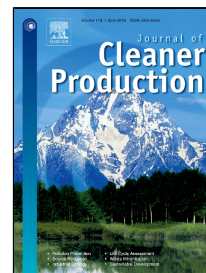


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S.U.N. Qiao, W.A.N.G. Chang, Z.U.O. Lyu-shui, L.U. Feng-hua

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Digital empowerment in a WEEE collection business ecosystem: A comparative study of two typical cases in China

SUN Qiao^a, WANG Chang^{a,*}, ZUO Lyu-shui^{a,b,*}, LU Feng-hua^a

^a Central South University, School of Business, Changsha 410083, China

^b The University of Queensland, Sustainable Minerals Institute, St Lucia, QLD 4072, Australia

* Corresponding author

E-mail address : changwang@csu.edu.cn(WANG Chang), lzuo@uq.edu.au(ZUO Lyu-shui)

Abstract: Affected by the dramatic growth in waste electrical and electronic equipment (WEEE) and the gradual withdrawal of informal collectors, the traditional collection system appears to be undergoing an unprecedented decline in China. However, more than fifty internet-based collection entities have been founded in the past two years in China, reflecting the increased fusion of digital technology and traditional industries. Since these enterprises fully utilize digital technology, dynamic and profitable business ecosystems have been established to boost development. In this paper, two typical internet-based collection enterprises are chosen to represent the C2B (customer to business) and B2B (business to business) online collection models in China, allowing a comparative case study to be performed. The objective of this research is to analyze the structures, digital empowerment activities, and types of WEEE collection business ecosystems. One key result of our study is our map of the structure of WEEE collection business ecosystems, including the identification of key actors, such as suppliers, customers, online platforms, intermediaries and complementors, as well as the definition of links, such as information, material and money flow. The focal platform facilitates other actors by providing structural, psychological and resource empowerment. However, these business ecosystems differ in various ways, including with respect to the role of actors, the direction of information, material and money flow, the intensity of digital empowerment and platform position. Therefore, two types of business ecosystems are generalized: embedded business ecosystems and central business ecosystems. This study not only contributes to the existing business ecosystem literature by introducing digital empowerment but also expands the application areas of digital empowerment by investigating internet-based collection entities in China. Our results are theoretically important and have implications for the practical development of internet-based collection enterprises.

Keywords: WEEE online collection; Digital empowerment; Business ecosystem; Case study; China

1. Introduction

With 8.53 million tons (Mt) of waste electrical and electronic equipment (WEEE) in 2014, China has overtaken the U.S. to become the world's leading producer of WEEE (Zeng et al., 2016). Owing to stricter environmental protection policies, the increasing pressure of population aging (Lutz et al., 2008), the rising education levels and the declining trend of WEEE prices, informal WEEE collectors are progressively withdrawing (MOFCOM, 2016), and WEEE collection in China has undergone an unprecedented decline. This issue has been seriously addressed by the Chinese government by strengthening the responsibilities of producers and

providing more convenient collection modes for residents or consumers. China has applied extended producer responsibility (EPR) principles to enact related laws and regulations on WEEE recycling since 2011 (Kumar et al., 2017), and pilot products are ready to be extended to cars, lead-acid batteries and packaging in 2017. Additionally, the development of WEEE online collection has been highly encouraged through a series of policies and measures, such as “Guidance on actively promoting the “Internet plus” action” in 2015 and “Guidance on promoting transformation and upgrading renewable resources recovery industry” in 2016. With strong support from government policies and the rapid development of the Internet, more than 50 internet-based collection entities, such as *Yizaisheng*, *Aihuishou* and *Huishouge*, have been founded in recent years in China. These enterprises’ platforms are categorized into two model categories, C2B (customer to business) and B2B (business to business), and some of the platforms have achieved great success.

In the information age, digital technology has been used to empower individuals and communities through better networking, communication and cooperation opportunities that increase their competence as influential participants (Mkinen, 2006). WEEE online collection will become more successful with the establishment of platforms based on digital technology, linking diverse groups together, empowering them and inducing benign network effects. Therefore, a dynamic and profitable business ecosystem should be established to encourage such developments. Although studies have recognized online collection and discussed “what online collection is”, such as the current status of internet-based collection entities (Gu et al., 2017) or the effectiveness of these innovative business models (Tong et al., 2017), no studies have addressed or provided systematic and in-depth exploration of the new phenomenon of WEEE online collection business ecosystems. Therefore, the answers to several significant questions remain unknown: what are the structures, digital empowerment activities and types of WEEE collection business ecosystems? To seek answers to these questions, a comparative case study is conducted with two typical internet-based collection enterprises representing the C2B and B2B online collection models in China. The structures, digital empowerment activities, and elements of each type of WEEE online collection business ecosystem are analyzed and summarized.

2. Theoretical background

2.1 WEEE collection

WEEE collection is not only a challenge for society but also attracts little attention from scholars. Thus far, there has been minimal discussion of online collection, as most studies focus on traditional offline collection and the behaviors of collectors or residents (Chi et al., 2014, Sun et al., 2015), offline collection systems (Queiruga et al., 2008, Gallardo et al., 2012), and the impacts of WEEE collection (Baxter et al., 2016, Nelen et al., 2014, Gu et al., 2016). Modern digital technologies such as websites or mobile phone applications are used to send waste equipment take-back requests from households (Król et al., 2016), but few scholars have focused on these technologies. Song et al. (2016) found that website-based collection systems have become an important area of development and are supported by the Chinese government. Gu et al. (2017) listed 7 internet-based collection entities and provided in-depth descriptions of *Aihuishou* and *Huishouge*. To better understand internet-based collection, Tong et al. (2017) described and evaluated its effectiveness from the perspective of a sustainable business model. Collectively, these studies simply described “what online collection is”; however, they did not address this topic

from an ecosystem-level perspective or discuss the structure, digital empowerment activities, and types of WEEE collection business ecosystems.

2.2 Business ecosystem

A new trend in strategic development is the construction of a business ecosystem based on platforms (Chen et al., 2013), similar to the approach of enterprises in the WEEE collection industry. The term “business ecosystem” was first introduced in the mid-1990s (Moore, 1993) and subsequently has become pervasive in strategic management. Currently, the concept consists of two main schools of thought: “ecosystem-as-affiliation” and “ecosystem-as-structure” (Ander, 2017). Moore first described the group of “ecosystem-as-affiliation”. Iansiti et al.(2004) defined networks of affiliated organizations as business ecosystems and placed emphasis on the breakdown of traditional industry boundaries, the rise of interdependence, and the potential for symbiotic relationships in productive ecosystems. This perspective focuses on questions of access and openness, highlighting measures such as numbers of partners, network density, and actors’ centrality in larger networks. However, Ander et al.(2010,2016) suggests that, in an “ecosystem-as-affiliation”, it is often difficult to distinguish a business ecosystem from other similar concepts, such as networks, platforms, and multisided markets; therefore, he defined an ecosystem as a structure with four basic elements—activities, actors, positions and links—whose foundation is the value proposition. Actors are one of the key factors in a business ecosystem and generally include a focal firm, suppliers, customers, complementors, intermediaries and competitors (Iansiti et al., 2004, Ander et al., 2010,2016). Under the momentum of the new industrial revolution, platforms have become a core pillar of many technology industries, which not only enables the development of new products and services but has also been shown to influence strategies, shape business models, and transform entire industries (Basole et al., 2011). Currently, platforms play a particularly important role in business ecosystems and link other actors with information, materials and money flow based on the development of digital technology (Mahadevan, 2000). Although there is a growing body of research emphasizing the business ecosystem, the focus remains on the business ecosystem in the high technology sector, such as technology investments in the health care industry (Kapoor et al.,2013), enterprise software platforms (Ceccagnoli et al.,2011) and the semiconductor lithography equipment industry (Adner et al., 2016). There has been minimal focus on the business ecosystem of waste management (Peltola et al., 2016), particularly, internet-based WEEE collection.

2.3 Digital empowerment

Digital empowerment is a new phenomenon that has emerged with the popularization and development of digital technology. Digital technology empowers the innovation of business and society, thereby promoting consumerization and reformation. Previous studies of digital empowerment have been conducted at the individual and community levels. Mkinen (2006) offered a clear definition of digital empowerment as a multi-phased process to produce better networking, communication and cooperation opportunities and to increase the competence of individuals and communities to act as influential participants in an information society. Leong et al. (2015) showed how social media empowers community members to achieve collective participation, shared identification, and collaborative control in the community at the community level. Currently, the application area of digital empowerment has expanded to the level of e-

commerce business ecosystems due to its explanatory power for activities in a business ecosystem (Leong et al.,2016).

Scholars have focused on the process of digital empowerment, which has been divided into three key dimensions: structural, psychological, and resource empowerment. Structural empowerment focuses on improving objective external conditions (such as organizational, institutional, social, economic, political, and cultural conditions) to provide the power to take action (Spreitzer, 1995; Thomas et al.,1990). A direct mechanism is the removal of structural barriers that impede community access to information, opportunities, and resources. Psychological empowerment focuses on improving social psychology and intrinsic motivation or on individuals' subjective interpretations (e.g., self-confidence, self-awareness, and assertiveness) such that they feel in control of their own destiny (Spreitzer, 1995; Thomas et al.,1990). The mechanism of psychological empowerment focuses on employees' perceptions concerning the delegation of authority and responsibility (Maynard et al.2012) or meaning, competence, self-determination, and choice or impact (Thomas et al.,1990; Spreitzer, 1995). Resource empowerment focuses on improving the competence and ability of the powerless to acquire, control, and manage resources (Leong et al.,2015). Eisenhardt et al. (2000) noted that competence in resource management consists of competence in gaining, integrating, and releasing resources, which are applied in the WEEE collection business ecosystem. However, there is no published information on digital empowerment in the WEEE collection business ecosystem.

Consumers, collectors, dismantlers, recyclers, and EEE producers and remanufacturers are connected to each other around a platform and empowered by a platform, thus forming a WEEE online collection business ecosystem. However, far too little attention has been paid to this new phenomenon. In addition, no studies have investigated internet-based WEEE collection systems from the perspectives of the business ecosystem and digital empowerment. To address this gap, this paper targets structures and digital empowerment activities in the WEEE online collection business ecosystem.

3. Methods and data

A qualitative double-case study was conducted for the following reasons. First, digital empowerment in the WEEE collection business ecosystem is complex and must be studied in its context, and a case study is an appropriate mode for this type of exploration. Second, a case study is phenomenon-driven rather than theory-driven (Eisenhardt et al., 2007), and it describes actors and processes in an accessible format (Eriksson et al., 2015), which makes it more suitable to explain the phenomena in our study. Third, since a single case study's point is often easily lost when describing a story, it is better to use a double-case study and compare two typical models of WEEE online collection. Moreover, case comparison strengthens the generalizability of the results and improves external validity.

Guided by the principle of theoretical sampling and polarization (Eisenhardt, 1989), we selected *Aihuishou* and *Yizaisheng* as the study cases. *Aihuishou* is the largest internet-based WEEE collection company in China and the first C2B platform providing a bidding system in China. *Yizaisheng* is a B2B platform for collecting municipal solid waste created by Sound Environmental Resources Co., Ltd. (Sound hereafter), a pioneer in solid waste treatment in China.

To ensure reliability and validity, data were triangulated from multiple sources (Yin, 1994): 1) information on the company collected from the company's website, microblog and WeChat; 2)

interviews with participants conducted in-person and through email and WeChat; 3) 30-minute speeches made by enterprise managers at industrial conferences; 4) published magazines from *Aihuishou* and *Yizaisheng*; and 5) published literature, media materials and related books.

4. Case analysis

Data analysis involved two steps: within-case and cross-case (Eisenhardt, 1989). We analyzed the structure and digital empowerment activities of each WEEE collection business ecosystem and then conducted a comparative study to clarify their similarities and differences.

4.1 Case of *Aihuishou*

4.1.1 Business ecosystem structure of *Aihuishou*

Aihuishou was founded in 2010 as an online exchange platform called *Aiyiwang* and began to collect WEEE in April 2011. The company was the first C2B bidding WEEE collection platform, focusing on mobile phones, laptops, and household electric appliances. In 2016, the annual turnover of *Aihuishou* was 1.8 billion RMB; it disposes of more than 5 million phones annually, and nearly 200 outlets have opened in 18 cities. The company holds more than half of the WEEE collection market share via close cooperation with Jingdong, Samsung, Xiaomi, Dji, and other platforms. Consumers who want to sell used EEE, cooperative collection companies, disposers, individual consumers who want to purchase second-hand goods and other actors are involved in the *Aihuishou* business ecosystem. Fig. 1 shows the most important links among these actors: information flow, material flow, and money flow.

Information flow. There are three routes for consumers placing collection requests: 1) self-owned channels of *Aihuishou*, such as its website, WeChat and mobile phone application; 2) E-business websites such as Jingdong or Yihaodian; and 3) official website of EEE brands, such as Xiaomi, and Samsung. After selecting several descriptions of their used products online or on a machine at an outlet, consumers will receive a price evaluation. When the transaction between a consumer and *Aihuishou* has been completed, cooperative collection companies will obtain the supply information.

Material flow. After the take-back intention is completed, there are three different routes to send WEEE to *Aihuishou*: by mail carried out by third-party logistics enterprises, door-to-door collection entities and outlets. The collected WEEE are then sold to various parties based on a quality inspection and pricing. Using mobile phones as an example, cell phones valued at 5-20 RMB will be sold to disposers such as GEM High-tech Co. Ltd, those with a middling value will be sent to cooperative collection companies via a bidding system, and nearly new cell phones will be sold as second-hand goods after *Aihuishou* deletes the private data.

Money flow. The money flow within the business ecosystem constructed by *Aihuishou* is simple. After consumers accept the final price and submit their used products, the money is paid to them in the form of cash, through online channels such as Alipay or WeChat or in coupon form. The money flow between *Aihuishou* and cooperative collection companies, disposers and second-hand goods purchasers takes the form of a cash transaction or occurs via a third-party online payment.

This analysis of information, material, and money flow shows that the main actors involved in the *Aihuishou* business ecosystem consist of consumers, e-business platforms, brand traders, *Aihuishou*, third-party logistics enterprises, cooperative collection companies, disposers, and

second-hand goods purchasers. These entities play different roles in the business ecosystem. *Aihuishou* is the core collection platform that connects various actors. Consumers who want to sell used EEE play the role of suppliers; cooperative collection companies, disposers and second-hand goods purchasers are customers; E-business platforms and EEE brands act as intermediaries; third-party logistics enterprises are complementors in the *Aihuishou* business ecosystem (Ander,2006).

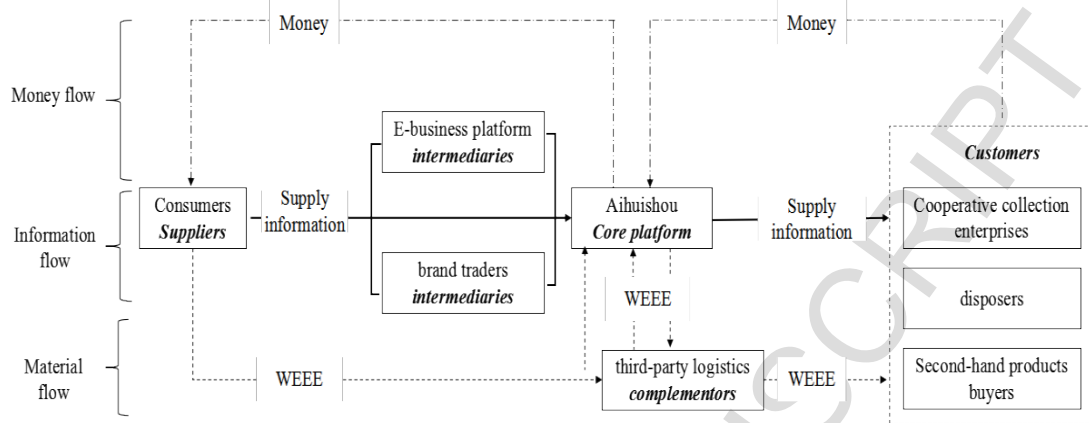


Fig.1. Business ecosystem structure of *Aihuishou*

4.1.2 Digital empowerment in the *Aihuishou* business ecosystem

The core platform is the **builder** of a business ecosystem that connects different actors and facilitates the digital empowerment of different actors through three routes: structural empowerment, psychological empowerment, and resource empowerment. Structural empowerment removes the hindrance of participation in information, **material and money flow**, which consists of four elements: an information support system, user interface, logistics channel and pricing and payment system. A brief literature review and the actual cases show that meaning, impact, competence and self-determination are the major routes of psychological empowerment, while the competencies of gaining, integrating, and releasing resources are involved in resource empowerment. Details of digital empowerment by *Aihuishou* are shown in Table 1 and Table 2.

(1) Digital empowerment of suppliers (consumers) by a core platform (*Aihuishou*)

Structural empowerment. *Aihuishou* provides various information support systems, such as official websites, APP, WeChat, microblogs, e-business, and websites of EEE brands. Thus, consumers are able to choose any of these options according to their own likes or habits. Regarding the design of the user interface, a user noted, “*the options in the Aihuishou interface are so easy to understand that even customers lacking sufficient experience can complete the collection process very quickly*”. In terms of logistics channels, *Aihuishou* provides three options for customer convenience: mail, door-to-door collection and outlets. Pricing and payment are key factors for customers; therefore, *Aihuishou* has launched a comprehensive analysis of product wear, uses market information to provide a reasonable price and pays customers via *Aihuishou* wallet, Alipay, WeChat, online banking and other methods.

Psychological empowerment. Psychological empowerment of suppliers by *Aihuishou* is conveyed through meaning, competence, and self-determination (Maier et al.,1976). First, *Aihuishou* has participated in public benefit activities to build a green and environmentally concerned enterprise image, which is consistent with the pro-environment values of consumers.

Second, *Aihuishou* has opened more than 200 outlets in Shanghai, Beijing, Shenzhen, and Guangzhou to provide face-to-face communication, transactions and repair services for consumers. As a consumer stated, “*deals in outlets are convenient for me and seem more reliable*”. More importantly, suppliers are made more aware of their participation by sharing their feelings or solving puzzles regarding online collection on *Aihuishou*'s microblog, WeChat, and Baidu PostBar.

Resource empowerment. *Aihuishou* mainly targets upgrade capacity for newly released resources by suppliers using information technologies. Consumers are informed in a timely manner by mobile phone text messages throughout the transaction process if they send unwanted WEEE by mail. Thus, consumers can efficiently and successfully complete the online collection process. Recently, *Aihuishou* established a research institute for big data to release reports on collected WEEE, which provides more information about the brands and prices of collected goods to guide suppliers.

Table 1
Digital empowerment of WEEE suppliers (consumers) by *Aihuishou*

Types of digital empowerment		Typical materials
Structural empowerment	Information support system	Websites, APP, WeChat, microblogs, e-business websites, and official brand websites
	User interface	Simple options
	Logistics channel	By mail, door-to-door collection and outlets
	Pricing and payment system	Pricing based on data analysis Payment channel: <i>Aihuishou</i> wallet, Alipay, WeChat and online banking
Psychological empowerment	Meaning	Participating in public benefit activities to enhance suppliers' meaning
	Competence	Opening more than 200 outlets to provide more reliable and convenient methods for suppliers
	Self-determination	Enabling suppliers to attain the power of self-determination through online communities such as microblogs, WeChat, and PostBars
Resource empowerment	Resource release capacity	Releasing reports on collected WEEE to guide suppliers

(2) Digital empowerment of WEEE customers (cooperative collection companies, disposers, and second-hand product buyers) by the core platform (*Aihuishou*)

Structural empowerment. *Aihuishou* has developed a bidding system through which cooperative collection companies conveniently obtain timely information and quotes. In addition to the bidding system, the platform *Koudaiyoupin* was opened to enable purchasing for second-hand product consumers. However, there is no specific information support system for disposers. Regarding the user interface, there are different WEEE partitions on *Aihuishou*'s website, and the maximum take-back prices are listed. *Aihuishou* also opened a section named “releasing desire”, where second-hand product buyers input information on desired products. Then, *Koudaiyoupin* of *Aihuishou* attempts to satisfy the demand. When the transaction with consumers has been completed, *Aihuishou* offers home delivery for cooperative collection companies and disposers. For second-hand product buyers, ShunFeng, a famous express-delivery company in China, is used for delivery. In terms of payment systems, transactions with collection and disposal enterprises are

conducted offline; therefore, there are few payment channels available to them. However, Alipay, WeChat, Jingdong and online banking are available for consumers who are willing to purchase second-hand products.

Psychological empowerment. The empowerment of *Aihuishou* customers is primarily achieved by promoting meaning and impact. **Participating in public benefit activities not only affects *Aihuishou*'s consumers but also enhances confidence in environmental protection of collection and disposal enterprises.** Additionally, *Aihuishou* strengthens contacts with cooperative collection companies and actively adopts their advice. For instance, Chen Xuefeng, the founder of *Aihuishou*, once stated, “*the key options in the user interface should be contributed as suggestions by cooperative collection companies*”. According to psychological theory, this method allows customers to feel reassured of their own importance and enhances their sense of self-worth (Ashforth, 1989).

Resource empowerment. The resource empowerment of customers from *Aihuishou* mainly focuses on improving customers’ abilities to engage in resource acquisition and release. In terms of resource acquisition, the bidding system with dynamic management is designed for cooperative collection enterprises to provide more resources to high-quality collection enterprises. **Another significant aspect of resource release is that *Koudaiyoupin*, established by *Aihuishou*, occasionally restocks second-hand products from cooperative collection companies to reduce the inventory of recyclers and improves their capacity to release resources.**

Table 2

Digital empowerment of WEEE customers by *Aihuishou*

Types of digital empowerment		Typical materials
Structural empowerment	Information support system	Bidding system; <i>Koudaiyoupin</i>
	User interface	Partitions according to WEEE type
	Logistics channel	Home delivery service, third-party logistics companies such as Shunfeng
	Pricing and payment system	Pricing based on data analysis Payment channels: Alipay, WeChat, Jingdong digital wallets and online banking
Psychological empowerment	Meaning	Undertaking greater social responsibility by engaging in public benefit activities to enhance customers’ meaning
	Impact	Actively adopting customers’ advice to make them feel important
Resource empowerment	Ability to gain resources	Providing high-quality collection enterprises access to more resources via the bidding system
	Ability to release resources	Purchasing second-hand products from cooperative collection companies to reduce their stock

(3) Digital empowerment of intermediaries (e-business, brand traders) and complementors (third-party logistics enterprises) by the core platform (*Aihuishou*)

The major function of intermediaries in the business ecosystem is the transmission and transformation of information flow. With coupons for discounts on new products, *Aihuishou* transforms suppliers into users of e-business and brand traders such that intermediaries are able to

obtain access to more users and promote resource gains. Third-party logistics enterprises provide supporting services in *Aihuishou's* business ecosystem. It is possible to obtain more transaction opportunities and improve resource gains after joining the business ecosystem built by *Aihuishou*.

4.2 Case of *Yizaisheng*

4.2.1 Business ecosystem structure of *Yizaisheng*

Yizaisheng is a B2B trading and payment platform for renewable resources in China that was established by Sound. WEEE-related activities constitute one of the primary business activities of *Yizaisheng*. The *Yizaisheng* website launched on June 5, 2015 and began online payment on August 1, 2016. Financial, logistics and transaction security services are now provided. As of November 2016, there are over 600 enterprises registered on the platform, and monthly turnover is more than 300 million RMB.

The online platform of *Yizaisheng* bridges the transactions between WEEE suppliers and customers. Suppliers include third-party collectors, subsidiary corporations of Sound focusing on collection and equipment suppliers. Customers are mainly third-party recycling plants and subsidiary corporations of Sound focusing on recycling. The platform connects other intermediaries, such as logistics and financial institutions, to build its business ecosystem (Fig. 2). The information flow, material flow and money flow are described below.

Information flow. Suppliers such as third-party collectors, subsidiary corporations of Sound focusing on collection, and equipment suppliers post their supply information on the website or APP, as do customers. The platform matches the information precisely and then distributes and makes recommendations to suppliers and customers. Additionally, there is a comprehensive information zone that posts information such as industry news, policies and regulations, financial news, environmental protection information, and socially focused information.

Material flow. After achieving a preliminary agreement on a deal, customers and suppliers engage with *Lahuobao*, a well-known logistics company, to complete delivery. *Lahuobao* is an e-commerce logistics platform, built by Hongtu Logistics, that matches owners of cargo and transporters with low profit; this overturns the traditional logistics price model of differential pricing. By introducing *Lahuobao*, *Yizaisheng* provides logistics services for registered enterprises.

Money flow. In the *Yizaisheng* business ecosystem, money flows through *SuningPay*, an independent third-party payment company of Suning Commerce Group, and *YiPay*, an online payment service supported by *Yizaisheng* and China Citic Bank. Users freely choose their payment type based on business, volume of trade and their habits. Money directly flows from customers to suppliers. Moreover, considering the fund shortage in upstream and downstream firms of the WEEE industry, the financial service center of *Yizaisheng* plans to establish a one billion RMB industry development fund in cooperation with banks to provide financial support for qualified companies that have registered on the platform.

The above analysis shows that the participants in the *Yizaisheng* business ecosystem include third-party collectors, subsidiary corporations of Sound focusing on collection, disassembling and recycling equipment suppliers, third-party recycling plants, subsidiary corporations of Sound focusing on recycling, logistics companies and financial institutions. *Yizaisheng* is the core platform and the ecosystem creator. Third-party collectors, subsidiary corporations of Sound focusing on the collection, equipment coporates are the suppliers, providing WEEEs and relevant

disassembly and recycling equipment. The customers include third-party recycling plants and subsidiary corporations of Sound focusing on recycling that purchase material and equipment through the platform. Third-party logistic companies and financial institutions play the role of complementors, providing logistics and financial services for enterprises registered on the platform.

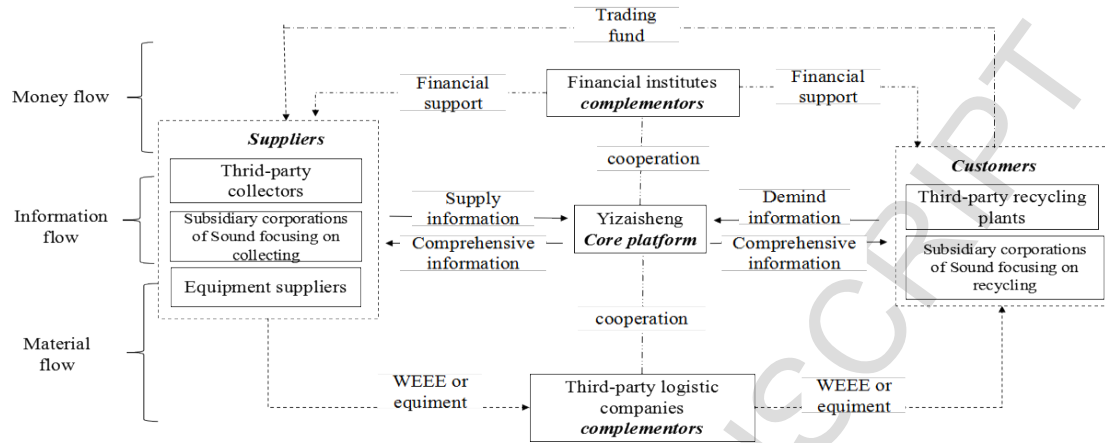


Fig.2. Business ecosystem structure of *Yizaisheng*

4.2.2 Digital empowerment in the *Yizaisheng* business ecosystem

Suppliers and consumers post supply and demand information on the *Yizaisheng* platform and obtain services from *Yizaisheng*, such as logistics services, financial services and industry information. *Yizaisheng's* digital empowerment of suppliers and customers is the same because they both have access to the same functions and services. Details of digital empowerment by *Yizaisheng* are shown in Table 3.

(1) Digital empowerment of suppliers and customers (collectors, equipment suppliers and recycling plants) by the core platform (*Yizaisheng*)

Structural empowerment. Regarding information support, *Yizaisheng* has built a website and app, and suppliers and customers choose which platform to use for registration. The user interface employs five features for simplicity and convenience: one-button posting, abundant information, quick searches, smart matching, and fast trade. In terms of distribution channels, *Yizaisheng* provides a free information matching platform in cooperation with Hongtu Logistics. Regarding pricing and payment, *Yizaisheng* compiles the '*Yizaisheng* Waste Household Appliance Price Index' together with the *China National Resources Recycling Association*. This price index gathers data every week and then provides a comprehensive price index utilizing a weighted average of waste household appliances in different forms. The price index helps collection and disassembly enterprises to engage in rational pricing. Furthermore, online payment via *SuningPay* and *YiPay* is feasible.

Psychological empowerment. Psychological empowerment from *Yizaisheng* to suppliers and customers reflects two aspects. First, *Yizaisheng* provides mental safeguards, based on its capital advantage as a listed company, the resource advantages of parks and entity enterprises, and the brand advantage of its leading position, to suppliers and customers to make them feel eligible to complete online trading. Moreover, trade security is supported by *Yizaisheng* based on its credit rating, guaranteed money mechanism, and trade remedies. Second, *Yizaisheng* improves the

impacts of suppliers and customers by strengthening communication with suppliers and customers and adopting their suggestions. *Yizaisheng* has built several marketing teams to communicate with over 600 suppliers and customers in 14 provinces, to gain insight into user requirements, and to utilize their feedback and advice. For example, the APP was developed based on customers' opinions.

Resource empowerment. The major method used by *Yizaisheng* to engage in resource empowerment for its suppliers and customers consists of improving their ability to gain, integrate and release resources. For example, *Yizaisheng* provides financial support to registered companies together with financial institution and established a commercial company to run its WEEE business, based on the resource advantages of Sound. Additionally, free offline training activities for enterprises have been held in cooperation with industrial associations. Registered companies improve their ability to gain resources with the support of asset resources, such as finance and material assets, and knowledge resources, such as industry, market, product and technology knowledge (Wiklund et al., 2003), which are provided by *Yizaisheng*. Regarding integrated resources, *Yizaisheng* has assembled over 600 enterprises, has improved their informatization and provides information services and offline communications. All these activities have changed the way companies recognize and organize external resources, facilitating the integration of decentralized information and resources. In terms of resource release, *Yizaisheng* helps registered enterprises to operate, market and broaden transaction channels based on its enterprise database. Moreover, a great deal of information on supply and demand is gathered to realize rapid matching for suppliers and customers, promoting their ability to release resources. One of the suppliers stated, 'my loans to the account are 1 month earlier than before, after registering on the platform and trading online.'

Table 3
Digital empowerment of suppliers and customers by *Yizaisheng*

Types of digital empowerment		Typical materials
Structural empowerment	Information support system	Website, APP
	User interface	One-button posting, simple and convenient
	Logistics channel	<i>Lahuobao</i>
	Pricing and payment system	<i>SuningPay, YiPay</i>
Psychological empowerment	Competence	Advantage of resource and brand, credit ranking, guaranty money mechanism, and trade remedy
	Impact	Adopting advices of suppliers and customers
Resource empowerment	Ability to gain resources	Financial support, offline training
	Ability to integrate resources	Gathering enterprises, communicating online and offline
	Ability to release resources	Rapid matching, promoting operations and marketing

(2) Digital empowerment of complementors (financial institutions and third-party logistics) by the core platform (*Yizaisheng*)

Structural empowerment and resource empowerment are the two main methods that *Yizaisheng* uses to empower complementors such as third-party logistics and financial institutions. As the providers of value-added services in the *Yizaisheng* business ecosystem, third-party logistics and financial institutions enter the ecosystem through the structural empowerment of information support and then gain customers by eliminating information asymmetry, which

improves their ability to gain resources.

4.3 Comparative analysis

As typical representatives of C2B and B2B online collection models in China, *Aihuishou* and *Yizaisheng*, respectively, have constructed business ecosystems with distinct characteristics. We conducted a comparative analysis of the four basic elements of business ecosystems: actors, links, activities and positions (Ander, 2017). Specifically, the role of actors; the direction of information, material and money flow; the intensity of digital empowerment; and the centrality of the platform were compared (Table 4).

Actors. There are generally two groups in a business ecosystem: leaders and followers. The focal platforms are leaders, and other actors are followers of the *Aihuishou* and *Yizaisheng* ecosystems; however, their roles differ significantly. Specifically, *Aihuishou* plays the role of “connection leader” by connecting other actors in its own business ecosystem and other business ecosystems such as the Jingdong e-business ecosystem. By taking on the role of a connector, *Aihuishou* may enhance ecosystem productivity by maintaining the population of the ecosystem within an optimum range or by connecting different nodes within the network, thus decreasing the complexity of coordination and integration in value co-creation (Iansiti et al., 2004). Other actors play the role of “independent followers” because they have more options of information, material and money flow. *Yizaisheng* plays the role of a “controllable leader” by exploiting its centrality in the network to take control or extract value from the ecosystem. By taking on the role of a controller, *Yizaisheng* draws related subsidiary companies into its own business ecosystem, depending on the support of a strong resource and powerful reputation from the Sound group; expands horizontally and vertically to control a large proportion of the business network; and becomes primarily responsible for value creation within the ecosystem (Tan et al., 2009). Although other actors, including subsidiary corporations of Sound, focus on collection and recycling, they are actually bound to the *Yizaisheng* business ecosystem due to the tremendous strength of the Sound group and value-added services such as financial support. Based on the above analysis, we suggest that other actors in the *Yizaisheng* business ecosystem play the role of “dependent followers”.

Links. In the *Aihuishou* business ecosystem, information and material flow begin with suppliers, which unidirectionally run through the platform to customers. While the start and end nodes of money flow lie in opposite directions, this flow is also unidirectional. The directions of information, material and money flow in the *Yizaisheng* business ecosystem are more complex. Information flow tends to be bidirectional because supply-demand information is gathered on the platform from customers and suppliers, while relevant news and information spread from the platform. As is evident in the *Yizaisheng* business ecosystem, money flows in multiple directions. Material flow is simple, with a unidirectional tendency from suppliers to customers.

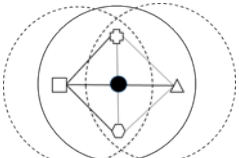
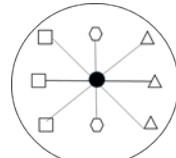
Activities. In the *Aihuishou* business ecosystem, the intensity of structural empowerment is high, perhaps due to the multiple channels of information, material and money flow, as designed by *Aihuishou*. Suppliers have the richest channels; moreover, the bidding system and the online retailer *Koudaiyoupin* remove the structural obstacles for cooperative collection companies and second-hand product buyers to participate in online collection. Additionally, *Aihuishou* empowers intermediaries by providing transfer channels for users. Conversely, *Yizaisheng* provides an alternative information support system, pricing system, and payment system for suppliers and

customers. However, there is only one option, *Lahuobao*, for logistics; therefore, we suggest that the intensity of structural empowerment in the *Yizaisheng* business ecosystem is relatively high. In terms of psychological empowerment, *Yizaisheng* performs better than *Aihuishou*. As described earlier, *Aihuishou* psychologically empowers other actors using three approaches: participating in public benefit activities, opening outlets and organizing an online community. *Yizaisheng* also demonstrates high intense psychological empowerment to enhance the competence and impact of suppliers and customers. Indeed, the intensity of resource empowerment by *Yizaisheng* is high because it empowers all other actors, including suppliers, customers and intermediaries, with the help of resources from the parent company. In contrast to *Yizaisheng*, *Aihuishou* demonstrates relatively high resource empowerment intensity with limited resource channels.

Position. In this paper, the term “position” refers to the position of the platform in a business ecosystem; it specifies the accessibility of resources for the platform and has a similar meaning to network position (Tsai,2001) in social network theories. In general, centrality is an important measure of network position, and it is used to examine the degree to which a network acts as a hub, accessing and controlling the resources of corporations (Wasserman et al.,1994). In business ecosystems, the centrality mainly reflected in two aspects: keystone and dominator (Iansiti et al.,2004). keystone exercise the power of their position within an ecosystem in a somewhat indirect manner. But ecosystem dominators wield their clout in a more traditional way, exploiting a critical position to either take over the network, more insidiously, drain value from it (Iansiti et al.,2004). Based on our analysis of the roles and links in our two cases, *Yizaisheng* intergrates vertically or horizontally to own and manage a large proportion of a network directly as a controllable leader with the background of the parent company, therefore, the centrality of *Yizaisheng* is dominator. However, as a core platform, *Aihuishou* simplifies the complex task of connecting network of participants to one another indirectly and has less control over key resources; therefore, its centrality shows up as keystone.

Table 4

Comparison of the *Aihuishou* and *Yizaisheng* business ecosystems

Comparison dimensions		<i>Aihuishou</i>	<i>Yizaisheng</i>
Actors	The role of platform	Connection leader	Controllable leader
	The role of other actors	Independent follower	Dependent follower
Links	The direction of information flow	Unidirectional	Bidirectional
	The direction of material flow	Unidirectional	Unidirectional
	The direction of money flow	Unidirectional	Multiple
Activities	The intensity of structural empowerment	High	Relatively high
	The intensity of psychological empowerment	Relatively high	High
	The intensity of resource empowerment	Relatively high	High
Positions	Centrality	Keystone	Dominator
		Embedded business ecosystem	Central business ecosystem
Type of business ecosystem			

By analyzing and comparing the four basic elements of business ecosystems, we conclude that there are two types of WEEE online collection business ecosystems: embedded business ecosystems and central business ecosystems. As a connection leader, *Aihuishou* acts as a node for information flow, material flow and money flow and demonstrates high structural empowerment, removing structural barriers for other actors and embedding itself in other business ecosystems; therefore, we consider the *Aihuishou* business ecosystem to be an embedded business ecosystem. Conversely, as a controllable leader, *Yizaisheng* has become a distribution center that is dependent on its resources and capabilities; therefore, we have designated it a central business ecosystem. Interestingly, different types of business ecosystems are associated with different collected products. In the embedded business ecosystem, the value logic is goods-dominant logic that generated by cascade utilization of products, since WEEE with different value are collected and most of collected items are sold as second-hand goods. While, in the central business ecosystem, most of collected items are with low value and disposed directly by recycling plants, so the value logic of core platform is service-dominant logic, providing various value-added services like financial support, logistics and transaction security for other participants.

5. Conclusions and Implications

This study not only contributes to the existing business ecosystem literature by introducing digital empowerment but also expands the application areas of digital empowerment by investigating WEEE online collection platforms in China. We mapped the structures of WEEE collection business ecosystems by identifying key actors and the links between them. Our analysis revealed five groups of actors in WEEE collection business ecosystems: suppliers, customers, focal platforms, intermediaries, and complementors. The links among actors are maintained by information flow, material flow and money flow. Furthermore, the results show that digital empowerment is a key activity in WEEE collection business ecosystems in the context of digital technology. A focal platform empowers other actors across three dimensions of empowerment: structural, psychological, and resource empowerment.

After providing a comprehensive analysis of the role of actors, the direction of information flow, material flow and money flow, the intensity of digital empowerment and platform centrality, we revealed two types of WEEE collection business ecosystems: embedded business ecosystems and central business ecosystems. In the embedded business ecosystem, the platform, which has low centrality, plays the role of a “connection leader”, and other actors act as “independent followers” with unidirectional information, material and money flow among them. Furthermore, the intensity of structural empowerment within the embedded business ecosystem is high. In the central business ecosystem, the platform plays the role of a “controllable leader”, and other actors in the business ecosystem act as “dependent followers”. Links are multidirectional, while information flow tends to be bidirectional. Furthermore, the platform has centrality of dominator and empowers other actors, primarily through psychological and resource empowerment.

Our research also provides important insights for internet-based collection enterprises. First, the platform should consider the characteristics and types of collected products and then carefully choose the appropriate business ecosystem type to meet enterprise needs. Second, it is suggested that platforms focus on the companies associated with WEEE collection and construct a business ecosystem structure by designing smooth channels for information flow, material flow and money flow. Our case study shows that digital empowerment activities are key to platform function. The

platform should strengthen capacity to enable other actors in the business ecosystem. In terms of the effective use of digital empowerment, its content and intensity should be resilient to different types of actors to generate a forward-facing force for sustainable development.

This article has limitations. Although we conducted this study with two internet-based collection enterprises in China, we are unable to eliminate the possibility that different structures and types of digital empowerment are present in other WEEE collection business ecosystems. However, future research will increase the number and types of cases to replicate our study findings. A second limitation of our study concerns the cases themselves. Currently, WEEE online collection in China is in the exploratory phase; therefore, the achievements of the enterprise cases we chose are the only results available at this stage. We will attempt to conduct a tracking study with our cases to examine our conclusions.

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