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Mobile Phones and Business Efficiency: The Case in Thailand

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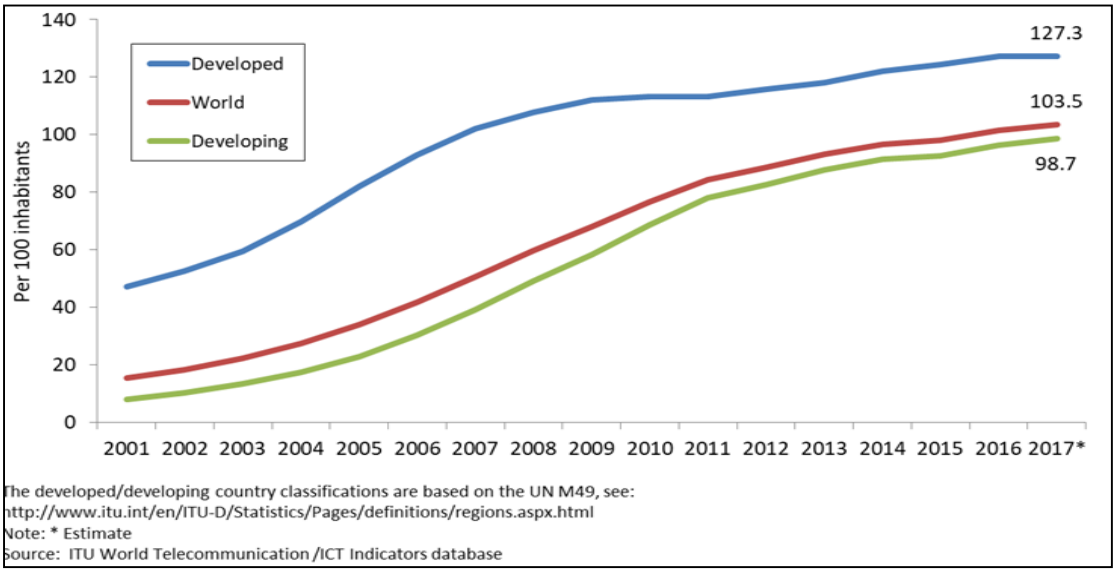
Abstract: The rapid and sustained growth of mobile phones globally has been driven by both developing countries and least developed countries. This recent technological push of information communication technology (ICT) is decreasing the global "digital divide." As a result, the diffusion of mobile phones in developing countries has sparked interest from an economic and social perspective. However, there are limited studies that address the role of mobile devices in driving business efficiencies. Using household survey, panel data from rural and urban Thailand in 2014 and 2015, I find that mobile phones positively affect gross revenue but do not decrease business problems. These findings lead me to believe a likely issue of reverse causality.

The world now has more mobile telephone subscriptions than people, according to the International Telecommunications Union's Facts and Figures for 2017. Specifically, mobile broadband subscriptions have grown 20% annually in the last five years where developing countries have grown over 30% and least developing countries (LDCs) have grown approximately 53% over the same period of time. In the past two decades, developing countries are decreasing the "digital divide" through their adoption of Information Communication Technology (ICT), as seen in Figure 1.

Figure 1: Mobile Cellular Subscriptions per 100 inhabitants, 2001 - 2017



Despite developing countries' accelerated growth, there are twice as many mobile-broadband subscriptions per 100 inhabitants in developed countries compared to developing countries and four times as many mobile broadband subscriptions in developed countries as in LDCs. The rapid growth of mobile phone adoption has spurred substantial interest with its effect on economic development. A bulk of the current literature analyzes the adoption of mobile phones in developing countries focusing on the social and cultural implications, poverty reduction, studying specific markets, and overall economic impact (Mbiti & Weil 2011; Kaplan

2006; Waverman *et al* 2005; Jensen 2007; Aker 2010; Donner *et al* 2010; Dutta 2001; Lee *et al* 2001). Yet, there has been limited research on the specific effects of mobile phones on businesses in developing countries. A few exceptions, however, do exist: mobile phone adoption in developing country firms have yielded decreases in price dispersion, expanded networks, reduces search and transaction costs, limits uncertainties and risks, increases access to information, and results in more efficient use of labor and capital (Aker *et al.* 2010*;* Baye, Morgan, and Scholten, 2007; Jensen 2007; Jensen and Miller 2018; Donner 2008). This paper estimates the impact of mobile phones on business efficiency in Thailand.

Information communication technology (ICT) is an essential tool for businesses to maintain competitiveness. Mobile phones with mobile internet capability connect individuals, information, markets, and services, allowing people and firms to send and obtain information quickly and cheaply. Mobile phones have the potential to reduce the digital divide and accelerate business growth. Prior studies have concluded that mobile phones have benefited businesses stating that in Nigeria "the speed and access to information increased; communication costs decreased; travel requirements were reduced, and buyers could deal directly with suppliers and customers – all resulting in greater efficiency" (Jagan *et. al*.).

There are several constraints that explain the lack of literature on mobile phone adoption and businesses. First, there is limited data on mobile phones impact from a business context and subscriber identity. Second, it is challenging to use a credible estimation strategy to address the effect of mobile phones on businesses. Therefore, this method relies on panel data derived from annual household micro surveys provided by the Townsend Thai dataset. The data ask detailed questions that address business efficiency. These questions include: sources of income and expenses, business problems, necessary assets, varying occupation sectors, business experience,

and education. The survey also asks if the households own a mobile phone or a landline phone. To test this hypothesis, I will gather annual data from 2014 to 2015 and empirically analyze the impact of mobile phone ownership on business efficiency using regression analysis.

The outline of the paper is as follows: Section 2 will describe the previous literature, conceptual theory, and the likely motivations of mobile phone usage in developing nations. Section 3 seeks to define business efficiency. Section 4 provides background on the status of ICT in the developing country for this study, Thailand. Section 5 analyzes data from the Townsend Thai dataset and generates estimates of the effect of mobile phone use on business efficiency. Section 6 considers several robustness checks accounting for age, business experience, and the potential for diminishing returns of mobile phone ownership. Finally, section 7 concludes.

Section 2: Evidence on the effects of mobile phone adoption in developing countries

As the world becomes increasingly interconnected, both economically and socially, technology adoption remains one of the driving factors in human progress. Developing nations are quickly joining this technological push to improve daily living through their adoption of ICT. The adoption of mobile phones is a primary form of ICT that developing countries are incorporating into their lives. There has been a noticeable rise over the past decades in the percentage of people in emerging and developing nations who say that they use the internet and own a smartphone (Pew Research Center 2016).

Specifically, in 2000, just 4 percent of the people living in low- and middle-income countries had access to a mobile phone. In 2015, that number skyrocketed to 94 percent of people in that same population — making it easier to find someone who might lend you their mobile phone than finding clean water or electricity (Gharib). The significant growth is largely motivated by the attractiveness of mobile phones including common themes of affordability,

accessibility, compatibility, ease of use, service quality, safety concerns, and mobility. Despite the increased access and use of mobile phones on a global scale, richer countries and people with more education are more likely to use the internet and own a smartphone (Pew Research Center 2016; Waverman *et al*, Coloa *et al*.)

The lowest levels of smartphone ownership are in poorer countries concentrated in sub-Saharan Africa and South Asia. These levels include smartphone ownership rates of two-in-ten or less in Senegal (19%), India (17%), Burkina Faso (14%), Tanzania (11%), Pakistan (11%), Uganda (4%) and Ethiopia (4%) (Pew Research Center 2016). However, while these countries have low levels of smartphone ownership compared to others, access and use of mobiles in sub-Saharan Africa has increased dramatically during the past decade. This furthers the logic that even the poorest countries are participating in this mobile phone boom (Aker *et al* 2010). There are ten times as many mobile phones as landline phones in sub-Saharan Africa (ITU, 2009), and 60% of the population has mobile phone coverage. Mobile phone subscriptions increased by 49% annually between 2002 and 2007, as compared with 17% per year growth in Europe (ITU, 2008).

This relatively recent yes constant growth of mobile phones has motivated research that analyzes the economic, social, and business development implications. Much of the literature shows a positive relationship between mobile phone adoption and economic growth (Dutta 2001, Lee 2012, Fuss *et al* 2007). Dutta analyzes the causal links between telecommunications infrastructure and economic growth using data for 15 developing and 15 industrialized countries from 1960 to 1993. For this purpose, Granger causality tests are applied, in which telecommunications usage is quantified through the number of telephones (total and per 100 inhabitants). The authors observe that telecommunications infrastructure leads to economic

growth in over half of the examined developing countries. Another study by Wavermen *et al.* found similar findings. The authors utilize data for 92 countries from 1980 and 1996 to 2003.The estimations indicate that while a higher average mobile penetration level for the years from 1996 to 2003 led to a significant increase in the average growth rate of GDP per capita from 1980 to 2003, the level of fixed-line penetration in 1980 did not have a significant effect. In particular, the effect of mobile adoption was twice as large for low income countries relative to the high income countries. Given that developing nations are benefitting from mobile phone growth, it is imperative to analyze the social implications of mobile phone use.

Mobile phones have brought many benefits and improved the lives of those living in under-developed conditions with limited resources. The abundant possibilities of the platform are advantageous for various reasons, including those in the educational, healthcare, and banking industries (Kaplan 2006; Mbiti and Weil 2010). There is evidence that mobile phones can be used to improve healthcare, acting as a cost-effective form of "mobile medicine." Instead of travelling a long distance to receive treatment or a diagnosis, mobile phones increase communication between patient and caregivers and can improve adherence to medicine (Kaplan 2006).

Like healthcare, mobile phones also provide a platform for mobile banking. A study by Mbiti and Weil analyzed the impact of the M-Pesa in Kenya. The M-Pesa is a mobile telephone based money transfer system in Kenya which grew at a rapid rate after its inception in 2007. The study looked at the banking system prior to its inception in 2006 and compared it to the year of its inception in 2007 and beyond. Results show that in 2006, people sent money using friends, bus companies, or the post office. In 2007, 50% of the population sent money using M-Pesa and 65% received funds with M-Pesa. In two years, 8.5 million Kenyans had registered to use the

system and $3.7 billion had been transferred using M-Pesa, accounting for 10% of Kenya's GDP (Mbiti & Weil 2011). There is therefore a potential for mobile phones to facilitate economic livelihood and to improve financial access allowing people and firms who may not have the means for formal banking. Small-scale firms have specifically benefited from mobile banking. Plyler *et al* (2010) argues that "M-Pesa has promoted the growth rates of (small-scale) firms in the communities they studied, and they argue that this was largely driven by the increased circulation of money in these communities." Evidently, mobile phones have been an effective platform for improving the economic and social welfare of developing countries.

Much of the literature surrounding mobile telephony has analyzed the role of mobile phones on economic growth. However, limited studies have addressed mobile phones impact on businesses and markets in developing countries. In most developing countries, markets and firms are dispersed and isolated and communication infrastructure is costly and sparse. Producers and traders have limited information on prices, networks, and capital for example in nearby villages. This disconnect results in business inefficiencies. Until recently, studies have found a positive relationship between mobile phone adoption and business productivity. A significant and recent study in this body of literature by Robert Jensen analyzes the impact of mobile phone use by Kerala fisherman in India. Jensen found that mobile phones decreased price dispersion and wastage of a highly perishable commodity (fish), by spreading information which made the market operate more efficiently. Mobiles allowed fisherman to communicate price information to land and sell their daily catch at the best, most profitable market. The fishermen could also take advantage of supply and demand information. They spent less time idling on shore and at sea, because they only went to the landing docks when they received the notice to do so via their

mobile phones. Also, the fishermen felt safer, as the mobile phones provided vital access to weather information (Jensen 2007).

A similar study assesses the impact of mobile phones on grain markets in Niger. Aker (2010) finds that the use of mobile phones reduces dispersion of grain prices across markets by 10 percent. Also, mobile markets had more contacts and sold in different markets driven by increased communication amongst sellers and buyers. The effect is stronger for markets with higher transport costs given by poor-quality roads. For example, an average trip to a market located 65 kilometers away can take 2 to 4 hours roundtrip, compared to only a two minute phone call. Therefore, this study shows how the mobile phones increase business efficiency by reducing search and transaction costs. Overall, mobiles lowered price dispersion by 10 percent and increased profits by 29 percent (Aker *et al* 2010). These studies indicate the mobile communication feature of these phones reduce search costs, coordinate supply and demand, provide access to information, reduce product wastage, limit risk and uncertainties, and decrease price dispersion, all resulting in increased market efficiencies. By analyzing specific markets like the fishing industry and grain market, mobile phone adoption is advantageous for developing firms. However, there is still limited research on the specific effects of mobile phones on businesses in developing countries from a general business perspective. Therefore, I seek to estimate the impact of mobile phones on business efficiency, specifically in Thailand.

Section 3: Defining Business Efficiency from a conceptual perspective

One reason for the limited research on this topic, aside from the newness of the development, is the constraint of objectively measuring the effects of mobile use on businesses. Therefore, before analyzing the role of mobile phones on business efficiency, it is necessary to define what makes businesses operate efficiently. However, measuring business efficiency is

challenging and ambiguous. Economists have long debated what creates efficiency. For example, "two of the most well-known results in economics, are the First Fundamental Theorem of Welfare Economics (i.e., competitive equilibria are Pareto efficient) and the 'Law of One Price' (i.e., the price of a good should not differ between any two markets by more than the transport cost between them). These theories rely heavily on the assumption that agents have the necessary price information to engage in optimal trade or arbitrage" (Jensen 2007). In its simplest form, a mobile phone's primary function is to provide information by means of communication, the internet, or various applications. Increased communication and a channel for accessing information should improve a firm's productive efficiency by allowing them to better manage their supply chains. Also, mobile phones can facilitate communication among social networks in response to shocks, therefore limiting households' and firms' exposure to risk. Finally, mobile phone based projects, known as "m-development" have the potential to deliver financial, agricultural, healthcare, and educational services (Aker 2010). The mobile phone, therefore, serves as a conduit for information, which is critical for the effective functioning of markets, as stated above. However, due to distance and costs of developing nations' businesses, many do not always have access to this necessary information.

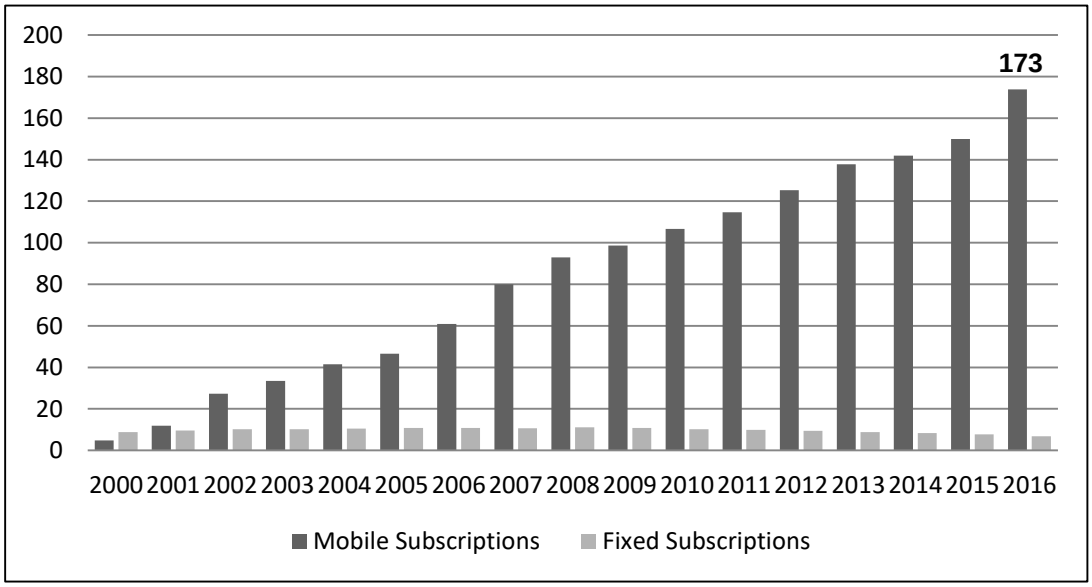
A majority of people in developing countries live in rural, remote regions, isolated from markets and information (Jensen 2018). Therefore, the mobility of mobile phones is an attractive and useful feature to receive and exchange information from a distance. Mobile phones connect individuals to other individuals, information, markets, and services. In making these connections, they lessen the information asymmetries in markets, thereby making undeveloped markets more efficient. Mobile phones can reduce the uncoordinated information inevitable in households and firms in these rural regions. Evidently, information is necessary for households and firms to

operate efficiently and remain competitive. As a result, these people need a variety of information for optimal decision making including: input prices, output prices, jobs, the status of buyers and sellers, natural disasters, new technologies, politics, and the status of family and friends (Aker *et al.* 2010). The shipping tycoon Aristotle Onassis remarks that "the secret of business is to know something that nobody else knows. The secret of market design, conversely, is to enable information to flow" (Abraham 2007). Overall, mobile phones allow people to communicate at a distance and exchange information instantaneously thus driving business efficiency.

Section 4: Information Communication Technology in Thailand

Before analyzing the data to estimate the impact of mobile phone ownership on business efficiency, it is necessary to understand the status of the mobile market in the specific developing country for this study, Thailand. ICT is a facilitator of growth in Thailand. For instance, mobile phones were introduced in the early 1990's in the country, and there has been continued growth since its inception. As seen in Figure 2, the latest industry statistics indicate that there are 173

Figure 2: Mobile Cellular Subscriptions per 100 Inhabitants, 2000 - 2016



Source: ITU Facts and Figures 2017

phones per 100 inhabitants in Thailand; there are more mobile phones than people in the country. Fixed subscriptions, or landlines, have declined in growth where mobile subscriptions far outweigh fixed subscriptions. According to the ICT development index, Thailand is slightly ahead of other Asia-Pacific countries and well above developing countries average. The ICT index combines eleven indicators to monitor and compare the development of ICT in countries. The International Telecommunications Union includes measures such as wireless infrastructure, internet access, computer ownership, mobile versus fixed subscriptions, and the level of use of mobile phones. In 2013 Thailand had an index of 4.76 compared to 4.57 of the average of Asian countries and 3.90 average for developing countries. Within their Asian peer market, Thailand is positioned favorably for ICT.

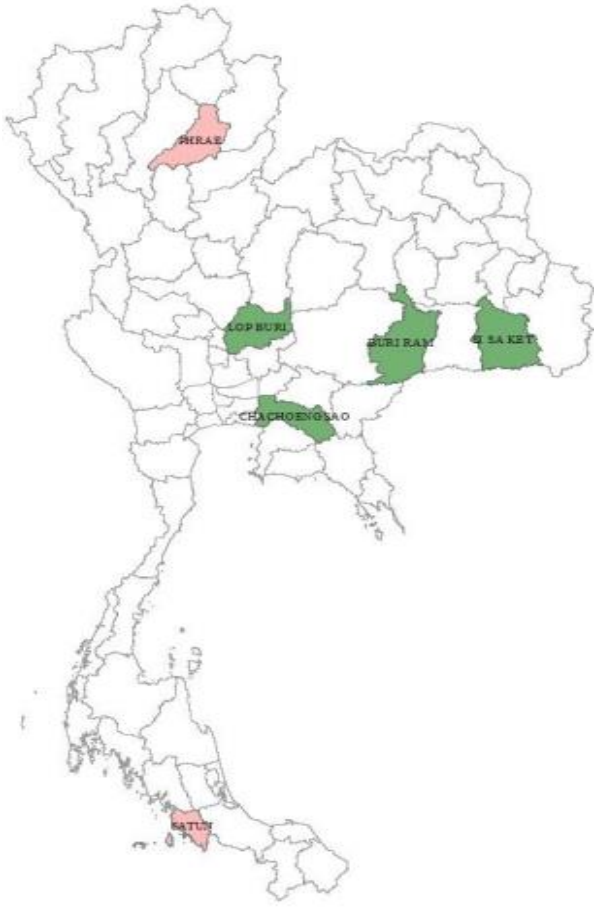
The mobile phone, and more specifically smartphones, largely contributes to this technological push. According to 2017 data from the National Statistical Office of Thailand, more than 90 percent of internet users in the country access the internet via smartphone, far exceeding the rates for any other device. The second most popular device for internet access was a desktop, used by just half of internet users surveyed (National Statistical Office of Thailand 2017). Thailand has established a globally competitive electronics industry. Proactive government policies have played a pivotal role in creating an enabling environment for the development of that industry. The industry has acquired most of its technology through foreign direct investment and trade (Mailisuwan *et al* 2015). In value terms, about $4.5 billion was invested in the electronics industry between 1986 and 2001 (United Nations 2005). These technological developments within the country are some of the main factors for driving competitiveness of Thai small and medium enterprises (SMEs) in the global market (Yuwawutto *et al* 2010).

Many government agencies in Thailand have generated support and intervention to promote research and development (R&D) in SMEs. The group approach initiated by the Industrial Technology Assistance Program (ITAP) is one of the most successful cases to significantly improve technology and innovation at the firm level (Yuwawutto *et al* 2010). The group approach is based on the idea of using networking to capitalize on innovations, seminars and training, and technology acquisitions. The Industrial Technology Assistance Program (ITAP) was initiated and currently operates under the Technology Management Center (TMC) of the National Science and Technology Development Agency (NSTDA), Ministry of Science and Technology of Thailand. The program plays a supporting role for technology development of the private sector, particularly SMEs. Thailand is forthcoming with their innovation and development given their investments and projects in R&D. However, despite the clear importance and adoption of smartphones for digital access in the country, the device is not equally used across Thailand's geographic regions. In the capital city of Bangkok, the country's largest urban area, more than 70 percent of the population uses smartphones, according to the National Statistical Office. By contrast, the country's less developed Northeastern region has a usage rate of just 39.3 percent—though overall mobile phone usage is higher at 76.1 percent (National Statistical Office of Thailand 2017). Overall, Thailand is an intriguing developing country to analyze the effect of mobile phones on business efficiency given its diverse geography where urban and rural regions are present in addition to its widespread coverage of mobile phones.

Section 5: Empirical Strategy and the Effects of Mobile Phones on Business Efficiency

I utilize panel survey data from the Townsend Thai dataset. The Townsend Thai project began in 1997 and includes annual and monthly resurveys that track millions of observations about the economic activities of households and institutions in both rural and urban Thailand. I utilize two years of annual data from 2014 to 2015 from rural and urban household villages in Thailand. I specifically focus on household heads' responses. The household panel data includes approximately 1,200 rural households and 1,440 urban households. The surveys are collected from six provinces (*changwats*) of Thailand in four regions, as seen in Figure 3: the central region – Chachoengsoa and Lop Burin, the northeast region – Buri Ram and Si Sa Ket, the southern region – Satun, and the northern region – Phrae.

Figure 3: Thailand and the Corresponding Provinces



The Townsend Thai household dataset has several strengths. First, it is one of the most extensive datasets in the developing world. Analyses and studies of cell phone usage in developing countries is still growing, and so data is relatively limited. Therefore, this survey offers unique information on the adoption of cell phones in a developing country. Second, this dataset offers exceptional breadth and level of detail from a household and business context. It provides detailed information on household composition, education, age, household and business assets, expenses, investments, borrowing, lending, and savings. Additionally, there are specific data relevant to business efficiency that includes: primary occupation, worker type, business expenses, farm expenses, income, gross revenue, business problems, involvement in agricultural activities, worst income year and why, whether the household stopped their business and why, number of years in business, wages, if the household was affected by turmoil, and revenue sources. The business types tended to be small household businesses. For example, the most popular job was a rice farmer followed by general agricultural occupations. Other occupations included housework, furniture maker, own a grocery store, trader, mechanic, or raising frogs.

To understand the impact of cell phone usage on business efficiency, I analyzed the number of cell phones a household owns and its effect on the profitability of the business. I measure business efficiency by the level of business income, gross revenue, and farm revenue. Revenue from farming was an ideal variable, considering 47% of the observations participate in an agricultural activity. I reasoned that for Thai businesses to yield positive profits as defined by the three dependent variables, they must have had some form of useful information, a defining factor of efficiency. Despite the dataset's scope and detail, limitations exist that affects the variables and accuracy of the data. As mentioned, business efficiency is an ambiguous variable

that is challenging to precisely measure. Income, gross revenue, and revenue from farming were the conclusive variables that the dataset provided to most accurately measure business efficiency.

However, other variables such as price dispersion, travel time, changes in supply and demand, and the speed and access to information are other suitable factors to consider when analyzing business efficiency. Yet this information was not included in the dataset. Also, the survey does not specify if the cell phone is a smart phone or simple mobile phone. The internet feature on a smart phone would significantly change the way a business could efficiently operate as compared to a regular mobile phone that is limited to texting and calling. Ideally, it would have also been more effective to analyze a wider range of years including years before households in Thailand owned a cell phone. The years for analysis, 2014 and 2015, are not the most current; however, these years were the most current and consecutive years published on both the rural and urban side. Despite these constraints, I will use annual household data from Thailand to run a regression incorporating individual and year fixed effects, to better understand and gain further insights into firm level mobile phone usage.

Using panel survey data, I regress the outcomes of interest on control variables using individual and year fixed effects:

$$Y_{it} = \alpha_0 + \alpha Cell_{it} + \alpha_2 X_{it} + \theta_t + \delta_i + \varepsilon_{it} \text{ ; } i = \text{Household head}, \quad t = (2014,2015)$$

where:

Y_{it} *= log of Gross Revenue*
= log of Revenue from Farming
= log of Net Income

$Cell_{it}$ *= number of cell phones*
X_{it} *= number of fixed phones, net income, business expense, occupation, age, gender, education, agricultural activity, economic turmoil*

Θ_t *= Time-effects*
δ_i *= Individual-effects*

The variable of interest is the number of cell phones with relevant control variables (X_{it}) that I believed would impact business efficiency. The dependent variables include the log of gross revenue, log of revenue from farming, and the log of net income.

Table 1 provides baseline summary statistics, highlighting important variables, for rural and urban households. The average number of cell phones for the total observations was approximately two phones and fixed phone ownership was less than one. Also, the currency is presented by the Thai Baht. The average number of years in business was 15 and overall, businesses earned positive gross revenue. Business problems and issues were dummy variables where approximately 28 percent had a business issue or problem.

Table 1 - Summary Statistics for Key Variables

Variable	Observations	Mean	Standard Deviation
Number of Cell Phones	5,269	1.99	1.23
Number of Fixed Phones	5,269	0.25	0.45
Business			
Net Income	5,269	298,999.30	306,159.10
Gross Revenue	5,269	489,080.10	848,957.10
Daily Wage	1,239	9,907.98	12,144.67
Number of Years in Business	2,390	15.48	10.73
Business Problems	2,390	0.03	0.16
Business Issues	2,389	0.25	0.43
Total Farm Expense	5,269	190,139.60	699,687.10
Total Business Expense	5,269	164,659.20	692,515.80
Education Expense	5,269	10,325.91	19,466.66

Issues included factors like decreases in the value of the total output or profitability of the business, limited availability of workers, lack of credit, decrease in the number of suppliers, or difficulty delivering goods. Other important demographic variables not included in Table 1 are as

follows: 5 percent of the observations did not own a mobile phone, the average age of household heads was 58, and primary school was the highest educational level for 65 percent of the observations where only 5 percent attained university level schooling.

Table 2 provides a deeper analysis of cell phone ownership in rural and urban households in 2014 and 2015. Overall, in rural regions, more households owned fewer phones and in urban regions, more households owned more phones. Urban households also had greater cell phone ownership, however, there was overall positive growth in mobile phone ownership from 2014 to 2015.

Table 2: Cell Phone Ownership per Rural and Urban Households

Number of Cell Phones	2014		2015	
	Urban	Rural	Urban	Rural
0	3.96%	7.42%	3.19%	6.07%
1	32.43%	43.08%	29.47%	40.27%
2	32.71%	27.08%	33.43%	29.53%
3	16.94%	14.08%	19.21%	14.95%
4	9.31%	5.92%	10.12%	6.66%
5	2.78%	2.17%	2.77%	2.08%
6	1.25%	0.25%	1.11%	0.42%
7	0.35%	0.00%	0.42%	0.00%
8	0.28%	0.00%	0.28%	0.00%

Table 2 gives a breakdown of mobile phone ownership at the household level. However, if a household has eight members but only four phones, the interpretation and impact of the device greatly differs. For that reason, Table 3 outlines cell phone ownership per capita at the household level.

Table 3: Cell Phone Ownership per Capita – Rural and Urban Households

Number of Cell Phones per capita	2014		2015	
	Urban	Rural	Urban	Rural
0 - 0.25	15.49%	25.75%	12.41%	22.05%
0.26 - 0.50	34.86%	38.67%	34.54%	38.02%
0.51 - 0.75	18.27%	16.67%	19.62%	17.39%
0.75 - 1.0	25.07%	14.00%	28.02%	16.48%
> 1.0	4.38%	2.42%	4.79%	3.08%

Cell phone ownership per capita clarifies and levels overall cell phone ownership where less than 5% of the households in rural and urban regions have more than one phone per person and roughly 25% of urban households have one phone per person and approximately 15% of rural households have one phone per person. Therefore, a large majority of household members share a cell phone.

As noted above, for markets to operate efficiently, they must have access to information. Because the dataset did not have a more specific variable to measure business efficiency, I ran three regressions using the log of gross revenue, the log of revenue from farming, and the log of net income to measure business efficiency. I reported t-statistics and found that two thirds of the time, (Gross Revenue and Net Income) the number of mobile phones was significant on business efficiency, as seen in Table 4. I included control variables to reduce the emitted variable bias and found many of these variables to be insignificant; however, my variable of interest, the number of cell phones, was significant in two of the regressions. Mobile phones were insignificant for revenue from farming; cell phones may not matter as much for the farming market but the impact could be driven by non-farm, household businesses.

Table 4 - Regression Results: Gross Revenue, Revenue from Farming, Net Income

	Log Gross Revenue (1)	Log Revenue From Farming (2)	Log Net Income (3)
Number of Cell Phones	0.0784263	0.0430126	0.068957
	4.55	0.98	3.17
Number of Fixed Phones	0.0529987	0.2145149	0.068957
	1.01	1.73	1.08
Net Income	1.26E-06	6.89E-07	
	36.48	8.03	
Business Expense	2.26E-07	2.69E-08	1.35E-07
	16.9	1	8.14
Occupation	0.0012375	0.0009261	0.0005088
	4.45	1.6	1.45
Age	0.0050805	0.0031083	0.0053088
	1.89	0.41	1.56
Gender	-0.0677154	-0.1291891	0.0000856
	-2.01	-1.56	0
Education	0.0018307	0.0005421	0.005819
	0.59	0.05	1.49
Agricultural Activity	-0.0230835	-0.0937684	-0.0415455
	-1.25	-0.62	-1.78
Economic Turmoil	0.0074145	0.0086743	0.0200692
	0.72	0.34	1.55
Constant	11.72116	11.05014	11.63462
	47.84	15.92	37.57
R squared	64.25%	10.58%	30.80%
Fixed Effects	Individual	Individual	Individual
	Year	Year	Year
Observations	5,268	2,211	5,268

Gross revenue appeared to show the largest, positive results; as seen in column one, as you increase the number of mobile phones, gross revenue increases approximately 8%. Although mobile phone ownership affects gross revenue to some extent by making the business run more efficiently, 8% appears to be a large increase in revenue as you increase the number of cell

phones. Therefore, I ran four additional regressions to examine the potential issue of reverse causality where if you have a lot of revenue, you are more likely to own a phone and thus revenue is affecting mobile phone ownership and not the reverse.

Section 6: Regression Extensions

To test for the likelihood of a reverse causality issue, I replaced gross revenue with business problems. I reasoned that business problems were less prone to causality as compared to gross revenue. Also, it is a useful variable to measure business efficiency; if your business has less overall issues, you are likely operating effectively. Approximately 26% of the businesses noted a problem. I ran a regression using business problems as my dependent variable, seen in column four. The number of cell phones on business issues became insignificant, limiting a conclusive analysis on reverse causality. Further, I created three interaction terms to analyze the likely "candidate" or demographic features of cell phone users. I examined the impact of age (column 1) and business experience (column 2), measured in years, on cell phone ownership and the potential for diminishing returns of cell phones (column 3), defined by cell phones squared. I predicted that younger generations are more likely to use a cell phone optimally. Similarly, the younger businesses, such as startups, would be more likely to use a mobile phone effectively. Finally, I predicted that one cell phone is likely to result in business efficiencies but each additional phone brings less of an effect. Table 5 reports t-statistics and shows the results where business experience and cell phones squared is insignificant. The interaction term of age shows that the older you are, the more likely you are to own a phone. Therefore, the older you are and the greater business experience yields more likelihood of one using mobile phones to increase business efficiency. Also, diminishing returns were not present. These conclusions negate my predictions: the younger your age does not impact mobile phone ownership,

Table 5 - Regression extensions: effects of age, business experience, cell phones squared, and business issues

	Log Gross Revenue (1)	Log Gross Revenue (2)	Log Gross Revenue (3)	Business Issues (4)
Number of Cell Phones	-0.1054653	0.0585505	0.125215	-0.0159254
	-1.51	2.01	2.86	-0.60
Age × Cell	0.0032209			
	2.71			
Experience × Cell		0.0013875		
		1.95		
Number of Cell Phones Squared			-0.009694	
			-1.16	
Number of Fixed Phones	0.0501749	0.0346535	0.0641775	-0.1013487
	0.96	0.45	1.21	-1.37
Net Income	0.0000003	1.07E-06	1.26E-06	-7.48E-08
	36.49	24.33	36.47	-1.78
Business Expense	0.0000023	2.41E-07	2.26E-07	1.14E-08
	17.12	17.28	16.91	0.85
Occupation	0.0012244	0.0014112	0.001226	-0.0008971
	4.41	3.01	4.41	-1.99
Age	-0.0014054	0.0118563	0.0051758	-0.0002979
	-0.39	2.63	1.92	-0.07
Gender	-0.0725594	-0.211668	-0.0692193	0.0482836
	-2.15	2.63	-2.05	0.85
Education	0.0015019	0.0050618	0.0018339	0.0008165
	0.49	1.02	0.59	0.17
Agricultural Activity	-0.0228599	-0.0150618	-0.0236359	-0.0554554
	-1.24	-0.45	-1.28	-1.69
Economic Turmoil	0.0077422	0.039228	0.007771	-0.1208446
	0.76	2.37	0.76	-7.61
Constant	12.1159200	11.79886	11.67604	12.7741
	42.53	31.89	47.07	2.18
R squared	64.73%	56.84%	64.98%	6.09%
Fixed Effects	Individual	Individual	Individual	Individual
	Year	Year	Year	Year
Observations	5,268	2,388	5,268	2,387

younger business experience also does not improve cell phone use, and for each additional phone you own, there are not diminishing returns

These results indicate a likely issue of reverse causality. Replacing gross revenue with business problems attempted to correct this constraint, however, the number of cell phones became insignificant. Likewise, I examined whether the demographics of the observations were affecting the results, but this did not appear to be as expected. Overall, the number of cell phones had a significant and positive impact on gross revenue and net income with the potential for reverse causality.

Section 7: Limitations and Conclusion

The rationale for the impact of mobile phone adoption is clear: the mobile phone is an incredibly powerful tool for exchanging ideas at a distance, accessing information, and for managing daily life, especially business operations. This study sought to examine the effect of mobile phone ownership on business efficiency, specifically in the case of Thailand. I found that the number of cell phones creates business efficiency when using gross revenue and net income to define efficiency. Increased cell phone ownership, increased gross revenue by approximately 8%. I attribute this increase to a reverse causality problem, where households with greater income are more likely to own a cell phone. When attempting to correct for reverse causality by exchanging gross revenue for business problems, cell phone ownership became insignificant. Additionally, cell phone ownership differed amongst rural and urban households, whereas urban households owned a larger quantity of phones and more phones overall and rural households owned less mobile phones. Nonetheless, there was overall growth in ownership from 2014 to 2015. The relationship between cell phone ownership and business efficiency in Thailand theoretically shows likely evidence of correlation but not necessarily causation.

The adoption of mobile phones is growing and influencing the way in which people live and work, especially in developing countries. The results from businesses in Thailand serves as a case study to further this research addressing ICT and efficiencies. However, access to mobile telecommunications is certainly not the only factor that affects business efficiency. Therefore, the importance of complementary skills and other infrastructure is necessary for the technology of mobile phones to fulfill its potential. There is no benefit in farmers knowing the prices that their produce could be sold for in different markets if the roads are too poor for them to be able to transport the goods to those other markets. Similarly, the value of mobile phones in delivering greater efficiency is only fully realized when the workers and employees have the basic literacy skills to optimally utilize the technology. Telecommunications cannot be seen in isolation from other parts of the development process. Therefore, access to and use of mobile phones should be seen as a foundation and catalyst to build on other initiatives to impact business efficiency. Broadening the vision of mobile phones in developing countries and businesses would allow for substantial and potentially longer-lasting business efficiencies, just-in-time service, and what Townsend has called the “real time city” (Donner *et al* 2010).

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