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SPECIAL ISSUE

Female leadership, internet use, and performance of agricultural cooperatives in Vietnam

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Abstract

Supporting agricultural cooperatives might contribute to the livelihood improvement of many small-scale farmers in developing countries. This research examines the factors affecting the internet use of agricultural cooperatives with a focus on female leadership, its effects on cooperatives' economic, social, and innovative performance, and the distributional effects of internet use on economic performance. Our analysis relied on the data of 3,512 agricultural cooperatives collected in 2021 from Vietnam. We addressed the endogeneity issue of internet use in impact assessment by employing an instrumental variable approach. Our results show that female leadership was positively and significantly associated with internet use and that internet use had a positive and significant effect on returns on assets, returns on equity, labor productivity, payment per laborer, contribution to labor union and insurance per laborer, and innovation in products of agricultural cooperatives. In addition, unconditional quantile regressions show

that internet use in agricultural cooperatives exacerbated income inequality. Enhancing female leadership and promoting rural education were recommended to improve agricultural cooperatives' performance.

KEYWORDS
endogeneity, heterogeneity, instrumental variable, internet use, performance

1 | INTRODUCTION

Many of the world's poor depend on agriculture for their livelihoods; most of them are small-scale farmers and live in developing countries where they face various constraints that impede them from taking advantage of market opportunities (Fischer and Qaim, 2012). Small-scale farmers often live in poor areas with limited infrastructure and face high transaction costs for both agricultural input and output exchange (Barrett, 2008). Farmer organizations, cooperatives, and other forms of collective action are thus expected to be a venue to reduce high transaction costs (Valentinov, 2007), improve the economies of scale (Hoang et al., 2021; Ma et al., 2023), and increase the bargaining power of their members (Su & Cook, 2020). They also play an important role in facilitating agricultural technology adoption and innovations among their members (Ma et al., 2022; Jabbouri et al., 2022; Zhang et al., 2020). Other advantages of agricultural cooperatives might include, for example, increases in farm productivity and income, farm sustainability, and gender equality (Candemir et al., 2021; Govindapuram et al., 2022; Ferguson & Kepe, 2011; Fischer & Qaim, 2012; Ho et al., 2017; Lijia & Xuexi, 2014; Nguyen et al., 2017; Ma et al., 2022; Sarpong-Danquah et al., 2022; Zheng et al., 2023). In this regard, supporting agricultural cooperatives might improve the livelihoods of many small-scale farmers in developing countries.

In several developing countries, agricultural cooperatives face challenges that significantly affect their performance. From the production side, the development of cooperatives mainly relies on the expansion of production resources (e.g., using more land and/or more labor) rather than the improvement of productivity (e.g., using more advanced technologies) (Grashuis & Su, 2019). From the market side, cooperatives struggle to market their products, contact business partners, and inform customers (Cristobal-Fransi et al., 2020). One of the opportunities that might be useful for improving the performance of agricultural cooperatives in developing countries is the rapid development of information and communication technology (ICT) in general and the internet in particular, which is becoming available to an increasing share of the global population (Goldfarb & Tucker, 2019; Nguyen et al., 2023). Using these new ICTs such as the internet might benefit agricultural cooperatives by reducing transaction and information costs, providing them with better access to information, knowledge, and technology (Ma et al., 2022; Nguyen et al., 2021; United Nations, 2018), improving the efficient use of agricultural inputs such as fertilizers, and promoting the adoption of sustainable farming practices (Kaila & Tarp, 2019; Ma & Wang, 2020). These would help improve their performance by increasing productivity and improving market coordination (Galperin & Fernanda Viecens, 2017; FAO, 2018; Lio & Liu, 2006). However, the number of cooperatives adopting these new ICTs, including the internet, appears to be low (Bastida et al., 2022). This raises the need to examine the factors affecting internet use of agricultural cooperatives.

Women in several developing countries are often considered disadvantaged with low literacy rates, poor access to education, and limited economic and social mobility (Lechman, 2019). They have to devote more of their time to family obligations (unpaid work) such as household chores, and taking care of children than men. At the same time, they might also have to engage in paid activities (Nguyen & Do, 2022). The burden of work is even heavier for those women with leading positions in their workplaces. In recent years, the expansion of internet access has brought broad opportunities for women to improve literacy, education, and skills which help them gain better access to the formal economy (Lechman, 2019). Collective business models such as cooperatives have been found to be more suitable for women as an entrepreneurial activity (Bastida et al., 2022). Internet use can help female leaders save time in several activities such as looking for and contacting business partners, and reducing costs of trade settlement (Nguyen & Do, 2022; Zanello et al., 2014). However, the association between female leadership and internet use in collective businesses such as agricultural cooperatives has not been adequately studied. In addition, previous studies on the factors affecting internet use and its welfare impact in rural areas of developing countries focused on rural individuals or households (Kaila & Tarp, 2019; Ma & Wang, 2020; Nguyen et al., 2022). This is because it is easy to know whether these individuals or households have used the internet. The issue has been paid less attention when it is a group of rural individuals or households such as agricultural cooperatives because each cooperative usually consists of several members and is managed by a group of people such as a management board.

Against the above background, our research aims at addressing the following research questions: (i) How is female leadership associated with internet use of agricultural cooperatives? (ii) How does internet use influence their performance? and (iii) How are the economic benefits of internet use distributed among agricultural cooperatives? Addressing these questions provides useful information for policy responses to design development programs to stimulate efficient and inclusive economic growth. Our study contributes to the current literature in several ways. First, the association between internet use and female leadership of agricultural cooperatives as a form of collective business models has been ignored in the previous studies. This is accounted for in our study as one of the factors affecting internet use of agricultural cooperatives. Second, previous studies focused on economic performance, and our study assesses the impacts of internet use on economic, social, and innovative performance. Third, previous studies focused more on the economic gains from internet use, but largely ignored how the gains were distributed. Our study evaluates the distribution of the gains and thus is able to identify who benefits more from internet use.

We use the data of agricultural cooperatives from Vietnam, an emerging economy in Southeast Asia, because of several reasons. First, Vietnam is among the fastest-growing economies in the world, but a large proportion of its population still lives in rural areas and relies mainly on agriculture for their livelihoods (Nguyen et al., 2021; Schulte et al., 2023). Second, Vietnam used to belong to a former communist bloc with a centrally planned economic system in which all agricultural cooperatives were state-owned. The poor performance of the former state-owned agricultural cooperative system in the past and the fact that Vietnam is still a communist country means that an examination of the current agricultural cooperatives is needed, especially after the amendment of the national cooperative law in 2012 (Hong, 2017). Third, cooperatives in Vietnam are usually led by a management board in which the president is the highest position and is chosen by their members. Therefore, examining the gender aspect of this top position is significant in supporting women empowerment in developing countries. Fourth, internet development has been very rapid in Vietnam during the last decade. The share of internet users in 2019 was more than 70% of its population (ITU, 2020), and the internet has been available and affordable

in many rural areas in Vietnam (Kaila & Tarp, 2019). Thus, it is interesting to see how agricultural cooperatives take this opportunity to improve their performance.

The remaining parts of this paper are organized as follows. Section 2 presents the conceptual framework and reviews the previous literature to highlight the contributions of our study. Section 3 describes the data and methodology. Section 4 presents and discusses the empirical results. Section 5 concludes with policy implications and the outlook for future studies.

2 | CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 | Conceptual framework

We start with the potential factors determining internet use of an agricultural cooperative. The management board led by its president of the cooperative decides to use the internet if the perceived net (social) benefit from using the internet for the cooperative is positive. This perception depends, theoretically, on several factors, including the characteristics of the management board. One of the benefits from using the internet is that it helps users save time (and probably also money) from looking for information needed for business activities and contacting business partners. Therefore, in addition to the fact that the age and education level of management board members have been found to be important in affecting internet use (Khanal et al. 2015; Ojo et al., 2019; Yang et al., 2021), female leadership is expected to be positively associated with internet use because female leaders understand more the benefit of using the internet in saving their time, which is relatively more constrained than men's time. In fact, women are also well-known for being constrained from economic and social mobility due to the "double burden" created by their responsibilities for unpaid family obligations and paid working activities (Lechman, 2019; Nguyen & Do, 2022). This burden is heavier for cooperatives' female leaders. Internet use in the workplace, therefore, can help female leaders save time and money in business activities such as governing and managing their cooperatives, looking for and contacting business partners, and reducing costs of trade settlement (Nguyen & Do, 2022; Zanello et al., 2014).

The potential mechanism through which internet use can help improve the performance of the cooperative is that it can reduce transaction costs (Garicano & Kaplan, 2001; Goldfarb & Tucker, 2019) via better market coordination and increase productivity via more efficient use of inputs and adoption of sustainable farming practices (Ma & Wang, 2020). Without internet use, the costs for communication, search, price discovery, and trade settlement are relatively higher (Lee & Clark, 1996). For instance, when the marketing shifts to online platforms by using the internet, the cooperative can lower its search costs, replication costs, tracking costs, and verification costs (Goldfarb & Tucker, 2019). Using internet banking for financial transactions can also help the cooperative reduce its operation costs (e.g., going to the bank to make a financial transaction or withdraw money to pay for purchases). Internet users can reduce their costs for search and trade settlement (Lee & Clark, 1996; Troy & Michael, 1999). Internet use can also provide more and rapid information on new technologies and thus facilitate the adoption of innovations (FAO, 2018; Lio & Liu, 2006; Ma et al., 2022; Ma & Wang, 2020; Nguyen et al., 2021). Further, it might increase the awareness of the cooperative's leaders to act in a more socially acceptable manner, such as to care more about the welfare of their employees and to understand better the benefits of innovations. In these ways, internet use is expected to improve the performance of the cooperatives in economic, social, and innovative terms. However, as the ability to take the opportunities brought by internet use is different among individuals, farmers, and organizations, there might be heterogeneities in the

gains from internet use among agricultural cooperatives. For instance, large cooperatives might be able to benefit more than small ones. Several previous studies showed that these heterogeneities existed for farmers in Vietnam (Nguyen et al., 2023) or in China (Ma & Wang, 2020).

In summary, we expect that (i) female leadership is positively associated with internet use of agricultural cooperatives, (ii) internet use has a positive effect on the performance of agricultural cooperatives, but (iii) the benefits from using the internet are heterogeneous among agricultural cooperatives.

2.2 | Literature review

Regarding the factors affecting internet use, empirical evidence is available with household data (for example, Chang & Just, 2009; Mishra & Park, 2005; Nguyen & Do, 2022; Nguyen et al., 2022; Yang et al., 2021), but only a few with cooperative data (Cristobal-Fransi et al., 2020; Dholakia & Kshetri, 2004). These studies showed that fixed assets, the number of laborers (size), and the fields of business were key variables affecting cooperatives' digitalization, while external factors such as regional indicators did not have a significant correlation with the digitalization (Hejkrlik et al., 2021; Yueh et al., 2013). Khanal et al. (2015) found that the operator's age had a negative correlation, while the operator's education was positively correlated with internet adoption. Lack of computer skills and knowledge could be a significant constraint for internet use (Briggeman & Whitacre, 2010; Yang et al., 2021). These studies revealed that the decision to use the internet depended on the availability of internet connection and the characteristics of adopters. Since the internet connection in Vietnam is available throughout the country, agricultural cooperatives have a choice to use or not to use the internet; hence their characteristics and resources are the major factors determining their use of the internet.

Even though the literature shows that there is a difference in the purpose of internet use between males and females (Ojo et al., 2019) and the impact of internet use has also been found to be different between males and females (Nguyen & Do, 2022), there are only a few studies accounting for the gender aspect in examining the association between internet use and the performance of cooperatives (Ferguson & Kepe, 2011; Bastida et al., 2022), and their findings are inconclusive. On the one hand, Campbell & Mínguez-Vera (2008) found that the share of female leaders on the board of directors positively affected firms' financial performance. On the other hand, Carter et al. (2010) concluded that no significant relationship existed between female leadership and firms' financial performance. However, the role of female leadership in adopting the internet in the operation of agricultural cooperatives has been largely ignored (Campbell & Mínguez-Vera, 2008; Dholakia & Kshetri, 2004).

Empirical evidence on the impacts of internet use on the performance of agricultural cooperatives in developing countries is limited (Khanal et al., 2015) and their findings are also inconclusive. Some studies found that internet use positively affected firms' productivity and innovation capacity (Paunov & Rollo, 2016), while some other studies pointed out that ICTs had causal effects on firms' scale but did not affect firms' productivity (DeStefano et al., 2018). Besides, internet use, such as email and internet banking, had no significant influence on productivity (Colombo et al., 2013).

In addition, several other research gaps need further attention. First, while women belong to disadvantaged groups in using the internet (Goldfarb & Prince, 2008; Lassithiotaki & Roubakou, 2014), the aspect of gender has been ignored in previous studies, especially when women take leadership. In our study, two gender-related variables, namely the gender of cooperatives' presi-

dents and the share of female labor in cooperatives, are taken into account in the estimations of the factors affecting internet use in cooperatives and the impacts of internet use on cooperatives' performance. The results from these estimations are expected to enrich the literature on the role of women in agricultural cooperatives in developing countries. Second, we consider several aspects of cooperatives' performance instead of only a single indicator of productivity. Notably, we examine the impact of internet use on (i) economic performance and productivity; (ii) social performance; and (iii) innovative performance. The evidence on the effects of internet use contributes to the fulfilment of the so-called "productivity paradox" (Galperin & Fernanda Viecens, 2017). Third, we assess the distribution of economic benefits from internet use for agricultural cooperatives to enrich the literature regarding the problem of inequality. Last, we overcome the endogeneity problem of internet use in impact assessment by using an internal instrumental variable approach.

In this study, we use the cross-sectional data from 3,512 agricultural cooperatives collected in Vietnam to examine those issues. We first use a Probit model to identify the factors affecting the internet use of agricultural cooperatives. Next, we use the heteroskedasticity-based instrumental variable (IV) approach proposed by Lewbel (2012) to examine the effects of internet use on different indicators of cooperatives' performance. Last, we use an unconditional quantile regression (UQR) model to capture the heterogeneous impacts of internet use on the economic benefits of agricultural cooperatives. Since cooperatives are important to many developing countries where the farm size is small (Eastwood et al., 2010), the findings from our study could also be relevant to other developing countries with similar characteristics as Vietnam.

3 | DATA AND METHODOLOGY

3.1 | Source and description of data

We use the data from the Economic Census 2021 from the General Statistics of Vietnam (GSO) (see https://www.gso.gov.vn/en/economic-census/ for further information). The data in this round include the operational information in the year 2020 of (i) firms and cooperatives; (ii) individual businesses in the non-agricultural sector; (iii) state-owned businesses; (iv) associations; and (v) non-governmental organizations. Those groups are engaged in 19 different economic sectors in Vietnam, for example, agriculture-forestry-aquaculture, manufacturing, transportation, retailing, communication and technology, and education. This economic census is conducted every five years. In this study, we use the cross-sectional data of the most recent wave of the economic census in 2021 due to the availability of internet use information.

Roughly 15,300 cooperatives participated in the economic census 2021 (GSO, 2022) of which about 7,000 cooperatives are in the agricultural sector (including those in agriculture, forestry, and aquaculture). Their main function is to support their members by providing the services needed for agricultural production, such as input supply, irrigation, and access to credit. We use the data from three sections (i) information of cooperatives' management boards (gender, age, and education of presidents and other members of management board) and the number of cooperatives' members, (ii) information of cooperatives' resources such as land areas, equipment and machines, and if they use the internet for the operation, and (iii) information of cooperatives' performance (see Appendix 1 for the detailed name, definition, and measurement of variables). Among these 7,000 agricultural cooperatives, 2,000 were reported to be inactive at the time of the census (temporarily shut down, already shut down but still waiting for a dissolution, or already declared bankruptcy). From the remaining 5,000 active agricultural cooperative, about 1,500 were further excluded as they did not fully report their performance data. Hence, the final sample includes

TABLE 1 Descriptive statistics of agricultural cooperatives' performance

Variables	Whole sample ($n = 3512$)	By internet use: No ($n = 1887$)	By internet use: Yes ($n = 1625$)	By gender of president: Male ($n = 3299$)	By gender of president: Female ($n = 213$)
A. Economic performance					
Revenue (mil. VND)[c]	1340.24	890.76	1862.20***, [a]	1343.42	1291.06 [a]
	(3887.97)	(2145.28)	(5179.63)	(3977.96)	(2042.73)
Profit (mil. VND)	87.28	98.01	74.82 [a]	87.15	89.20 [a]
	(644.64)	(383.44)	(852.86)	(657.68)	(391.37)
Total assets (mil. VND)	2390.36	1811.30	3062.79***, [a]	2392.17	2362.37 [a]
	(7336.58)	(7849.23)	(6631.41)	(7325.79)	(7519.29)
Total equity (mil. VND)	1828.78	1368.47	2363.31***, [a]	1841.33	1634.42 [a]
	(5324.00)	(5973.18)	(4394.69)	(5201.85)	(6959.82)
Returns on assets (%)	16.56	22.71	9.43***, [a]	16.76	13.48 [a]
	(73.95)	(78.84)	(67.15)	(74.57)	(63.62)
Returns on equity (%)	23.59	32.60	13.12***, [a]	23.73	21.46 [a]
	(100.27)	(108.79)	(88.26)	(100.35)	(99.33)
Labor productivity (mil. VND per laborer)	277.29	184.74	384.75**, [a]	278.96	251.39 [a]
	(2934.96)	(772.07)	(4231.93)	(3025.39)	(518.84)
B. Social performance					
Payment per laborer (mil. VND per laborer)	23.62	20.35	27.41***, [a]	23.21	29.95***, [a]
	(23.28)	(20.29)	(25.82)	(22.97)	(26.87)
Contribution to union and insurance (mil. VND per laborer)	1.55	1.05	2.13***, [a]	1.55	1.65 [a]
	(3.61)	(3.07)	(4.08)	(3.60)	(3.76)
C. Innovative performance					
Innovation in production process (yes = 1)	0.11	0.06	0.17***, [b]	0.10	0.16**, [b]
	(0.31)	(0.23)	(0.37)	(0.31)	(0.37)
Innovation in products (yes = 1)	0.08	0.04	0.13***, [b]	0.08	0.14***, [b]
	(0.27)	(0.20)	(0.34)	(0.27)	(0.35)

Standard deviations in parentheses.
[a]Two-sample *t*-test;
[b]Non-parametric two-sample rank-sum test;
[c]1 US$ is approximately 23,125 Vietnam Dong (VND) in December 2020.
***$p < 0.01$,
**$p < 0.05$,
*$p < 0.1$.

3,512 agricultural cooperatives across Vietnam (see Appendix 2 for the distribution of active agricultural cooperatives by geographical region). Since the attrition rate is high, our empirical results should be interpreted with care.

Table 1 stacks the descriptive statistics of agricultural cooperatives' performance in the three aspects of interest, namely economic, social, and innovative performance, by the status of internet use and the gender of the president. Regarding economic performance, it appears that

cooperatives with internet use have higher revenue, higher total assets, higher labor productivity, and higher total equity than those without internet use. However, the returns on assets (ROA) and returns on equity (ROE) of the former are lower than those of the latter. Regarding the gender aspect of the presidents, the descriptive statistics of male-presided and female-presided cooperatives show that the differences in all economic performance indicators are not statistically significant between the two groups. Regarding social performance, cooperatives with internet use have a higher payment and higher contribution to labor union funds and insurance per laborer. Female-presided cooperatives have a higher payment per laborer. Regarding innovative performance, cooperatives with internet use and female-presided cooperatives are more likely to conduct innovations in the production process and products.

Table 2 reports the descriptive statistics of agricultural cooperative characteristics. Only 6% of agricultural cooperatives have a female president, and the figure is slightly higher in cooperatives using the internet. Those with a younger president or a higher education level of the presidents or management board members are more likely to use the internet. Cooperatives with a higher share of female laborers, a higher number of laborers, and a higher number of members tend to use the internet more. Presidents and management board members of female-presided cooperatives are better educated and younger. In addition, although female-presided cooperatives have a lower number of laborers and a lower number of members, they have a higher share of female laborers. Cooperatives engaging in livestock are more likely to use the internet, while those engaging in aquaculture are not. Female-presided cooperatives are more likely to work in the fields of livestock and aquaculture than male-presided ones. There are no significant differences in internet use between cooperatives in delta and coastal regions. The differences in productive assets are significant in the numbers of boats, water pumps, tractors, combine harvesters, vehicles, and other equipment and machines. There are no significant differences in the numbers of productive assets between the two groups of male and female-presided cooperatives.

3.2 | Methodology

3.2.1 | Identifying the factors affecting internet use of agricultural cooperatives

In the first step, we identify the factors affecting internet use of agricultural cooperatives. As conceptualized and reviewed in Section 2, when the internet is available, the use of the internet of agricultural cooperatives is mainly affected by their internal characteristics rather than external ones. A dummy variable (R) represents whether a cooperative uses the internet. R is equal to one if the cooperative uses the internet in its operation and equal to zero otherwise. Thus, the probability of internet use of cooperative i can be estimated using a Probit regression as:

$$P(\mathrm{R}_i = 1) = \alpha_0 + \alpha_1 FE_i + \alpha_2 X_i + \varepsilon_i \quad (1)$$

where P is the probability of internet use; FE represents the female leadership which is equal to 1 if the president is a female, and 0 otherwise; X is a vector representing the characteristics such as demographic characteristics, geographical characteristics, and productive assets; and ε is the error term. Demographic characteristics included in our studies are: the education and age of the president, the education and training participation of management board members, the share of female laborers, the number of laborers (in logarithm), and the number of cooperatives' members

TABLE 2 Descriptive statistics of agricultural cooperatives' characteristics

Variables	Whole sample ($n = 3512$)	By internet use		By gender of the president	
		No($n = 1887$)	Yes($n = 1625$)	Male($n = 3299$)	Female($n = 213$)
A. Demographic characteristics					
Gender of cooperative's president (female president = 1)	0.06	0.05	0.07**, [b]		
	(0.24)	(0.22)	(0.25)		
President with vocational training degree or higher (yes = 1)	0.26	0.19	0.34***, [b]	0.26	0.38***, [b]
	(0.44)	(0.40)	(0.48)	(0.44)	(0.49)
Age of president (years old)	53.29	54.07	52.39***, [a]	53.67	47.52***, [a]
	(9.82)	(9.62)	(9.98)	(9.68)	(10.24)
Training of management board members (yes = 1)	0.51	0.48	0.56***, [b]	0.51	0.48 [b]
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Management board members with vocational training degrees (yes = 1)	0.10	0.06	0.14***, [b]	0.09	0.16***, [b]
	(0.30)	(0.24)	(0.34)	(0.29)	(0.37)

(Continues)

TABLE 2 (Continued)

Variables	Whole sample ($n = 3512$)	By internet use		By gender of the president	
		No($n = 1887$)	Yes($n = 1625$)	Male($n = 3299$)	Female($n = 213$)
Share of female laborers (%)	21.66	19.71	23.94***, [a]	19.93	48.53***, [a]
	(21.14)	(21.13)	(20.94)	(19.32)	(28.67)
Number of laborers	9.68	8.65	10.88***, [a]	9.83	7.37***, [a]
	(9.58)	(8.15)	(10.90)	(9.73)	(6.52)
Number of members	458.72	338.89	597.86***, [a]	471.47	261.13***, [a]
	(868.95)	(738.15)	(981.64)	(881.43)	(614.12)
B. Cooperative type and land area					
Total land areas (ha)	1124.72	1534.30	649.10 [a]	1187.96	145.23 [a]
	(43224.50)	(58292.27)	(9626.97)	(44597.16)	(892.19)
Livestock cooperative (yes = 1)	0.02	0.02	0.03 [b]	0.02	0.05***, [b]
	(0.15)	(0.15)	(0.16)	(0.15)	(0.22)
Aquaculture cooperative (yes = 1)	0.02	0.03	0.02***, [b]	0.02	0.04 [b]
	(0.15)	(0.17)	(0.13)	(0.15)	(0.19)
C. Geographical characteristics					
Delta region (yes = 1)	0.48	0.48	0.48 [b]	0.49	0.34***, [b]
	(0.50)	(0.50)	(0.50)	(0.50)	(0.48)
Coastal region (yes = 1)	0.38	0.37	0.39 [b]	0.38	0.34 [b]
	(0.48)	(0.48)	(0.49)	(0.49)	(0.47)
D. Productive assets					

(Continues)

TABLE 2 (Continued)

Variables	Whole sample ($n = 3512$)	By internet use		By gender of the president	
		No($n = 1887$)	Yes($n = 1625$)	Male($n = 3299$)	Female($n = 213$)
Number of boats	0.10	0.15	0.04***, [a]	0.10	0.01 [a]
	(1.00)	(1.30)	(0.43)	(1.03)	(0.15)
Number of electric generators	0.28	0.24	0.32 [a]	0.27	0.32 [a]
	(1.60)	(1.31)	(1.88)	(1.61)	(1.53)
Number of water pumps	2.88	2.13	3.76***, [a]	2.94	2.06 [a]
	(10.44)	(5.70)	(14.01)	(10.59)	(7.64)
Number of seed-sowing machines	0.12	0.08	0.16 [a]	0.12	0.04 [a]
	(1.52)	(1.28)	(1.76)	(1.57)	(0.24)
Number of tractors	0.08	0.06	0.10**, [a]	0.09	0.02 [a]
	(0.62)	(0.55)	(0.69)	(0.64)	(0.22)
Number of combine harvesters	0.08	0.05	0.10**, [a]	0.08	0.03 [a]
	(0.69)	(0.48)	(0.88)	(0.71)	(0.42)
Number of vehicles	0.04	0.03	0.06**, [a]	0.04	0.08 [a]
	(0.34)	(0.28)	(0.40)	(0.34)	(0.31)
Number of other equipment and machines	5.51	4.14	7.10**, [a]	5.64	3.54 [a]
	(29.58)	(21.13)	(36.98)	(30.41)	(9.98)

Standard deviations in parentheses.
[a]Two-sample *t*-test;
[b]Non-parametric two-sample rank-sum test.
***$p < 0.01$,
**$p < 0.05$,
*$p < 0.1$.

(in logarithm). We also include the total land area (in logarithm) and control for the cooperative categories (livestock or aquaculture with crop production as the bases) and geographical locations (delta or coastal region with the mountainous region as the base). We include important physical assets for production, such as the number of boats, electric generators, water pumps, seed-sowing machines, tractors, combine harvesters, vehicles, and other equipment and machines. The choice of these assets is based on previous studies (Cristobal-Fransi et al., 2020; Dholakia & Kshetri, 2004; Khanal et al., 2015; Seewald et al., 2023; Yueh et al., 2013).

Furthermore, we examine the combined effect of gender and education of the president by including an interaction term between these two variables as follows:

$$P(\mathrm{R}_i = 1) = \beta_0 + \beta_1 FE_i + \beta_2 FE_i * EDU_i + \beta_3 X_i + \varepsilon_i \quad (2)$$

where EDU is the education of the president and ε is the error term; other variables are defined as in Equation (1). We check for the potential multicollinearity problem among independent variables in our model. The Variance Inflation Factor (VIF) values show that there are no severe multicollinearity problems (see columns (1) and (2) in Appendix 3 for the VIF values of Equations (1) and (2), respectively). We bootstrap and cluster our estimations at the provincial level to obtain robust standard errors and to prevent spatial autocorrelation.

3.2.2 | Examining the effects of internet use on agricultural cooperatives' performance

In the second step, we examine the effects of internet use on agricultural cooperatives' performance as follows:

$$Y_i = \gamma_0 + \gamma_1 R_i + \gamma_2 FE_i + \gamma_3 X_i + \eta_i \quad (3)$$

where Y_i represents a measure of the cooperative i's performance and η_i is the error term. We use three groups of indicators representing the performance of agricultural cooperatives, namely (i) economic performance, (ii) social performance, and (iii) innovative performance. For economic performance, we use three indicators, namely returns on assets (ROA), returns on equity (ROE), and labor productivity (in logarithm). For social performance, we use two indicators, namely the payment per laborer (e.g., wages and extra payment to laborers) and contribution per laborer (e.g., contribution to the budget of labor union, social insurance, medical insurance, and unemployment insurance). Both of these social indicators are converted into logarithms. For innovative performance, we use two dummies, one is whether the cooperative had an innovation in the production process, and the other one is whether the cooperative had an innovative product in the last year.

Estimating Equation (3) is challenging because R_i is endogenous, as explained in Equation (1). Further, there might be a reversed causality between internet use and performance. We address these issues by employing an instrumental variable (IV) approach, which follows the heteroskedasticity-based identification strategy developed by Lewbel (2012) and Baum et al. (2012). In this approach, the endogenous variable (internet use denoted as R_i) is regressed in the first stage as:

$$R_i = \delta_0 + \delta_1 Z_i + \xi_i \quad (4)$$

where Z includes both X and FE defined above and ξ_i is the error term. Theoretically, this heteroskedasticity-based IV method employs the estimated residuals of independent variables (Z_i) from the first stage to create internal IVs for the second stage. Lewbel (2012) and Baum et al. (2012) propose to employ the estimated residuals $[Z_i - E(Z_i)]\hat{\xi}_i$ as internal IVs for R_i in estimating Equation (3), where $\hat{\xi}_i$ is the predicted residuals obtained from the estimation of Equation 4. These internal IVs are valid because $[Z_i - E(Z_i)]\hat{\xi}_i$ is uncorrelated with $_i$ in Equation (3) (Nguyen et al., 2021). This approach assumes there is an existence of heteroskedasticity in ξ_i. We check for the presence of heteroskedasticity in our model (Equation (3)) using the Pagan–Hall statistic for homoskedastic, the Breusch–Pagan/Cook–Weisberg test for heteroskedasticity, and the White's test for homoscedasticity. The results of these tests (in Appendix 4) confirm the presence of heteroskedasticity. Next, we conduct several quality tests, namely the under-identification test (a LM test based on Kleibergen & Paap, 2006), the weak identification test (Kleibergen–Paap rk Wald F statistics), and the over-identification test (Hansen J statistic test) to check for the appropriateness of these internal IVs. The results of these tests presented in Tables 4 and 5 show that these IVs are valid. Then, we check for the problem of multicollinearity by using the VIF values. The results of VIF values of the independent variables in Equation (3) do not show a problem of multicollinearity (see column (3) of Appendix 3). The robust standard errors are clustered at the provincial level to prevent spatial autocorrelation.

3.2.3 | Determining the distributional effects of internet use on agricultural cooperatives' economic performance

The economic effects of internet use determined from Equation (3) only provide a mean-based estimation of the economic performance of agricultural cooperatives. Hence, we further examine who benefit(s) more in the last step with regard to economic performance. We use an unconditional quantile regression (UQR) model proposed by Firpo et al. (2009) to estimate the distribution. This UQR model estimates unconditional partial effects of changes in the distribution of independent variables (the economic performance of agricultural cooperatives) on the distributional statistic of the outcomes (Rios-Avila, 2020). Furthermore, the UQR model not only includes robust and clustered standard errors but also considers the effects of independent variables on unconditional quantiles of dependent variables (Baltagi & Ghosh, 2017). The procedure of this UQR model includes two steps (Borgen, 2016). In the first step, the re-centered influence function (RIF) is calculated as follows:

$$RIF\,(P; q_\tau,\ F_P) = q_\tau + \frac{\tau - 1\{P \le q_\tau\}}{f_P\,(q_\tau)} \tag{5}$$

where q_τ is the value of the economic performance, P, at the quantile τ. In our case, P denotes three economic outcomes of cooperatives, namely (i) revenue, (ii) profit, and (iii) labor productivity. F_P presents the cumulative distribution function of outcome variable P, and $f_P(q_\tau)$ is the density of P at q_τ. In Equation (5), $1\{P \le q_\tau\}$ is an indicator function that identifies whether the value of outcome variable P is below q_τ.

In the second step, the impacts of internet use on three indicators of cooperatives' economic performance is estimated by:

$$I\,[RIF\,(P_i; q_\tau)\,|X, FE, R] = \theta_0 + \theta_1 R_i + \theta_2 FE_i + \theta_3 X_i + \mu_i \tag{6}$$

where μ is the error term. To facilitate the interpretation of UQR models, we calculate the unconditional partial effects of internet use as explained by Rios-Avila (2020) as follows:

$$\phi = \frac{\partial \upsilon (F_P)}{\partial \bar{R}_k} \tag{7}$$

We address the endogeneity concerns in Equation (6) using the same procedure as in estimating Equation (3). First, we estimate Equation (3) and generate the internal IVs using the heteroskedasticity-based method. We then include these generated internal IVs in Probit models to predict the probability of internet use. In the final step, the instrumented and predicted probabilities of internet use are included as R_i in regressing Equation (6).

4 | RESULTS AND DISCUSSION

4.1 | Factors affecting the internet use of agricultural cooperatives

Table 3 reports the results from Probit estimations of the factors affecting internet use of agricultural cooperatives, including female leadership. While the coefficient in Model 1 (without interaction between gender and education of presidents) is not significant, the coefficient of the female president variable in Model 2 (with the interaction between gender and education of presidents) is significant and implies that cooperatives with female presidents are more likely to use the internet by 5.6%. Regarding the share of females, results from Models 1 and 2 denote that an increase of 1% in the share of female laborers leads to an increase of 0.2% in internet use by agricultural cooperatives.

The education of presidents and management board members is essential for internet use in cooperatives. Our results show that presidents with vocational training degrees or higher have a higher probability of using the internet in their cooperatives by about 10%. Cooperatives with all management board members having vocational training degrees or higher and participating in training courses are more likely to use the internet in their cooperatives by approximately 10.5% and 6.0%, respectively. Our results of education are in line with the results for individuals from Lera-López et al. (2011), for farm businesses from Miranda et al. (2015) and Khanal et al. (2015), for rural households from Nguyen et al. (2022), and for countries from Poushter (2016).

The results from our estimations further show that the older the cooperative president is, the lower the likelihood of using the internet by the cooperative is. An increase in age by one year leads to a decrease in the probability of using the internet by 0.3%. This result is consistent with that of Fang and Yen (2006), Khanal et al. (2015), Penard et al. (2015), and Nguyen et al. (2022). We further find that larger-scale cooperatives, in terms of laborers and members, appear to be more likely to use the internet. These results align with the findings from Yueh et al. (2013) on the size of farmers' associations. The variables representing productive characteristics, geographical location, and productive assets do not show a significant correlation with internet use in agricultural cooperatives (except for the number of water pumps). These results imply that, since the internet connection in Vietnam is available throughout the country, the major factors affecting internet use in agricultural cooperatives are their demographic factors.

TABLE 3 Factors affecting the internet use of agricultural cooperatives

	Model 1: without interaction		Model 2: with interaction	
	Internet use	Marginal effects	Internet use	Marginal effects
Female president†	0.059	0.022	0.150*	0.056*
	(0.087)	(0.032)	(0.089)	(0.033)
Education of president†	0.263***	0.098***	0.280***	0.104***
	(0.085)	(0.030)	(0.082)	(0.030)
Female president*education of president†			−0.244	−0.091
			(0.177)	(0.066)
Age of president	−0.008***	−0.003***	−0.008***	−0.003***
	(0.003)	(0.001)	(0.003)	(0.001)
Training of management board members†	0.159***	0.059***	0.161***	0.060***
	(0.043)	(0.016)	(0.044)	(0.016)
Education of management board members†	0.280***	0.104***	0.285***	0.106***
	(0.085)	(0.030)	(0.086)	(0.031)
Share of female laborers	0.006***	0.002***	0.006***	0.002***
	(0.002)	(0.001)	(0.002)	(0.001)
Number of laborers (ln)	0.132**	0.049**	0.131**	0.049**
	(0.055)	(0.020)	(0.055)	(0.020)
Number of members (ln)	0.080***	0.030***	0.080***	0.030***
	(0.027)	(0.010)	(0.027)	(0.010)
Total land areas (ln)	−0.001	−0.000	−0.001	−0.000
	(0.014)	(0.005)	(0.014)	(0.005)
Livestock cooperative†	0.194	0.072	0.181	0.067
	(0.164)	(0.061)	(0.163)	(0.061)
Aquaculture cooperative†	−0.164	−0.061	−0.159	−0.059
	(0.219)	(0.081)	(0.215)	(0.080)
Delta region†	−0.086	−0.032	−0.086	−0.032
	(0.178)	(0.066)	(0.178)	(0.066)

(Continues)

TABLE 3 (Continued)

	Model 1: without interaction		Model 2: with interaction	
	Internet use	Marginal effects	Internet use	Marginal effects
Coastal region†	−0.029	−0.011	−0.028	−0.010
	(0.134)	(0.050)	(0.134)	(0.050)
Number of boats	−0.093	−0.034	−0.093	−0.034
	(0.065)	(0.024)	(0.065)	(0.024)
Number of electric generators	0.008	0.003	0.007	0.003
	(0.019)	(0.007)	(0.019)	(0.007)
Number of water pumps	0.019*	0.007*	0.019*	0.007*
	(0.010)	(0.004)	(0.010)	(0.004)
Number of seed-sowing machines	0.019	0.007	0.019	0.007
	(0.037)	(0.014)	(0.038)	(0.014)
Number of tractors	0.030	0.011	0.030	0.011
	(0.051)	(0.019)	(0.051)	(0.019)
Number of combine harvesters	0.020	0.007	0.020	0.007
	(0.057)	(0.021)	(0.057)	(0.021)
Number of vehicles	0.087	0.032	0.086	0.032
	(0.172)	(0.064)	(0.172)	(0.064)
Number of other equipment and machines	−0.000	−0.000	−0.000	−0.000
	(0.003)	(0.001)	(0.003)	(0.001)
Constant	−0.592**		−0.597**	
	(0.279)		(0.276)	
Number of observations	3512		3512	
Likelihood	−2274.34		−2273.49	
Pseudo *R*2	0.062		0.062	
Wald chi2	303.93		303.98	
Prob. > chi2	0.000		0.000	

Note: Robust standard errors bootstrapped and clustered at provincial level in parentheses;
†Dummy; ln: natural logarithm;
***$p < 0.01$,
**$p < 0.05$,
*$p < 0.1$.

4.2 | Effects of internet use on agricultural cooperatives' performance

Table 4 summarizes the results of the effects of internet use on the economic performance of agricultural cooperatives from the heteroskedasticity-based IV method (full results in Appendix 5). It appears that internet use positively and significantly affects the returns on assets, equity, and labor productivity. While the results of the effects of internet use on the returns on assets and returns on equity are new in the literature, our results of the effects on labor productivity are consistent with the previous studies that internet use has a positive impact on adopters' productivity (Chen et al., 2020; Galperin & Fernanda Viecens, 2017; Paunov & Rollo, 2016). The results of the effects of internet use remain unchanged when we include the interaction between the gender and the education of cooperatives' presidents (see Appendix 6).

We further find that the gender of the president and the share of female laborers do not have a significant effect on the returns on assets and labor productivity of cooperatives, while only the share of female laborers has a negative and significant impact on the returns on equity of cooperatives. These results, to some extent, are similar to those from Adams and Ferreira (2009), Campbell and Mínguez-Vera (2008), Carter et al. (2010), and Rose (2007). However, these findings are expected because women lack adequate access to resources such as education, knowledge, and business experience (Nippierd, 2012), especially in developing countries such as Vietnam (Tran et al., 2019). The two education-related variables, namely the president with vocational training degrees or higher and the training of management board members, show a positive and significant effect on cooperatives' labor productivity. However, the education of management board members shows a negative and significant effect on the returns on equity of cooperatives. Our findings, hence, imply that female leadership should be promoted simultaneously with the improvement of women's knowledge of business to increase agricultural cooperatives' economic performance.

Table 5 summarizes the results of the effects of internet use on the social and innovative performances of agricultural cooperatives (full results in Appendix 7). Internet use in agricultural cooperatives has a positive and significant effect on the two indicators of social performance: payment per laborer and contribution to labor union funds and insurance per laborer. The impact of internet use on workers' earnings is strong (DiMaggio & Bonikowski, 2008). Our results are also in line with the findings from Chen et al. (2020), indicating the positive effect of internet use on social effects in the form of workers' welfare. These findings are still consistent when we include the interaction between the gender and the education of cooperatives' presidents (see Appendix 8).

We further find that a female president is associated with a lower payment per laborer, while the share of female laborers has a positive and significant effect on this indicator. These results imply that female-presided cooperatives pay less to laborers, and cooperatives with a higher share of female laborers pay more. These results are plausible because women in power positions have a negative and significant correlation with gender segregation (Stainback et al., 2016) and might reduce the unequal pay gap between male and female laborers (which male laborers are being paid higher than female ones). Furthermore, these results also support the findings from Magnusson (2013), suggesting that payments to laborers increase when the percentage of females rises, especially in female-dominated occupations. Therefore, female leadership positively affects social performance (Périlleux & Szafarz, 2015). Again, the effects of education-related variables show the important role of education in agricultural cooperatives. The education level of the president positively and significantly influences the payment and contribution per laborer. The educa-

TABLE 4 Effects of internet use on the economic performance of agricultural cooperatives

	Economic indicators		
	Returns on assets	**Returns on equity**	**Labor productivity (ln)**
Internet use in cooperative†	0.519**	0.837***	0.728**
	(0.236)	(0.272)	(0.305)
Female president†	−0.073	−0.057	0.102
	(0.051)	(0.072)	(0.089)
Education of president†	−0.049	−0.115	0.124**
	(0.056)	(0.072)	(0.060)
Age of president	0.004***	0.005**	−0.000
	(0.001)	(0.002)	(0.003)
Training of management board members†	−0.009	0.016	0.123*
	(0.028)	(0.035)	(0.072)
Education of management board members†	−0.025	−0.155**	−0.023
	(0.067)	(0.062)	(0.093)
Share of female laborers	−0.002	−0.004**	0.000
	(0.001)	(0.002)	(0.002)
Number of laborers (ln)	−0.012	−0.061	−0.490***
	(0.046)	(0.060)	(0.048)
Number of members (ln)	−0.062***	−0.078***	0.107***
	(0.020)	(0.027)	(0.024)
Control of productive characteristics	Yes	Yes	Yes
Control of geographical characteristics	Yes	Yes	Yes
Control of productive assets	Yes	Yes	Yes
Constant	1.408	3.545*	4.300***
	(0.962)	(1.932)	(0.277)
Number of observations	3512	3512	3512
F(22, 46)	9.63	10.14	42.64
Prob > F	0.000	0.000	0.000
Under-identification	0.000	0.000	0.000
Over-identification	0.498	0.130	0.066
Weak identification	10.148	10.148	10.148

Notes: Robust standard errors clustered at provincial level in parentheses.
†Dummy variable; ln: natural logarithm;
***$p < 0.01$;
**$p<0.05$;
*$p<0.1$. The under-identification test is an LM test based on the rk LM statistics in which the null hypothesis indicates that the model is under-identified. The over-identification test relied on the Hansen J test with the null hypothesis indicating all instruments are valid in the model. The reported values of these under-identification and over-identification tests are p-values. The reported test of weak identification is the Kleibergen–Paap rk Wald F statistics. Full results are presented in Appendix 5.

TABLE 5 Effects of internet use on the social and innovative performance of agricultural cooperatives

	Social indicators		Innovative indicators	
	Payment per laborer (ln)	Contribution per laborer (ln)	Innovation in production process	Innovation in products
Internet use in cooperative[†]	0.512*	1.172***	0.076	0.119**
	(0.270)	(0.443)	(0.053)	(0.054)
Female president[†]	−0.171**	0.106	0.019	0.032
	(0.080)	(0.122)	(0.024)	(0.026)
Education of president[†]	0.130***	0.458***	0.024*	0.015
	(0.048)	(0.090)	(0.013)	(0.013)
Age of president	−0.002	0.001	0.000	−0.000
	(0.002)	(0.004)	(0.001)	(0.001)
Training of management board members[†]	0.009	0.104	0.051***	0.024***
	(0.042)	(0.095)	(0.012)	(0.008)
Education of management board members[†]	0.179***	−0.011	0.099***	0.054**
	(0.067)	(0.100)	(0.028)	(0.025)
Share of female laborers	0.005***	0.002	0.000	0.000
	(0.001)	(0.002)	(0.000)	(0.000)
Number of laborers (ln)	−0.211***	0.185***	0.022**	0.004
	(0.035)	(0.056)	(0.009)	(0.007)
Number of members (ln)	0.052***	0.249***	−0.002	−0.006**

(Continues)

TABLE 5 (Continued)

	Social indicators		Innovative indicators	
	Payment per laborer (ln)	Contribution per laborer (ln)	Innovation in production process	Innovation in products
	(0.020)	(0.036)	(0.004)	(0.003)
Control of productive characteristics	Yes	Yes	Yes	Yes
Control of geographical characteristics	Yes	Yes	Yes	Yes
Control of productive assets	Yes	Yes	Yes	Yes
Constant	2.866***	−3.440***	0.012	0.046
	(0.150)	(0.333)	(0.035)	(0.030)
Number of observations	3512	3512	3512	3512
$F(27, 46)$	32.65	22.44	20.16	12.68
Prob. > F	0.000	0.000	0.000	0.000
Under-identification	0.000	0.000	0.000	0.000
Over-identification	0.965	0.762	0.899	0.691
Weak identification	10.148	10.148	10.148	10.148

Notes: Robust standard errors clustered at provincial level in parentheses.

[†]Dummy variable; ln: natural logarithm.

***$p < 0.01$,

**$p < 0.05$,

*$p < 0.1$.

The under-identification test is an LM test based on the rk LM statistics in which the null hypothesis indicates that the model is under-identified. The over-identification test relied on the Hansen J-test with the null hypothesis indicating all instruments are valid in the model. The reported values of these under-identification and over-identification tests are p-values. The reported test of weak identification is the Kleibergen–Paap rk Wald F statistics. Full results are presented in Appendix 7.

tion of cooperatives' management board members also has the same effect on the payment per laborer.

Regarding the effect of internet use on cooperatives' innovation, our results show that the use of the internet has a positive and significant effect on the innovation of cooperatives' products. This result is reasonable because the internet facilitates product innovation via an improved channel for customer feedback (Sawhney et al., 2005). Our finding is consistent with that of Bertschek et al. (2013) and Paunov and Rollo (2016), indicating that internet use positively and significantly impacts innovation activities. The education level of presidents appears to have a positive and significant effect on the innovation of the production process. Furthermore, the two education-related variables of management board members, namely the training and education level of management board members, positively and significantly impact cooperatives' innovations in both the production process and products. Hence, promoting innovations in cooperatives should start with the education improvement of their members (Ma et al., 2022).

4.3 | Distributional effects of internet use on agricultural cooperatives' economic performance

We further examine the distribution of economic impact from internet use in agricultural cooperatives. We take a closer examination of three economic indicators, including (i) revenue, (ii) profit, and (iii) labor productivity. We summarise the results of all these estimations with regard to the effects of internet use on these economic indicators in Table 6 (full results in Appendices 9–11). Regarding revenue, internet use appears to have positive and significant effects in all quintile groups. In absolute terms, the gain in revenue from internet use is proportional to the revenue of agricultural cooperatives. This means agricultural cooperatives with larger revenue benefit more. However, in relative terms, the effect is highest in the 10th group when each 1% increase in the probability of internet use results in about 6.05% increase in revenue, and the effect decreases in higher quintile groups. This effect is similar for labor productivity. Although internet use has a positive and significant effect on labor productivity across all quintile groups, the largest impact in relative term is for the 10th group.

Regarding the profit, the effect of internet use is only significant for the 50th, 75th, and 90th groups. Each 1% increase in the probability of internet use leads to an increase of 6.78%, 5.58%, and 5.26% of the profit of these groups, respectively. This means that these groups probably can reduce their costs relatively more than the other groups. It also implies that internet use in agricultural cooperatives might exacerbate income inequality (Paunov & Rollo, 2016; Galperin & Fernanda Viecens, 2017; Nguyen & Do, 2022; Nguyen et al., 2022).

5 | CONCLUSION AND POLICY IMPLICATIONS

Understanding the drivers and effects of internet use in agricultural cooperatives is essential to take advantage of ICT development and support small-holder farmers in developing countries. In this study, we examine the factors affecting the use of the internet in agricultural cooperatives, the effects of internet use on cooperatives' performance, and the distribution of the effects on economic performance. We use a dataset of 3,512 agricultural cooperatives across Vietnam to investigate these research issues. We use a Probit model to examine the factors affecting internet use, a heteroskedasticity-based approach to account for the endogeneity concern to investigate

TABLE 6 Distributional effects of internet use on the economic performance of agricultural cooperatives

	Quintile groups				
	10th group	**25th group**	**50th group**	**75th group**	**90th group**
Revenue (mil. VND)					
Internet use in cooperative	4.891***	9.318***	25.252***	50.330***	108.421**
	(1.719)	(2.488)	(5.508)	(13.066)	(47.820)
Sample mean RIF of revenue	80.802	197.320	534.500	1234.200	2621.900
Impact magnitude on revenue	6.05%	4.72%	4.72%	4.08%	4.14%
Profit (mil. VND)					
Internet use in cooperative	0.068	0.065	1.191***	3.724***	10.736**
	(0.117)	(0.095)	(0.253)	(1.326)	(4.243)
Sample mean RIF of profit	−3.803	9.617	17.568	66.679	203.960
Impact magnitude on profit	–	–	6.78%	5.58%	5.26%
Labor productivity (mil. VND per laborer)					
Internet use in cooperative	0.786***	1.393***	1.918***	5.254***	21.727***
	(0.203)	(0.344)	(0.712)	(1.745)	(5.950)
Sample mean RIF of labor productivity	12.857	29.414	69.381	163.24	413.740
Impact magnitude on labor productivity	6.11%	4.74%	2.76%	3.22%	5.25%

Notes: Robust standard errors clustered at provincial level in parentheses.

***$p < 0.01$,

**$p < 0.05$,

*$p < 0.1$. Full results are presented in Appendices 9–11.

the effects of internet use on cooperatives' performance, including three aspects of economic, social, and innovative indicators, and an unconditional quantile regression model to examine the distributional effects of internet use on revenue, profit, and labor productivity of agricultural cooperatives. Our study pointed out some important findings and policy implications.

First, female leadership is a driver of internet use in agricultural cooperatives. Female-presided cooperatives and cooperatives with a higher share of female laborers are found to have a positive and significant correlation with internet use. These findings imply that female leadership should be promoted to improve the internet use. Regarding the effects of these gender-related variables on cooperatives' performance, the results of female leadership are less pronounced in all three aspects of cooperative performance. This finding calls for a policy response to improve women's knowledge and experience in business operations. In addition, we find a positive and consistent role of education in affecting internet use and the performance of cooperatives in three different aspects of economic, social, and innovative indicators. The effect of education is significant when management board members have a vocational training degree or higher. Therefore, education should also be developed.

Second, we find that internet use positively and significantly affects the returns on assets, equity, and labor productivity. This indicates a positive association between internet use and economic performance of agricultural cooperatives. Regarding social and innovative performances, our results show that internet use has a positive and significant effect on the two indicators of social performance, namely the payment per laborer and contribution to labor union funds and insurance per laborer. The effect of internet use on the innovative performance of agricultural cooperative is pronounced only for product innovation. These findings reveal that the promotion of internet use in agricultural cooperatives is recommended.

Last, our findings regarding the distributional effects of internet use on revenue, profit, and labor productivity of agricultural cooperatives show that internet use increases the problem of income inequality. This should be accounted for, for example, by supporting cooperatives with lower levels of efficiency. Furthermore, public support should also put more emphasis on cooperatives which are willing to adopt sustainable innovations and technologies (e.g., environmentally-friendly technologies and climate-smart agricultural practices) to improve their performance and, at the same time, enhance sustainable development.

Although our paper has provided several important insights, it still has some limitations. First, our data are cross-sectional, and we are unable to account for unobservable factors of agricultural cooperatives. Extending the temporal coverage of the data is thus recommended. Second, a high attrition rate of the sample due to data un-reporting means that our empirical results should be interpreted with care. Third, the effects of agricultural equipment and machines on the performance of agricultural cooperatives need to be reexamined as we have only the data on the quantity but not on the quality of these equipment and machines. Last, we could not find an external instrumental variable for our heteroskedasticity-based model. Thus, our evidence on the impact of internet use would be more associative rather than causal. These issues should be taken into account in future studies.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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