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Comparing the development of agricultural technology and information technology in rural Vietnam

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Abstract: This paper presents a descriptive analysis on the ownership of different types of technology—both agricultural machinery and information technology—within households in rural areas of Vietnam. We find that there has been little development in the ownership of agricultural machinery, but a rapid expansion of information technology, especially phones. Households without phones or internet access are more likely to be poor, female-headed, have less education, and rely more on transfers. When controlling for a number of household characteristics including income, households that already own technology are likely to acquire more, suggesting that there are households that are particularly tech-savvy.

Keywords: technology adoption, internet, mobile phones, agricultural machinery, Vietnam
JEL classification: Q16, O33

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1 Introduction

We investigate the development of technology ownership within rural households of Vietnam over the period 2006-14 by using a bi-annual panel data of more than 2,000 households, using the Vietnam Access to Resources Household Survey (VARHS). We present descriptive evidence on both agricultural technology (i.e. machinery), as well as information technology (IT) such as phones, computers, and the internet. We find that there has been a rapid expansion of IT; a true revolution has taken place. Even though Vietnam has experienced high economic growth over 2006-14, development in the ownership and rental rates of agricultural machinery has been modest.

With respect to the adoption of IT, a tremendous increase has taken place especially in the number of mobile phones in all regions. Geographical differences have narrowed in ownership rates of phones. Infrastructure might have played a role in the adoption choices of these technologies during the time span studied, but in 2014, the coverage of 2G and 3G was universal, and hence infrastructure constraints cannot fully explain these differences (Vietnam Post and Telecommunication Group 2015).

Literature on the determinants of technology adoption is often motivated by the finding that there are barriers to technology adoption or that technology is used sub-optimally. Duflo et al. (2011) provide evidence on farmers being present-biased leading to the suboptimal use of fertilizers and overcoming this barrier by using small time-limited discounts on fertilizers as 'nudges'. A growing part of the literature demonstrates how technology adoption spreads though social networks: knowledge of benefits and ways of using new technologies can spread through neighbours and friends (Munshi 2004; Bandiera and Rasul 2006; Conley and Udry 2010; Oster and Thornton 2012; BenYishay and Mobarak 2014).

In this paper, we find that households that have no mobile phones or internet are less educated and have lower income than households with access to these technologies have. Our regression results on the determinants of the internet and mobile phone adoption suggest that households that already own IT technology are likely to acquire more. One explanation might be that they are already more knowledgeable about its benefits. Moreover, education is an important determinant of technology adoption, when controlling for other factors. One mechanism through which higher education might lead to higher IT technology adoption could indeed be that the education system provides knowledge about the benefits of IT, but this is a hypothesis left for future studies to answer.

Since agriculture is the single most important source of income to the households studied, we also devote a smaller part of the paper to discussing agricultural technologies (i.e. machinery). Overall, we observe very small changes over time in the ownership of agricultural machinery, but some increase in the rental rates of machinery. Mechanizing agriculture in the VARHS provinces remains thus a policy issue for the coming years.

Literature on endogenous growth shows how the development of technology through innovations determines growth in the long run.[1] Studying the development of agricultural machinery is related to technological progress on the one hand and moving towards more capital-intensive production on the other.

[1] For an overview, see Aghion and Howitt (1998).

Information technology is clearly more related to taking into use new technology and employing it in ways that might have previously been unimaginable. Information technology should, by definition, be able to reduce information asymmetries and therefore increase efficiency in markets.

Evidence on the effects of information technology on market efficiency using developing country data is mainly focused around the benefits of mobile phones (Jensen 2007; Aker 2010; Fafchamps and Minten 2012; Aker and Fafchamps 2015; Muto and Yamano 2009). The literature finds consistently that the introduction of mobile phones has contributed to more efficient pricing (Jensen 2007) or reduced price dispersion with respect to both consumer and producer prices (Aker 2010; Aker and Fafchamps 2015), or increased market participation (Muto and Yamano 2009).

The Vietnam Access to Resources Household Survey (VARHS), the dataset employed throughout this paper, has been collected in 2002 and bi-annually between the years 2006-14. The survey is a collaboration between the Development Economics Research Group (DERG) at the Department of Economics at the University of Copenhagen, the Central Institute of Economic Management (CIEM), the Institute for Labour Studies and Social Affairs (ILSSA), and the Institute of Policy and Strategy for Agriculture and Rural Development (IPSARD) in Hanoi, Vietnam. We mostly employ the durables and the information modules, which were introduced to the questionnaire in 2006. Throughout the paper, we use a balanced panel in order to trace the same households over time.

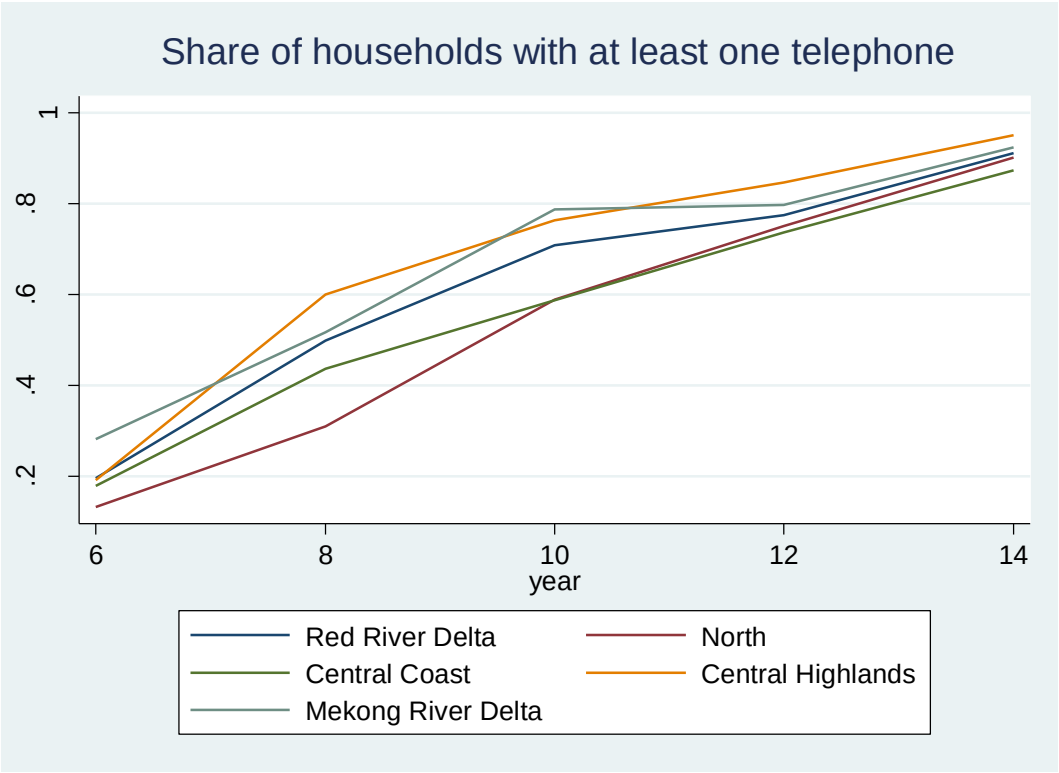
2 Geographical differences

In this section, we investigate geographical differences related to adopting new technologies. We have grouped the provinces into five categories according to their region. The categories constitute the following provinces: Red River Delta (Ha Tay), North (Lao Cai, Phu Tho, Lai Chau, and Dien Bien), Central Coast (Nghe An, Quang Nam, and Khanh Hoa), Central Highlands (Dak Lak, Dak Nong, and Lam Dong), and Mekong River Delta (Long An).

2.1 Information technology

There has been a significant increase in the number of telephones as well as convergence across regions in telephone ownership. Figure 1 shows the average share of households per region that have either a fixed-line phone or a mobile phone. There has been a tremendous increase in phone ownership across the country and also a convergence across provinces. In 2006, the share of households with phones ranged from 13 per cent on average in the northern provinces to 28 per cent at the Mekong River Delta (Long An province). The gap has narrowed ranging from 87 per cent in the Central Coast provinces to 95 per cent in the provinces in the Central Highlands in 2014.

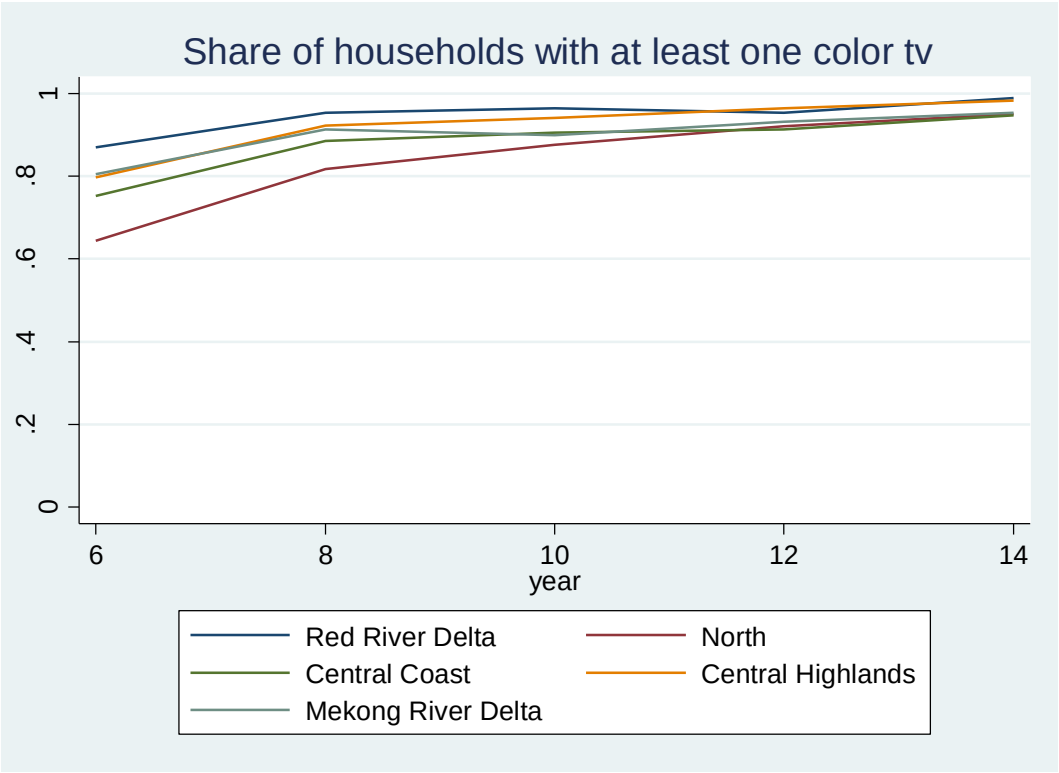
Figure 1: Share of households with at least one telephone



Source: Author's calculations based on VARHS dataset for 2006-14.

Television ownership presented in Figure 2 follows a similar converging pattern to that of phones, with the difference that the initial levels of ownership rates were much higher in 2006. Like with phones, television ownership in the northern provinces has caught up with the rest of the country.

Figure 2: Share of households with at least one colour television

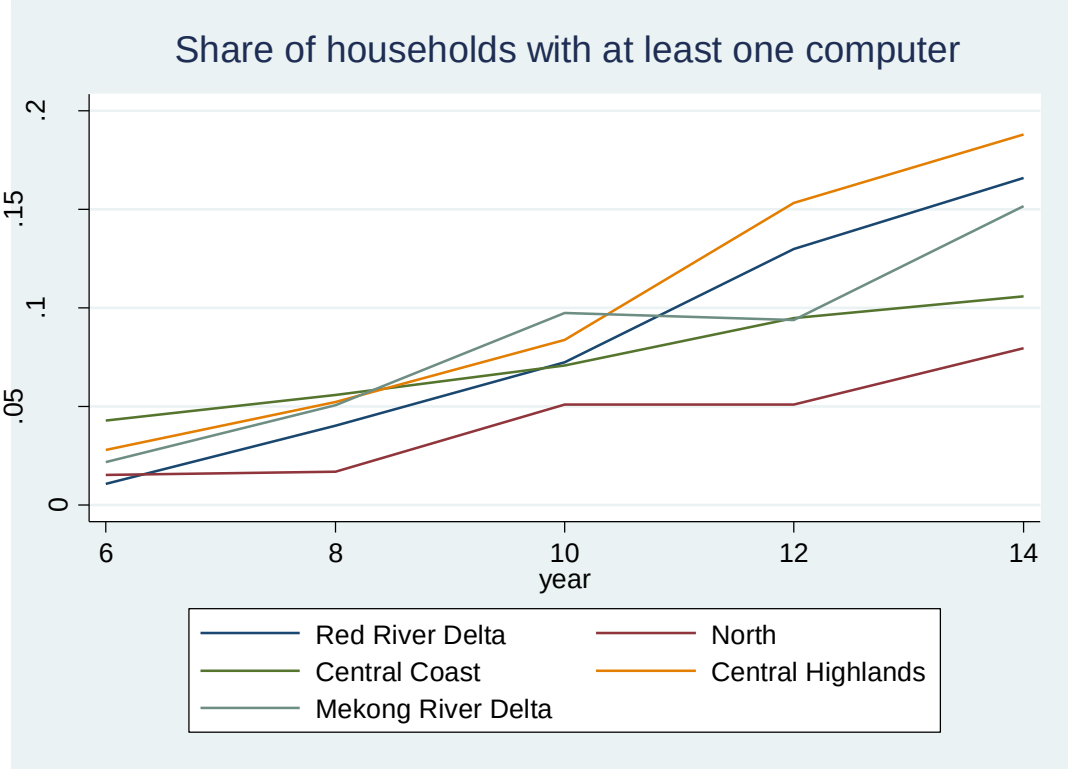


Source: Author's calculations based on VARHS dataset for 2006-14.

Internet and computer adoption is presented in Figures 3 and 4, respectively, in which we do not see geographical convergence, but rather a diverging pattern. In 2006, there were almost no computers in any of the provinces and owning computers was still quite uncommon in 2014. There have been slight increases in computer ownership in all of the provinces, with the most rapid increases taking place in the provinces in the Central Highlands and Red River Delta. In the northern provinces, the increase has been much slower on average. In all of the areas the share of households with at least one computer is less than 20 per cent, so the development has overall been very moderate compared to that of telephones.

What we observe with computer ownership can in fact be considered as a lower bound of computer use. Internet cafés, work, and education provide households with opportunities for computer use, when they do not own a computer themselves. Therefore, studying access to internet, a variable that also takes into account use from work and from an internet café, might give us a more realistic view of computer use.

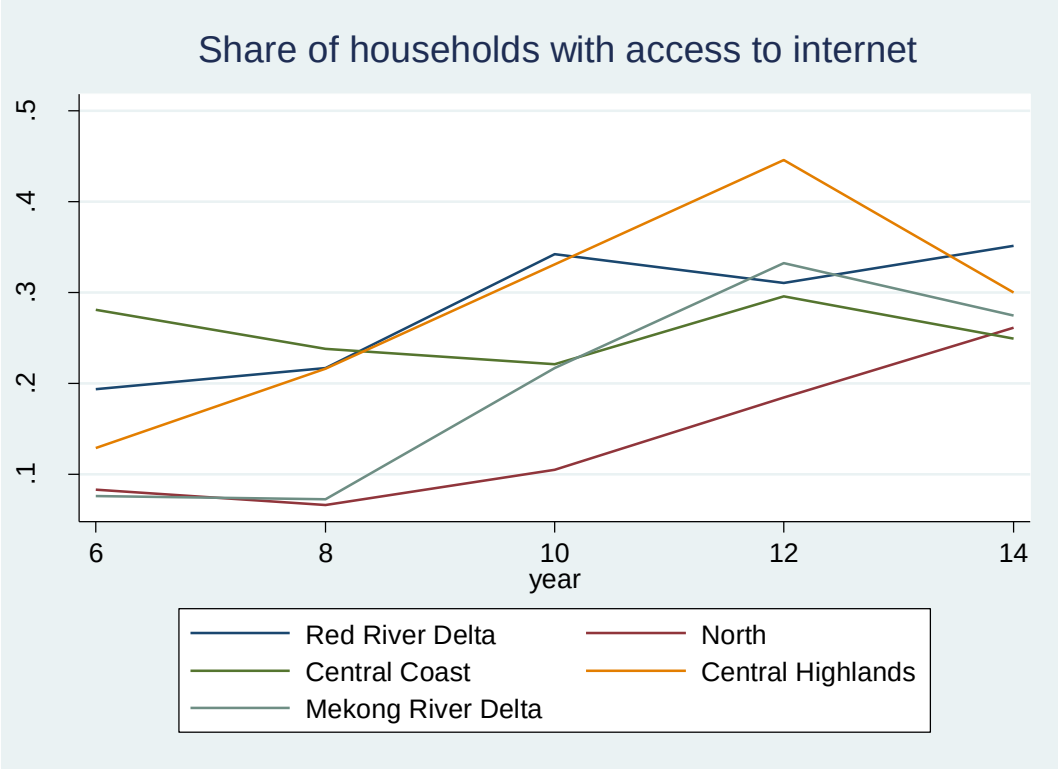
Figure 3: Share of households with at least one computer



Source: Author's calculations based on VARHS dataset for 2006-14.

Development in internet access (limited to categories 'home', 'work', or 'internet café') is presented in Figure 4. The variation across provinces is hard to analyse. There seems to be quite a lot of transition in and out of internet use, which is of course plausible, especially if internet is used from an internet café or work. The sharpest increase has been in the northern provinces, where there was nearly zero access in 2006. Measurement error might also explain the large variation and especially the downward development from 2012 to 2014 in the Central Highlands, Central Coast, and Mekong River Delta provinces. Using internet from a phone has surely become more common, but this is not captured in our data.

Figure 4: Share of households with internet access (home, work, or internet café)



Source: Author's calculations based on VARHS dataset for 2006-14.

2.2 Agricultural technology

Geographical differences in the use of agricultural technology can be explained largely by different regions being suitable for different crops. Of course, other household and farm characteristics such as land size and income certainly play a role, but disentangling those two effects is left out of this paper.

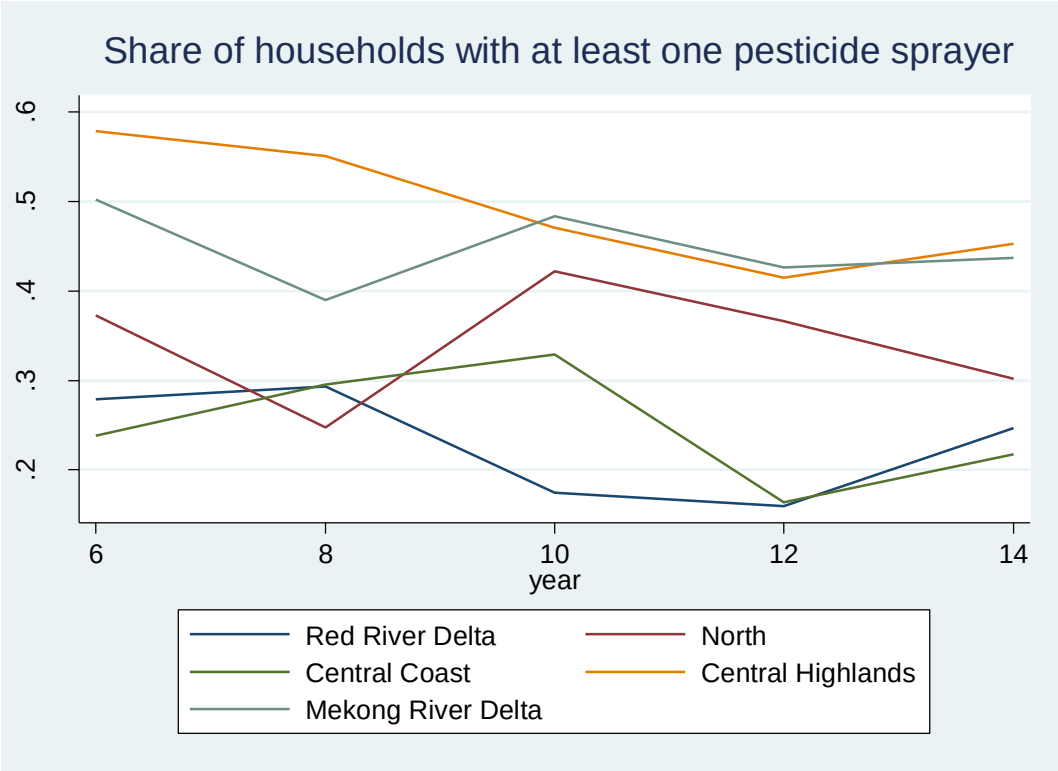
In the Northern provinces, rice production dominates agricultural activities, alongside maize and cassava production. In the south, production is more focused on perennial crops such as fruit. Coffee production is predominant in the Central Highlands, complemented by fruit and cashew nuts as well as some rice and maize growing (Markussen et al. 2013).

According to a United Nations Centre for Sustainable Agricultural Mechanization (CSAM) Report (Duc Long 2013), the development of agricultural mechanization in Vietnam is still at a preliminary stage, the highest degrees of mechanization being at the Mekong River Delta areas, which we also observe. Mechanization is needed for two main purposes, namely, to improve yield and quality of main crops, and to reduce post-harvest losses ensuring quality and food safety (Duc Long 2013).

On a national scale, the increase in the horsepower of the engineering equipment used has increased by 33 per cent at the national level (Duc Long 2013), which implies an increase in the machinery employed. Within the VARHS provinces, we do see mechanization occurring in the form of machinery rented. Both the total amount of machinery and machinery per household has stayed at very similar levels throughout the period studied.

Figure 5 illustrates the development of pesticide sprayer ownership over 2006-14. There is large variation across the time period studied in the ownership rates. It is hard to say what causes this high variation; it could for instance result from households actively buying and selling pesticide sprayers or a result from measurement error. We do not observe similar volatility in the ownership of other agricultural machinery.[2] In any case, the overall trend is that the share of households with at least one pesticide sprayer has either decreased or stayed at more or less the same level since 2006. In the Central Highlands' provinces, the share of households with pesticide sprayers has decreased from 58 per cent to 45 per cent and in the Mekong River Delta; the change has dropped from 50 per cent to 43 per cent.

Figure 5: Share of households with at least one pesticide sprayer



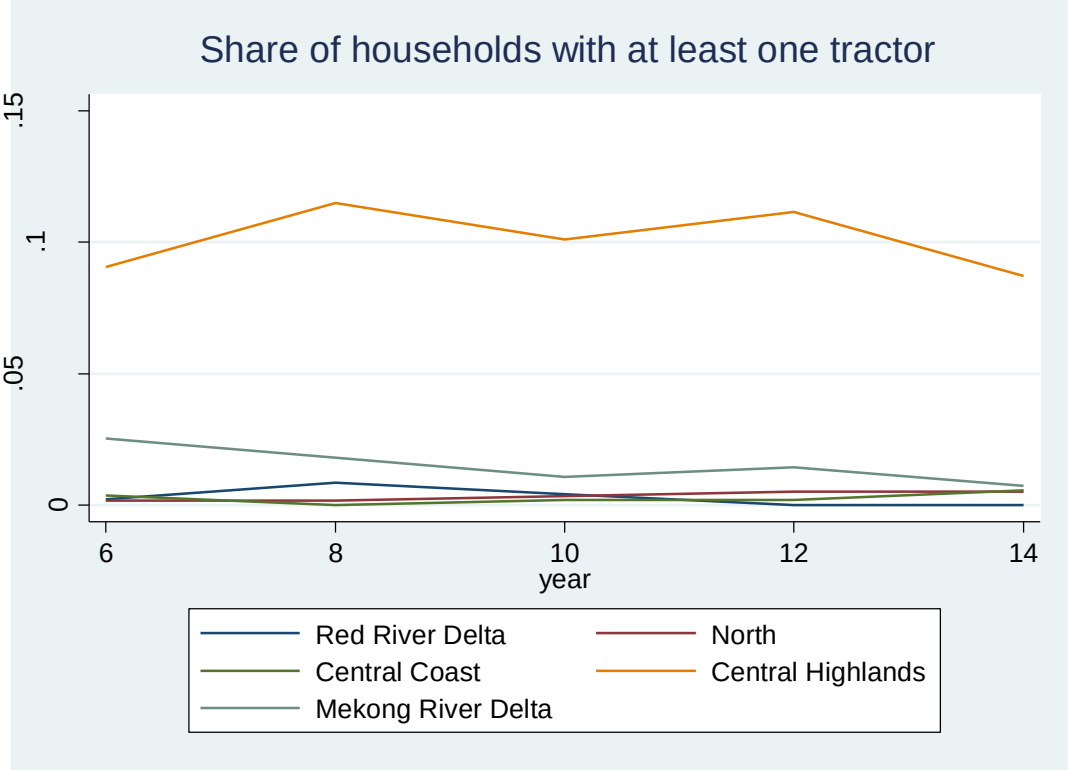
Source: Author's calculations based on VARHS dataset for 2006-14.

The decrease in pesticide sprayer ownership could be due to national concern that there has been overuse of pesticides (Meisner 2005; Duc Long 2013), which has had a negative impact not only on the environment but also on farmers' health (Dasgupta et al. 2007). Pesticides occur in water, soil, and sediments of fields and canals, which is a concern when surface water is used as drinking water. Pesticides occurring in water can also have a detrimental effect on fisheries (Klemick and Lichtenberg 2008; Toan et al. 2013). The studies are focused especially on the Mekong River Delta, where we also see the sharpest decrease in pesticide sprayer ownership.

[2] Figure 6, which presents the share of households with at least one tractor, is the only figure of the regional development of other type of agricultural machines, but we know from the data, that the volatility with respect to other machines is quite similar to that of tractors and there is very little development to begin with. Therefore, in Tables 1 and 2, we have presented the development for the years 2006 and 2014 for all of the machinery across all of the regions.

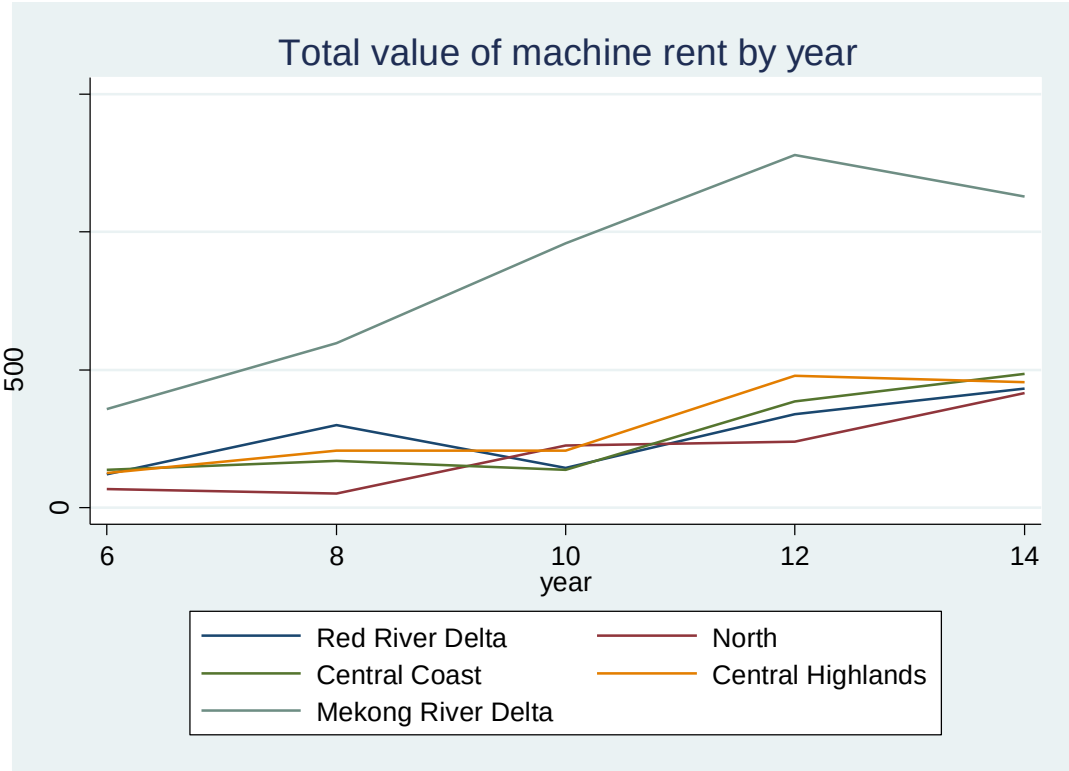
With respect to other agricultural technology, there seems to be very little change in ownership over time. In Figure 6, we can see that tractor ownership has changed very little during the period studied. It is still significantly highest in the provinces in the Central Highlands and close to zero elsewhere.

Figure 6: Share of households with at least one tractor



Source: Author's calculations based on VARHS dataset for 2006-14.

Figure 7: Total value of rental of asset, machinery, equipment, and means of transport for cultivation of crops (Million VND)



Source: Author's calculations based on VARHS dataset for 2006-14.

The ownership of assets and machinery does not give a full picture of the use of machinery in agriculture. As we can see from Figure 7, the rental value of machinery has increased in all the provinces, particularly in Long An province in Mekong River Delta, where the total value of assets rented has grown nearly threefold during the period studied. A much slower increase has also taken place in other provinces.

Table 1 presents the development of the ownership in all types of machinery in 2006 and 2014. Changes are also small in grain-harvesting machine ownership, which has overall slightly declined. It is noteworthy that the levels are low to begin with: there have been no regions in which more than 10 per cent of households own a grain-harvesting machine. The same finding also applies to rice-milling machines.

The result that the number of households having at least one of each of the machines has stayed fairly constant does not rule out the possibility that the total amount of machinery might have increased, if farms that already have machinery purchase more of it. This is why we have presented the total amount of machinery owned by the households in 2006 and 2014 in Table 2. We can see that the total amount has developed similarly to the amount of households owning machinery. Hence, we can say that it is unlikely that there are large distributional differences driving these results. We can also see that the numbers observed for all machinery except pesticide sprayers are so low, that we cannot really infer much from these changes. The only large change is the increase of feed-grinding machines in Red River Delta.

Finally, it is worth pointing out that given the moderate change in the ownership of machinery, it is likely that much of the machinery used in 2006 is the same that is still employed in 2014. Even though we do not directly observe whether old machinery has been replaced with new

machinery, for instance if we look at the steady constant trend of tractor ownership, it would be surprising if there were large changes in replacing old tractors with new ones. On the contrary, the more volatile development in pesticide sprayers might suggest that there might be more market interaction going on, if not measurement error. Furthermore, we do not observe the quality of the machinery used. If there is replacement from old machinery to new, it could be the case that quality improvements in agriculture have contributed to an increase in agricultural productivity.

Overall, we can conclude that apart from a mild decline in the number of pesticide sprayers, which might be due to the decline in the overuse of pesticides, there are very little changes in the ownership of agricultural machinery. Fortunately, the rental rates of machinery do show some sign of increased mechanization.

The modernization of agriculture is a target of the Vietnamese officials, and it has been recognized that modernization should be carried out so that environmental challenges such as climate change are understood (Duc Long 2013). The lack of mechanization of the agricultural sector is indeed a concern in the VARHS provinces and should be given attention in the policy-making processes. However, it is important to highlight that solutions need to be ecologically sustainable.

It is not surprising that the possession of agricultural machinery has not followed similar patterns to that of information technology, since the increases in information technology are related to the emergence of the new economy that has taken place during the 2000s all over the world. Therefore, in the following section we will investigate more thoroughly the new economy by focusing on the rapid expansion of information technology.

Table 1: Percentage of households with at least one agricultural durable in 2006 and 2014 by region

		Pesticide sprayer	Plough	Tractor	Grain-harvesting machine	Rice-milling machine	Feed-grinding machine
Red River Delta	2006	27.87	1.06	0.21	2.13	2.34	0.43
	2014	24.68	0.43	0.00	1.06	0.64	1.91
North	2006	37.29	1.86	0.17	6.78	6.78	1.36
	2014	30.17	2.88	0.51	3.73	6.10	1.53
Central Coast	2006	23.79	0.37	0.37	5.95	0.74	0.00
	2014	21.75	1.12	0.56	6.13	0.74	0.19
Central Highlands	2006	57.84	18.47	9.06	4.18	2.09	0.35
	2014	45.30	16.38	8.71	3.48	0.70	0.00
Mekong River Delta	2006	50.18	5.78	2.53	3.61	0.00	0.72
	2014	43.68	3.25	0.72	1.81	0.00	0.00

Source: Author's calculations based on VARHS dataset for 2006-14.

Table 2: Total amount of agricultural machinery in 2006 and 2014 by region

		Pesticide sprayer	Plough	Tractor	Grain-harvesting machine	Rice-milling machine	Feed-grinding machine
Red River Delta	2006	145	7	1	10	11	3
	2014	129	5	0	5	3	29
North	2006	238	11	1	40	50	8
	2014	185	17	3	22	36	9
Central Coast	2006	140	2	2	32	4	0
	2014	118	6	3	33	4	1
Central Highlands	2006	178	64	36	13	6	1
	2014	144	48	25	10	2	0
Mekong River Delta	2006	149	16	8	10	0	2
	2014	130	13	2	6	0	0

Source: Author's calculations based on VARHS dataset for 2006-14.

3 Information technology

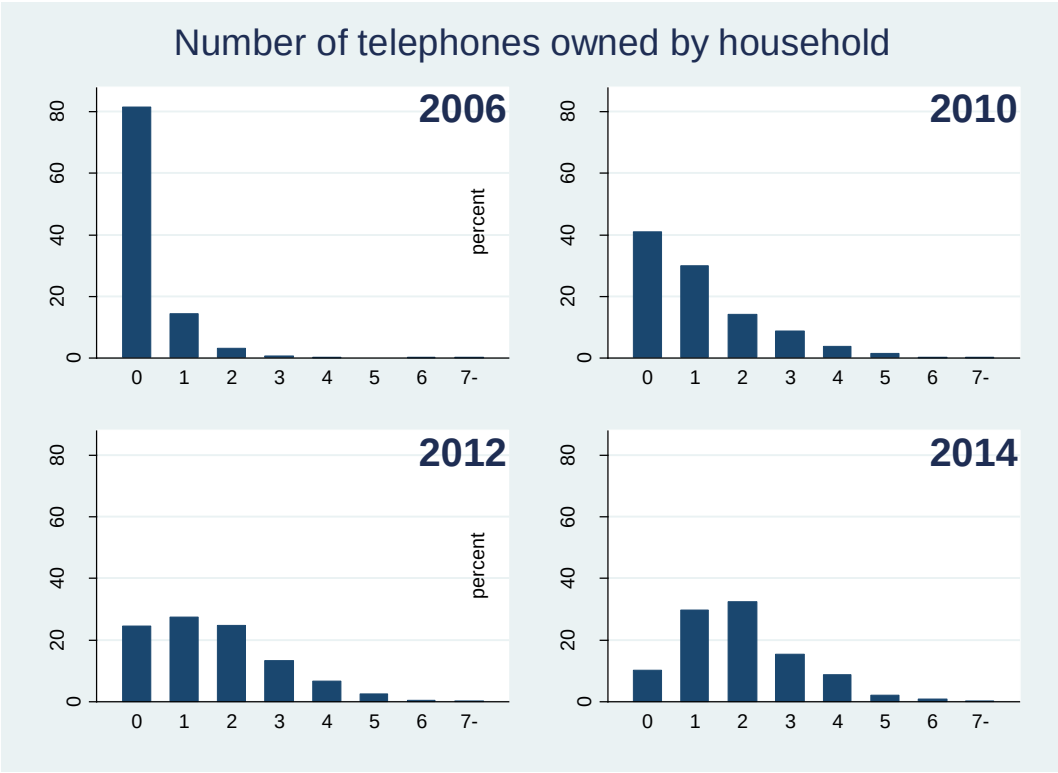
There are several factors that determine the choice of adopting new information technology. In the early stages, infrastructure plays a key role: for instance, electricity or a telephone grid are necessary conditions for the adoption of a television and a landline telephone. In this section we study how households with and without a phone or an internet connection differ in terms of access to infrastructure, wealth, income composition, and other characteristics.

3.1 Phones

3.1.1 Descriptive statistics on phone ownership

From all the technologies studied in our dataset, the expansion of phones has been the most striking one. Figure 10 illustrates a tremendously rapid expansion of phone ownership over 2006-14. Between 2006 and 2010 the average number of phones owned by household was close to zero—in 2014 it was two. Between 2006 and 2008, the share of households that had at least one telephone doubled from 18.6 per cent to 38 per cent. In 2014, there was almost full coverage of phones, the share of household with at least one phone being 89.8 per cent.

Figure 10: Number of telephones owned by household



Source: Author's calculations based on VARHS dataset for 2006-14.

In VARHS, we cannot differentiate between a fixed-line phone and a mobile phone. General Statistics Office of Vietnam GSO (2015a) provides national level subscription rates of both fixed-line connections and mobile phones to which we can compare our figures. According to GSO, on a national level the number of fixed-line connections has increased by 9 per cent between 2006 and 2012. Over this same time period, the share of fixed-line subscriptions of all subscriptions has decreased from 30.7 per cent to 6.7 per cent. This confirms that the vast majority of the increases in phones are attributable to the increase in mobile phones, not fixed-line connections.

The average number of phones owned by a household in VARHS has increased almost sevenfold between the years 2006-12 (from 0.25 to 1.61 phones per household) and almost eightfold between the years 2006-14 (to 1.94 phones per household). Comparison to national statistics reveals that the increase in the amount of telephone subscriptions has not been quite as rapid in the country on average: the total number of all telephone subscriptions has increased nearly fivefold between the years 2006-14, from 28.5 to 141.2 million. During the same period, the number of mobile phone subscriptions has gone up more than sixfold (from 19.7 to 131.7 million). This goes to show that the adoption of mobile phones has been more rapid in VARHS provinces than in Vietnam in aggregate.

Even though adoption rates have been higher, due to the initially low levels of ownership of phones in 2006, the VARHS provinces have not yet caught up with the national average in 2014. In 2006, nationally there were about 0.34 subscriptions per capita compared to 0.25 phones per household in 2006 in VARHS provinces. If we compare these same numbers for the most recent period available, 2012, we can see that the number of phone subscriptions was 1.59 per capita on a national level and 1.61 per household in the VARHS provinces. Since the average size of a

household in VARHS is 4.4 members, we can clearly conclude that the VARHS provinces still have not caught up mobile phone penetration rates to the national average.[3]

Another aspect that we do not observe in the data is the quality of the mobile phones used, whether they are newer smartphones or traditional mobile phones. Anecdotal evidence suggests that quality smartphones are popular and carry a special luxury status in Vietnam—Apple experienced its largest increase in iPhone sales in the world in Vietnam in the first half of 2014 (Heinrich 2014). Apple holds a dominant position in the country, unlike in China where the local cheaper brands dominate the market.

An earlier study by Hwang et al. (2009) investigates the determinants of mobile phone services diffusion in Vietnam. Their conclusion is that policies taken to open the market for competition has been a significant factor determining the diffusion of mobile phone services, due to new service providers entering the markets and the subsequent decrease in prices. Their analysis with aggregated data covers the years 1995-2006, thus extending to the beginning of our dataset. This evidence is in line with standard economic theory and is, in broad terms, an evident policy recommendation. As 3G and 2G have nationwide coverage in Vietnam (Vietnam Post and Telecommunication Group 2015), the infrastructure constraints should no longer play a large role in the purchasing decision of a phone in 2014. The quality of the signal might of course be weaker in more remote areas.

Table 3 describes the differences between households that still do not have a phone in 2014 with those that have one. As coverage is almost universal, the amount of households with no phone in 2014 consists of only 10 per cent of the sample, 203 households, the amount of households with a phone being as high as 1,959.

[3] The national phone subscriptions per capita are author's calculations based on General Statistics Office of Vietnam (2015a, 2015b).

Table 3: Mean comparison across households with and without a phone, 2014

	No phone	Phone	Difference
Household size	2.70	4.28	-1.58***
Female hh head	0.47	0.22	0.26***
Education per capita	4.45	8.56	-4.12***
Number of children <15	0.44	0.77	-0.33***
Total area owned	5243.38	7475.80	-2232.42**
Total area owned per capita	1698.87	1855.74	-156.88
Monthly income per capita	1316.54	2167.49	-850.95***
Crop production last year per capita	3525.82	8884.96	-5359.15***
Classified as poor	0.39	0.10	0.29***
Income share wage	0.20	0.36	-0.16***
Income share non-farm enterprises	0.04	0.13	-0.09***
Income share crops	0.17	0.21	-0.04**
Income share private transfers	0.26	0.09	0.17***
Income share public transfers	0.20	0.08	0.12***
Electricity	0.94	0.99	-0.05***
Toilet	0.78	0.91	-0.13***
Good water	0.81	0.86	-0.05*
Household has access to internet	0.06	0.31	-0.25***
Number of motorcycles	0.42	1.47	-1.06***
Number of motorcycles per capita	0.13	0.36	-0.23***
Number of colour TVs	0.81	1.08	-0.27***
Number of colour TVs per capita	0.44	0.31	0.13***
Number of computers	0.02	0.16	-0.14***
Number of computers per capita	0.00	0.04	-0.03***
Distance all-weather road	1.90	1.82	0.08
Distance People's Committee	2.34	1.97	0.37*
Distance public healthcare	2.30	1.95	0.35*
Distance private healthcare	7.38	5.36	2.02*
Distance primary school	1.90	1.72	0.19
Distance crop buyer	1.25	1.15	0.10
Trust (positive)	0.90	0.90	-0.00
Trust (negative)	0.56	0.47	0.09**

Notes: Number of households with a phone 1,959 (the number of households with no phone was 203).
Significance levels: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Source: Author. Based on VARHS dataset for 2014.

We can see that households vary tremendously over phone ownership. Households with at least one phone are typically much larger than households without a phone are. Households without a phone comprise on average 2.7 members, when households with a phone have on average 4.3 members, which is close to the sample average 4.13. The differences are also very large with respect to gender of the household head: Almost half of the households without a phone are female-headed, compared to 22 per cent of households with a phone.

There are also large differences with respect to education level and income. Education in years per capita is almost twice as high for households with phones. Income per capita in households without a phone is 61 per cent of the income per capita in households with a phone. We can also see that almost 40 per cent of the households without a phone are classified as poor by the authorities versus 10 per cent of households with a phone.

In addition, the sources of income differ significantly: households without phones rely heavily on transfers, both public and private. Transfers account for nearly half of the incomes of these households, when the respective number for phone owners is 17 per cent. Of the actual income-generating activities, wage-earning activities are the most important income source for households without phones, followed by income from crop sales. Income share of own non-farm enterprises is 4 per cent compared to 13 per cent in households with phones.

Finally, we have also investigated whether infrastructure and a remote location distinguish households with and without a phone. We do observe that households without a phone are less likely to have electricity, but the difference is rather small, electricity being almost universal in 2014. Households with no phone are also less likely to have a toilet[4] or access to good water.[5]

Distance to public services, such as healthcare facilities, all-weather roads, schools and People's Committees can be regarded as proxies for remoteness. Households without phone are somewhat more remotely situated, but the differences are quite small.

3G being universal, infrastructure constraints should not play a large role in the purchasing decision of a phone. It might still be that very remote areas do have a weaker signal. On the other hand, if a phone is mostly used to keep in touch with other family members, it is possible that smaller households simply have less demand for phones. However, given that these households are also significantly poorer, the decision not to buy a phone might be due to poverty.

We have also investigated phone ownership and ownership of other durables or information technology to study the assumption that being 'tech-savvy' plays a role in the purchasing decision, keeping in mind the fact that wealthier households can better afford any kind of technology. Households without a phone own one-third of the number of motorcycles per capita of that of households with a phone. In addition, they are less likely to have internet access[6] or to own a computer. Contrary to these findings, households without phones do own more televisions per capita than households with phones.

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[4] Variable toilet gets the value one if household has a toilet, otherwise zero.

[5] Good water is a dummy variable taking value one, if the water comes from the following sources: tap water (private or public), tank, bought water, water from deep drilled wells, or hand-dug and reinforced wells. Any other kind of source of water gets value zero.

[6] Internet use is a dummy getting value one if using internet from home, work, or internet café.

Given that households without phones are slightly more remotely located, purchasing a phone might actually be beneficial for these households, if a phone can be used to gain market information or information about public services. In addition, since we observe that households that do not own a phone very rarely have access to the internet or own a personal computer, these households are then not having the means to benefit from possibilities brought by information technology.

Since a telephone functions as a means to keep in contact with one's community, we have also investigated whether there are differences with respect to social capital. It is plausible that those that do have some kind of a central role in a social network, or have stronger ties to their community, are more likely to own a phone. Our data has two variables related to trust, which enable us to study whether households not owning a phone do have less trust in their own community, and might therefore be less inclined to purchase the kind of technology that allows them to keep contact with their community.

The variable 'trust (positive)' is a dummy that takes value one if the respondent agrees with the statement 'most people are basically honest and can be trusted'. We observe no difference with respect to this general perception of trust, 90 per cent of respondents in both groups agree with this statement. However, we do observe a significant difference in the variable 'trust (negative)', which takes value one if the respondent agrees with the statement 'in this commune one has to be careful, there are people you cannot trust'. Therefore, households without a phone do tend to have slightly less trust in their community than phone owners do: over one-half of the respondents in this group agree with this statement. It is therefore possible that lower social capital also plays a role in the purchasing decision of a phone. Of course, lower trust might also be related to lower income, education, or a number of other factors.

3.1.2 Determinants of phone ownership

In Table 4 we have investigated the determinants of phone ownership over 2008-14, where the dependent variable is the number of phones in a household. Columns 1-4 show ordinary least squares (OLS) results, controlling for year fixed effects, Column 4 also controls for commune level time-invariant characteristics. Column 5 displays the results with household fixed effects and therefore the coefficient estimates can be interpreted as the effect of the changes in the explanatory variables to the change in the number of phones.

The results show that when controlling for a number of household characteristics, household income has a very small but statistically significant effect on the number of mobile phones or on the purchasing decision.[7] One important determinant in the number of phones is household size. When controlling for household size however, having more children has a negative effect on the number of phones. Hence, the amount of adult members in a household is positively associated with the number of phones.

The remoteness of the household is not a statistically significant determinant of phone adoption, even when we do not control for commune fixed effects. In addition, land size does not seem to play a role. What is interesting is that the ownership of other technology—computers, internet, televisions, and motorcycles—has a large effect on the amount of phones and on the decision to acquire more. Being tech-savvy therefore seems to play a large role in the ownership of phones, even when controlling for income and other factors.

[7] We also ran the analysis splitting income into different income sources. The effects were qualitatively very similar (results not reported here).

Table 4: Dependent variable: number of phones

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) HH FE
Household size	0.211***	0.125***	0.126***	0.121***	0.147***
	(0.017)	(0.012)	(0.012)	(0.013)	(0.016)
Education per capita	0.115***	0.065***	0.064***	0.061***	0.037***
	(0.005)	(0.004)	(0.004)	(0.005)	(0.007)
Female hh head	-0.095***	-0.063**	-0.064**	-0.060*	0.053
	(0.037)	(0.030)	(0.0299)	(0.033)	(0.056)
Number of children <15	-0.165***	-0.115***	-0.114***	-0.116***	-0.136***
	(0.018)	(0.015)	(0.015)	(0.016)	(0.024)
Total area owned	0.000**	0.000**	0.000**	0.000*	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Monthly hh income per capita	0.000***	0.000***	0.0000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Electricity	0.135**	-0.004	-0.028	0.007	0.071
	(0.058)	(0.058)	(0.058)	(0.058)	(0.072)
Toilet	0.3140***	0.202***	0.195***	0.140***	0.074*
	(0.042)	(0.036)	(0.036)	(0.037)	(0.041)
Good water	0.115***	0.038	0.034	0.021	0.0290
	(0.0390)	(0.031)	(0.030)	(0.025)	(0.026)
Internet access		0.304***	0.302***	0.304***	0.272***
		(0.031)	(0.031)	(0.031)	(0.032)
Number of motorcycles		0.383***	0.3840***	0.365***	0.303***
		(0.030)	(0.030)	(0.032)	(0.034)
Number of colour TVs		0.204***	0.197***	0.175***	0.082***
		(0.036)	(0.035)	(0.032)	(0.031)
Number of computers		0.3947***	0.3941***	0.3699***	0.303***
		(0.045)	(0.045)	(0.048)	(0.055)
Distance all-weather road			-0.003	-0.003	-0.003
			(0.002)	(0.002)	(0.003)
Distance People's Committee			-0.002	-0.003	-0.005
			(0.003)	(0.003)	(0.004)
Distance public healthcare			-0.000	-0.004	0.001
			(0.004)	(0.004)	(0.005)
Distance primary school			-0.006	-0.004	-0.003
			(0.004)	(0.004)	(0.004)
Constant	-0.341***	-0.087	-0.023	0.121	0.373***
	(0.115)	(0.086)	(0.088)	(0.093)	(0.128)
Observations	12116	12116	12116	12116	12116
Commune	No	No	No	Yes	No
Year	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variable is number of telephones owned by a household. In Columns 1-4 pooled OLS is used, in Column 5 household fixed effects is used. Standard errors are clustered at the commune level. Standard errors in parentheses *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Source: Author. Based on VARHS dataset 2008-14 (balanced panel).

To conclude our discussion about phones, we have found that VARHS provinces have indeed been catching up with the Vietnamese average in phone ownership, the adoption of phones has been faster than in the country on average. However, we can say that there are still less phones per head in the VARHS provinces than in Vietnam on average. Since infrastructure exists, the constraints to mobile phone adoption are plausibly financial in 2014. This is supported by the fact that households not having phones are much poorer and rely heavily on transfers. Moreover, our regression results show that phone ownership is very strongly associated with the ownership of other technology, when other factors are controlled for. Finally, the regression

results with fixed effects go to show that acquiring more technology is related to purchasing more phones.

3.2 Computers and internet

3.2.1 Descriptive statistics on computers and internet

The ownership of personal computers for the years 2006-14 is presented in Table 5. We can see that the share of households owning a computer has increased fivefold from 2.4 per cent in 2006 to 12.9 per cent in 2014. Compared to development in the ownership of mobile phones, this increase is very moderate; computer ownership is far from being universal. Moreover, most households still have only one computer. In 2014, the share of households with two or more computers was 17 per cent of all computer-owning households. As smartphones have recently gained popularity in Vietnam, it is possible that smartphones do complement the functionalities of personal computers subsequently decreasing the demand for computers.

Table 5: Households with at least one computer 2006-14

		2006	2008	2010	2012	2014
No	n	2,111	2,074	2,009	1,950	1,884
	%	97.64	95.93	92.92	90.19	87.14
Yes	n	51	88	153	212	278
	%	2.36	4.07	7.08	9.81	12.86

Notes: Balanced panel, number of households 2,162.

Source: Author's calculations based on VARHS dataset for 2006-14.

Figure 11 illustrates the development of internet use. There is a large increase in the share of users, but this development is less striking than that of mobile phones. In VARHS, internet access is measured by the question 'does anyone in your household have access to internet services? If so, where mainly?', with the response categories given in the figure. We can see that altogether 16.1 per cent of households had internet access (from work, home, or internet café combined) in 2006, and 28.4 per cent of households in 2014. The increase is fully attributable to the increase in access from home and workplace that has gone up from close to zero to around 9 per cent. Simultaneously we observe a decrease in the category 'access from internet café' from 13.9 per cent in 2006 to 10.8 per cent in 2014. The overall level of access has stayed the same since 2012, after which the decrease in access from internet café has been compensated by access from home and from work.

Compared to national development in internet subscription, the VARHS provinces are really lagging behind. According to GSO, the national subscription rate for ADSL connections has increased *more than eightfold* during the period 2006 to 2012. At the same time, and even going further to 2014, internet access in the VARHS provinces, as measured by our sample has increased by only 57 per cent. The difference is striking, even though we do have several reasons to believe that these numbers are not fully comparable.

First of all, national ADSL subscriptions take into account all the subscriptions by firms. Clearly, the demand has been higher in urban areas due to a different economic structure in large cities. It is only natural that in areas largely dependent on agriculture, there is less demand for ADSL.

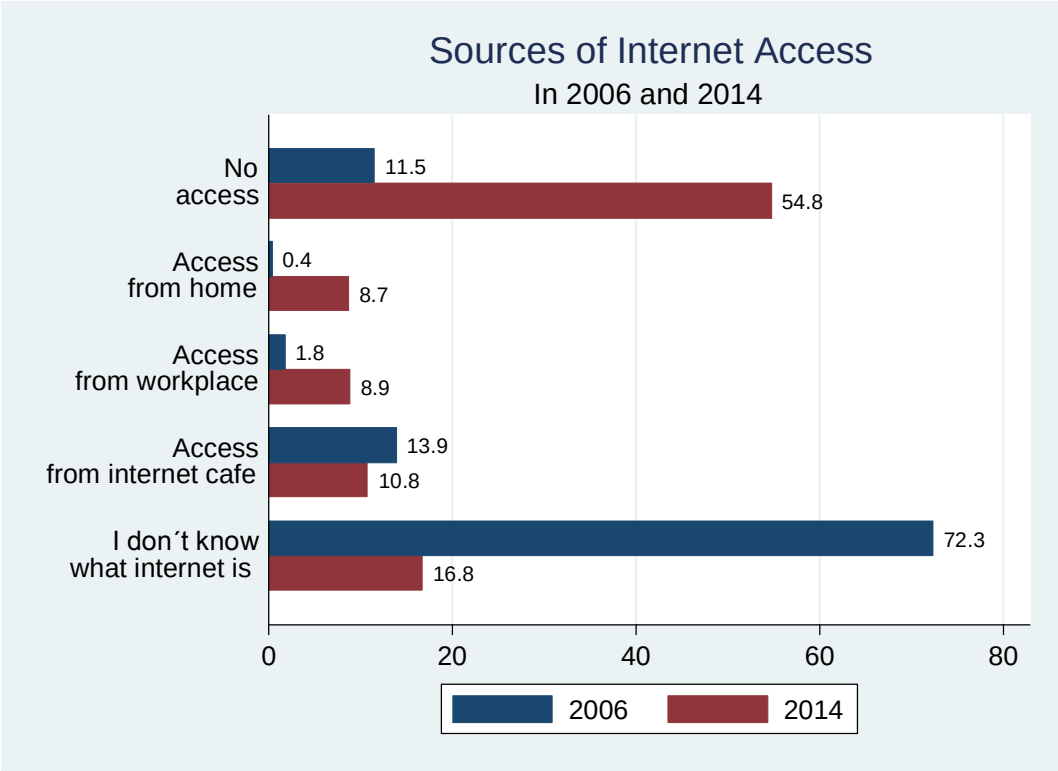
Even though we allow the households to report that they have access from work, we are unable to capture all internet use from work, since respondents could have chosen another category for internet access.

Second, there might be measurement error in our internet access measure. Internet use from a mobile phone might also have replaced internet cafés to some extent. As we do not observe any kind of access via mobile phone, whether it was through a subscription or through Wi-Fi, it is reasonable to assume that our measure of internet access is biased downwards.

Even considering all these caveats, the difference between the eightfold increase in national ADSL subscriptions, compared to the 57 per cent increase in internet access together with the low level of computer ownership, does raise the concern that VARHS provinces are lagging behind in the national average on internet access.

Even though internet use has increased relatively moderately, we can observe from the data that knowledge about what internet is has increased over 2006-14. In 2006, more than 70 per cent of respondents chose the category 'I don't know what internet is' and only 11.5 per cent reported that they 'don't have access'. In 2014 the share of respondents that chose the former was just 16.8 per cent and of the latter 54.8 per cent. Hence, knowledge about internet had indeed increased, even though the households have not reported having internet access.

Figure 11: Sources of internet access in 2006 and 2014



Source: Author's calculations based on VARHS dataset for years 2006 and 2014.

Next, in Table 6 we investigate differences across households in internet access in 2014, with respect to the same characteristics as in Table 3 on phones. The share of households with internet access was 28 per cent, that is 615 households, and the number of households without access was 1,547.

It is worth pointing out that households with no phones represent a small minority in 2014 (10 per cent), households without internet access are still a large majority (70 per cent). However, the differences between users and non-users of these two technologies are qualitatively similar.

Table 6: Mean comparison across households with and without internet access 2014

	No Internet	Internet	Difference
Household size	3.95	4.58	-0.62***
Female hh head	0.26	0.20	0.06***
Education per capita	7.40	10.13	-2.73***
Number of children <15	0.76	0.66	0.10**
Total area owned	7186.91	7465.62	-278.72
Total area owned per capita	1898.56	1696.25	202.32
Monthly income per capita	1787.87	2841.54	-1053.67***
Crop production last year per capita	7775.76	9906.14	-2130.38*
Classified as poor	0.16	0.05	0.11***
Income share wage	0.30	0.46	-0.15***
Income share non-farm enterprises	0.10	0.17	-0.06***
Income share crops	0.22	0.17	0.05***
Income share private transfers	0.12	0.06	0.06***
Income share public transfers	0.10	0.06	0.04***
Electricity	0.99	0.99	-0.01
Toilet	0.88	0.96	-0.09***
Good water	0.84	0.90	-0.06***
Number of telephones	1.74	2.81	-1.06***
Number of telephones per capita	0.48	0.64	-0.16***
Number of motorcycles	1.16	1.93	-0.77***
Number of motorcycles per capita	0.30	0.44	-0.14***
Number of colour TVs	1.01	1.18	-0.17***
Number of colour TVs per capita	0.33	0.29	0.05***
Number of computers	0.03	0.45	-0.42***
Number of computers per capita	0.01	0.11	-0.10***
Distance all-weather road	2.04	1.29	0.75***
Distance People's Committee	2.10	1.78	0.32***
Distance public healthcare	2.10	1.69	0.41***
Distance private healthcare	6.37	3.50	2.86***
Distance primary school	1.80	1.58	0.21**
Distance crop buyer	1.27	0.86	0.41**
Trust (positive)	0.89	0.92	-0.02
Trust (negative)	0.48	0.48	-0.00

Notes: Number of households with internet access 615, without 1,547. Significance levels: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Source: Author. Based on VARHS dataset for 2014.

Households without internet access are also smaller and more often female headed than households with internet, but these differences are very small compared to the difference in phone ownership. The gap in education per capita is also strikingly large; households without

access have more than three years less education. In addition, income differences are very large: households with internet earn nearly twice as much as households without internet. Again, we also observe that the value of crop production in per capita terms is larger for households with internet access.

Income share of wages is 46 per cent in households with internet access, compared to 30 per cent with households with no internet access. This difference is explained mostly by there being more households with no income at all from wage labour among non-user households than among user households.[8] Households without internet access are also more dependent on transfers and also rely slightly more on agriculture as an income source.

With respect to distance measures, the differences between households with and without internet access are larger than between households with and without a phone. Households without internet access are more remotely located. With respect to infrastructure, we observe very similar results to those with phone ownership: households without access to internet are less likely to have a toilet or access to good water.

An explanation might be simple. In 2014, not having a phone seems to be associated more with poverty, whereas not having internet access is certainly related to lower income, but maybe also generally to relying more on agriculture as a source of income. Of the households without internet access, only 16 per cent have a poverty status, compared to 5 per cent of households with internet access. This difference is significant, but not nearly as large as the difference in poverty status in phone ownership.

When we look at the ownership of other technology, we have again more support for the hypothesis that there are tech-savvy households that tend to own all kinds of technology more than others do. Households without internet access have more than one mobile phone less on average than households with access, and the difference is significant even in per capita terms. In addition, motorcycle ownership is significantly smaller, and unsurprisingly, also the number of computers. Households with internet access have on average 0.45 computers at home compared to almost zero in households without access. Finally, with respect to trust measures, we cannot say that households with and without internet access differ at all.

Internet access appears to be related to a wealthy and possibly urban lifestyle: working outside agriculture, being more centrally located, and also to having higher income and education. These factors are surely correlated with each other as well.

3.2.2 Determinants of internet adoption

Table 7 presents regression results for the determinants of internet access over the period 2008-14. Columns 1-4 show the results from pooled OLS. In Column 4, we are controlling for commune fixed effects that should absorb all commune specific time-invariant characteristics. Column 5 is a random effects model and Column 6 a probit model with random effects (marginal effects reported), as our internet access measure is a dummy. In all specifications, we control for time dummies and cluster the standard errors at the level of the commune.

[8] The statistically significant differences in several of the income share variables are largely due to the difference in the share of households that have zero income in that category. For instance, with respect to wage income, the distributions are almost uniform in the positive values for both households with and without access to internet, but the share of households with zero wage income is much larger among households with no internet access.

We can see that the determinants of internet adoption are somewhat similar to that of phones. Owning other type of technology has a strong positive impact on having internet access; owning a computer is the most important one. Larger households are also more likely to have access (especially those with more adult members) and education also seems to be a driving factor.

Even though households that do not have internet access are more remotely located, when controlling for other household characteristics, the distance measures are no longer statistically significant.

As the take-up of internet has not been as rapid in the VARHS provinces as in the country overall, the question as to how to make the internet lucrative and accessible to the rural population arises.

As more and more citizens are gaining access to the internet, they are also using it increasingly as a source of information, in communication, and as a platform for working. The rural areas should not be left out of this development—internet and IT in general could also open up possibilities in the rural economy if the infrastructure and knowledge is there. Moreover, as internet cafés are losing their popularity and internet access is happening more and more through mobile phones and gadgets, easy ways of accessing the internet should be available for households, who do not have the means to purchase these technologies or are not fully aware of their possible benefits.

Table 7: Dependent variable: Internet access

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) RE	(6) RE PROBIT
Household size	0.035***	0.018***	0.018***	0.019***	0.019***	0.023***
	(0.004)	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)
Education per capita	0.032***	0.020***	0.020***	0.018***	0.019***	0.022***
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Female hh head	0.015	0.013	0.013	-0.006	0.012	0.008
	(0.011)	(0.010)	(0.010)	(0.011)	(0.009)	(0.009)
Number of children <15	-0.041***	-0.030***	-0.030***	-0.029***	-0.030***	-0.038***
	(0.006)	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)
Total area owned	0.000	-0.000	-0.000	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Monthly income per capita	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Electricity	-0.004	-0.007	-0.007	-0.023*	-0.017	0.017
	(0.009)	(0.010)	(0.010)	(0.012)	(0.015)	(0.022)
Toilet	0.023**	0.005	0.005	0.002	0.003	0.015
	(0.009)	(0.008)	(0.008)	(0.009)	(0.009)	(0.010)
Good water	0.031***	0.021**	0.021**	0.015*	0.021**	0.027***
	(0.009)	(0.008)	(0.008)	(0.009)	(0.008)	(0.009)
Number of telephones		0.039***	0.039***	0.039***	0.039***	0.024***
		(0.004)	(0.004)	(0.004)	(0.003)	(0.003)
Number of motorcycles		0.020***	0.020***	0.017***	0.019***	0.013***
		(0.006)	(0.006)	(0.005)	(0.004)	(0.004)
Number of colour TVs		0.000	0.000	-0.008	-0.000	0.013*
		(0.007)	(0.007)	(0.007)	(0.008)	(0.007)
Number of computers		0.334***	0.334***	0.313***	0.322***	0.199***
		(0.014)	(0.014)	(0.013)	(0.011)	(0.010)
Distance all-weather road				0.000	-0.000	-0.002**
				(0.000)	(0.000)	(0.001)
Distance People's Committee				0.000	-0.000	-0.000
				(0.001)	(0.002)	(0.002)
Distance public healthcare				-0.001	-0.002	-0.002
				(0.001)	(0.002)	(0.002)
Distance primary school				0.001	0.001	0.002
				(0.001)	(0.001)	(0.001)
Observations	12116	12116	12116	12116	12116	12116
Commune FE	No	No	No	Yes	No	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Number of households 3,029. Dependent variable is internet access, 1=yes, 0=no. In Columns 1-4 pooled OLS is used, Column 5 uses a random effects model. In Column 6 a probit model with random effects is used, the coefficients reported are marginal effects. Standard errors are clustered at the commune level. Standard errors in parentheses *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Source: Based on VARHS dataset for 2008-14 (balanced panel).

3.3 Information sources

Even though the adoption of ICT and mobile phones in particular has been rapid, we still know very little about for which purposes these media are used. Figure 7.12 illustrates the answers to the question: 'which sources of information are important for you? Regarding the following issues, list up to three for each issue'. Hence, each household has often named more than one information source.

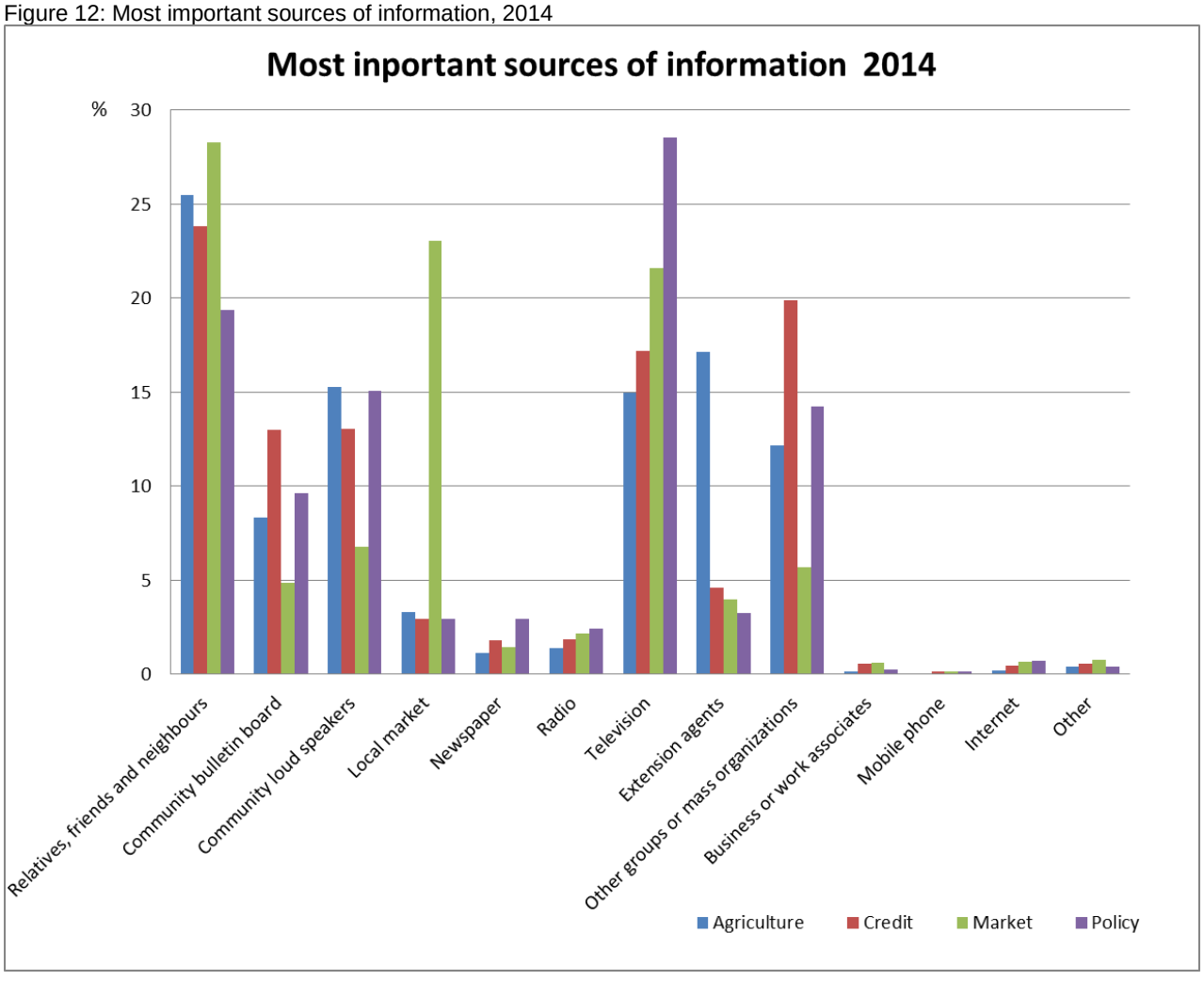
The full descriptions of the categories are: agricultural production and extension; sources of credit and insurance; market information—such as jobs, prices of goods, or crops; and government policy changes.

We can see that the internet still plays a minor role as one of the most important information sources, as do mobile phones. However, both of the mediums can operate as a means of communicating with one's social network, which is listed as a separate category and not only for obtaining information from outside sources.

Indeed the social network—friends, relatives, and neighbours—is the most important information source for agriculture, credit, and market information. In light of this finding, it is not surprising that technology adoption choices are also strongly affected by social networks as suggested by recent literature (Munshi 2004; Bandiera and Rasul 2006; Conley and Udry 2010; Oster and Thornton 2012; BenYishay and Mobarak 2014).

For government policy, television is the most important source and it is also used extensively to acquire other information. For information about agriculture, the local market is an important source. For all the categories, more traditional channels of information-spreading, community bulletin boards, community loud speakers, and other groups and mass organizations, are still very relevant.

Figure 12: Most important sources of information, 2014



Source: Author compilation using VARHS dataset 2014.

4 Conclusions

Technological development has followed very different patterns in the VARHS provinces over 2006-14. The increase in the ownership of phones has been extraordinary and probably even more rapid than in the country on average—the median number of phones in a household has increased from zero to two in eight years.

Despite the large relative increases in internet access and computer ownership, the VARHS provinces are lagging behind the national average in ownership levels. As phones become more sophisticated, phone ownership might aid this issue in the future, provided that smartphones are also gaining popularity in the VARHS provinces.

In 2014, households that did not own phones were much more likely to be female-headed, poor, and less educated than households with phones were. Internet access is associated with a relatively wealthy and possibly urban lifestyle more than phone ownership in 2014. The determinants of purchasing a new phone or obtaining internet access are nevertheless qualitatively similar: over 2006-14 we observe that education seems to be an important factor driving IT adoption. In addition, households that already have technology are more likely to acquire more. There seems to be some households that simply are more tech-savvy than others are.

Even though there has been a rapid increase in the number of mobile phones owned and also in internet use in 2014, VARHS households still did not report using mobile phones or the internet as a main source for acquiring information about agriculture, markets, credit, and policy. More traditional channels are still more popular. Nevertheless, as the popularity of IT increases, people will surely use IT to substitute and complement old means of communication with one's community and acquiring information.

As households that already have technology seem to be acquiring more of it, it might be that the barriers to adopting technology are related to not knowing about its benefits. When information technology becomes part of people's everyday lives, it can be exploited in various realms of life in such ways that were unimaginable before. Therefore, having access to technology could serve as a means to empowerment. Households without access to any IT services might be at risk of exclusion from economic activity and have less means to make economic choices. It is thus crucial that the rural population can afford to keep up with a certain level of information technology.

Investigating whether there are barriers to access to technology and knowledge about its use is a challenge for policy makers. In a growing economy, knowledge about IT technologies will surely bring about possibilities for the young generations of today.

With respect to agricultural technology, the picture is very different from that of IT. The amount of machinery owned has stayed very close to constant, except for pesticide sprayers, where the numbers have slightly declined, possibly as a result of tackling the problem of pesticide overuse. What we do observe is the increased renting of machinery, and that development has been especially rapid in the Long An province. Hence, we find that rapid economic growth has aided the mechanization of agriculture especially in Long An province, but in the other provinces the development has been much more modest. Mechanization of agriculture remains to be a concern for policy makers, keeping in mind that environmental concerns should be addressed properly.

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