Spill-over effects of ICT use in school to Thai communities

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Abstract

Policymakers around the world are considering whether to invest in putting information and communications technology (ICT) in schools. While the primary impact of this ICT is likely to be on the education that students get while at schools, there may be additional effects that are worth considering: adoption of ICT in the households of these students, and impact on utilization of adults who live with these students. Through an econometric analysis of survey data collected while Thailand was in the process of deploying ICT in schools, this paper first shows how the presence of students in a household affects both household adoption and adult utilization. Then the study examines how this effect changes depending on the extent to which students can access ICT at school. The ICT considered consists of computers and Internet connections. The study finds that households with students are far more likely to have adopted ICT, and this effect is stronger for students at higher educational levels, but adults in those households are no more likely to use ICT. Thus, not only is adult utilization relatively unaffected by the presence of students, but it is also relatively unaffected by the presence of ICT in the adult's own home. For these adults, clearly making ICT more available and less costly will not increase Internet use. When a student accesses ICT at school, there is a spill-over effect on his or her household ICT adoption and ICT utilization by family members. The largest spill-over effect occurs with primary schools: making computers available in primary school increases household computer adoption somewhat, and adding Internet in the schools greatly increases both household adoption and adult utilization of computers and Internet. For junior high and high schools, computer access in schools alone has little impact on ICT adoption at home, and putting Internet access into high schools shows a small substitution effect on Internet adoption at home. Making Internet available in high schools may thereby reduce residential penetration. As for adult utilization, giving students at all educational levels access to computers without Internet has little impact on the ICT use of family members, but making Internet accessible in schools as well has a large spill-over effect on Internet usage of adults. In addition to the direct educational value, policy-makers should also consider these indirect benefits when making decisions about supporting ICT in schools.

[1] Jon Peha contributed to this work solely in his capacity as Carnegie Mellon University professor. The opinions expressed in this paper are solely those of the authors and do not necessarily reflect those of Carnegie Mellon University or other institutions to which the authors have been affiliated with.

1.0 Introduction

Policymakers around the world are considering whether to invest in putting Information and communications technology (ICT) in schools. While the primary impact of this ICT is likely to be on the education that students get while at school, there may be additional effects that are worth considering: adoption of ICT in the households of these students, and impact on utilization of adults who live with these students. This paper presents an econometric study of how putting ICT in schools affects the adoption and use of ICT in the surrounding communities, based on a study of the SchoolNet project in Thailand, which aims to provide student benefits of online information by connecting all schools to the Internet (SchoolNet, 2010). This study also looks at how adult utilization of ICT is affected by living with students, and indirectly, by living with ICT that was likely brought into the households for those students.

Past studies conducted in developed countries have found that households with children are more likely to adopt ICT (Holloway and Valentine, 2003), and adults in that household are more likely to use ICT (Horrigan, 2009). Whether this is the result of or even related to whether those children who are students use ICT at schools is unclear. To understand the spill-over effects of ICT in schools, we first examine the impact of having students in a household, and then examine how this impact might change depending on whether students have access to computers or the Internet at schools. The paper therefore addresses spill-over effects by answering the research questions; to what extent does (i) the presence of students in a household, or (ii) giving those students access to ICT at school have spill-over effects on (a) household adoption of ICT, or (b) utilization of ICT by the family members of students?

By separating the spill-over effects on household adoption of ICT from the spill-over effects on adult usage of ICT, we are able to examine another important issue. As this paper will show, there are many circumstances in which we see a profound effect on household adoption of ICT in the home, but limited or no change in the use of ICT by adults in that household. In such cases, not only is adult utilization relatively unaffected by the presence of students with ICT access in school, but it is also relatively unaffected by the presence of ICT in the adult's own home. For these adults, clearly neither the availability of ICT nor the cost of ICT is the primary reasons they have not become ICT users, which means some of the common methods of trying to increase Internet use are unlikely to affect these users.

The study quantifies the spill-over effects of Thailand's SchoolNet project, which has been deploying ICT in K-12 schools throughout Thailand. This study analyzes data from a survey of household in Thailand in 2007, with variables associated with each household and its family members related to ICT adoption and utilization, geographic, and demographic information. The ICT considered in this paper consists of computers and Internet connections (either dial-up or broadband). The data was collected at a time when some but not all schools had ICT, allowing the study to make comparisons between schools with no ICT, schools with computers but no Internet access, and schools with computers and Internet access. This paper also explores how these spill-over effects depend on various factors, such as the

educational level of a student, and the number of students in a household. Results are based on logistic regression models and the propensity score matching technique.

Section 2 discusses related studies about the effect of having students in a household as well as the effect of putting ICT in schools on ICT adoption at home and ICT utilization of family members. Background information on ICT in Thailand and the SchoolNet project is presented in Section 3. Section 4 discusses the data set and research methodology. After presenting results in Section 5, the policy implications are discussed in Section 6.

2.0 Literature Review

Section2.1 discusses studies related to the possible impact of having students in a household. Section 2.2 discusses various studies that investigate possible spill-over effects of having ICT in schools.

2.1 Effect of having students in a household

Studies have been conducted to find possible effect of having students in a household on ICT adoption at home. Using survey data from the UK, both Selwyn (2004) and Holloway & Valentine (2003) concluded that having students is a main reason for the purchase of computers in households. The presence of students is also a very important factor in the subscription of Internet at home as confirmed by Newberger (2001) using survey data from the US, and Van Rompaey et al. (2002) using a survey of Flemish families in Belgium. This positive effect of student's presence on household adoption of ICT could happen because students persistently ask to have ICT as well as because parents believe that ICT can provide educational benefit to their offspring (see Robertson *et al*., 2004 in the study using household survey data of the UK).

The presence of students can also affect ICT use by family members. From the survey of Internet users in the US, Horrigan (2009) found that an individual is more likely to become an Internet user (in particular, broadband user) if he/she is a parent of a minor child in a household. Some parents start using computers and the Internet to make sure that they stay ahead of their children (Selwyn, 2004). Even though living with students is associated with family members having access to ICT because they have opportunity to use it, merely having physical access to ICT does not necessary make family members actually use it, as discussed in Gorand & Selwyn (2003) and Selwyn (2004) using survey data from the UK.

These previous studies related to the impact of having students in a household were conducted in developed countries. In this study, we show the extent to which there are similar effects in Thailand, where computer and Internet use is far less pervasive.

2.2 Spill-over effect of putting ICT in school

Technological knowledge can spill-over from person to person as Haddon found that there is a technological seepage where expertise and access to technologies could spread from one member of a household to another (Haddon, 2003; Haddon and Silverstone, 1996). Like any other technological knowledge, the knowledge of ICT in schools can also spill-over from students to their parents. For example, students may be able to teach their parents something new about computer and Internet.

It is also possible that ICT in school can have spill-over effects on ICT adoption of surrounding communities. Using Internet usage data of Portugal schools, Agyapong et al. (2010) found putting broadband Internet in schools is associated with significant increase in Internet penetration (household) in the schools' neighborhood.

To the best of our knowledge, there are not many literatures about spill-over effects of ICT in school on household adoption of ICT or utilization of ICT by family members, either in developed or developing countries.

3.0 SchoolNet project and ICT in Thailand

This section discusses background information on ICT in Thailand as well as the details of SchoolNet project.

3.1 Background of ICT in Thailand

Unlike in developed countries, ICT adoption and utilization are not yet common in Thailand. Out of 60 million people in 2007 who are older than 5 years old, 27% and 16% of them are computer and Internet users respectively (NSO, 2007). Out of 18 million households in Thailand, 17% and 8% have computer and Internet respectively. About 60% of households with Internet connect via broadband connections (mainly ADSL service), 20% of households connected via dial-up connection, and the rest are uncertain about their connection type.

There were more than 10 Internet service providers throughout the country. They provided both dial-up connections via fixed-line telephone services and broadband connections via ADSL technology, though broadband connections are mainly available in major cities and not in the countryside. For dial-up connections, consumers can connect in every province by paying only local telephone call charges. Consumer broadband Internet bandwidth ranges from 2 Mbit/s to 16 MBit/s with a monthly fee starting from $20.[2]

3.2 SchoolNet project

Started in 1995, the Thailand SchoolNet project aims to provide Internet connections to all students in schools. The project began at a few schools in the capitol city of Bangkok and by 2002 had expanded to include several thousand schools connected throughout the country (Koanantakool and

[2] Exchange rate as of December 2007. 1 US dollar = 30 Thai Baths

Thuvasethakul, 2004). In 2003, administration of the project had been transferred from the National Electronics and Computer Technology Centre (NECTEC) to the Ministry of Education and the targeted number of schools that will connect to the Internet was revised to 38,000, where Thailand had roughly 50,000 schools at that time (MoE, 2010). Schools were not selected to target any particular geographic or demographic group, so this study assumes that the selection of schools was random.

Facilitated by the Telephone Organization of Thailand (TOT), each school originally connected to the Internet by dial-up access and paid only a local telephone connection charge of 3 THB. As the project progressed, an "educational price" leased line and telephone lines were available for schools. Each participating school was allocated free disk space on the central server as mailbox and web storage. There were trainings from NECTECT to support teachers and students in developing websites, content, as well as managing the network (SchoolNet, 2010).

Table 1 shows the percentage of students at different educational levels who use ICT anywhere in the past 12 months derived from NSO (2007). The study defines student as someone who is currently in any K-12 school or college. On average, 56% and 11% of primary school students use computer and Internet, respectively. Partly because of the SchoolNet project, most students who use computer and Internet mainly use this ICT at schools.

Table 1: Mean statistics of students using ICT.

Variables	Primary	Junior High	High	College	All students
COM USER	0.56	0.89	0.93	0.96	0.76
NET USER	0.11	0.48	0.74	0.86	0.42
Use COM@School *	0.51	0.85	0.87	0.74	0.69
Use NET@School **	0.08	0.40	0.61	0.61	0.32
Total numbers	5,974,336	2,951,654	2,779,651	1,605,106	13,310,747

* Students answered "school" as one of their two main places of using computer
** Students answered "school" as on the their two main places of using Internet
Source: Derived from The National Statistics Office of Thailand (NSO) 2007

4.0 Methodology

Section 4.1 discusses the data set and variables of interest used in this study. Various analysis methods applied to explore the possible spill-over effects of ICT in school are explained in section 4.2.

4.1 Data set

The data set used in this study was collected in a census survey of Thailand's households and individuals within selected households in 2007. The National Statistical Office of Thailand (NSO) conducts a survey of 80,000 sampled households throughout Thailand annually about their household adoption of Information and Communication Technology (ICT) and usage of ICT by every family member

of the selected households who are older than 5 years old.[3] The questions related to adoption of ICT in the household were answered by the head of household while other questions related to individuals' utilization of ICT were answered by each family member of the household.

For each selected household and its family members, variables representing geographic, demographic and other characteristics were surveyed. While the household information included data about ICT adoption in the household, the family member information contained data about individuals' usage of ICT. Table 2 shows a list of variables at household and population level from the survey.

Table 2: Descriptive statistics of related variables at household level and population level.

	Household Variables	Definition (total households = 18,188,014)	Mean	Std.Dev.
1	COMPUTER	Existence of computer (1 is yes)	0.17	0.38
2	INTERNET	Existence of Internet connection (1 is yes)	0.08	0.27
3	BB	Existence of broadband Internet (1 is yes)	0.04	0.21
4	URBAN	Household located in urban area (1 is yes)	0.32	0.47
5	INCOME	Household income level (1 is lowest, 9 is highest)	2.90	2.13
6	Hd EDU	Educational level of head of HH (0 is no edu., 8 is highest)	2.53	1.40
7	Hd EMPLOY	Head of household is employed (1 is yes)	0.80	0.40
	Population Variables *	Definition (total adults = 45,969,371)	Mean	Std.Dev.
8	COM USER	A person uses computer in the past year (1 is yes)	0.13	0.33
9	NET USER	A person uses Internet in the past year (1 is yes)	0.08	0.27
10	URBAN	A person lives in urban area (1 is yes)	0.31	0.46
11	INCOME	HH income level (1 is lowest, 9 is highest)	3.21	2.25
12	EMPLOY	A person is employed (1 is yes)	0.81	0.39
13	MALE	A person is male (1 is yes)	0.48	0.50
14	MOBILE USER	A person has mobile telephone (1 is yes)	0.53	0.50
15	EDU PRIM	Highest education is primary school (1 is yes)	0.56	0.50
16	EDU JUNI	Highest education is junior high school (1 is yes)	0.14	0.34
17	EDU HIGH	Highest education is high school (1 is yes)	0.11	0.32
18	EDU COLL	Highest education is college (1 is yes)	0.13	0.33
19	AGE	Age (years)	42.52	15.89

* Population data only includes people > 15 years old and currently not in school

[3] The households were selected based on Stratified Two-stage technique. The sampling method used geographical areas as units of selection (by villages and households). For more details about the method, see Hanson *et al.*, 1993.

4.2 Analysis of ICT in school

This study uses logistic regression models to analyze the spill-over effects of putting ICT in schools on household adoption of ICT and ICT utilization by adult family members. We study adoption of ICT in the household by defining three binary variables representing whether or not the household has one or more computer, Internet connection (either dial-up or broadband), and broadband connection, respectively. Utilization of ICT by adult family members is defined as two binaries variables representing whether or not an adult has used computers or the Internet in the past 12 months, where an adult means a person who is more than 15 years old and currently not in school.

To understand the spill-over effects of ICT in schools, we first examine the impact of having students in a household, and then examine how this impact might change depending on whether students have access to ICT at school. A student is defined as a person who is currently in a K-12 school or college. Because the SchoolNet project is designed to bring ICT into the curriculum in those schools in which ICT has been deployed, a K-12 student is considered to have access to ICT in school if and only if the student identified school as one of the places at which the student uses ICT most frequently[4]. Note that results must be viewed very differently for college students. All Thai colleges make ICT available to their students, but unlike their K-12 counterparts, a college student may choose not to make use of this ICT.

The study predicts household adoption of ICT and ICT utilization by adult family members by using demographic and geographic factors as predictors of the regression models. Specifically the study controlled for variables at the household level and population level as shown in Table 2. A factor controlling for the existence of student(s) who access ICT in school is included in the model.

Additionally we explore how the spill-over effects depend on the educational level of a student by applying the same logistic regression approach on different set of households. There are four educational levels in this study; primary school, junior high school, high school, and college. For the impact of having students in a household, the household with the students at a certain educational level, whether or not the students have access to ICT in school, is compared to the household that does not have student at that educational level. For the impact of having students who access ICT at school in a household, the household with such students at a certain educational level is compared to the household that also has students at the same educational level but the students do not access ICT in school.

5.0 Results

Results of the study are presented in two sections. Section 5.1 shows how the presence of students in a household affects household adoption of ICT and ICT utilization by adult family members. In the process, this section also explores the extent to which ICT adoption in a home can affect whether

[4] A question in the survey asked family members to identify the two places at which they most frequently use ICT. Choices of answer are home, school, office, Internet Café, Telecenters, and friend's house.

adults living in that home choose to utilize ICT. Section 5.2 discusses the spill-over effects of putting ICT in schools on households' ICT adoption and family members' ICT use.

5.1 Effect of having students in a household

Section 5.1.1 discusses how the presence of a student in a household affects the household's adoption of ICT. Section 5.1.2 discusses how family members' use of ICT is affected by the presence of students, and how it is affected by ICT adoption in the home.

5.1.1 Effect on household adoption of ICT

As described in Section 4, using logistic regression, this study predicts the likelihood that a household will have ICT (computer, Internet, or broadband connection) using demographic and geographic characteristics of the household.

Figure 1 shows increased likelihoods that a household will adopt ICT when there is at least one student, whether the student has access to ICT in school or not, at the given educational level in the household. For example, having at least one high school student in a household makes the household 3.8 times more likely to adopt computer, 2.8 times more likely to adopt Internet (either dial-up or broadband), and 2 times more likely to adopt broadband Internet compared to a household without a high school student.

Except for students in primary school, having at least one student in a household makes it strongly more likely to adopt computers and Internet. This is consistent with previous studies in developed nations which have found that the presence of students positively affects ICT adoption at home (see Newberger, 2001; Holloway and Valentine,2003; Van Rompaey *et al.*, 2004). In a developing country like Thailand where adoption of computer and Internet is not yet common compared to the developed countries used in those studies, the presence of students is also a major influence on household adoption of ICT. The higher the educational level of students, the stronger the increase in likelihood of a household to adopt. This effect is strongest for household adoption of computers, followed by adoption of Internet and broadband, respectively. It is unlikely that the presence of ICT in a household will cause people to have children, so this correlation implies that the presence of students causes households to adopt ICT in fairly large numbers.

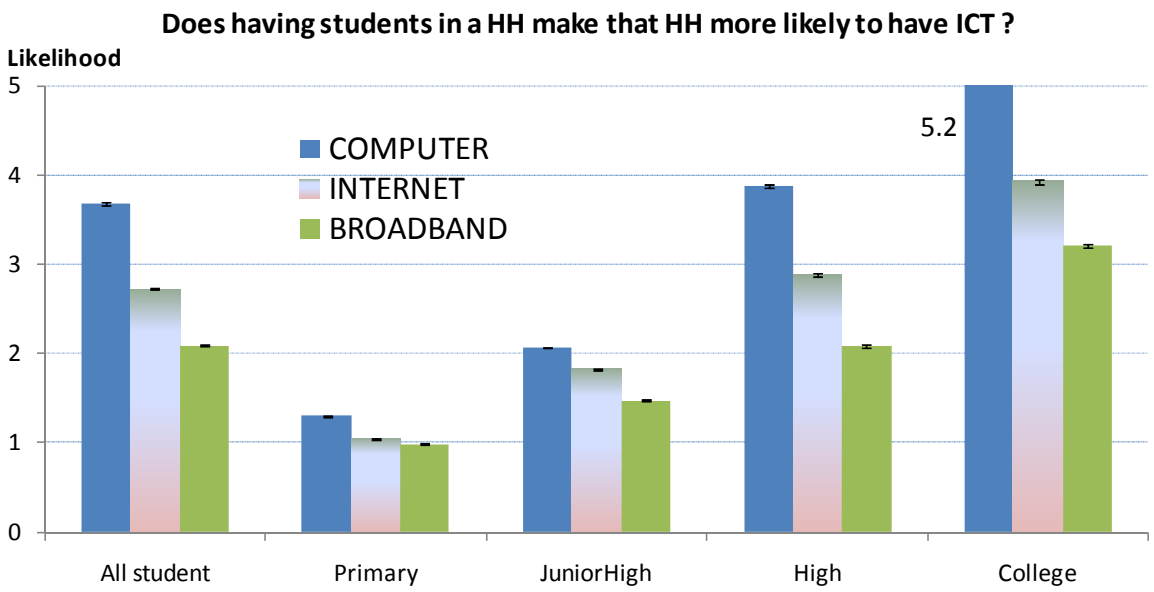

Figure 1: Increased likelihood that a household will adopt ICT when the household has one or more student at the given educational level. Analysis uses all 18 million households in Thailand. Error bars show the 95% confidence interval.

The study also predicts the increased likelihood that a household will adopt ICT when the household has more than one student compared to a household that has only one student. The study finds that the additional number of students in the household does not matter very much to the household ICT adoption regardless of the student's educational level, as shown in Figure 2.

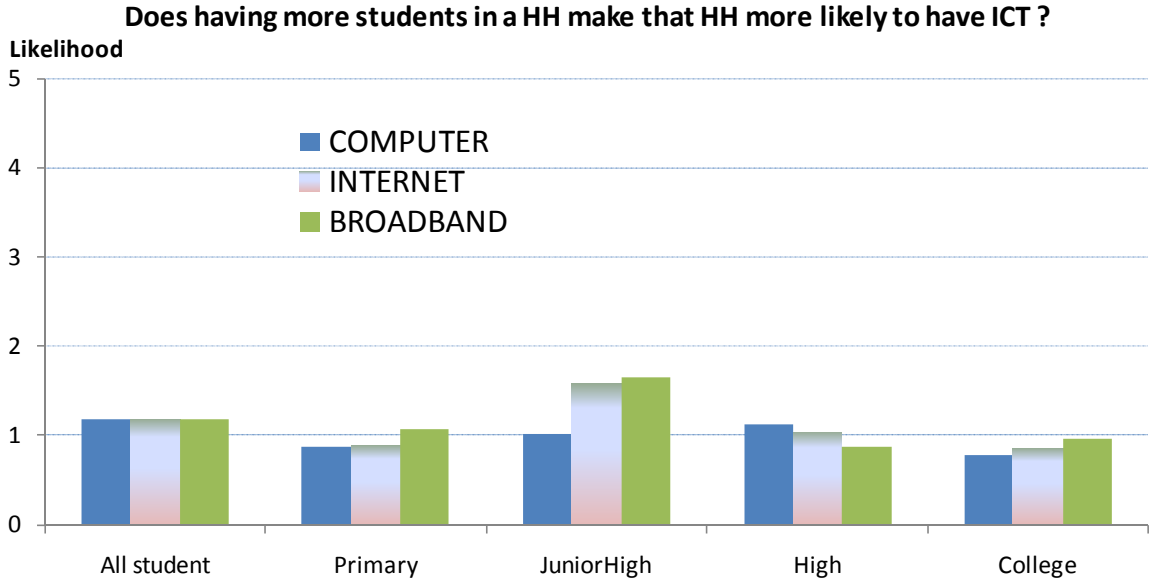

Figure 2: Increased likelihood that a household will adopt ICT when the household has each additional student at the given educational level. Analysis uses only households that have at least one student.

5.1.2 Effect on family ICT utilization by adult family members

This section analyzes the extent to which adult family members will use ICT when living with students. Figure 3 shows the increased likelihood that a non-student adult family member will use ICT when living with at least one student, whether or not the student has access to ICT at school. For example, living with a junior high school student makes an adult family member about 1.1 times more likely to use computers, but equally likely to use Internet, compared to an adult living with no student. Overall, Figure 3 shows that living with a K-12 student has very little impact on adult ICT utilization.

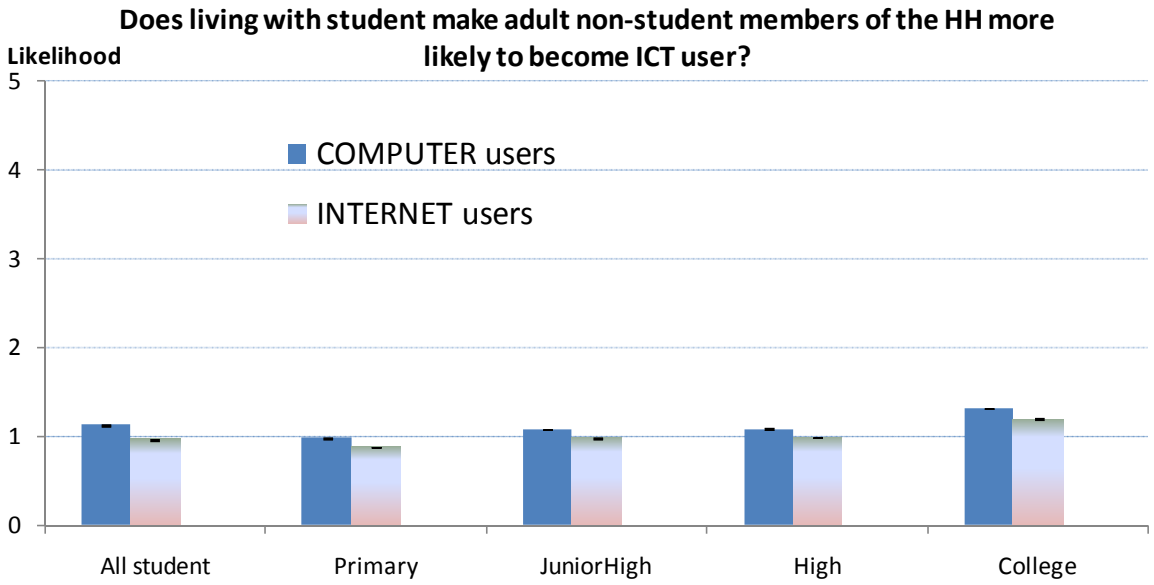

Figure 3: Increased likelihood that an adult will use ICT when living with one or more student at the given educational level. Analysis uses all 46 million adults in Thailand. Error bars show the 95% confidence interval.

The results from Figure 3 are particularly surprising when the results of Figure 1 are also considered. We find that households with students are far more likely to have adopted ICT, but the adults in those households are not more likely to use ICT. Again, we assume that the presence of students leads to ICT adoption rather than the other way around. Consequently, even after adults have gone to the expense of adopting ICT because of their children, those adults choose not to utilize the ICT that resides in their own homes. Thus, neither cost nor convenience is the reason they do not use ICT.

To further understand how the presence of students might affect adoption and utilization, we would ideally separate those households that adopted ICT specifically for their children from those who would have adopted anyway. While it is impossible to do this exactly, it can be roughly approximated using the Propensity Score Matching (PSM) technique, which tries to match each household from the treatment group to a household in the control group that has similar demographic and geographic characteristics (See Rosenbaum & Rubin, 1983; Dehejia & Wahba, 2002). In this case, the treatment group is those households with students, and the control group is those households without students.

We are trying to predict how computer adoption might change if there was a change in the presence or absence of students. The results are in Table 3.

Table 3: Predicted computer adoption in households with students if the households did not have students using PSM. Households are differentiated into 4 groups based on their current (COM) and predicted (pCOM) adoption of computers.

	Group	1	2	3	4	"Treatment"	"Control"	Total
	COM	Yes	Yes	No	No	(Household with students)	(Household without students)	
	*p*COM	Yes	No	Yes	No			
1	**# Household**	617,704	1,420,614	345,446	6,236,424	8,620,188	9,567,826	18,188,014
2	URBAN	0.78	0.39	0.81	0.17	0.28	0.35	0.32
3	INCOME	6.88	4.21	4.81	2.20	2.97	2.83	2.90
4	Hd EDU	4.61	3.09	3.24	2.13	2.51	2.55	2.53
5	**# Adults**	1,639,038	3,550,934	957,621	15,813,977	22,019,581	23,998,143	45,969,371
6	COM USER *	0.53 *872,912*	0.29 *1,044,762*	0.14 *130,130*	0.03 *439,706*	0.11 *2,501,268*	0.14 *3,379,897*	0.13 *5,881,165*
7	NET USER	0.39	0.16	0.09	0.01	0.07	0.09	0.08
8	HH w/o adult using computer	0.26	0.57	0.76	0.95	0.83	0.81	0.82

* numbers in italic represent absolute numbers of computer users in each household group

Table 3 shows observed and predicted computer adoption in households that have students and their demographic/ geographic characteristics. COM indicates whether the household has a computer, *p*COM is a prediction as to whether the household would have a computer if it did not have students. Based on the current and predicted computer adoption, households with students are differentiated into 4 groups. The first group is households that currently have computers and are predicted to have computers even when they have no student. The second group is households that currently have computers but are predicted to have no computer in the absence of students. Computers are apparently adopted in this group of households for their students. The third group is households that currently have no computer and are predicted to adopt computers if they had no student. The last group is households that currently have no computer and are predicted to stay that way even if the households did not have students.

From those households that currently have one or more students and have adopted computers (household group #1 and #2), the PSM technique predicts that 70% of them have computers only because they have students. In these households (group#2), only 29% of adults use computers, as compared to 53% in those households that PSM predicts would adopt even without students (group #1). Indeed, the majority (57%) of those group #2 households contain no adult who use computers or the Internet, even though they all live with computers in their homes. Although we must expect significant uncertainty in PSM results, there is a good reason to believe that there are a large number of adults who are choosing not to use ICT despite having easy access. This means there is a sizable portion of the adult population that is not likely to become ICT users only through policies designed to make ICT less

expensive or more accessible. These adults appear to live in households in which income, educational level of the head of household, and likelihood of living in an urban area all fall somewhere between the levels seen in households predicted to adopt computers whether they have students or not (group # 1), and the households predicted not to adopt computers whether they have students or not (group #4).

5.2 Spill-over effect of putting ICT in school

This section discusses how putting ICT in schools has spill-over effects on ICT adoption at home (Section 5.2.1) and ICT utilization of adult family members (Section 5.2.2).

5.2.1 Effect on households adoption of ICT

In this section, the paper analyzes the extent to which putting ICT in schools has a spill-over effect on adoption of ICT at students' homes by comparing three groups of households: A) households that have students who do not access ICT in school, B) households that have students who access only computers and not Internet in school, and C) households that have students who access both computers and Internet in school. The study analyzes the effect of putting only computers in school on ICT adoption at home by comparing household groups A and B. Comparing household groups B and C helps answer if there is a spill-over effect from putting both computers and Internet in schools on household adoption of ICT compared to putting only computers in schools.

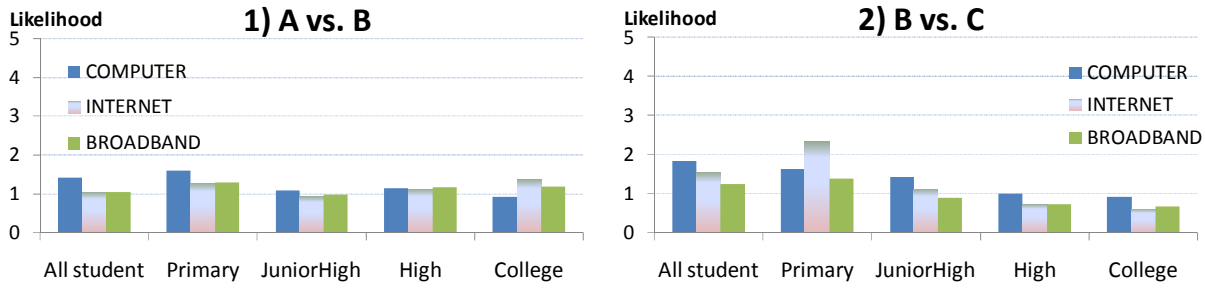

Figure 4: Increased likelihood that a household will adopt ICT when putting ICT in their kids' school. Each analysis uses only households that have students on a given educational level. Graph 1) compares between households with students who do not access ICT in school (household group A) to households with students who access computer in school (household group B). Graph 2) compares between household group B and households with students who access both computer and Internet in school (household group C).

Figure 4 shows how the increased likelihood of household ICT adoption when their students access ICT in school. The impact of ICT in schools differs greatly depending on the grade level of the student. Somewhat surprisingly, the effect is largest in primary school. Figure 4.1 shows that computers in primary schools make households with primary school students 1.5 times more likely to adopt computers at home, but only a slight 1.1 times more likely to adopt Internet. Household Internet adoption can also be affected, but this requires access to internet and not just computers at school. Households with students who access both computers and Internet in primary schools are 1.5 and 2.3 times more likely to adopt computers and Internet at home, respectively, as shown in Figure 4.2.

For junior high and high schools, computer access in schools alone has little impact on ICT adoption at home. However, putting Internet access into high schools is inversely related to Internet adoption at home, which would seem to imply a substitution effect; once high school students have access to Internet in school, it is possible that parents decide not to subscribe to an Internet service at home. Thus, deployment of Internet in high schools may actually reduce residential Internet penetration.

From Figure 4.2, there also appears to be a substitution effect for college students between Internet usage at college and Internet adoption at home. However, as discussed in Section 4.2, we believe that use of ICT on campus by college students reflects the choices made by college students, whereas in K-12 schools this usage reflects the choices that school systems impose on students. Thus, we cannot tell whether households are less likely to adopt because their college students choose to use Internet on campus, whether college students choose to use Internet on campus because there is no Internet at home, or both.

5.2.2 Effect on ICT utilization by adult family members

In this section, the paper analyzes the extent to which putting ICT in schools has a spill-over effect on ICT utilization by adult family members. Using the same method as the previous section, Figure 5 shows possible spill-over effects of putting ICT in schools by comparing 3 groups of adults: A) adults living with students who do not access ICT in school, B) adults living with students who access only computers and not Internet in school, and C) adults living with students who access both computers and Internet in school.

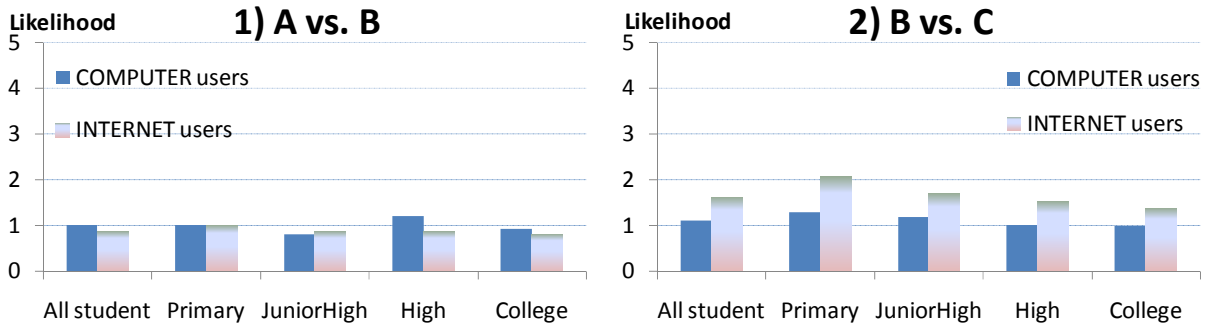

Figure 5: Increased likelihood that an adult will use ICT when putting ICT in their kids' school. Each analysis uses only adults living with students on a given educational level. Graph 1) compares between adults living with students who do not access ICT in school (adults group A) to adults living with students who access computer in school (adults group B). Graph 2) compares between adults group B and adults living with students who access both computer and Internet in school (adults group C).

From Figure 5.1, putting computers without Internet access in K-12 schools has little impact on the ICT use of the students' family members. However, there is clear relationship between student Internet access at school and adult ICT utilization at home. At least at the K-12 levels, adult ICT

utilization cannot affect access at school. Thus Figure 5.2 shows that making Internet accessible in K-12 schools has a large spill-over effect on Internet usage of adults. There is also a more modest increase in adult utilization of computers, at least for those adults who share a household with primary school students.

6.0 Discussion and Policy Implication

Even though computer and Internet adoption in Thailand is not yet common, this study finds results consistent with past studies in developed countries that the presence of students in a household strongly affects both computers and Internet adoption at home. For example, households with high school students are nearly 4 times more likely to adopt computers and 3 times more likely to adopt Internet at home compared to households without high school students. It has previously been found that ICT is viewed by parents in developed countries as a useful tool that can provide educational benefit to their offspring (Robertson *et al.,* 2004), our study indicates that it is viewed the same by parents in developing countries. The higher the educational level of students, the stronger the increase in likelihood of a household adopting ICT. While the presence of college students makes households more than 4 times more likely to have ICT at home, the presence of junior high school students makes households about 2 times more likely to adopt ICT. Our study finds that the presence of additional students at a given educational level does not matter much to ICT adoption in households.

If a student has access to ICT at school, this changes the impact his or her presence may have on household ICT adoption. This effect differs greatly depending on the grade level of the student. Putting ICT in primary school shows large positive spill-over effects on household adoption of both computer and Internet. For example, households with primary school students who access computers with no Internet access in schools are 1.5 times more likely to adopt computers at home compared to households with students who do not access ICT in schools. When the primary school students also have access to Internet at schools, households with such students are 2.2 times more likely to have Internet at home compared to households with students who have access only to computers at schools. This means making computers and Internet available in primary school may largely increase both residential computer and Internet penetration. For junior high and high schools, computer access in school alone has little impact on ICT adoption at home. Putting Internet access into high schools is even inversely related to Internet adoption at home, which would seem to imply a small substitution effect; once high school students have access to Internet in school, it is possible that parents decide not to subscribe to an Internet service at home. Making Internet available in high schools may, thereby reduce residential penetration.

The effects of students on adult utilization of ICT are far less dramatic than the effects on household adoption described above. Putting aside whether students have access to ICT at school, merely living with a K-12 student has very little impact on adult ICT utilization. Putting the adoption and utilization results together, this means that households with students are far more likely to have adopted ICT, but the adults in those households are still no more likely to use ICT. Thus, not only is adult utilization relatively unaffected by the presence of students, but it is also relatively unaffected by the

presence of ICT in the adult's own home. For these adults, clearly neither the availability of ICT nor the cost of ICT is the primary reasons they have not become ICT users. Policy-makers seeking to increase Internet use would need to look for other approaches rather than only traditional policies that make ICT less expensive or more accessible.

Giving students access to ICT in schools does change this somewhat. Putting computers without Internet access in K-12 schools has little impact on the ICT use of the students' family members. However, there is clear positive relationship between student Internet access at school and adult ICT utilization at home. Thus, making Internet accessible in K-12 schools has a large spill-over effect on Internet usage of adults. There is also a more modest increase in adult utilization of computers, at least for those adults who share a household with primary school students. Policies to provide Internet access in K-12 schools can expect these spill-over effects as an extra benefit from improving the education of students.

From all of the results described above, we see that placing ICT in schools does have a spill-over effect outside schools, it is strongest when that ICT includes Internet as well as computer access, and it is strongest in primary schools. In addition to the direct educational value, policy-makers should also consider these indirect benefits when making decisions about supporting ICT in schools.

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