Robots on Blockchain: Emergence of Robotic Service Organizations

By Nobuyuki Fukawa

Radical changes in the technological environment have been forcing service providers to consider whether, if so, how to automate any aspects of their services with robots and other emerging technologies. Some service providers have been adopting robotic service assistants, and even creating organizations partially or fully automated by robots. However, some service providers have not been able to fully take advantage of RSAs' benefits in a way that enhances customer service experiences. We review those challenges of RSAs and discuss the potential application of blockchain technology in governing a *robotic service organization*, the concept we propose in this study. Drawing on transaction cost theory and resource-based theory, we discuss theoretical implications of the impact of blockchain technology on the governance of a robotic service organization. Our study represents one of the first theoretical research to evaluate the impact of blockchain technology in a robotic service economy.

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1. Introduction

More service providers have been introducing robotic service assistants (RSAs) in various service encounters, including airports (e.g., Airport Guide Robot at Incheon International Airport in Seoul), hotels (e.g., Mario Robot at Marriott Hotel in Belgium), and banks (e.g., Softbank's Pepper Robot at HSBC Bank in New York City). The latest RSAs are expected to perform not only standardized tasks, such as greeting customers, but also personalized tasks, such as showing empathy (Huang and Rust 2018). As a result, customers may soon interact with RSAs as part of "routine marketplace experiences" (Mende et al. 2019). Reflecting the growing interests toward the advanced technology, the market for professional service robots is expected to expand with a 21 percent annual growth rate on average through 2021 and to reach $37 billion by 2021 (RIA 2019).

However, service providers have been struggling to transform RSAs into their unique resources (e.g., Barney 1991) and to fully take advantage of RSAs' capabilities in service encounters in an effort to enhance customer service experiences. Due to their performance and other issues (Reed 2018; Gale and Mochizuki 2019), some service providers, such as Hen-na hotel in Japan, a hotel operated mainly by robots, have been discontinuing the use of some RSAs. Additionally, some customers have been expressing privacy concerns regarding some RSA features, such as facial recognition, and some studies point out RSAs' vulnerability associated with cybersecurity (Giaretta et al. 2018).

Despite such struggles of RSAs in service encounters, robots are expected to contribute significantly to automating a large portion of the work currently done by people. About $16 trillion worth of activities can potentially be automated, and robots would contribute to this automation (Manyika et al. 2017; Duffy and Petrova 2019). Automation efforts with robots have been traditionally taking place in an industrial setting. However, as some RSAs are now capable of interacting with customers, RSAs could contribute to automation efforts in service encounters. To optimize those efforts, scholars have been studying customers' perceptions and behavioral intention toward RSAs (e.g., Rosenthal-von der Pütten et al. 2018, Ivanov and Webster 2019, Jörling et al. 2019). Indeed, some service providers, from the banking industry (e.g., China Construction Bank) to the hotel industry (e.g., Hen-na Hotel, Alibaba's hotel), have started to automate services with RSAs. For instance, in a newly opened branch of China Construction Bank, an RSA assists customers in opening accounts, conducting money transfers, and making gold investments (Zhang 2018).

Such an automated organization may need to be maintained and controlled differently than a traditional organization. Thanks to its potential capability to lower transaction costs, blockchain technology may offer a solution for efficiently and effectively governing such an organization consisting of RSAs and for solving existing issues associated with a robotic system (Davidson et al. 2018; Iansiti and Lakhani 2017). To evaluate this idea, we propose the idea of a *robotic service organization*, where a service provider could virtually integrate its RSAs and its partners in its supply chain (e.g., suppliers and distributers) with a blockchain technology without vertically integrating those as a single organization. Davidson et al. (2018) calls such a new governance structure enabled by blockchain technology, a decentralized collaborative organization, distinguishing it from an organization or a market proposed by transaction cost theorists (e.g., Williamson 1985). Building on this discussion, we discuss the benefits of a *robotic service organization* theoretically and managerially.

In summary, we try to answer the following research questions: (1) How can a service provider transform RSAs into valuable, rare, and imperfectly imitable resources? (2) How can a service provider protect such resources associated with RSAs from external threats such as cyber security issues? (3) How does blockchain technology help a service provider manage its RSAs and its relationships with its partners? To answer those questions, first, drawing on resource-based theory, we study how a service provider can transform RSAs into valuable, rare, and imperfectly imitable resources and possibly protect these resources with blockchain technology. Furthermore, we propose the concept of a robotic service organization. Drawing on transaction cost theory, we study whether, if so how, blockchain technology lowers transaction costs in a robotic service organization and enhance service experience of customers.

2. Literature review

2.1. Defining robots and RSAs

Service providers in a wide range of service industries have been introducing RSAs of different shapes and features (Please see *Tab. 1* for the latest applications of RSAs). Thus, it is crucial to first define the term *robot*, as it may mean differently for each service provider. According to ISO, an industrial robot is defined as "an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which may be either fixed in place or mobile for use in industrial automation applications" (ISO 2012). As is reflected in this definition, the application of robots has been focused on industrial settings. However, more service providers have been introducing RSAs to assist customers than in the past, ranging from the hotel industry (e.g., Space Egg by Alibaba) to the banking industry (e.g., Xiao Long, meaning "Little Dragon", by China Construction Bank).

To reflect these applications in service encounters, Wirtz et al. (2018) define an RSA as "system-based autonomous and adaptable interfaces that interact, communicate and deliver service to an organization's customers" (p. 909) and discuss an RSA's impact at a macro level (e.g., society) and a micro level (e.g., customer experiences). As robots are adopted beyond industrial settings and interact more with customers in service encounters, scholars discuss their social presence to study whether customers feel as if "someone" is present (van Doorn et al. 2017; Wirtz et al. 2018). Indeed, the elderly perceive RSAs as social entities possibly with positive impacts (e.g., empowering) and negative impacts (e.g., interfering) (Čaić et al. 2018).

In this study, RSAs include not only those robots that interact with and assist customers in a service encounter, but also those robots that enhance the logistic capabilities of a service provider, as we believe that enhanced logistics capabilities eventually improve customer service experiences. In the former case, RSAs may directly enhance customer service experiences, while in the latter case, RSAs may indirectly enhance customer service experiences. From this perspective, an RSA is defined as an autonomous, reprogrammable, multi-purpose interface with a physical embodiment that directly or indirectly enhances the customer experience in a service encounter (ISO 2012; Wirtz et al. 2018; Jörling et al. 2019).

2.2. Illustrative examples of RSAs

As you can see in the top of *Tab. 1*, some RSAs are focused on providing services to customers, such as providing information about available services (e.g., Xiao Long, "Little Dragon") and navigating customers to the correct location (e.g., Cheetah GreetBot). As in the bottom of *Tab. 1*, other RSAs are focused on enhancing the logistic capabilities of a service provider without the capability of interacting with customers (e.g., Marty, Bossa Nova). Those RSAs are not required to respond to customers' inquiries, thus no two-way communications between the RSA and a customer are required. The other RSAs, in the middle of *Tab. 1*, (e.g., Space Egg, Relay) may focus more on enhancing service logistics capabilities (e.g., delivering items to hotel guests) with limited interactions with customers. Service logistics is generally defined as "the management of activities that respond to customers on an individual

RSA Orientation*	Name	Locations	Image	Features/Applications	Source
Service-oriented	Cheetah GreetBot	Cheetah Mobile		Greet guests as a receptionist and navigate them to a meeting location Equipped with voice- and visual-recognition capabilities	Allied Market Research (2018) Si (2018)
	Xiao Long, "Little Dragon"	China Construction Bank		Greet customers and provide information on basic services Respond to questions from customers using voice-recognition technology	WBR Insights (2019) Zhang (2018)
	Airport Guide Bot (or Troika)	Seoul's Incheon International Airport		Assist customers at an airport Retrieve flight information from the boarding pass of a customer and escort him/her to the boarding gate if needed	LG Electronics (2017) Medeiros (2018)
	Space Egg	Alibaba Hotel		Deliver items (e.g., food, laundry) to hotel guests and confirm delivery using facial recognition technology Respond to voice commands from guests	Palmer (2018) Vincent (2018)
	Relay (nicknamed Botlr or Hannah)	Aloft Hotel, H Hotel		Deliver items (e.g., bottled water) to hotel guests Offers a swivel dance after completing the delivery	Walsh (2018) Savioke (2017)

* Based on the information available about features and applications for each RSA, we have subjectively ranked each RSA from more service-oriented RSAs to more logistic-oriented RSAs. As a result of technological advancements, each RSA may be equipped with new features in the future, which may require alteration to this evaluation.

Tab. 1: Latest Service/Logistics Applications of RSAs

	Marty	Giant Food Stores		Detect any hazards (e.g., spill on a floor) in a store and alert customers as well as employees Check on-shelf inventory and price inaccuracy in a store	Holley (2019) NRF (2019)
Logistic-oriented ↓	Bossa Nova	Walmart		Check real-time on-shelf inventory in a store to better integrate offline and online businesses Expected to be introduced at 350 Walmart stores	Smith (2019) Banker (2019)

Tab. 1 (continued)

basis" (Davis and Manrodt, 1991, p. 4). In our example, such capability includes confirming delivery with facial recognition technology (e.g., Space Egg) or offering a swivel dance upon completing delivery to guests (e.g., Relay).

It is common for service providers to adopt RSAs with a human-like appearance hoping to receive favorable responses from customers. Especially, RSAs that interact with customers often have a humanoid appearance (e.g., Xiao Long, "Little Dragon") or at least a certain aspect of their appearance looks like a human (e.g., both Cheetah GreetBot and Airport Guide Bot seemingly have a face). Even for those RSAs that require limited interaction with customers, a service provider may still add a certain human-like appearance (e.g., googly eyes on Marty) to an RSA to make it fun for customers (Lacy 2019). For those RSAs that do not interact with customers at all, a service provider may not feel the need to make RSAs human-like and instead leave its appearance machine-like (e.g., Bossa Nova robot introduced by Walmart).

2.3. Issues with RSAs

In introducing these RSAs, service providers have been relying on the novelty of robots to attract customers' attention rather than on their utilitarian benefits (Kidman 2018; Mogg 2018). For instance, at Seoul's Incheon International Airport, airport users have been more attracted by the novelty of RSAs – to take selfies with them – rather than by their utilitarian benefits (e.g., providing directions to customers at the airport) (Kidman 2018). Once the novelty of RSAs wears off, maintaining customer engagement toward RSAs has been a challenge for service providers; some customers even ignore the presence of RSAs (Mogg 2018; Boxall 2017). Additionally, due to their limited capabilities, RSAs have not been able to assist customers as expected in some applications, and even create more work for human associates instead of helping them (Parker 2018; Gale and Mochizuki 2019). For instance, in one of the grocery stores in the UK, a customer asked an RSA in which aisle beer can be found and the RSA responded with a very vague response (Parker 2018). As a result, some service providers have been firing RSAs (Gale and Mochizuki 2019; Reed 2018; Nichols 2018).

In another case, other technologies may assistant customers' shopping experiences better than RSAs. In the banking sector, with the advancement of mobile technology, customers feel less need to visit physical branches of banks, especially for standardized services (Sentance 2018). Thus, service providers may not be able to expect much impact from robotic automation in their retail locations (e.g., China Construction Bank's branch automated by RSAs). Additionally, for more personal services, customers often must talk to human associates anyway, instead of to RSAs (Mogg 2018; Zhang 2018). Overall, the incompetency of RSAs may have been discouraging service providers to introduce or continue to utilize RSAs in service encounters. To address those issues of RSAs, we consider a potential application of blockchain technology to govern RSAs.

2.4. Blockchain technology

A blockchain is defined as "a distributed database of records, or public ledger of all transactions or digital events that have been executed and shared among participating parties" (Crosby et al. 2016, p. 7). Despite cryptocurrency being one of the most popular applications of blockchain technology, blockchain technology can potentially be applied to many other areas (Zheng et al. 2018). Major characteristics of blockchain technology include its distributed structure and its transparency (Iansiti and Lakhani 2017; Crosby et al. 2016). In a blockchain community, consensus is formed by each member of the community, instead of by a single third party, making its structure more distributed (vs. centralized). Additionally, all of its transactions are recorded, and those records are almost irreversible, thus ensuring the transparency of the community.

Despite those common characteristics, blockchain differs depending on several factors, including the way consensus is formed; scholars distinguish three types of blockchain: public blockchain, consortium blockchain, and private blockchain (Buterin 2015; Zheng et al. 2018). In public blockchain, each node can participate in forming a consensus. In consortium blockchain, a particular set of nodes (i.e., a group of individuals/organizations) is responsible for forming a consensus. Finally, private blockchain requires permission to join the network, and a single organization is responsible for forming a consensus. In this study, we discuss the potential application of blockchain technology for a service provider in managing RSAs, and its relationships with its partners in a robotic service organization. Here, we assume that a robotic service organization and its major partners somehow control forming the consensus of the blockchain, similar to consortium blockchain, the second type of blockchain.

Blockchain may potentially "create new foundations for our economic and social systems," (Iansiti and Lakhani 2017, p. 4) and provide a new way of governing organizations in the digital economy (Crosby et al. 2016). To reflect this notion, scholars have recently started discussing the possible application of blockchain technology for robotic systems. In December 2018, MIT Media Lab organized the first symposium on blockchain and robotics, and in its conference proceedings, Lopes & Alexandre (2019) stated that "the introduction of blockchain technologies to robotic systems could solve many problems that those systems face" (p. 1). Drawing on transaction cost theory and resource-based theory, we review theoretical implications of applying blockchain technology in the governance of a robotic service organization in the following section.

3. Theoretical background and a robotic service organization

According to transaction cost theory, an organization is more capable of controlling and monitoring the behavior of its members than a market is (Heide and John 1990). An organization may be able to reduce opportunistic behavior of its members through rewarding good behavior and cultivating common goals. To reduce potential opportunistic behavior of its partners in the supply chain, a service provider may vertically integrate its supply chain network. Without a traditional organizational structure or formally integrating its supply chain vertically, blockchain technology may offer an alternative mechanism of governance (Davidson et al. 2018). On a blockchain-enabled platform, every transaction is recorded and can be shared among each member of the community, thus enhancing transparency. Thus, it is perhaps easier to identify opportunistic behavior than in a community without blockchain technology. Without combining each member or organization into a single entity, blockchain technology may enable service providers to virtually connect multiple organizations.

Davidson et al. (2018) refer to such an organization as a DCO (decentralized collaborative organization), a new type of governance structure that is made possible through blockchain technology and "adds an additional category" (p. 654) to those governance structures such as markets and organizations discussed in transaction cost theory (e.g., Williamson 1985). This DCO is somewhat similar to the *virtual integration* proposed by Michael Dell in the past (Magretta 1998). In a virtually integrated community, a firm integrates its partners "as if they're inside the company" (Magretta 1998, p. 74). We call such a DCO a *robotic service organization*. In a robotic service organization, a service provider (e.g., Walmart) may virtually integrate its RSAs and its partners (e.g., suppliers of lettuce) and lower its transaction costs with blockchain technology as if all the participants are inside the organization.

To contribute to the success of the robotic service organization, one of the suppliers may invest in its physical capital (e.g., software, databases, and systems to connect to the RSAs) and human capital resources (e.g., hiring new IT professionals to integrate and maintain those systems). These resources are so unique to specific activities in the robotic service organization that they are not transferable outside of it, and are referred to as asset specificity in transaction cost theory (Williamson 1985; Rindfleisch and Heide 1997). Generally, in a vertically integrated supply chain, a supplier may be able to safe guard specific investments better than in a supply chain without a vertical integration (Heide and John 1990; Rindfleisch and Heide 1997). Similarly, the supplier in the robotic service organization may be more willing to make a greater investment in those resources, notwithstanding high asset specificity, than another supplier outside of the robotic service organization.

Asset specificity of an organization contributes to building its unique resources that are difficult for another organization to imitate (Mahoney and Pandian 1992). This view, partly drawing on transaction cost theory, is reflected in resource-based theory that explains how a firm's resources contribute to gain a competitive advantage (Williamson 1999; Mahoney and Pandian 1992). More specifically, valuable, rare, and imperfectly imitable resources are believed to provide an organization with a competitive advantage in a market against its competitors (Barney 1991). Commonly, resources are categorized as physical, human, and organizational capital resources (Barney 1991). A service provider (e.g., Microsoft stores) oftentimes utilizes an RSA technology developed by a third party (e.g., Softbank's Pepper Robot) outside of its organization. Can these standardized technologies be considered unique resources of the service provider? If so, would it be physical capital or human capital resources? How can a service provider protect these resources associated with its RSAs? Is blockchain technology capable of protecting these resources in the robotic service organization? We discuss these issues in introducing series of propositions in the following section.

4. Propositions

4.1. Transforming RSAs into resources

Generally, an RSA can be reprogrammed and is capable of serving multiple functions (Wilson 2015). Especially with the recent advancement of technology, more standardized RSAs are available at more affordable costs than in the past. Thus, a service provider may not have to develop its own RSAs using a proprietary technology. This may make it easier for a smaller service provider to adopt standardized RSAs than in the past (Duffy and Petrova 2019). Despite this advantage, standardized technology available in a market for any service providers would not be considered valuable, rare, and imperfectly imitable resources, and thus would not provide service providers with a sustainable competitive advantage (Barney 1991). To transform standardized technologies such as RSAs into imperfectly imitable resources and to fully take advantage of RSAs, a service provider must incorporate relevant resources into its organization (Barney 1991).

To do so, a service provider could customize specifications of RSAs to meet the unique service needs of its customers through letting RSAs access its customer information and other unique company information (e.g., inventory information). This may potentially improve performance of RSAs by personalizing their interactions with customers. For instance, recently, Fabio (i.e., Softbank's Pepper robot) performed poorly in interacting with customers in a grocery store (Reed 2018). When Fabio was asked to explain where a customer could find beer, it gave only a very general response: "beer is in an alcohol section" (Parker 2018). Some customers were frustrated with Fabio's limited capability and started avoiding the RSA (Parker 2018). To enhance capabilities of RSAs, the service provider could allow its RSAs to access customer information through its customer relationship management system (i.e., physical capital resources). As a result, a customer perhaps could expect a more personalized response as follows: "*Hi John, How are you doing today? You are looking for beer? You purchased Guinness last week, are you interested in the same beer? It is on sale at $6.99 for a six pack in aisle 7. We may still have two units left at this point*." Additionally, the service provider may consider having its experienced service associates (i.e., human capital resources) train its RSAs and share their tacit knowledge on how to interact with customers and pursue service excellence. Furthermore, the service provider may need to optimize its decision-making process (i.e., organizational capital resources) in service encounters in a way for RSAs to make their own decisions in solving customers' problem and/or for RSAs and human associates to work together in a more efficient way. Overall, if a service provider integrate its physical, human, and organizational capital resources around its RSAs (please see *Fig. 1*

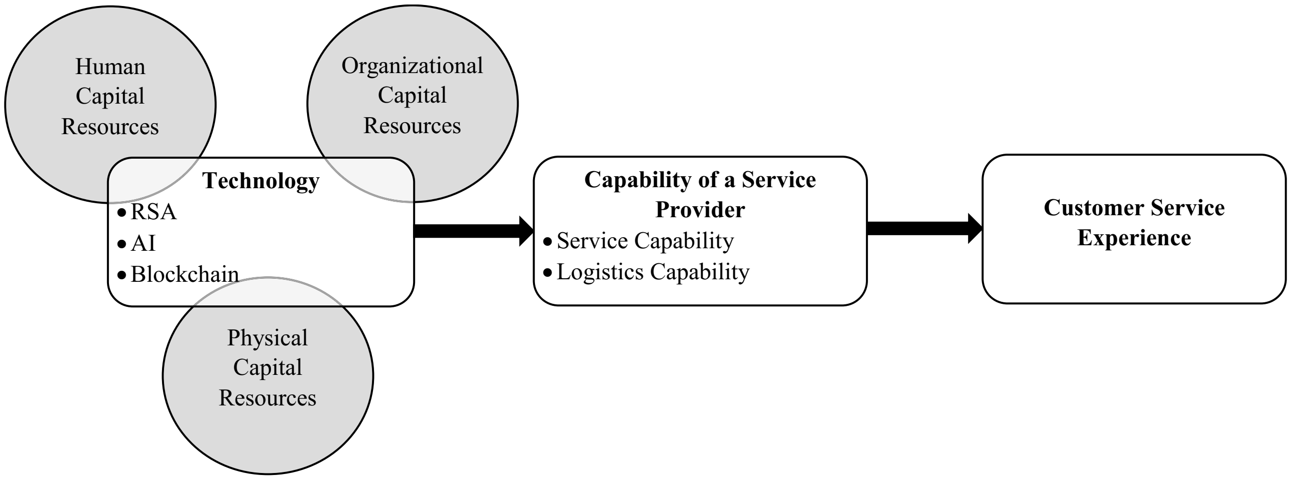

Fig. 1: Impacts of RSA Technology on Customer Service Experience

for the illustration), the service provider could transform RSAs into valuable, rare, and imperfectly imitable resources and improve their performances.

P1: The better a service provider incorporates its resources in implementing RSAs, the better a service provider transforms RSAs into valuable, rare, and imperfectly imitable resources.

Once successfully converting RSAs into unique resources, a service provider could enhance its logistics and service capabilities. For instance, Walmart recently introduced RSAs in some of its stores to automate inventory-checking activities (Green 2019). Such RSAs do not need to interact directly with customers, and thus require only a limited capability to respond to an environment, such as detecting store inventories and avoiding obstacles in a store. Thus, an application of RSAs in a logistics environment provides a service provider with a quick way to enhance its capabilities.

As more retailers use physical stores as distribution centers for online orders, products in a physical store are purchased by customers in the store as well as online customers (Smith 2019). Thus, it is becoming more difficult for retailers to assess the accurate inventory level in a physical store. The automation effort of using RSAs may enhance the accuracy of inventory information and avoid online customers experiencing their ordered products being out of stock (e.g., a product was available online, but actually out of stock in a store due to inaccurate information). The more accurate the inventory information is, the better a service provider can control its inventory (e.g., restocking its items in a store before running out). As a result, the automation effort may enhance the service experience of customers in a store.

Alternatively, the automation effort by RSAs may enable service providers to free up some of their human associates' time for more personalized services and indirectly enhance customer service experiences. The H Hotel in Los Angeles introduced RSAs to deliver items to its guests, and its manager described RSAs' benefits as follows: "it was a great timesaver for our team because no one has to leave their station to make a delivery" (Walsh 2018). Overall, application of RSAs in logistics may enhance the service experience of customers both directly and indirectly.

In contrast, interacting with customers requires more sophisticated capabilities to understand and respond to customers in a service environment than the capabilities RSAs need in a logistic environment. An RSA's poor ability to respond to an environment may negatively affect customer experience in a service encounter. For instance, at Hen-na Hotel, RSAs had been accidentally responding to guests' snoring in the middle of the night and generating unnecessary tasks for human associates (i.e., a human associate at a front desk must respond to customers' complaints) (Gale and Mochizuki 2019). Even its CEO, Hideo Sawada, admits that "you realize there are places where they (robots) aren't needed or just annoy people," and, as a result, the service provider fired half of its robots (Gale and Mochizuki 2019). Overall, RSAs may need to be equipped with more sophisticated capabilities to interact with customers in service encounters than in logistic environments.

P2: RSAs may enable a service provider to enhance both its logistics capability and service capability. RSAs require more sophisticated technology, such as AI (artificial intelligence), for a service provider to enhance its service capability than its logistics capability.

4.2. Protecting resources with blockchain technology

Furthermore, for a firm to achieve a sustainable competitive advantage, a firm must be capable of protecting those resources associated with RSAs from external environments by neutralizing threats and enhancing a firm's performance with those resources (Barney 1991). Thanks to its distributed system, blockchain technology could neutralize external threats by protecting RSAs from such threats as technology vulnerability (Iansiti and Lakhani 2017). In the process of incorporating RSAs uniquely into its organization, a service provider may connect RSAs with its customer database. Despite these service providers' efforts to customize capabilities of their RSAs to respond to unique customer needs, customers may have concerns about sharing their personal information with a service provider through RSAs (Woo 2014). Some service providers (e.g., a hotpot restaurant) are utilizing cloud services to store customer information (e.g., customer preferences for soup base) to be utilized in their RSAs (Tao 2018). Some of the cloud services are centralized and may have vulnerability in cyber security (Kshetri 2017). Without relying on these centralized cloud services, blockchain technology may provide a service provider with a more secured alternative platform to store even sensitive customer information (e.g., their facial images) for RSAs. Due to its distributed system (Iansiti and Lakhani 2017), a service provider with blockchain technology could more securely store sensitive customer information than one without blockchain technology. RSAs could securely access such information through a blockchain-enabled platform to personalize their interactions with customers. In this sense, blockchain technology might be a key for a service provider to exploit RSAs as potential sources of sustainable competitive advantage.

P3: A service provider with blockchain technology is able to protect valuable, rare, and imperfectly imitable resources associated with RSAs from external threats (e.g., technology vulnerability) with greater success than a service provider without blockchain technology.

4.3. Robotic service organization

A service provider could utilize blockchain technology not only to protect its resources, but also to manage its RSAs and its partners. To reduce opportunistic behavior of its RSAs and its partners in the supply chain, a service provider could consider vertically integrating its supply chain as a single organization, and thereby reduce its transaction costs (Rindfleisch and Heide 1997). However, blockchain technology could enable a service provider to do so by virtually integrating its supply chain as a robotic service organization, without physically and formally integrating them as a single organization. Interestingly, this is not achieved through incentive systems, such as reward or promotion, but through its transparency (e.g., Crosby et al. 2016). In a robotic service organization, every transaction is recorded and generally shared with every member in the blockchain network. These transactions may include a transaction between an RSA and a customer, that between a service provider and its partner (e.g., supplier), and that between its partners (e.g., a supplier and a distributer). Since the activities in the platform are constantly recorded and monitored by members of the blockchain-enabled platform, a service provider may better monitor and control opportunistic behavior of its RSAs and its partners than a platform without blockchain technology (Davidson et al. 2018; Lopes and Alexandre 2019). Without necessarily relying on long-term relationships among its supply chain partners through building trust (e.g., Keiretsu system) or vertically integrating and building its own supply chain network (e.g., Zara), blockchain technology could enable a service provider to virtually connect its RSAs and its partners, and build a robotic service organization. In such an organization, blockchain technology enables the service provider to better monitor and control activities of its members and, as a result, lower transaction costs within the robotic service organization.

P4: Blockchain technology lowers transaction costs in a robotic service organization.

The lowered transaction costs benefit a service provider and its partners in a robotic service organization. Working with Hanson Robotics, SingularityNet has recently launched a blockchain-based marketplace for AI-related technology. This marketplace is aimed to share AI-related technology (e.g., emotion and speech recognition) not only with tech companies in Silicon Valley, but also with smaller businesses and government organizations (Berman 2019). Each transaction made on a blockchain-based platform is verifiable by its members without involving a particular third-party organization, and thus is believed to be relatively secure (Iansiti and Lakhani 2017). Such a secured platform has been employed in a B2B context, such as the agricultural industry in Indonesia, to better diagnose crop diseases, and improve the productivity and income of farmers using algorithms available on the platform (Faridi 2019). Similar efforts could be implemented in enhancing the performance of RSAs. Currently, some service providers have been experiencing their RSAs interacting poorly with customers (Gale and Mochizuki 2019). Some of these poor interactions could be improved with better AI (e.g., speech recognition). A blockchain-based platform could be utilized to share AI related to robotic technology more securely and openly with various organizations than a platform without blockchain technology. As a result, a robotic service organization could improve its service capability with RSAs.

P5: In a robotic service organization, blockchain technology could improve the capability of securely sharing its resources (e.g., AI that supports RSAs) among its members, and consequently improve its service capability.

5. General discussion

5.1. Theoretical implications

One of the objectives of our study is to understand the impact of blockchain technology on a robotic service organization. To do that, we drew on transaction cost theory and explained the impact of blockchain technology on a robotic service organization. The impact of blockchain technology is so significant that Davidson et al. (2018) claim that it results in the emergence of a new type of governance structure, decentralized collaborative organization. Similarly, one of the key scholars of transaction cost theory, Benkler (2006), calls such a new way of cooperative economic production in the digital age *social production* (Rindfleisch 2019). Consistent with those arguments, we proposed the idea of a robotic service organization.

In a robotic service organization, we argue that a service provider and its partners enjoy relatively low transaction costs thanks to blockchain technology. In such a decentralized organization, blockchain may enable a service provider to securely share local knowledge of an RSA with others RSAs as global knowledge (Lopes and Alexandre 2019; Ferrer 2019). Such local knowledge could be a preference of one customer in one RSA that may help other RSAs to enhance their interactions with the same customer in another service encounter when shared as global knowledge. As a result, RSAs could collectively collaborate efficiently and effectively as *swarm robotics* (Tran et al. 2019). Decentralized nature of a robotic service organization could enable those *swarm robotics* to make their own decisions with securely shared global knowledge.

Furthermore, from the resource-based theory perspective, we discussed how the service provider could transform standardized RSA technology into valuable, rare, and imperfectly imitable resources. In the process, a service provider may need to coordinate not only physical capital resources, but also human and organizational capital resources around RSAs (see *Fig. 1*) to exploit the benefits of RSAs and possibly achieve a sustainable competitive advantage. From this perspective, the impacts of RSAs may not be as simple as RSA technology replacing human capital resources (Webster and Ivonov 2020). Perhaps RSA technology might not yet be mature and advanced enough to perform in a service encounter independently without a careful coordination of related resources.

5.2. Managerial implications

Our paper could offer insights for those service providers that wish to automate some aspects of their services with RSAs. A service provider should first try to transform its RSAs into valuable, rare, and imperfectly imitable resources. Then, to reduce the opportunistic behavior of RSAs and its partners in the supply chain, a service provider could build a robotic service organization using blockchain technology. Such an ideal robotic service organization could fully exploit its RSAs, enhance its logistics and service capabilities, and improve customer service experience (see *Fig. 1* for the illustration). Those insights would be useful for some service providers that are already introducing services operated mainly by RSAs (e.g., Alibaba's "Fly Zoo" hotel, China Construction Bank). Any of these service providers, if having issues in fully exploiting benefits of RSAs, could review those steps and evaluate which step they may have issues with.

Second, we discussed how a service provider could utilize blockchain technology as a platform to share AI-related technology on robotic systems securely among members of the community. Blockchain-enabled platforms could enhance service providers' efforts for open innovation associated with RSAs. We are starting to see an effort to build blockchain-enabled platforms in the area of AI. SingularityNet reflects such a pioneering effort to integrate blockchain and AI, and its beta version was launched in early 2019 (AI Business 2019; Lee 2017). A similar platform on robotic systems and AI could allow service providers to better take advantage of technological improvements and potentially improve their interactions with customers. One RSA could learn to improve its AI, and subsequently its performance, through interacting with customers. Sharing such an improvement among all the members of blockchain-enabled platform could dramatically improve AI related to robotic systems, improve overall performance of RSAs, and enhance overall customer experience with RSAs (Baker 2018).

Finally, in some countries with a declining population (e.g., Japan), service providers are finding it more and more difficult to hire sufficient numbers of service workers. In these countries, some service providers might be unable to maintain their current service level without the help of RSAs. Thus, those service providers are perhaps forced to find a solution to current issues with RSAs, such as performance issues and privacy concerns. Indeed, some companies, such as Toyota, are accelerating their efforts to produce more robots in Japan (Economist 2019). Our study could provide service providers in these countries with potential solutions to current issues with RSAs.

6. Limitations and future research

We discussed the impacts of blockchain technology on a robotic service organization from perspectives of transaction cost theory and resource-based theory. As blockchain enables a service provider to form a self-governing collaborative organization (Davidson et al. 2018), loosely connecting other partners with RSAs, scholars are encouraged to study the meaning of valuable, rare, and not perfectly imitable resources. If a service provider shares these resources with its partners within a robotic service organization, can we still consider these resources valuable, rare and not perfectly imitable resources? Should we perhaps study resources not at a firm level (service provider), but at a robotic service organization or DCO level as a unit of analysis?

In our study, we evaluate the potential application of a particular type of blockchain technology (i.e., consortium blockchain) in a robotic service organization as a new governance structure. In such an organization, we assume that a service provider and its major members of the supply chain may be responsible for forming a consensus (e.g., approving participation of a new member). This is most likely to be associated with consortium blockchain, one of the three types of blockchain technology. As more individual consumers may adopt RSAs at home, the robotic service economy may be transformed from something organized by a service provider and its partners to something consisting of each individual and his/her RSAs. If so, it might be interesting to study the application of public blockchain, where anyone can join the community without approval from members of the community.

Furthermore, this study investigated only one example of applying blockchain technology; how a service provider could use blockchain technology to manage its RSAs and work with its partners. Blockchain could be utilized in many aspects of service activities. For instance, Everledger is building a blockchain-based supply chain network of diamonds with 2.2 million diamonds already registered (Mims 2018). The system allows a service provider (e.g., a jewelry boutique) to trace the journey of a diamond all the way from a mine to a customer who purchases the diamond (Mims 2018). As another example, Walmart has been asking its suppliers to adopt blockchain technology to better track its produce in case of food recalls (e.g., lettuce) and enhance food safety for its customers (Fingas 2018; Corkery and Popper 2018). Scholars are encouraged to investigate other potential ways to take advantage of blockchain technology in service encounters.

We discuss that both RSAs and blockchain technology could be beneficial for service providers' automation efforts. However, Jörling et al. (2019) argue the negative impact fully automated RSAs may have on the perception of service outcomes from RSAs (i.e., even if a customer has a positive experience with fully automated RSAs, customers may not think that the RSA is responsible for the outcome). To avoid this, Jörling et al. (2019) argue that it is beneficial to let customers partially control RSAs. Building on their study, researchers are encouraged to study the impact of fully automated versus partially automated RSAs on customer experience in relation to blockchain technology.

Overall, we sometimes have a narrow view of blockchain technology by focusing on cryptocurrencies and discussing its potential dark-side (Scheck and Shifflett 2018). Cryptocurrency Libra by Facebook is one of the recent examples (Wilberding 2019). Despite the significance of those recent developments, we must have a broader perspective of the blockchain technology and brainstorm its impacts on various marketing activities, including RSAs and other automation efforts in service encounters. Blockchain may provide service providers with opportunities in various digital service activities associated with robotic service economy in the age of AI.

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Keywords

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