by Fintech that can combine digital technologies with financial business structures and process [6]. Thus, SCF is a suitable phenomenon for CN 4.0 research in the academia. However, research on the formation process of SCF networks remains limited.

Given that value co-creation and participant co-evolution are significant features of business ecosystems and Fintech enables SCF networks, DBE [7] is a suitable theoretical lens that we adopt to study the formation process of SCF networks and to address the research gap of CN4.0. DBE is defined as a self-organizing environment relies largely on synergy between different business entities through its platforms based on digital technologies during value co-creation [7]. Although the “what” question has been investigated in many studies, the “how” question (i.e. *“How is DBE shaped through the combination of the business ecosystems and digital platforms?”*) has yet to be explored, which lead to that logic of value co-creation in CN 4.0 or DBE is still in the black box. Thus, this study aims to uncover the formation process of SCF networks which contribute to collaborative value co-creation in CN 4.0. Guided by DBE theory, we conducted in-depth case analysis of China Communications Construction Co., LTD. (CCCC) and derive our research question: *how to develop a digital business ecosystem (DBE) to create collaborative value in supply-chain finance (SCF)?*

Process theory focuses on a series of activities to explain how specific outcomes evolve over time of the studied case [8]. Process models can make it easier for scholars and practitioners to understand the underlying mechanisms involved [9]. This study proposes a three-phase process model on DBE formation in the field of SCF. In each phase, the model reveals a kind of focal IT/IS enablers that triggers a value co-creating mechanism and further shapes corresponding dominant types of ecosystems. Thus, the process model reveals a complete process of formation of DBE and makes both important theoretical and practical contributions. First, by examining the value co-creation process of DBE for SCF and uncovering the key factor of DBE – focal IT/IS enablers, this study contributes not only to the SCF and CN 4.0 literature but also to DBE literature. Second, the core firms may use the findings to implement integration of digital fintech platforms and business ecosystems, and by doing so, increase the success rate of the adoption of SCF to co-create collaborative value.

2 Literature Review

2.1 Supply-chain Finance (SCF) as a Typical Phenomenon of CN 4.0

Supply chain, a stable long-term goal-driven network composed of raw material suppliers, manufacturers, distributors, retailers and final consumers, is obviously one typical form of CN [10]. SCF is a value extension of the traditional supply chain by improving the management of the transaction, physical, and information flow at an inter-organizational level [11]. The supply chain collaboration dimensions has received significant attention in the research on SCF [12], which state that SCF is a

collaborative entity primarily encompassing three participants: borrowers, banks and LSPs [13] as well as the integration of financing processes with customers, suppliers, and financial service providers [11].

Meanwhile, the development of e-commerce not only forces the improvement of supply chain sustainability, but also moves it into the digitalization era [14], digitization is increasingly emphasized in SCF [6]. Especially, Fintech, the acronym for financial technology, supports and enables many aspects of SCF, resulting in new business models, applications, processes or products [15]. Fintech describes the connection of the typical business activities in financial services and the existing internet-related technologies (e.g., cloud computing, mobile internet) or emerging information technologies (e.g., blockchain, AI) [16]. As we know, the new business ecosystems focusing on value co-creation in era of digital transformation is a hot topic of CN 4.0. Therefore, as a fintech-enabled business model which focus the supply chain value extension, SCF is clearly a typical practice phenomenon for CN 4.0 research. However, research on the formation process of SCF networks remains limited. Thus, DBE, the digital concept with the value co-creation and co-evolution as the important characteristics, is a suitable theoretical lens we can adopt to study this phenomenon and address the gap of CN4.0 in the academia.

2.2 Digital Business Ecosystem (DBE) Perspective towards SCF

DBE comprises two main tiers: digital (ecosystem) and business (ecosystem) [17]. Digital ecosystem refers to a virtual environment consist of digital entities (e.g., software applications, hardware and processes) [18]. The concept of business ecosystem was introduced by Moore in the 1990s as an economic community supported by loosely-coupled interacting individuals and organizations who produce valuable goods and services [19]. Digital business ecosystem (DBE) derives from the natural evolution of business ecosystem for which strongly emphasis on the centrality of digital technology. DBE is defined as a socio-technical environment made up of different entities with collaborative and competitive relationships, including individuals, organizations and digital technologies, to achieve value co-creation through shared digital platforms [7]. The main characteristics of DBEs are platform, symbiosis, co-evolution and self-organization [20].

Given that DBEs has to integrate new technologies and to leverage digital platforms [7], it is important to understand how to strategically control platforms to benefit participants of business ecosystems [21]. Hence developing the DBE involves not only traditional business ecosystems but also digital technology platforms [22] [23], the combination of the two may contribute to new value co-creation in ecosystems of digital era (CN 4.0). However, research focused on the process of how DBE is shaped through the combination receives little attention. SCF, as the typical concept of DBEs which integrate digital technologies and financial business, offers us an opportunity to study the logic of value co-creation in DBE and also CN4.0 with a thorough discussion of collaborative networks and related ecosystems. From there, we derive our research questions: *how to develop a digital business ecosystem (DBE) to create collaborative value in supply-chain finance (SCF)?*

3 Research Methodology

The case research methodology is particularly appropriate for this study for three reasons. First, the research aims to answer the “how” question and is thus better addressed through inductive methods [24] [25]. Second, the case study is more effective to build a new theoretical model with its strength in exploring new conceptual arguments [26]. Third, the case study method is suitable for a process-based analysis concerning the “how” question [27].

Given the research question, three criteria were identified. First, the sample organization should be reasonably large, and have sufficiently complex supply chain relationships so that their types of ecosystems and value co-creation processes can be identified; Second, the company should establish its own supply chain finance systems, so that the theoretical insertion in this aspect has practical significance. Third, the sample companies were willing to provide enough detailed information to support the research, especially senior management.

CCCC is particularly suitable for our research purposes, as it is the second largest infrastructure enterprise in Asia, with a large and complex industrial chain network of design, construction and equipment manufacturing enterprises at its core. CCCC has successfully built a supply chain financial service platform covering all its equipment manufacturing enterprises. In addition, the company has given us sufficient authority and detailed information for promotion research.

3.1 Data Collection

Data was collected in two steps. Research access was first negotiated and approved in April 2019. Before onsite data collection, we systematically collected secondary data from various sources, including newspapers, magazines, books and the Internet, in order to accurately determine the appropriate direction and facilitate on-site interviews. Meanwhile, we selected and confirmed the theoretical lens [24] that we would employ in the study, and read both the classic and current literature. Based on the collection of secondary data, the adoption of SCF concepts and digital business ecosystem perspective, a preliminary theoretical model guides us for subsequent on-site data collection and analysis.

On-site data collection was then conducted at CCCC’s headquarters and its subsidiaries, through meetings and telephone interviews, and from October 2019 to January 2020. We applied the top-down interview method [24], interviewing a total of 26 informants (see Table 1), including the director, CIO, project manager, product manager, among others. Each interview lasted approximately 30–120 min, and the questions were customized to the informants. Each digitally recorded interview was transcribed after and then formed a document total of more than 210 pages. The transcripts with the secondary data allowed for triangulation, which enabled greater substantiation of the constructs and hypotheses [28].

Table 1. List of Interview.

Position/departments	The number of interviewees	Duration of the interview (per person)
Director of Xingyu Data	1	120min
CIO of Xingyu Data	1	120min
Senior managers in the procurement, strategy and IT of CCCC	3	120min
Project manager of Fuhe bridge project in CCCC	2	90min
Domain experts in SCF	2	90min
Project manager of SCF project in CCCC	2	40min
Mid-level managers in product, development, technology and market of Xingyu Data	15	30-40min

3.2 Data Analysis

To organize the large volume of data, we focused on two themes: the history of SCF construction of CCCC and the IT/IS enablers for ecosystems evolution. The exhibition of the history could facilitate the development of people's familiarity with the strategies and activities for SCF formation, thus allowing them to identify the focal IT/IS enablers and different forms of ecosystems more easily, which is important to the understanding of DBE practices and theories. Focusing on the two sets of constructs—the focal IT/IS enablers and dominant types of ecosystems, we identified CCCC's three important phases for DBE development in SCF: developing an originally digital application of SCF, building a Fintech platform for potentially diverse applications of SCF and enriching digital business ecosystems of SCF through complementing diverse applications. Correspondingly, we conceptualized three structures of business ecosystems by identify its three main characteristics, and thereby outlined three ecosystems forms established by CCCC: a value-added business ecosystem, a financial technology (Fintech) ecosystem, and digital business ecosystems for SCF (See Table 2).

Data analysis was performed concurrently with data collection to take advantage of the flexibility afforded by the case study research methodology [28]. Based on the emerging data, to facilitate the examination of the value co-creation process of DBEs for SCF, we divided events and activities into three distinct phases: original applications of “Accounts Receivable Financing Vouchers” based on digital credit, unified Fintech platform for potentially applications based on core functionalities, and complementing diverse applications for CCCC manufacturing enterprises based on Fintech platform. The theoretical model was then verified and modified accordingly. To achieve theoretical saturation, the data analysis constantly iterative among the empirical data, the relevant literature, and the emerging model [24].

4 Case Description

China Communications Construction Co., LTD. (CCCC) is the world's leading provider of super-large infrastructure integrated services. In 2017, a subsidiary of CCCC was established-Xingyu Data, dedicated to promoting the industrialization of cutting-edge technologies such as CCCC's supply chain finance. With Xingyu Data as the operating subject, CCCC has spent more than three years actively exploring the SCF practice for large infrastructure enterprises, and finally built an extensible and scenario-based supply chain finance service platform. Through credit digitization of core enterprises, this platform can effectively empower upstream and downstream enterprises in the supply chain to reduce management and operation costs, and help SMEs to solve the problems of financing. At present, with the bridge of digital credit-enabled fintech platform built by CCCC, digital business ecosystems (DBEs) in supply chain finance (SCF) has been established and full covered in CCCC equipment manufacturing enterprises. So, how did CCCC do it?

4.1 Original Applications of "Accounts Receivable Financing Vouchers" based on Digital Credit

Relying on the business characteristics of long industrial chain and long construction period, CCCC has the problems of high asset-liability ratio and long cash flow cycle, which lead to rising prices for raw materials from upmarket suppliers. Against the background of fierce competition and rapid technological iteration, CCCC, as one of the leading infrastructure construction companies in Asia, is facing difficult challenges, as explained by Xingyu Data's director Wang:

For us, the company's procurement and management costs remain high. For the upper middle and small suppliers, it is difficult to obtain financing due to their insufficient credit. The information asymmetry between the credit parties is the root of these problems. We know very well that we were at a turning point in financial technology reform, and SCF offered an answer.

At the beginning of 2016, SCF construction project of CCCC was officially launched. For Xingyu Data, as the actual implementation subject, the primary task is the concept design of future core products. "Account Receivable (AR) Financing Vouchers" was born in this context, which has the characteristics of quick disassembly, transferability and realizability. The vouchers record the trade data of core enterprises and suppliers based on the real business scenario.

AR Financing Vouchers can be used as regular payment means. Meanwhile, it is the credit symbol of the core firms involved, using the vouchers as the carrier to lend the credit endorsed by core firms to multi-tier suppliers, thereby the flow of data realizes the transfer of credit, "Digital Credit" from "Trade Data", and also "Commercial Credit" from "Financial Credit". It is the technology that empowers the credit of participants to be fully demonstrated, thereby facilitating the convenient and low-cost circulation in the supply chain and accelerating the bank's financing response.

The concept of the AR Financing Vouchers received more and more support, and verified in practical applications. The bid for the Fuhe Bridge project, undertaken by a subsidiary of CCCC, was opened in October 2017, with a total steel volume of 40,000 tons. During the checkout phase of the Fuhe Bridge project, CCCC used the vouchers as the payment means, the suppliers can sign them and use them to apply for account receivable financing. After the financing, the supplier re-quoted the purchase price according to the actual cost it bears. Then the procurement cost of the core enterprise was reduced by 48 yuan/ton, moreover, it only needed online operation for no more than 10 minutes, which greatly improved the efficiency and promoted the cooperation enthusiasm of the suppliers. As mentioned by Li, a project manager in charge of CCCC's SCF projects:

From the perspective of actual benefits, the applications of the digital credit-enabled AR financing vouchers in the supply chain is indeed a win-win! For us, suppliers will no longer urge us as before, so cash flows are precipitated. And it also promotes the speed of the supplier's fund recovery.

4.2 Unified Fintech Platform for Potentially Applications based on Core Functionalities

Value can only be realized if it is landed as soon as possible. The innovative concept of digital credit was recognized as the core to build a supply chain financial service platform, and CCCC's member enterprises requested the implementation as soon as possible. CIO Qi recalled:

The organizational structure of CCCC is huge and complicated. Where should the platform start? In view of the uneven informatization degree of member companies, finally the overall idea of the platform building was "unify first, then customize!"

Then, building a unified SCF service platform became the primary goal of technology implementation. The unified platform collects business data by docking with business systems such as office, approval, and payment of the enterprise, and then grafts it to the bank, electronically reconstructs the industrial chain financial scene, which realizes the digitization of the entire industrial chain assets. Taking the SCF service platform as a bridge, the digital credit transmission channel among core enterprises, suppliers and financing institutions is opened up. Data of business flow, capital flow, logistics and information flow are transported from the enterprise side to the financing institutions side in the form of various electronic invoices, vouchers and receipts, realizing the "Four flows in one" and "Everything is credit".

The guarantee of data authenticity and reliability is permeated in the process of unified platform design and deployment. One is the agreement text standard is consistent. The platform agreement is based entirely on the traditional bank loan standard text, realizing the online 100% reproduction of the traditional offline financing and factoring text format, and the final electronic confirmation is performed by CS electronic signature. Another one is the true and reliable data source. The unified platform is grafted on the internal ERP systems, OA approval office systems

and audit systems of the enterprises, so the platform's trade data is directly captured from the aforementioned systems.

The platform can connect with all financial institutions, realizing diverse supply chain financial applications, such as accounts payable reverse factoring, accounts receivable factoring, ABS, ABN, etc. After that, applications can be customized designed to meet various requirements of specific scenarios. The three characteristics of the unified platform provide the basis for its scalability. As product manager Jack explained:

Asset digitization, credit transferability, information traceability, are the three characteristics of our unified platform. Based on this, the platform realizes the unified docking of capital channels, conducts overall management of different types of financing service applications, and finally, through the construction of scenes, can customize the design of financing service.

4.3 Complementing Diverse Applications for CCCC Manufacturing Enterprises based on Fintech Platform

Relying on stable supplier relationship and smooth existing information systems, equipment manufacturing sector became the first pilot unit to implement the customized SCF service platform. However, it was not easy to go from a unified platform to customization, as mentioned by project manager Li:

As a leading enterprise in the heavy equipment manufacturing industry in China, this sector has built mature OA systems, material ERP systems, Inspur systems and supplier portals. We must think about how the platform to integrate with the existing organizational structure, basic data, and authority system.

In the second half of 2017, Xingyu Data successfully built a SCF service platform covering CCCC's equipment manufacturing enterprises. Based on the connection with existing mature systems, the platform realizes the online operation of the whole process of single business document provision, agreement signing and approval. On January 19, 2018, an upstream supplier of an CCCC equipment manufacturing enterprise successfully applied financing of 15.85 million yuan through its customized SCF service platform, which is the first online SCF business of Industrial and Commercial Bank of China to connect with a third-party platform.

As the payment means, electronic vouchers are transferred on the customized SCF service platform, the financial behavior is embedded into every node involved in the business process for convenient operation and seamless connection. With digital credit as the core and unified fintech platform as the driver, the original data comes from the business and serves the payment stage in the way of credit, so as to accelerate the flow of capital chain and finally return to the practical business. Intelligent contracts as legal protection, digital fintech (e.g., blockchain) enables trust assurance, integrate into a stable governance mechanism for participants. As director Wang illustrated:

Digital credit enables business demand, and fintech boosts platform functions. By virtue of CCCC's equipment manufacturing enterprises customized SCF service platform, the multi-participants are mutually beneficial and symbiotic.

5 Case Analysis

5.1 Formation Process of DBEs towards SCF

This study proposes a three-phase process model on DBE formation in the field of SCF. In each phase, the model reveals a kind of focal IT/IS enablers that triggers a value co-creating mechanism and further shapes corresponding dominant types of ecosystems. Thus, the process model reveals a complete process of formation of DBEs (See Table 2).

Specifically, the concepts of digital assets and digital credit enable an account receivable (AR) financing application and are the foundation of a value-added business ecosystem as well as the basis of core fintech functionalities in the second phase. Then, the three major functions, including credit transferability, information traceability and asset digitization, are abstracted from the AR financing application and used to construct the underlying architecture of Fintech platform, so that potentially diverse SCF applications and a corresponding Fintech ecosystem will be available. Finally, with the growth of number and diversity of SCF applications, the Fintech platform and complementary applications enable a prosperous and robust DBE for SCF with prosperous.

Table 2. A process model of DBEs development for SCF.

Phases	Developing an original digital application of SCF (e.g., Vendors' AR Financing)	Building a Fintech platform for potentially diverse applications of SCF	Enriching digital business ecosystems of SCF through complementing diverse applications
Focal IT/IS enablers for Ecosystems	<i>Digital assets and digital credit:</i> Vouchers with economic value can be digitalized as data assets which embody the credit endorsed by the core firms. Digitalization enables credit to be divided and then transferred to all the nodes of supply chain.	<i>Core functionalities of Fintech platform:</i> Because of the logic that digital credit is supported by data assets, three cascading core functionalities, e.g., asset digitization, information traceability and credit transferability, can be abstracted from then original applications.	<i>The Fintech Platform and applications:</i> Complementary applications are enriched according to concrete business needs and models (e.g., receivables financing, receive storage financing and financial leasing).
Dominant types of ecosystems	<i>A value-added business ecosystem:</i> The AR financing, as an original SCF application, is a kind of value-added service designed based on the supply-chain networks. The application centers on the core firms and connects upstream multi-tier suppliers and financial institutions around the core firm.	<i>A financial technology (Fintech) ecosystem:</i> The Fintech platform is constructed on the basis of core functionalities and then offer application developers with technical environment (e.g., interfaces) is provided to develop potentially diverse SCF applications.	<i>Digital business ecosystems for SCF:</i> Diverse SCF applications can be customized for different stakeholders, which enrich the DBEs. The core firm can coordinate multi-role actors to create collaborative value around the complementary SCF applications.
Forms of ecosystems			

5.2 Developing an Original Digital Application of SCF

With the support of financial institutions, core enterprises revitalize idle credit lines and convert electronic vouchers. Given the vouchers can be used for payment, it has the characteristics of a currency-like and realizes the digitization of assets. In terms of the transferability of the vouchers, the business credit endorsed by the core enterprise is split and transmitted to the far end of the supply chain, realizing the digitization of credit. In this phase, digital assets and digital credit, as the focal enablers, realize the application of SCF based on the supply-chain networks. In this case, the core enterprise of Fuhe Bridge project applied AR financing vouchers as the payment means. It was obviously a win-win option to help suppliers solve the financing problems and simultaneously reduce their own procurement and capital costs. Thus, core enterprise serves as the center to promote the collaborative benefits, connecting upstream N-tier suppliers and financial institutions. Transferability of digital credit realizes the transmission of value, and achieves the tripartite value co-creation and co-evolution of participants, which form a value-added business ecosystem.

5.3 Building a Fintech Platform for Potentially Diverse Applications of SCF

The three core functionalities abstracted from the aforementioned original digital applications are identified as the focal enablers of the second phase. First, assets digitization, as the payment means, the detachable vouchers realize the circulation of data assets, thereby creating superimposed value; Second, credit transferability, breaking through the isolation of credit, the credit endorsed by core enterprises penetrates all levels of the supply chain; Third, information traceability, guaranteeing the data source be true and reliable, and the data transmission process cannot be tampered with. Credit transferability uniforms allocation of credit resources, asset digitization helps achieve credit appreciation, and information traceability ensures the safety and reliability. Therefore, these three are the basis of Fintech platform and provide the technical environment (e.g., interfaces) to develop potentially diverse SCF applications. In this phase, with the platform as the coordination locus, the applications innovation and potential externalities (e.g., inventory financing, strategic relationship financing and so on) provide flexibility, as the main sources of value creation. Participants achieve value co-creation by using technologies, services and applications of the platform. Finally, extracting digital-credit-enabled core functionalities into a digital platform to develop a financial technology (Fintech) ecosystem, which contribute to complementary applications for SCF in next phase.

5.4 Enriching Digital Business Ecosystems of SCF through Complementing Diverse Applications

The business scenarios of the infrastructure industry are numerous, thus according to concrete business needs and models, diversified specific applications are developed, and become the focal IT/IS enablers in the third phase. Meanwhile, multiple scenarios lead to complex application stakeholders, forming business alliances/networks, which enrich DBEs for SCF. The core enterprises empowered by the Fintech platform serve as the new coordinated locus and diversified applications based on digital credit develop as a new source of value. The collaborative and cumulative interaction between different roles and their core capabilities of participants promote value co-creation and realize the symbiosis. Taking the case as an illustration, a customized SCF service platform for CCCC equipment manufacturing enterprises has realized complementing diverse applications (e.g., receivables financing, receive storage financing and financial leasing), which connect multiple types of participants, including multi-tier suppliers, multi-tier distributors, subsidiaries and financial institutions, together they build digital business ecosystems for SCF.

6 Conclusion

Because an increasing number of enterprises are launching supply chain finance while only a few know its process of formation, SCF construction by one Chinese super-large infrastructure enterprise was investigated in the present study, which suitable to adopt the DBE as the theoretical lens to improve both the research and practice in this field. Meanwhile, as a typical DBE, SCF, integrates business activities and digital fintech, offering a great opportunity to research on the process of how business ecosystems and digital ecosystems are combined to co-create value in CN4.0. Thus, employing SCF and DBE as the theory basis, this paper provides a process model to help explain how to develop digital business ecosystems to create collaborative value for the successful adoption of supply chain finance by infrastructure enterprises. Specifically, the process model demonstrates that in each phase for DBE formation in SCF-developing an originally digital application of SCF, building a Fintech platform for potentially diverse applications of SCF and enriching digital business ecosystems of SCF through complementing diverse applications-requires particular focal IT/IS enablers: digital assets and digital credit, core functionalities of Fintech platform and the Fintech platform and applications. Moreover, the focal IT/IS enablers can trigger a value co-creating mechanism and further shapes corresponding dominant types of ecosystems, which serve as the source for focal enablers identification in the next phase. This research generates empirical insights into supply chain finance formation and has important implication for theoretical study on value co-creation of DBE. With respect to future research, there is a need to further develop both research and practice in the field of SCF by infrastructure enterprises by examining the specific effects of focal IT/IS enablers on formation of different types of ecosystems.

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