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## Study on the governance mechanism of rural e-commerce service centers in rural China: agency problems and solutions

### RESEARCH ARTICLE

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### Abstract

Agency problems, such as moral hazard and adverse selection, are prevalent in the public service sector, and the Chinese rural e-commerce service sector is no exception. With the focus on the top-down project ‘information and communication technology for development’ implemented in the underdeveloped areas in China, the rural e-commerce service center (RESC) operation mechanism was analyzed in this study. Based on the tension between RESC operators, local governments, and e-commerce service providers that was reported in a field survey, this study further employs the principal-agent framework to analyze the problems of asymmetric information. Based on this analysis, solutions are suggested that can remedy the moral hazard issues in rural e-commerce service delivery, including developing a service evaluation system, promoting the usage of ICTs, and enhancing rural social capital. To address the problem of adverse selection, the RESC recruitment process should be improved. Moreover, by dividing the potential RESC employees into native villagers and e-commerce entrepreneurs, the optimal subsidy schemes can be designed for both types of applicants according to their ability and sensitivity to incentive.

**Keywords:** rural e-commerce service, asymmetric information, moral hazard, adverse selection, rural China  
**JEL code:** Q16, Q28, R11

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## 1. Introduction

Since the 1990s, information and communication technologies (ICTs) have been promoted as an efficient tool to support rural bottom-up initiatives and poverty alleviation (Avgerou, 2010; Bhatnagar and Schware, 2000). In recent years, the continuous improvement in rural infrastructure and the rural market entry of e-commerce platform companies resulted in the rapid growth of the Chinese rural e-commerce market (Zeng *et al.*, 2017). The lack of market access and being in a disadvantaged position in the agrofood supply chain have always been the key issues for smallholders to survive and thrive in remote areas (Poulton *et al.*, 2010; Wiggins *et al.*, 2010; Zeng *et al.*, 2017). By reducing transaction costs, e-commerce improves the efficiency of existing supply chains or establishes new supply chain networks with looser partnerships (Devaraj *et al.*, 2007; Kinsey, 2000; Kinsey and Ashman, 2000; Wresch and Fraser, 2012). E-commerce not only provides smallholders access to the larger online market but also benefits both the producer and the customer by eliminating the middleman and marketing constraints such as information asymmetry (Eng, 2004; Zeng *et al.*, 2018).

The usage of e-commerce has a profound influence on rural economic and social development in China (AliResearch, 2014). The evidence shows that smallholders can sell their products at a higher price on an e-commerce platform and online chatting App to increase their revenue (Tang, 2017; Zeng *et al.*, 2018). The potential rural e-commerce market has attracted migrant workers, entrepreneurs, and investors to come back to and to start businesses in rural areas, which promotes local employment and helps to resolve social problems such as rural hollowing (AliResearch, 2015; Liu *et al.* 2010). This technology also provides women and the disabled with opportunities to start their own businesses and take care of their families at the same time (Rodgers and Harris, 2003).

An Information and Communication Technology for Development (ICT4D) project is successful when the main goals of the project are achieved without any negative consequences (Pade-Khene *et al.*, 2011). However, the long-term sustainability has been considered as the main issue for most of the ICT4D projects (Heeks, 2002a), especially in developing countries such as India (Best and Kumar, 2008; Kumar and Best, 2006), Malaysia (Nawi *et al.*, 2013), and China (Liu, 2016). As a model built on the Critical Success Factor and the Critical Failure Factor models (Heeks, 2002b; Heeks and Bhatnagar, 1999), the Sustainability Failure Model has been proposed and commonly employed to evaluate ICT4D projects from the perspective of financial, cultural, technological, institutional, and environmental sustainability (Best and Kumar, 2008; Kumar and Best, 2006; Liu, 2016).

To promote ICTs in rural areas, the ICT center emerged as a solution to address the accessibility of ICT service when a computer is not available for most of the rural households. The public ICT centers set in different counties and regions may have various target groups and offer diverse services (Almajali *et al.*, 2015; Attwood *et al.*, 2013; Best and Kumar, 2008; Gomez *et al.*, 2012; Jalali *et al.*, 2011; Proenza, 2001). Several frameworks have been developed and applied to investigate the service quality and effectiveness provided by the public ICT centers (Colle, 2005; Naik *et al.*, 2012) and the customer satisfaction (Abdulwahab and Dahalin, 2010; Best and Kumar, 2008).

The policy and regulatory framework of a country may affect the ICT4D project sustainability (Proenza, 2001). The governance structure decides how economic and political resources are procured and used and further influences the access and content of service that can be offered by an ICT center. In the case study of the Sustainable Access in Rural India project in Tamil Nadu, India, privately own telecenters received less technical and operational support compared with those run by a local NGO, which further resulted in a lack of long-term financial viability (Best and Kumar, 2008). In the Malaysian e-service project, the main factor for the failure of ICT center sustainability is that most of the government departments face difficulties in providing consistent e-service after the successful implementation of a center (Nawi *et al.*, 2013).

The agency problems have long been discussed in public service delivery, especially in health and education (Birdsall *et al.*, 2010; Olken *et al.*, 2014; SEKWAT, 2000). The tension arises between principal and agent since drafting and enforcing a contract incurs a cost (Fama and Jensen, 1983). The agency costs include the cost of drafting, monitoring, and binding a set of contracts between agents with conflicting benefits, plus the residual loss due to the cost of full execution exceeding the benefits (Jensen and Meckling, 1976). However, to the best of our knowledge, the agency problems including moral hazard and adverse selection that hinder the service quality and effectiveness provided by a public ICT center, which would further influence its long-term sustainability, have not been fully explored. Moreover, rural and urban areas pose distinct challenges to the optimal design of public service delivery and social care because of the differences in population distribution, infrastructure condition, and social environment (Asthana and Halliday, 2004).

By drawing on the principal-agent framework, this study contributes to the literature in two respects. First, the existing research on China's rural ICT service provision is limited (Liu, 2016). Moreover, most of the existing studies focus on the usage of communication technology such as the telephone and Internet (Harwit, 2004; Jayakar and Liu, 2014; Liu, 2016; Shi, 2008; Xia and Lu, 2008). Our work raises the awareness of academics and practitioners on e-commerce, which is an emerging sector in rural China (Zeng *et al.*, 2016). Second, empirical study indicates that households with different characteristics and endowments may benefit from e-commerce differently (Zeng *et al.*, 2018). The use of ICTs has the potential to significantly increase income inequality and by extension, wealth inequality within a rural community rather than to ameliorate it (Bach *et al.*, 2013; Xu *et al.*, 2013). In this regard, the rural e-commerce service provision for low-income populations and underdeveloped communities is worth great attention. As ICT4D projects heavily depend on technical and institutional support to achieve long-term sustainability (Best and Kumar, 2008), and the governance mechanism plays an important role in the efficiency improvement of public service outsourcing (Datta and Roy, 2013; Jensen and Stonecash, 2005), in this study, the principal-agent theory was employed to analyze the agency problems in Chinese rural e-commerce service delivery.

## 2. Operation mechanism of rural e-commerce service centers in rural China

Even though decades have passed since the beginning of e-commerce, only recently have many more smallholders in rural China gained access to the online market by selling agroproducts directly to consumers via online e-commerce platforms (e.g. Taobao) and online chatting apps (e.g. Wechat) (Tang, 2017). The total amount of Chinese rural e-commerce transaction doubled in 2015, reaching 353 billion Yuan (approximately US\$54 billion) (CCFA, 2017). In the following year, the figure exceeded 467.5 billion Yuan (approximately \$72 billion). A Taobao Village is defined by Alibaba (AliResearch, 2015) and refers to a village where at least 10% of its residents operate online stores with annual sales of at least 10 million Yuan (USD 1.6 million). Most of the Taobao Villages are in southeastern China and engage in processing industries such as garment, footwear, furniture and pottery businesses (AliResearch, 2014).

With the recognition of the very large impact of e-commerce on rural industries and household livelihoods, the Chinese government launched a top-down ICT4D project formally known as 'e-commerce goes into rural areas' to promote e-commerce development in rural areas. Since the project began in 2014, 756 counties have been selected as pilot areas until 2017, most of which are in underdeveloped regions in mid- and Western China. The pilot counties are funded through Chinese government budget appropriations and receive a 20 million Yuan (approximately \$3 million) block grant to improve e-commerce infrastructure, build up an e-commerce service system, and promote e-commerce usage in rural areas. For example, a typical three-level – county, town, village – rural e-commerce service system has been widely accepted by local governments to meet the increasing demand of rural residents. The rural e-commerce service center (RESC) is the essential component of the three-level rural e-commerce service system. The aim of a center is to facilitate local e-business by offering services such as logistics and delivery, packaging, marketing, website design, photography, customer service, etc. To ensure the service access of every rural household, the plan is to establish a RESC in every available rural community. In addition to providing basic assistance,

the center is also considered as a rural distribution center, since most of the logistic companies only deliver packages to the town distribution center due to poor road conditions and small package volume.

In cooperation with e-commerce platforms including Alibaba, Ganjie, Jindong, and China Post (Chen, 2015), the local governments recruit RESC operators under the following conditions: (1) owning an available business spot in the village center for the RESC operation; (2) having an e-commerce education background, professional credentials, or working experience, and; (3) willing to provide assistance to rural community members. Once selected, the RESC operator receives a set of equipment (e.g. computer, desk, exhibition boards) and a financial subsidy to redecorate the spot into the local RESC uniform style. As shown in Table 1, the research team visited five pilot areas, including Jingxi city, Tianyang County, and Tiandong County in Guangxi Province in Southwest China and Macheng city and Fang County in Hubei Province in mid-China, from June 2017 to November 2017. The team also visited Liujiang County, which has not yet been nominated as a demonstration area. Without adequate funding, an RESC has been set up only in several selected villages by the Liujiang government. In the survey, we conducted semi structured and focus group interviews on the RESC operating and incentive issues with the local government officials, RESC operators, local residents and managers from the major Chinese rural e-commerce platforms including Alibaba and China Post.

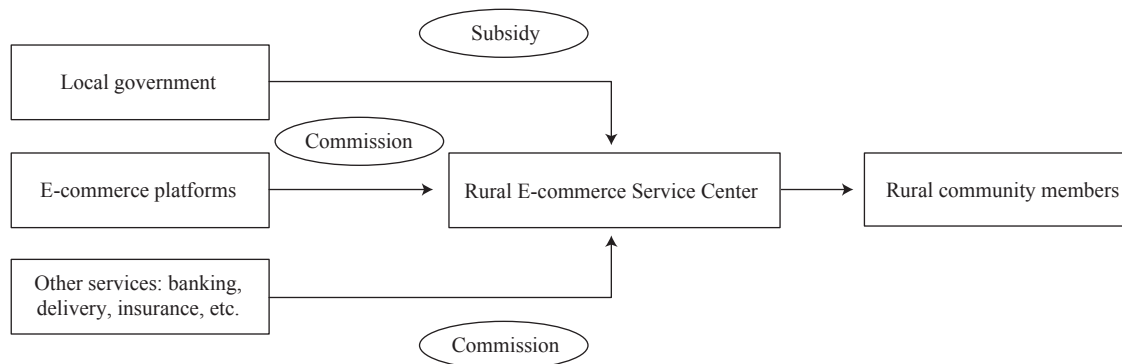
With service as the common agent of e-commerce service providers (e.g. e-commerce platforms, express delivery companies, banks, etc.) and institutional supporters (i.e. local government), the RESC is a mixture of the proactive pursuit of financial interests and the fulfillment of political obligations. The relationships among the participants in an RESC operation are shown in Figure 1. An RESC provides local residents with assistance on e-commerce related activities (e.g. online shopping and selling, bill payment, e-commerce consulting) and collects a commission based on the volume of online transactions. The rural community members can also seek banking services and express delivery in a RESC. Moreover, a RESC operator is also rewarded by the local government based on his performance on delivering the e-commerce service and promoting the usage of e-commerce. For example, the Macheng government subsidizes RESC operators with 5% cash back on assisting online purchases and 10% on helping local famers sell their homemade products online. A RESC operator is also subsidized for his efforts on encouraging rural residents to register in e-business training and providing e-commerce consultation.

The tension among RESC operators, local governments, and e-commerce service providers was similar to the case of the privately owned telecenters in the project ‘sustainable access in rural India’ (SARI) in Tamil Nadu, India (Best and Kumar, 2008). The largest challenge for the success of the project ‘e-commerce goes into rural areas’ is the long-term financial sustainability of the RESCs. For many RESC operator interviewees in our field survey, their household income was generated from various combinations of on-farm and off-farm work, as well as nonagricultural work. Because most of the RESC operators only possessed basic e-commerce skills and the demand was small when e-commerce was first introduced into a rural community, a RESC could barely sustain itself without the technical and institutional support from both the local government and the e-commerce service providers. In this regard, the implementation of a governance mechanism is vital to prevent RESC closures and encourage those operators to constantly improve their abilities and

**Table 1.** Survey areas.

Province	City/County	Rural e-commerce service center		Support period by ‘e-commerce goes into rural areas’
		Number	Grocery store-based	
Guangxi	Jingxi city	12	11	2015-2017
	Tianyang County	8	7	2016-2018
	Tiandong County	10	10	2016-2018
	Liujiang County	6	6	Not supported
Hubei	Macheng city	7	5	2016-2018
	Fang County	3	3	2017-2019





**Figure 1.** Operation mechanism of a rural e-commerce service center in rural China.

endeavor to meet the demands of local customers, such as by participating in the trainings offered by the local governments and e-commerce service providers. However, a few interviewees also came from urban areas and started their careers in rural areas as RESC operators. With their e-commerce working experience, they were remunerated by accepting offers from the many e-commerce companies that were crowding into the rural e-commerce sector or by starting their own businesses. Thus, monetary incentives are important to provide to these high-skilled RESC operators to prevent them from quitting the job.

### 3. Agency problems in the Chinese rural e-commerce service sector

In this section, we employ the principal-agent framework to discuss the agency problems arising from the information asymmetry within the relationship between the local government (principal) and the RESC operator (agent). The principal-agent framework is built on the agency theory (Akerlof, 1970; Ross, 1973; Rothschild and Stiglitz, 1976; Spence, 1973). The framework has been further applied to solve problems within a socioeconomic system where uncertainty, information asymmetry, fears of opportunism, and bounded rationality exist (Mallard, 2012; Milgrom and Roberts, 1992). Since the information possessed by the principal and the agent is not equal, issues arise, which further lead to two problems: moral hazard and adverse selection (Akerlof, 1970; Arrow, 2001; Jensen and Meckling, 1976).

#### 3.1 Moral hazard

Moral hazard arises when a principal cannot observe and contract based on an agent's effort. In our study case, even though the e-commerce service outcome can be measured by the amount of online transactions and the number of trainings and consultations a RESC operator managed to deliver, attempts can be made to manipulate indicators to collect more rewards. Moreover, an operator's service attitude, after-sale service, and customer's satisfaction are hard to measure. On one hand, geographical barriers limit the connections between remote areas and the outside world. The local government officials and RESC operators interviewed in our field survey pointed out that express delivery companies do not deliver packages to most of the remote villages due to poor road conditions and small package volume. The people who live in those areas have no alternative but to depend on a RESC operator to collect deliveries from the distribution center in the nearest town. On the other hand, as discussed above, the RESC operation is a part-time job for most of the operators in remote communities. Thus, local residents would have to endure service delays in the harvest season.

#### 3.2 Adverse selection

The problem of adverse selection occurs when a principal signs a contract with a potential agent but knows little about the agent's capability. The demonstration effect of a rural e-commerce grassroots leader and pioneer is of great importance in the initial stage of rural e-commerce development (Leong *et al.*, 2016).

The villagers would have a great desire to learn about e-commerce when they notice that an opportunity was available to work from home and receive benefits. This desire gives rise to the emergence of e-tailers who sell products via the Internet. However, the current e-commerce education and certification system gives local government less clue on an RESC applicant's ability type. Moreover, the low-ability individuals (defined as those with lower Internet skills and less e-commerce related experience) would have an incentive to enroll in the rural e-commerce service sector, because the principal can only observe the transaction record but cannot keep updated on the dynamic changes in the e-commerce environment within a rural community. In contrast, the high-ability agents will not be attracted to collaborate with the local governments because they can maximize their objective functions by joining e-commerce companies that can verify their skill sets or start up their own e-businesses.

#### 4. Conceptual framework

This section presents the analysis of the principal-agent relationship between the local government and RESC operator. The local government is viewed as the principal that hires a RESC operator (agent) to deliver e-commerce service to a rural community. In our research case,  $P$  is denoted as the e-commerce service performance of a RESC operator. In return, the operator receives a subsidy  $sP$  from the principal based on his performance. Let  $w$  be the coefficient of the increase in the public welfare by the e-commerce service delivery, and  $E\pi_G$  is the expected revenue of a risk-neutral local government. We obtain the following:

$$E\pi_G = \pi_G = wP - sP \quad (1)$$

Within a rural community, for the residents who lack access to the Internet or e-commerce skills, the demands are for stable service. Those needs are simply related to the local conditions such as the e-commerce climate, the resident's awareness of e-commerce, and the transport infrastructure. Therefore, when local smallholders are more exposed to e-commerce, they tend to have more demands for e-commerce service. A RESC operator can also attract more customers and achieve more revenue by offering considerable services, sharing latest discount news, and helping local farmers with online marketing. The assumption is that the service delivered by a RESC operator depends on the contribution of several but complementary components:  $a$ ,  $e$  and  $l$ . Let  $a$  be the operator's ability,  $e$  is his effort, and  $l$  represents the local e-commerce conditions. Together with the market uncertainty  $\varepsilon$ , they yield an e-commerce service demand:  $D = f(a, e) + g(l) + \varepsilon$ , where  $f_a > 0$ ,  $f_{aa} \leq 0$ ,  $f_e > 0$ ,  $f_{ee} \leq 0$ ,  $g_l > 0$ ,  $g_{ll} \leq 0$ , and  $\varepsilon \sim N(0, \sigma^2)$ . For the sake of simplicity, we assume  $f(a, e) = ae$  and  $g(l) = l(l > 0)$ , and then  $D = ae + l + \varepsilon$ .

The revenue of a RESC operator consists of two parts. The first part is the commission payments by the e-commerce service providers. We assume all of the e-commerce service providers offered the same commission rate for service delivery, and then,  $\pi_D = ae + l + \varepsilon$ . The second part is the compensation subsidized by the local government. The performance  $P$  of an operator of a RESC is measured by the amount of service he provided during a certain time period. This performance is directly related to the local e-commerce service demand; thus, let us assume  $P = D$ . Moreover, the assumption is the operator's cost for the hidden effort  $e$  is  $c(e)$ ,  $k$  is the effort coefficient, and  $c(e) = ke^2/2$ .

Accordingly, we have the total profit of an RESC operator  $\pi_0$ :

$$\pi_0 = \pi_D + sP - c(e) = (1 + s)(ae + l + \varepsilon) - \frac{ke^2}{2} \quad (2)$$

For a risk-adverse RESC operator, his expected utility  $E\pi_0$  is the following:

$$E\pi_0 = (1 + s)(ae + l) - \frac{ke^2}{2} - \frac{\rho(1 + s)^2 \sigma^2}{2} \quad (3)$$





2. Promoting the usage of ICTs. The opportunistic behavior of a RESC operator will disappear when local residents become more aware of and are capable of using ICTs. Currently, rural inhabitants can easily conduct online transactions and manage online shopping on their own via smartphones. The poor attitude and service delivery of a RESC operator would result in losing loyal customers when novice e-consumers and e-tailers can seek help from relatives and other community members.
3. Enhancing rural social capital. Since a RESC is designed to serve the rural community in which it is located, we argue that enhancing rural social capital could be an effective solution to mitigate the moral hazard issue in the rural e-commerce service sector. First, the public services are more effective in regions with a high-trusting environment (Putnam *et al.*, 1994). The rural residents can access more information from reciprocal interactions between rural community members and kin groups (Grootaert and Van Bastelaer, 2002) and thus can make a better decision on product selection. Second, from a bilateral point of view, reciprocal interactions can also function as a solution to mitigate agency risks in a long-term principal-agent relationship between a RESC operator and rural community members (Fehr *et al.*, 1997; Pouryousefi and Froomean, 2017). Moreover, civic norms and reputation concerns also contribute to the intrinsic motivation and good service attitude of a RESC operator, which further facilitate cooperation between a service provider and his clients (Mailath and Samuelson, 2006).

### 5.2 Potential solutions for the adverse selection problem

We further categorized the RESC operator applicants into two different groups: native villagers and e-commerce entrepreneurs. With most of their lifetimes spent living within a rural community, native villagers are intrinsically motivated to provide the optimal effort to develop their own communities (Besley and Ghatak, 2003, Burgess and Ratto, 2003). However, most villagers lack an effective educational background and do not have proper professional certificates. Moreover, since native households commonly participate in a combination of agriculture and non-agriculture livelihoods, the RESC operation is a part-time job for most of the native operators. In this regard, the major cost for service improvement is his or her time. With household chores, native operators are less elastic with regard to providing comprehensive e-commerce service and improving their skills. Therefore, the hiring of local residents to deliver rural e-commerce service diminishes the need for high-powered incentives but increases training costs and service delays. In contrast, the e-commerce entrepreneurs that include rural migrant workers who return from an urban area, individual investors, and college graduates have an advantage with computer skills and e-commerce operation experience. Their creativity and working experience would contribute to the value-added e-commerce services such as marketing, website and graphic design, and photography. Compared with the native villagers, the fixed cost for e-commerce entrepreneurs to appear in villages is higher, whereas the marginal cost for service quality improvement is relatively small since they take it as a new career. Furthermore, the e-commerce entrepreneurs are more sensitive to incentives. In this regard, we propose two potential solutions for the adverse selection problem as follows:

1. Improving the recruitment process. The education certificates and professional credentials provided by agents enable a principal to distinguish the best agent from all candidates (Spence, 1973). To address the issue of adverse selection in the RESC operator selection, the local governments should allow applicants to demonstrate their skill sets and knowledge and then evaluate their signals carefully. This approach will give the candidates a fair opportunity to compete for the job. Moreover, the intrinsic motivation of a candidate should be checked in interviews with village cadres and neighbors.
2. Designing the optimal subsidy scheme. The *ex-ante* contractual remedy can be used to address the adverse selection problem (Holmstrom and Milgrom, 1991). Based on the conceptual framework introduced in Section 4, we further assumed an operator's ability  $a$  represents his knowledge and skills to provide e-commerce services to meet the needs of rural residents. Let  $a \in A = [\underline{a}, \bar{a}]$ , and its density function is  $f(a) > 0$ . The principal will subsidize the agent under subsidy scheme  $s(a)$  based on the agent's ability. Considering the fact that the RESC operator's ability  $a$  is uncorrelated with the market uncertainty  $\varepsilon$ , we can rewrite the principal's expected utility  $E\pi_G(a)$  and the agent's expected utility  $E\pi_0(a)$  as follow (Hu *et al.*, 2014):

$$E\pi_G(a) = \int_{\underline{a}}^{\bar{a}} \pi_G f(a) da = \int_{\underline{a}}^{\bar{a}} [w - s(a)][ae(a) + l]f(a) da \quad (7)$$

$$E\pi_O(a) = [l + s(a)][ae(a) + l] - \frac{ke(a)^2}{2} - \frac{\rho[l+s(a)]^2\sigma^2}{2} \quad (8)$$

Based on backward induction, the agent would maximize his effort  $\bar{e}(a)$  to maximize his welfare. Therefore, we will obtain a subgame perfect equilibrium by allowing the principal to make the first move, i.e. design and offer a menu of contracts to the agent (Laffont and Martimort 2009). For  $\forall a \in A$ , we have  $\bar{e}(a) \in \text{agmax} E\pi_0(a)$ . The solution to this problem is to solve the first-order condition of Equation 8:

$$\bar{e}(a) = \frac{a[l+s(a)]}{k} \quad (9)$$

Equation 9 suggests that as long as the local government provides a RESC operator with a non-negative subsidy, the operator would respond with a positive effort in return. By substituting Equation 9 into Equation 8, we obtain the following:

$$E\pi_O(a) = l[l + s(a)] + \left(\frac{a^2}{k} - \rho\sigma^2\right) \frac{[l+s(a)]^2}{2} \quad (10)$$

For the native villager applicants, the e-commerce knowledge and skill levels are close, and the average ability is lower than that of the e-commerce entrepreneur applicants. Moreover, native villagers are also bothered by family chores such as farm work at peak harvest times. However, in the absence of e-commerce talents applying for e-commerce service provision in rural China, the recruitment of native villagers is essential to ensure that local residents have access to basic e-commerce services. In this regard, the design of monetary incentives and the provision of technical support are necessary to encourage native villager applicants to spend more time and effort on e-commerce service delivery and improving their abilities and thereby secure RESC financial sustainability.

The equilibrium contract is either one of pooling or separating (Wolfstetter 1999). Regardless of an agent's ability, a pooling contract provides the same incentives for all of the agents, i.e.  $s'(a) = 0$ . Therefore, the compensation for the operator only depends on his efforts. In this case, the principal's problem can be formalized as follows:

$$\begin{aligned} \max_{\{s(a)\}} E\pi_G(a) &= \int_{\underline{a}}^{\bar{a}} [w - s(a)] \left\{ \frac{a^2[l + s(a)]}{k} + l \right\} f(a) da \\ \text{s.t. IC: } s'(a) &= 0 \end{aligned} \quad (11)$$

$$\text{IR: } l[l + s(a)] + \left(\frac{a^2}{k} - \rho\sigma^2\right) \frac{[l+s(a)]^2}{2} \geq \underline{\pi}_O \quad (12)$$

Equation 11 is the Incentive Compatibility Constraint (IC) for the native villager applicants. The equation suggests that  $s_{(1)}^{SB}(a) = C$  ( $C$  is a constant). The superscript  $SB$  means the second-best optima with asymmetrical information, and the subscript (1) suggests that the solution is for the pooling contract scenario. In this case, the principal will provide a pooling contract-based subsidy scheme to the agent. Accordingly, the second-best maximized effort of a RESC operator and the expected utility of a local government and a RESC operator under a pooling contract scheme are as follow:

$$\bar{e}_{(1)}^{SB} = \frac{a[l+C]}{k} \quad (13)$$

$$E\pi_{G(1)}^{SB}(a) = (w - C) \left[ \frac{a^2(l+C)}{k} + l \right] \quad (14)$$

$$E\pi_{O(1)}^{SB}(a) = l(l + C) + \left(\frac{a^2}{k} - \rho\sigma^2\right) \frac{[l+C]^2}{2} \quad (15)$$

Obviously,  $E\pi_{O(1)}^{SB}'(a) > 0$ , which indicates that the agent would have a desire to maximize his effort, because the commission payment from the e-commerce service providers is relevant to it. The RESC operators with

greater ability can earn more rewards by attracting e-tailers and local residents to come for more reliable assistance. Hence, agents always have an incentive to improve their capacity by participating in the training curriculum offered by the local government and e-commerce service providers.

Equation 12 is the IR for the potential native villager employees. For the sake of simplicity, we assumed that all of the applicants have the same reservation profit  $\pi_0$ . In most of the pilot areas, the native villager operator interviewees in our survey indicated that the RESCs were not financially sustainable only based on the commission payments from the e-commerce service providers. In this regard, the local government should ensure that the expected profit of the native operator with the lowest ability is equal to the reservation profit, i.e.  $E\pi_0(a) = \pi_0$ , to prevent the operator from shutting down the RESC.

For the e-commerce entrepreneur applicants, the variance of their e-commerce knowledge and skills is large, which would lead to further different demonstration effects and neighborhood effects on the development of the local e-commerce. Moreover, the offers from e-commerce enterprises are attractive. In this regard, a screening contract employed to recognize the types of entrepreneur applicants and provide monetary incentives is necessary to prevent them from leaving. In addition, a screening contract can also provide more incentives ( $s'(a) > 0$ ) compared with those of a pooling contract ( $s'(a) = 0$ ). Thus, a screening contract is more suitable for e-commerce entrepreneur applicants. The principal's problem is considered as follows:

$$\max_{\{s(a)\}} E\pi_G(a) = \int_a^{\bar{a}} [w - s(a)] \left\{ \frac{a^2[l + s(a)]}{k} + l \right\} f(a) da \quad (16)$$

$$s. t. \quad IC: \begin{cases} s'(a) > 0 \\ s'(a) \left( l[l + s(a)] + \left( \frac{a^2}{k} - \rho\sigma^2 \right) \frac{[l + s(a)]^2}{2} \right) = 0 \end{cases} \quad (17)$$

Under most circumstances, the e-commerce entrepreneurs' IR would not bind at equilibrium since they are in a better financial situation than that of native villagers. By solving the Equation 17, we obtain that under the condition of  $\bar{a} < \sigma(\rho k)^{1/2}$ ,  $s_{(2)}^{SB}(a) = [lk/(\rho k\sigma^2 - a^2)] - 1$ , where the subscript (2) suggests that the solution is for a screening contract scenario. Moreover,  $s_{(2)}^{SB'}(a) = 2[lka/(\rho k\sigma^2 - a^2)^2] > 0$  satisfies the Equation 16.

Since a local government would not provide a negative subsidy plan to a RESC operator, i.e.  $s_{(2)}^{SB}(a) \geq 0$ , we obtain  $a^2 > k(\rho\sigma^2 - l)$ . As mentioned in the previous section that  $l > 0$ ,  $k > 0$ , and  $\rho > 0$ , we further obtain that when  $\rho\sigma^2 \leq l$ , the screening contract-based subsidy scheme  $s_{(2)}^{SB}(a)$  is suitable for potential employees whose ability  $a$  is subjected to  $\underline{a} \leq a \leq \bar{a} < \sigma(\rho k)^{1/2}$ . In the situation where  $\rho\sigma^2 > l$ ,  $a$  is constrained by  $[k(\rho\sigma^2 - l)]^{1/2} < a \leq \bar{a} < \sigma(\rho k)^{1/2}$ . By taking  $s_{(2)}^{SB}(a) = [lk/(\rho k\sigma^2 - a^2)] - 1$  into Equations 9, 4, and 3, the second-best maximized effort of a RESC operator and the expected utility of a local government and a RESC operator under a screening contract are as follow:

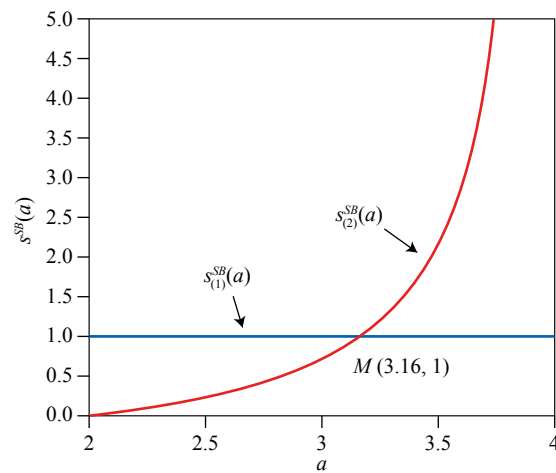
$$\bar{e}_{(2)}^{SB} = \frac{al}{\rho k\sigma^2 - a^2} \quad (18)$$

$$E\pi_{G(2)}^{SB}(a) = \left( w - \frac{lk}{\rho k\sigma^2 - a^2} + l \right) \frac{\rho k\sigma^2 l}{(\rho k\sigma^2 - a^2)} \quad (19)$$

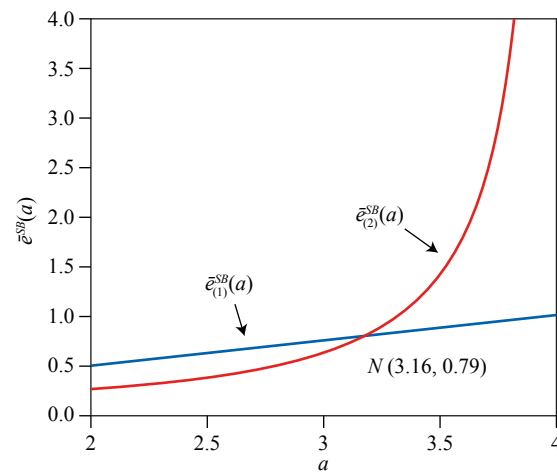
$$E\pi_{O(2)}^{SB}(a) = \frac{l^2 k}{2(\rho k\sigma^2 - a^2)} \quad (20)$$

The results suggest that by employing the screening contract scheme  $s_{(2)}^{SB}(a)$ , the principal can not only encourage the agent to make his best effort but also provides the agent with different compensation schemes depending on his capability. Thus,  $s_{(2)}^{SB}(a)$  provides more incentives than  $s_{(1)}^{SB}(a)$ .

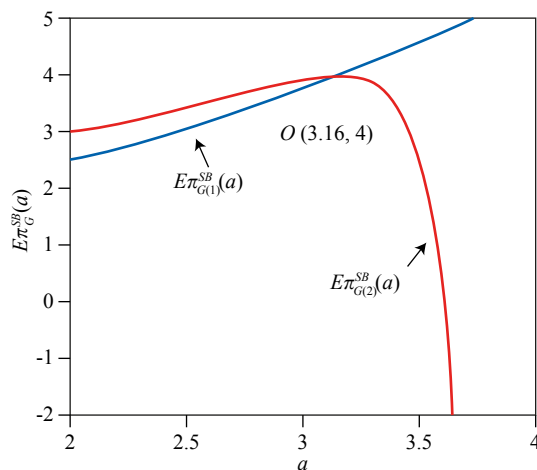
Numerical simulations were used for comparison. For further analysis, we present numerical experiments to compare the pooling contract scheme  $s_{(1)}^{SB}(a)$  and the screening contract scheme  $s_{(2)}^{SB}(a)$ . In Figures 2-5, we plot the agent's second-best maximized effort and the expected utility of the principal and the agent with regard to the agent's ability  $a$  under the different subsidy schemes. More precisely, we assume: g. The following



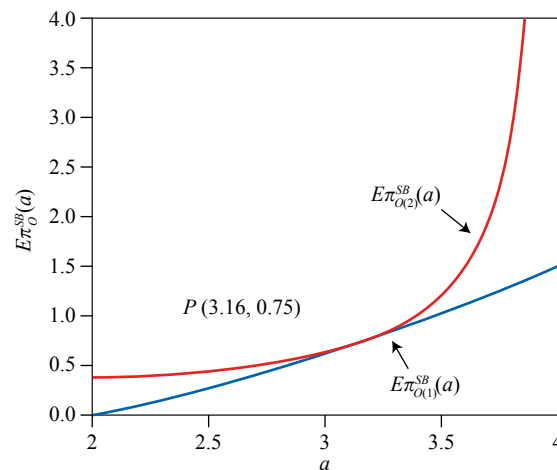
**Figure 2.** Subsidy based on agent's ability.



**Figure 3.** Agent's second-best maximized effort.



**Figure 4.** Local government's expected utility.



**Figure 5.** Rural e-commerce service center operator's expected utility.

numerical experiments are based on the scenario where  $\rho\sigma^2 = 1 > l = 0.75$ . The screening contract scheme is available for the RESC operator whose ability  $a \in (2, 4)$ , since  $2 = [k(\rho\sigma^2 - l)]^{1/2} < a \leq \bar{a} < \sigma(\rho k)^{1/2} = 4$ .

According to Figure 2, the RESC operators will receive the same amount of subsidy from the pooling contract scheme  $s_{(1)}^{SB}(a)$ , whereas the screening contract scheme  $s_{(2)}^{SB}(a)$  provides agents with a different amount of compensation depending on their ability. In addition, a candidate whose ability is within the scope of  $a \in (2, 3.16)$  will benefit more from choosing the pooling contract scheme. The figure further suggests that low-ability candidates would prefer the pooling contract-based subsidy scheme. In contrast, a potential employee with a high capacity, i.e.  $a \in (3.16, 4)$ , will prefer the screening contract scheme because he is able to distinguish himself from the low-ability applicants.

Figure 3 shows that some generalization of the results remains valuable even though Equation 14 indicates that the improvement of the local e-commerce condition  $l$  would increase the reward for a RESC operator under the screening contract, while the rise in the market uncertainty  $\sigma$ , effort cost coefficient  $h$ , and absolute risk coefficient  $\rho$  would reduce the compensation. First, the figure suggests that the agent with higher ability is motivated to exert a high-level effort under both subsidy schemes. Second, the RESC operator's second-best maximized effort  $\bar{e}^{SB}(a)$  is most sensitive to his ability  $a$  under the screening contract-based subsidy scheme.

We further rely on Figure 4 and Figure 5 to illustrate the features of the expected utility of the local government  $E\pi_G^{SB}(a)$  and the RESC operator  $E\pi_0^{SB}(a)$ , respectively, which are plotted using the same parametric as in the previous simulations. Under the pooling contract scheme, a positive correlation is found between the  $E\pi_{G(1)}^{SB}(a)$  and the operator's ability  $a$  in Figure 4. For the case of the screening contract scheme, a positive correlation is detected between the  $E\pi_{G(2)}^{SB}(a)$  and the operator's ability  $a$  within the interval  $a \in (2, 3.16)$ , whereas a negative correlation occurs when  $a$  surpasses 3.16. In the numerical experiment, the  $E\pi_{G(2)}^{SB}(a)$  is equal to the  $E\pi_{G(1)}^{SB}(a)$  at point  $O(3.16, 4)$ . Combined with the information in Figure 2, we conclude that the increase in compensation will in turn reduce the principal's expected utility. For the agent, his expected utility is positively correlated with his ability under either type of contract in Figure 5.

Based on the comparisons above, a rational decision would be for a local government to provide e-commerce entrepreneur applicants with a screening contract-based subsidy scheme. The e-commerce entrepreneurs possess more e-commerce knowledge and skills and thus have a chance to become e-commerce pioneers who can initiate, lead, and shape the local rural e-commerce development (Leong *et al.*, 2016). Moreover, the e-commerce entrepreneurs are more sensitive to incentives. However, the disadvantage of high-powered incentives is that excessive incentives may decrease the principal's utility and crowd out the agent's intrinsic motivation (Jensen and Stonecash, 2005). In this regard, a pooling contract scheme is more suitable for native villagers.

## 6. Conclusions and implications

Digital technologies have changed our lives, but the inequality in benefits from applying these tools should not be ignored (WorldBank, 2016). To achieve broader development benefits in the rapid growth of the Chinese rural e-commerce market, an upgrade is required in the rural public e-commerce service in terms of quality, effectiveness, and accessibility.

This study focuses on the Chinese top-down ICT4D project that has been widely implemented in underdeveloped areas in mid- and Western China. As the essential component of the project, we describe the responsibilities of the RESCs and the services that are currently available to deliver. We further discuss the tension among the RESC operators, local governments, and e-commerce service providers. The potential impact of moral hazard and adverse selection on a RESC operator's service performance is discussed under the principal-agent framework. A distinctive model such as ours is necessary as the rural e-commerce service delivery in rural China is influenced by a series of unique and realistic factors. Solutions that include developing a service evaluation system, promoting the usage of ICTs, and enhancing rural social capital are proposed to address the moral hazard issue.

Similar to the ICT4D projects implemented in other countries (Best and Kumar, 2008; Proenza, 2001), the long-term sustainability of the RESCs is the key to the success of the project 'e-commerce goes into rural areas'. Other than the pursuit of business revenue, the RESC operator is also responsible for promoting the policy of the local government and sharing the latest news and technology. The implementation of the appropriate governance mechanism from the principal-agent perspective is one of the many effective methods to enhance the long-term sustainability of RESCs. Effective collaborative relationships among the participants can enhance the efficiency and effectiveness of the technical and institutional support that the local governments and e-commerce service providers provide and thus result in a positive impact on the long-term sustainability of RESCs. Specifically, staff should be hired that can make the right decisions, and talented professionals should be brought in with a thorough and detailed hiring process. A costless and easily conducted performance monitoring and evaluation system will decrease the opportunistic behavior of RESC operators. By enhancing the reciprocal interactions among villagers within a rural community, a stronger social net can contribute to the desired outcome for both the RESC operator and the community members. The RESC operators also have to provide considerate service to attract customers in a highly competitive environment where rural villagers are becoming familiar with and capable of e-commerce themselves. Furthermore, financial support and monetary incentives are necessary to help the RESC operators avoid the



distractions from both household chores and tempting offers and thus allow them to commit to the RESC operation, which in turn will increase social welfare and promote the long-term sustainability of RESCs.

Although the goal and service content of a public ICT center vary from projects implemented in different scenarios (e.g. nation, leading organization, ICT deployment), and the principal-agent model developed in this research is within the context of China, some generalization of the results remains valuable for rural ICT service delivery and the development of programs in other countries. The agency problems such as moral hazard and adverse selection are prevalent in the public service sector. The implementation of an appropriate governance mechanism can reduce the agency problems and enhance the efficiency and effectiveness of the project, thereby promoting the long-term sustainability of the project. Moreover, in our research, the rural e-commerce services provided by the RESC operators are limited to basic supportive activities. In the near future, rural inhabitants will have increasing demands on services including online marketing, online store management, website and graphic design, and other e-commerce related consulting services. Those value-added services are hard to measure and will give rise to other agency problems such as multitasking and common agency issues. Therefore, the further investigation by scholars of the principal-agent relationships between the participants in the rural e-commerce service sector would be beneficial.

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