Cell Phones and Cattle:
The Impact of Mobile Telephony on Agricultural Productivity in Developing Nations

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Abstract

This paper examines the impact of mobile telephony on productivity in developing nations. Previous studies have suggested that mobile phones have real impacts on economic outcomes in these countries. Using micro-data from Swaziland, Cambodia, and Honduras, this study looks to identify the effects of mobile phone ownership on household productive outcomes in a two-stage regression. The results provide significant evidence that mobile phone ownership does indeed improve productivity at the household level.

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1. Introduction

Information and Communication Technologies (ICT) play an important part in economic efficiency and can also stimulate economic growth. Telecommunications networks are known to promote global information exchange, while also putting citizens in touch with each other, their media, and their governmental institutions. They are seen as complementary to, if not necessary for, attracting foreign direct investment. For this reason, the observed demand across developing countries for such technology has been high and growing rapidly, at both the government and individual levels.

Mobile telephony is one of the more exciting forms of ICT, particularly in the context of developing nations. It has the potential to allow countries to leapfrog older technologies and begin converging with the rest of the world in terms of economic performance. Perhaps most importantly, mobile phones require lower levels of skills to operate than do computers or the Internet, and the socio-economic barriers are also smaller because of the lower up-front expenditure required. In most developing nations with low-skilled and low-income labor forces, these factors make mobile telecommunications an enticing prospect. Mobile technology can also more easily overcome the geographic hurdles that have prevented remote areas from receiving modern communication in the past. The oft-used example is that of the rural farmer who, with access to prompt information regarding market prices, weather patterns and best practices for the first time on his mobile phone, can better optimize his outcomes and improve his productivity.

Mobile networks also tend to have shorter payback periods for investors, with the World Bank suggesting that telecommunications investments in developing countries generate high internal rates of return of around 20% (Coyle 2005). This further incentivizes such investment, and the last decade has thus born witness to an investment explosion in mobile phone networks. Statistics from the International Telecommunications Union (ITU, 2007) point to massive increases in mobile subscribers across Africa. In 2000, Africa had just over 15 million subscribers, yet a tremendous compound annual growth rate (CAGR) of over 50% since has seen this number soar in excess of 274 million. The next fastest growing region has been Asia with a CAGR of just under 30%, while the Americas have also grown at more than 20% per annum. These growth figures are remarkably high, and point to the value that mobile telecommunications presumably bring.

However, more in depth econometric analysis is required to determine and quantify the extent of the value added by mobile telephony. There is a real risk of endogeneity in comparing economic growth and mobile penetration rates, and causality is difficult to prove. Previous studies have suggested that mobile phones do in fact possess a positive and significant impact on economic outcomes. The results of this paper's analysis on Swaziland, Cambodia, and Honduras agree with these earlier findings, concluding that mobile phones can and do positively affect economic productivity in developing nations.

2. Existing Literature

Previous studies have employed various methods in determining the impact of ICT and mobile telephony on economic development, with the majority producing evidence of positive effects. Thompson and Garbacz (2007) demonstrate a positive relationship between ICT and economic success using stochastic production frontiers. This method allows them to determine the factors most responsible for shifting out the production frontier, while at the same time identifying why economies might fall short of this frontier. Their model is outlined in the equations below:

$$Y_{it} = X_{it}\beta + (V_{it} - U_{it})$$

$$U_{it} = Z_{it}\delta + W_{it}$$

Here, Y is the output variable – GDP – and X is a vector of production inputs such as capital, labor and human capital. The V are randomly distributed error terms independent of the U, which are the error terms that account for any technical inefficiency in production. The Z is a vector of explanatory variables for technical inefficiency, such as economic freedom and various ICT penetration rates, while W is a randomly distributed error term.

The study concludes that African nations fall drastically short of their optimal production frontiers, with the mean efficiency level for the African sample being approximately 30%. This is extremely low, especially when compared to the average for the global low-income group of 62%, and the OECD average of 94%. However, African countries do demonstrate a significant response to factors affecting productive efficiency, and in particular to fixed line and mobile phone penetration rates. Furthermore, the more economically efficient African countries are also the ones that have seen the most significant increases in landline and mobile phone penetration rates, allowing inferences to be made between the prevalence of ICT and positive economic outcomes. The Asian results are equally intriguing, with fixed line and mobile phone prevalence reducing inefficiency for these countries. However, the effect of the Economic Freedom Index on productive efficiency is unambiguously insignificant. The authors attempt to explain this as being driven by the larger, more controlling governments of China and India that provide the stability and public financing necessary to build an adequate infrastructure. Overall, Thompson and Garbacz find real and significant evidence that the positive impacts of ICT on economic growth are largest in the poorest areas. They conclude that increased mobile phone

penetration will have a large potential payback, because it can be spread into the most disadvantaged areas more easily than other forms of ICT.

Oyelaran-Oyeyinka and Lal (2005) examine the factors that have led to the current ICT penetration rates in Africa. They outline a series of factors that may influence internet diffusion – GDP per capita, human capital levels, telecommunications investment, telephone density and PC density – and employ suitable indicators for each of them. To deal with the endogeneity in the data, they outline a series of simultaneous equations. The first of these states that the level of internet users (IU) is a function of the level of internet hosts (IH) and the PC density ratio (PCDEN). Furthermore, IH is a function of the telephone density ratio (TELEDEN), the per capita investment on telecommunications (ITI) and the percentage of population enrolled in tertiary education (EDU). Finally, TELEDEN is a function of IU and the GDP per capita (GDP). Thus the regression is described by these three equations:

$IU = f(IH, PCDEN)$

$IH = f(TELEDEN, ITI, EDU)$

$TELEDEN = f(IU, GDP)$

Preliminary univariate analysis shows a relatively strong relationship between IU and GDP, and IU has even stronger relationships with TELEDEN and PCDEN. Unfortunately, because of the interdependence of these explanatory variables, it is impossible to read much into these correlations with regard to causality. However, when run through the simultaneous equation system, it is possible to make more detailed inferences. They find that in accordance with expectation, high levels of telecommunications investments and telephone densities are important determinants of the number of internet hosts present. In turn, this has a significant impact on the number of internet users, in tandem with the PC density of a country. Furthermore, economic wealth has a strong impact on the overall level of internet use. In sum, high levels of GDP, the strong presence of internet hosts and an effective existing telecom network are crucial for high internet diffusion rates, and Oyelaran-Oyeyinka and Lal conclude that wealth and ICT prevalence are strongly correlated. This is an important finding that cautions future researchers to be wary in assigning causality when looking at the impacts of ICT on national wealth.

A study by Waverman *et al.* (2005) on mobile telephony suggests that a valid way of measuring its economic value is by examining the willingness to pay of the poor for mobile phones. The evidence demonstrates that telecommunications services are very highly valued,

with a study from Chile finding that the poorest people spend more of their incomes on telecommunications than on water, and the average households spend more on telecommunications than on both water and electricity combined. Further anecdotal evidence from the Congo, where villagers in two jungle provinces were so eager for service that they built 50-foot high treehouses to catch signals from distant cell phone towers on their own accord, points to the value that the poor see in mobile phones. The research also found that both own-price and income elasticities of mobile phone demand in developing countries were significantly above unity, essentially leading demand to increase much more than proportionally to increases in income and reductions in price. Furthermore, they estimated that mobile networks cost half as much to roll out per connection as fixed lines, and they can be created much more rapidly. Thus mobile phones are advantageous as ICT development tools not only because they reduce costs per subscriber, but because they also benefit from smaller scale economies and greater modularity.

Waverman *et al.* find that the impact of mobile telephony may be twice as large in developing countries as it is in developed nations. Their endogenous technical change approach relates the average rate of growth of GDP over the period 1980 to 2003 to various other factors, namely the initial level of GDP, the average investment as a share of GDP, the initial stock of labor represented in terms of its educational attainment, and the initial telephone penetration rate. Thus, the contribution of telecommunications to economic growth is measured by the boost to the long-term growth rate. The results show that a developing country with an average of 10 or more mobile phones per 100 people between 1996 and 2003 would have enjoyed per capita GDP growth that was 0.59% higher than an otherwise identical country with a mobile density of less than 10 phones per 100 people. Furthermore, by employing an aggregate production function method they find that for the average country in 2002, a doubling of the mobile penetration rate would have led to a 10 percent increase in output, holding all else constant.

The existing literature, looking largely at a macro level, provides evidence that mobile phones seem to have a real and significant impact on economic performance. This lays a firm platform for further, more micro-level analysis on this technology's impact.

3. Methodology

The first instinct in determining the impact of mobile telephony on productivity might be to regress household wealth against mobile phone ownership. In fact, doing so for Swaziland with Demographic Household Survey (DHS) data generates a very high correlation. This simple regression is demonstrated in the table below.

Wealth	Coef.	Std. Error	t-stat	S.D. x Coef.
Mobile Ownership	1.0918	0.0175	62.45	0.5275
Landline	0.9383	0.0177	53.09	0.3266
Time to water	-0.0080	0.0003	-23.58	-0.2461
Education	0.0042	0.0038	1.11	0.0085
Rural	-1.1922	0.0171	-69.74	-0.5237
Constant	3.3370	0.0237	140.51	-

Number of obs	15192
F(5, 15186)	6700
Prob > F	0
R-squared	0.5667
Root MSE	0.9335

Table 1: Swaziland Wealth Regression

A blind interpretation of these results suggests that mobile phone ownership is correlated with a household being wealthier by over 1 point on the 5 point wealth index, all else remaining constant. However, it is just as likely that people purchase mobile phones because they are wealthy, rather than becoming wealthy as a result of purchasing them, so causality cannot be assigned. The ideal analysis would be to observe the productive outcomes of two identical households, one of which obtained a mobile phone and one of which did not, generating a direct measure of the added productivity of mobile telephony. However, this is infeasible, so the effect must be estimated in other ways, for instance by breaking mobile phone ownership down into two separate components – one consumptive, the other productive.

Purchasing a mobile phone solely to call friends and play games would make it a consumptive good. This adds to the utility of an individual without necessarily making him any more productive. However, the functions of mobile phones can also be productive, for example by allowing people to better keep track of market prices for agricultural goods at different times and locations. It can be assumed that households are more likely to consume mobile phones as they increase in wealth and education, because they can better afford them and have more exposure to them at that stage. Thus in order to measure the productivity

associated with mobile phones, a separate measure of mobile phone ownership that is distinct from such factors is required. It is this measure that can be pitted against a household's productive output in order to estimate the value of mobile telephony in improving productivity. If the econometrics are undertaken carefully, this random measure could well be estimated by the error term of the first regression below:

(1) Household Demand Regression:

$$Mobileownership_i = f(wealth_i, \ldots) + \varepsilon_i$$

(consumptive: $wealth_i, \ldots$; productive: ε_i)

(2) Household Productivity Regression:

$$Productiveoutput_i = f(wealth_i, labor_i, capital_i, potential_i\ (= g(mobileownership_i\ (= h(\varepsilon_i, \ldots),), \ldots))$$

Each unit in the dataset has a residual error 'ε' from the first regression. The residual is equal to the difference between a household's actual and predicted mobile ownership outcome, given its characteristics. Because it is a binary variable, the Household Demand Regression is run as a Probit function. By saving its residual as a variable and inputting it into the second regression, an estimator for the impact of mobile phone ownership on household productivity is developed. Of course, there are other factors that impact output too, and these must also be incorporated in the second regression to take account of this. Thus by substituting ε into the second regression, which is run using Ordinary Least Squares, the residual productive component of mobile phone ownership is accounted for. The analysis therefore does not rely on the coefficients of the included variables in the first regression, rather it seeks to isolate and capture the non-consumer demand effect. However, one must be mindful that the residual will also be correlated with any other relevant variables that are not present in the first stage regression.

The DHS datasets used in this study are not economic surveys, and as such do not have measures of output beyond wealth and asset ownership. While variables like capital and labor would be ideal to estimate household production functions, they are not available. Instead, livestock and land ownership are used as proxies for productivity, because they are often employed as productive assets and stores of wealth. Such a study excludes the entrepreneurial city dweller who does not deal in livestock, and this is unavoidable given the parameters of the exercise. However, this simply puts the attention on agricultural households, where output can be assessed more easily because inputs are relatively simple.

4. Descriptive Data Overview

Swaziland

Swaziland is a land-locked monarchy situated between South Africa and Mozambique in southern Africa. According to statistics from the ITU (2007), it has a mobile phone density of 33.29 subscribers per 100 people, nearly 5 points higher than the African average and over 15 points more than the sub-Saharan average, as demonstrated in Table 2. While Swaziland does not have the telecommunications sophistication of neighboring South Africa, it certainly outperforms its other neighbors like Mozambique and Zimbabwe.

	Mobile cellular subscribers				As % of total
	(000s)		CAGR (%)	per 100 inhabitants	telephone subscribers
	2002	2007	2002 - 07	2007	2007
Cameroon	701.5	4536.0	45.3	24.5	96.0
Kenya	1187.1	11349.4	57.1	30.2	97.7
Mozambique	254.8	3300.0	66.9	15.4	97.2
Nigeria	1569.0	40395.6	91.5	27.3	96.2
South Africa	13702.0	42300.0	25.3	87.1	90.1
Swaziland	68.0	380.0	41.1	33.3	85.0
Zimbabwe	338.8	1225.7	29.3	9.2	78.1
Sub-Saharan Africa	**-**	**138310.0**	**-**	**18.3**	**-**
Africa	**36923.8**	**274067.8**	**49.3**	**28.4**	**89.6**

Table 2: ITU Mobile Cellular Subscribers – Selected African Countries

The UNDP Human Development Report (2007) gave Swaziland a Human Development Index (HDI) value of 0.547, a number much higher than the sub-Saharan average of 0.493. Its PPP-adjusted GDP per capita is estimated at $5,100, and while this is less than half of South Africa's, it is much higher than that of most other sub-Saharan countries. As the subject of a micro-level study, Swaziland benefits from its small and relatively homogenous population. Estimated by the C.I.A. (2009) at just under one million people, its population is 97% African and 3% European. The large majority of its African population is Swazi, while there are also much smaller contingents of Zulu and Tsonga people. Such homogeneity is beneficial in that it makes the impacts of mobile phones more identifiable by all but eliminating ethnic diversity as an explanation for success differentials.

Figure 1: Swaziland in southern Africa

Swaziland has an area of 17,363 km^2, roughly equivalent to the size of New Jersey. While the land is mostly mountains and hills, there are some moderately sloping plains. Swazis have traditionally been subsistence farmers and herders, but the growing formal sector in the cities has changed this, with some Swazis also working in government or in the mines in South Africa. As of 2005, the Food and Agriculture Organization of the United Nations (FAO) reported that agriculture made up 12.7% of the nation's GDP, with livestock accounting for 26.9% of this as cattle are increasingly being used to produce milk and meat for profit in Swaziland. With cattle being the most commonly owned livestock, they serve as potential indicators for productivity under the assumption that the more productive a household becomes, the more resources it will have to invest, some of which will undoubtedly be put into cattle. This is especially true for a country like Swaziland where financial assets are not as available as they are in developed economies. Furthermore, mobile phones improve access to markets for assets like cattle, potentially enabling mobile phone owners to trade their livestock more effectively and for the best value. With an average ownership level of 4.1 heads of cattle per household across the survey, cattle are a ubiquitous and relatively homogenous agricultural output in Swaziland. Cattle ownership levels could thus be used as proxies for the productivity gains associated with mobile phone usage under the right econometric conditions, given the absence of standard economic output variables in the DHS data.

Variable	All Observations	
	Obs	Mean
Household Size	21058	7.02
Rural	21058	0.74
Time to Water	21046	19.78
Male hhold head	21058	0.50
Age of hhold head	21053	49.58
Landline	21049	0.14
Mobile phone	21050	0.63
Cattle owned	21058	4.13
Wealth Index Score	21058	3.07
Sq. metres for agriculture	14558	8517.75
Education	20922	4.88

Table 3: Swaziland Data Summary – All Observations

An overview of the 2006 DHS survey data used in this study provides a good insight on the demographics of Swaziland. The data contain 21,058 observations – a large number considering the country's relatively small population of just over one million. Table 3 shows that 63% of the households surveyed possess mobile phones, while only 14% possess landlines. This demonstrates the trend for developing nations to leapfrog older technologies in order to speed up their economic progress by going straight to the modern option.

Table 4 allows comparisons to be made between households that possess mobile phones and those that do not. Unsurprisingly, households with mobile phones tend to be wealthier and more educated. They are also less rural – only 57% of rural households have mobile phones, compared with 78% of their urban counterparts. Despite being more urban and having less land, the households with mobile phones do own one more head of cattle on average than those that do not. While this may be a partial function of their greater wealth, it is also the first sign that mobile phone owners may be more productive than their peers.

Rural households are more likely to have female heads – presumably because many of their husbands have migrated in search of work – and they also tend to be significantly older than their urban counterparts. Unsurprisingly, the urban population tends to be much wealthier and better educated, but despite this wealth advantage, rural households own 5.5 cattle on average compared to the 0.3 cattle per household found in urban areas. Furthermore, households in the lower echelons of the wealth index score own two head of cattle more on average than those in the upper echelons. This indicates that cattle are indeed

productive assets and stores of wealth for Swazis, particularly those in the lower quintiles of the income distribution. This highlights the separation of cattle ownership from overall wealth and helps to validate the use of cattle as productivity measures. The wealthiest and most entrepreneurial Swazis are likely to leave farming and cattle herding altogether, meaning that it is not necessarily the rich who are amassing cattle, but rather those who are not wealthy entrepreneurs. Thus by restricting the study to an area that is not particularly entrepreneurial, namely cattle herding, the risk of omitted variable bias is greatly diminished. In many respects, cattle ownership is a better indicator of unobserved productivity than income because it not favored by the wealthy.

In keeping with the hypothesis that mobile phones increase productivity, more educated households tend to have higher levels of ownership of mobile phones. While this trend will inevitably be tied to the higher wealth that is correlated with education, it is also probable that more educated people are better aware of the productive benefits of mobile telephony and are thus more willing and able to invest in it.

Variable	With Mobile Phone		No Mobile Phone	
	Obs	Mean	Obs	Mean
Household Size	13234	7.26	7816	6.62
Rural	13234	0.67	7816	0.85
Male hhold head	13234	0.54	7816	0.44
Age of hhold head	13234	48.11	7811	52.07
Landline	13229	0.18	7816	0.07
Cattle owned	13234	4.50	7816	3.49
Wealth Index Score	13234	3.63	7816	2.12
Sq. metres for agriculture	8581	8401.46	5973	8690.51
Education	13154	5.66	7761	3.56
	Rural		Urban	
Household Size	15559	7.79	5499	4.84
Mobile phone	15555	0.57	5495	0.78
Male hhold head	15559	0.47	5499	0.60
Age of hhold head	15554	51.94	5499	42.89
Cattle owned	15559	5.48	5499	0.31
Wealth Index Score	15559	2.59	5499	4.42
Sq. metres for agriculture	13368	8971.22	1190	3423.62
Education	15450	4.15	5472	6.93
	Low Education (< 3.5 yrs)		High Education (> 3.5 yrs)	
Household Size	9650	7.46	11408	6.65
Mobile phone	9646	0.55	11404	0.70
Male hhold head	9650	0.47	11408	0.53
Age of hhold head	9645	51.07	11408	48.31
Cattle owned	9650	4.37	11408	3.92
Rural	9650	0.82	11408	0.67
Sq. metres for agriculture	7243	8701.67	7315	8335.64
Wealth Index Score	9650	2.66	11408	3.41
	Low Wealth Scores (1-3)		High Wealth Scores(4-5)	
Household Size	12193	7.62	8865	6.20
Mobile phone	12193	0.45	8857	0.87
Male hhold head	12193	0.46	8865	0.57
Age of hhold head	12188	52.10	8865	46.11
Cattle owned	12193	5.05	8865	2.85
Rural	12193	0.94	8865	0.47
Sq. metres for agriculture	10335	8961.69	4223	7431.27
Education	12113	3.58	8809	6.67
	No Cattle		With Cattle	
Household Size	13820	5.91	7238	9.13
Mobile phone	13812	0.62	7238	0.64
Male hhold head	13820	0.50	7238	0.51
Age of hhold head	13815	46.33	7238	55.77
Education	13737	5.29	7185	4.10
Rural	13820	0.61	7238	0.98
Sq. metres for agriculture	7586	7838.24	6972	9257.10
Wealth Index Score	13820	3.31	7238	2.61

Table 4: Swaziland Data Summary – Cross Tabulations

Cambodia

Located on the Indochinese Peninsula, Cambodia is one of the poorest of the surrounding nations – both Cambodia and Laos maintain a low PPP-adjusted GDP per capita of $2,100, according to the C.I.A. (2009). With an HDI value of 0.598, the only local country faring any worse is Burma. Having failed to develop as rapidly as Thailand or China, its mobile penetration rates are expectedly low. ITU statistics put Cambodia below the Asian average, with a 2007 penetration rate of 17.88 subscribers per 100 people, as compared to the Asian average of 37.64. Its most immediate neighbors in Laos, Vietnam and Thailand all have much more developed mobile networks, as demonstrated in Table 5.

	Mobile cellular subscribers				As % of total
	(000s)		CAGR (%)	per 100 inhabitants	telephone subscribers
	2002	2007	2002 - 07	2007	2007
Cambodia	380.0	2583.0	46.7	17.9	98.6
China	206005.0	547306.0	21.6	41.2	59.9
India	13000.0	233620.0	78.2	20.0	85.6
Laos	55.2	1478.4	93.0	25.2	94.0
Malaysia	9053.0	23347.0	20.9	87.9	84.3
Thailand	10171.6	79065.8	50.7	123.8	91.8
Viet Nam	1902.4	23730.2	65.7	27.2	45.4
Asia	**443937.4**	**1497253.5**	**27.5**	**37.6**	**70.6**

Table 5: ITU Mobile Cellular Subscribers – Selected Asian Countries

In its favor, Cambodia does have a relatively small and homogenous population in comparison to its neighbors. 90% of its 14 million people are of Khmer ethnicity, with the majority of the remainder being either Vietnamese or Chinese, and 95% of the population speak the Khmer language. Cambodia therefore has a very low degree of ethnolinguistic fragmentation, which in turn allows greater inferences to be drawn from the econometric analysis.

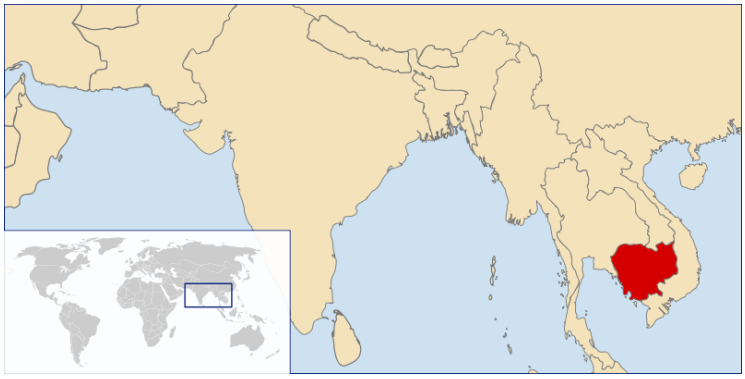

Figure 2: Cambodia in Southeast Asia

Cambodia has an area of 181,040 km^2, which is roughly the size of Oklahoma. This land consists mostly of low, flat plains, with mountains in the southwest and north. According to the FAO, the livestock sector is dominated by smallholders, with poor families commonly having chickens and perhaps one or two pigs, while richer farmers may have a pair of draught and breeding cattle. As of 2005, the FAO reported that agriculture made up 36.3% of the nation's GDP, with livestock accounting for 20.9% of this figure. Chickens and pigs in Cambodia are therefore similar to what cattle are in Swaziland in terms of being commonly owned productive assets, and they are able to be traded to the extent that they could represent household productivity in this setting. The household that enjoys the productive capacities of the mobile phone should, *ceteris paribus*, maintain higher levels of livestock than those that do not.

Variable	All Observations	
	Obs	Mean
Household Size	72292	6.08
Rural	72292	0.78
Male hhold head	72292	0.82
Age of hhold head	72292	44.97
Mobile phone	72282	0.21
Chickens owned	72286	6.15
Pigs owned	72292	1.03
Water buffalo owned	72292	0.36
Wealth Index Score	72292	2.91
Sq. metres for agriculture	52706	16142.54
Education	72200	3.19

Table 6: Cambodia Data Summary – All Observations

The 2005 DHS data for Cambodia has 72,292 observations, a significant number allowing for robust analysis. It is unsurprising that chickens, pigs and water buffalo are owned in descending amounts as illustrated in Table 6, given their respective expenses. Also unsurprisingly, given the low ITU statistics, is the fact that there is mobile phone ownership in only 21% of the households surveyed. Table 7 illustrates this, and as corroborated by the Swaziland data, mobile phone owners tend to be wealthier and more educated. In Cambodia, they also own higher numbers of pigs, however those without mobile phones tend to own more chickens while having less agricultural land – findings which contrast the scenario witnessed in Swaziland. While this is inevitably tied to the fact that mobile phone owners are on average wealthier and can therefore afford to move away from agriculture, it is nonetheless interesting that certain types of livestock are favored by mobile phone owners and non-owners. For this reason, it would be prudent to run regressions using more than one type of livestock as the productivity proxy for Cambodia, in order to determine if the effect of mobile telephony is witnessed evenly across each of them. While cattle or water buffalo may also be good examples of such assets, they are not prevalent enough in the survey data to derive significant results from – only 13**%** have water buffalo as opposed to the 40% and 64% that own pigs and chickens, respectively.

Further cross tabulations of the data, as seen in Table 7, demonstrate the urban bias of mobile phone ownership as well as the rural bias of livestock ownership. This may be a result of wealth concentrations in the cities and the lack of network coverage in many rural areas, both of which are seen in Swaziland. It is also striking to see that households without any chickens tend to be smaller, more urban and wealthier than those households that keep chickens. This gives weight to the idea that wealthier households do indeed move away from agriculture and into the cities, leaving livestock as the productive assets of the less wealthy tiers of Cambodian society.

Variable	With Mobile Phone		No Mobile Phone	
	Obs	Mean	Obs	Mean
Household Size	14835	6.51	57447	5.97
Rural	14835	0.49	57447	0.85
Male hhold head	14835	0.83	57447	0.82
Age of hhold head	14835	46.36	57447	44.60
Chickens owned	14835	5.83	57441	6.22
Pigs owned	14835	1.33	57447	0.96
Water buffalo owned	14835	0.12	57447	0.42
Wealth Index Score	14835	4.71	57447	2.45
Sq. metres for agriculture	6529	22399.95	46168	15259.15
Education	14806	5.39	57384	2.63
	Rural		Urban	
Household Size	56068	6.00	16224	6.37
Mobile Phone	56059	0.13	16223	0.47
Male hhold head	56068	0.83	16224	0.80
Age of hhold head	56068	44.81	16224	45.49
Chickens owned	56062	6.63	16224	4.48
Pigs owned	56068	1.09	16224	0.84
Wealth Index Score	56068	2.64	16224	3.85
Sq. metres for agriculture	45429	15462.29	7277	20389.19
Education	56011	2.89	16189	4.24
	Low Education (< 3.5 yrs)		High Education (> 3.5 yrs)	
Household Size	43771	6.12	28521	6.02
Rural	43771	0.81	28521	0.72
Male hhold head	43771	0.82	28521	0.82
Age of hhold head	43771	44.13	28521	46.24
Mobile phone	43768	0.12	28514	0.33
Chickens owned	43767	5.89	28519	6.54
Pigs owned	43771	0.95	28521	1.16
Wealth Index Score	43771	2.55	28521	3.48
Sq. metres for agriculture	33403	15778.48	19303	16772.54
	Low Wealth Scores (1-3)		High Wealth Scores(4-5)	
Household Size	45422	6.01	26870	6.20
Mobile Phone	45413	0.01	26869	0.53
Male hhold head	45422	0.83	26870	0.81
Age of hhold head	45422	43.98	26870	46.64
Chickens owned	45416	6.19	26870	6.08
Pigs owned	45422	0.93	26870	1.22
Rural	45422	0.88	26870	0.60
Sq. metres for agriculture	38402	14941.74	14304	19366.33
Education	45373	2.30	26827	4.71
	No Chickens		With Chickens	
Household Size	26091	5.93	46201	6.17
Rural	26091	0.64	46201	0.85
Male hhold head	26091	0.77	46201	0.85
Age of hhold head	26091	45.04	46201	44.92
Mobile Phone	26087	0.33	46195	0.14
Wealth Index Score	26091	3.29	46201	2.70
Sq. metres for agriculture	12961	14893.35	39745	16549.91
Education	26045	3.54	46155	3.00
Pigs owned	26091	0.44	46201	1.37

Table 7: Cambodia Data Summary – Cross Tabulations

Honduras

Honduras is located between Guatemala, El Salvador and Nicaragua in Central America, and the C.I.A. (2009) estimates its PPP-adjusted GDP per capita at $4,400. This is lower than all of its immediate neighbors. Its HDI value of 0.700 is higher than what is seen in Cambodia and Swaziland, but it still puts Honduras in the lower echelon of the Latin America cohort, which has an average HDI value of 0.803. Despite its low economic standing, Honduras has still managed to achieve decent mobile penetration rates, with 58.9 subscribers per 100 inhabitants as of 2007 according to the ITU. This puts it in the middle of the pack when compared to other countries in Latin American, as demonstrated below.

	Mobile cellular subscribers				As % of total
	(000s)		CAGR (%)	per 100 inhabitants	telephone subscribers
	2002	2007	2002 - 07	2007	2007
Costa Rica	502.5	1508.2	24.6	33.8	51.2
Cuba	17.9	198.3	61.8	1.8	16.0
Dominican Rep.	1700.6	5512.9	26.5	56.5	85.9
El Salvador	888.8	6137.4	47.2	89.5	85.0
Guatemala	1577.1	10150.0	45.1	76.0	84.1
Honduras	326.5	4184.8	66.6	58.9	83.6
Nicaragua	237.2	2122.8	55.0	37.9	88.1
Americas	**255451.3**	**656918.1**	**20.8**	**72.2**	**69.8**

Table 8: ITU Mobile Cellular Subscribers – Selected Latin American Countries

Its population of nearly eight million people is 90% Mestizo – mixed Amerindian and European – with the remainder being mostly Amerindian. This homogeneity is once more useful in decreasing the ethnolinguistic fragmentation that may otherwise interfere with results. Honduras has an area of 112,090 km^2 – slightly larger than Tennessee – and it has a mountainous interior with narrow coastal plains. Such terrain is not conducive to the types of agriculture seen in Swaziland and Cambodia. The C.I.A. estimates agriculture to make up 13.4% of Honduran GDP. However, little of this involves livestock, instead the main agricultural pursuits involve the growing of bananas, coffee, citrus fruits, corn and African palm. Cattle are mostly raised on farms owned by the very wealthy, suggesting that they are bad estimators of smallholder productive potential.

Figure 3: Honduras in Central America

Because of the reliance on crops, it appears that the amount of land a household has available for agriculture would be a better suited proxy for productivity in this case. Hondurans would be more likely to reinvest their profits in land than in livestock because it is more productive, given that the livestock trade is not as great as it is in the other countries examined. Of course, trading land is more difficult than trading livestock and land quality is also far more heterogeneous, but that is the nature of the Latin American setting. Negating this, however, is the fact that Honduras reformed its laws to improve the ease with which land can be transacted. The Agricultural Modernization Law, passed in 1992, improved the way in which land was titled, and allowed land that was previously owned by cooperatives to be broken up into smaller personal plots that could be bought and sold.

Variable	All Observations	
	Obs	Mean
Household Size	92455	6.28
Rural	92455	0.64
Time to Water	92439	4.03
Male hhold head	92455	0.78
Age of hhold head	92445	46.31
Landline	92411	0.17
Mobile phone	92425	0.30
Wealth Index Score	92455	2.68
Hectares for agriculture	35626	4.09
Education	92289	3.97

Table 9: Honduras Data Summary – All Observations

Table 9 demonstrates that only 64% of the households are rural, a much lower percentage than the 74% and 78% seen in Swaziland and Cambodia respectively. Mobile phone ownership is also low at 30% of households, almost half of the reported ITU penetration rate for 2007, which suggests that growth may have occurred in this sector in

recent years. With an average of 4.09 hectares of land for agriculture per household, Honduras far outpaces the other subject countries in this category, although only a third of households surveyed actually had a response recorded in the data for this variable. However, it still highlights the importance of agricultural land in Honduras' more crop-intensive economy, and the value in using this land as a proxy for productivity in these circumstances. Honduras also has the lowest average wealth index score of the three countries studied, which is interesting considering it has a much higher GDP per capita than Cambodia. This may be a function of a greater wealth disparity in Honduras, or it may mean that these scores are not entirely compatible across surveys.

Table 10 breaks the data up into cross tabulations that provide greater insight into Honduras' demographic makeup. As has been the case with the previous countries, those households with mobile phones tend to be wealthier, less rural, and better educated than the households without them. They also have more land available for agriculture – more than double the rest of the population – a phenomenon not seen in Swaziland or Cambodia, at least to this extent. This may be a result of the wealthy Honduran population choosing to enjoy both mobile phones and large amounts of land, however it may also demonstrate the perceived importance of being connected to markets in order to succeed with crop farming in Honduras. In any event, it means that regressing against agricultural land could have a greater chance of omitted variable bias in the production regression, which may lead to an overestimation of the impact of mobile phones. This demonstrates that land may not be as good at being a proxy for productivity as livestock, however it seems to be the most appropriate variable to use in this case.

Interestingly, of the households with more than 2ha of land, the average age of household head is 52 years old, compared to an average of 47 years old for households with smaller plots. This may be indicative of the entrenchment of land ownership in the hands of older families in Honduras, limiting wealth mobility in the country. The urban-rural wealth gap is very pronounced in Honduras, with the rural average wealth score being 1.94 compared to the urban equivalent of 3.98. These urban households also have more than double the average land of rural households, further highlighting the gap in prosperity between urban and rural Honduras. This can only be perpetuated by poor rural education figures, which see rural households receiving three fewer years of education on average than their urban counterparts.

Variable	With Mobile Phone		No Mobile Phone	
	Obs	Mean	Obs	Mean
Household Size	27762	6.08	64663	6.37
Rural	27762	0.36	64663	0.76
Time to Water	27762	2.36	64647	4.75
Male hhold head	27762	0.72	64663	0.80
Age of hhold head	27754	45.67	64661	46.58
Landline	27747	0.36	64663	0.09
Wealth Index Score	27762	3.97	64663	2.13
Hectares for agriculture	7003	7.32	28620	3.30
Education	27717	6.02	64542	3.09
	Rural		**Urban**	
Household Size	59005	6.65	33450	5.63
Mobile phone	58989	0.17	33436	0.53
Time to Water	58989	5.16	33450	2.04
Male hhold head	59005	0.82	33450	0.70
Age of hhold head	58998	46.63	33447	45.75
Landline	58977	0.02	33434	0.44
Wealth Index Score	59005	1.94	33450	3.98
Hectares for agriculture	31246	3.61	4380	7.52
Education	58923	2.89	33366	5.89
	Low Wealth Scores (1-3)		**High Wealth Scores(4-5)**	
Household Size	64139	6.64	28316	5.47
Mobile phone	64121	0.14	28304	0.67
Time to Water	64123	5.03	28316	1.77
Male hhold head	64139	0.81	28316	0.70
Age of hhold head	64132	46.68	28313	45.47
Landline	64106	0.02	28305	0.53
Rural	64139	0.84	28316	0.18
Hectares for agriculture	31057	3.31	4569	9.37
Education	64036	2.79	28253	6.64
	Low Education (< 3.5 yrs)		**High Education (> 3.5 yrs)**	
Household Size	50927	6.49	41528	6.03
Mobile phone	50912	0.21	41513	0.41
Time to Water	50918	4.73	41521	3.17
Male hhold head	50927	0.80	41528	0.75
Age of hhold head	50921	46.38	41524	46.23
Landline	50905	0.10	41506	0.27
Rural	50927	0.74	41528	0.51
Hectares for agriculture	21459	3.50	14167	4.98
Wealth Index score	50927	2.27	41528	3.18
	Little Land (< 2 ha)		**More land (> 2 ha)**	
Household Size	22958	6.68	12668	7.15
Mobile phone	22955	0.15	12668	0.28
Time to Water	22958	5.14	12668	3.64
Male hhold head	22958	0.84	12668	0.87
Age of hhold head	22958	46.92	12663	52.26
Landline	22955	0.05	12668	0.12
Rural	22958	0.90	12668	0.84
Education	22924	3.05	12652	3.97
Wealth Index score	22958	1.83	12668	2.33

Table 10: Honduras Data Summary – Cross Tabulations

5. Results

Swaziland

The following regressions were run using the 2006 DHS data for Swaziland, with the results of the first regression being displayed in Table 11.

(1) Household Demand Regression:

$$Mobileownership = a + \beta_1 wealth + \beta_2 landline + \beta_3 timetowater + \beta_4 education + \beta_5 rural + \beta_6 malehholdhead + \beta_7 agehholdhead + \varepsilon$$

(2) Household Productivity Regression:

$$Cattleowned = a + \beta_1 wealth + \beta_2 householdsize + \beta_3 rural + \beta_4 malehholdhead + \beta_5 agehholdhead + \beta_6 landline + \beta_7 timetowater + \beta_8 education + \beta_9 sqmetersforagriculture + \beta_{10} residual + regionaldummies + \varepsilon$$

Mobile Ownership	Coef.	Std. Error	t-stat	S.D. x Coef
Wealth	0.6247	0.0104	59.86	0.8984
Landline	-0.3307	0.0338	-9.80	-0.1151
Time to water	0.0002	0.0003	0.52	0.0053
Education	0.0193	0.0024	8.10	0.0389
Rural	0.5512	0.0305	18.08	0.2421
Male hhold head	0.1587	0.0199	7.97	0.0794
Age of hhold head	-0.0023	0.0006	-3.53	-0.0362
Constant	-1.9145	0.0569	-33.65	-

Number of obs	20893
Wald chi2(7)	5219
Prob > chi2	0.000
Pseudo R2	0.232

Table 11: Swaziland Household Demand Regression

The driving factor in mobile ownership is clearly wealth, with a movement of one standard deviation up the wealth index making a household nearly 90% more likely to own a mobile phone. This is logical, as mobile phones are expensive and wealthier households are more likely to consume them. If a household has a landline, however, it is less likely to have a mobile phone. This ties in with the findings of Waverman *et al.*, who claim that mobile phones are substitutes for fixed lines in poor countries, but complements in rich countries.

The time to water variable was included to account for remoteness, which could impact whether or not a household has cell phone coverage. However, it has a small and statistically insignificant impact on the regression, perhaps because the effects of this remoteness may have been picked up by the wealth, rural and landline variables. Education has a slightly positive effect on mobile ownership, probably because more educated people are more aware of mobile technology, how to operate it, and how to obtain it. The age of household head is negatively correlated with mobile ownership, as one would expect younger generations to be more familiar with and accepting of new technologies like mobile phones, even though it may be the households with older heads that are better able to afford them.

All else being equal, one would expect mobile phones to be more prevalent in urban areas, yet being rural makes a household 55% more likely to own a mobile phone in this study. Table 4 shows that urban dwellers do indeed have higher rates of ownership than those in a rural Swaziland. Table 4 also demonstrates the severe wealth gap between urban and rural households, with rural households having an average wealth score of 2.59 compared to the urban score of 4.42. Thus, it could be that the expected rural effect is captured by the wealth coefficient in the regression. If this wealth gap between urban and rural is the main reason rural households do not own phones, then it will be picked up by the wealth variable, not the rural one. The rural variable may thus be positive due to other factors, like the added necessity and value of having a mobile phone in a remote area without landline service or markets in close proximity.

Table 12 breaks the first regression up into separate urban and rural regressions. While there are some minor changes in the size of coefficients as would be expected, there are no changes in the sign or significance of any of them across all of the regressions, except for time to water which is insignificant in all of them regardless. The landline variable makes the most change, having a larger impact in the rural regression, probably because rural areas that have access to landlines are more developed and closer to major settlements than those that do not. They would therefore be more exposed to mobile phones and probably have network coverage. Regardless, the regressions demonstrate that these econometric methods produce similar results in both urban and rural settings.

After the first regression is run, the residuals are saved to be plugged into the Household Productivity Regression. A quick look at this residual variable provides an

interesting commentary on the data. The households with the most negative residuals – that is, the households most expected to own mobile phones but actually do not – are extremely wealthy. This is no surprise given the huge impact wealth has on mobile phone ownership in the Household Demand Regression. One would expect such wealthy households to own them, so a large residual is generated when they fail to. Strikingly, of the households that do own mobile phones when they are least predicted to, most of them tend to have levels of education higher than the average household. Given the relatively low impact of education in the first regression, this is very interesting as it implies that there may be more to the correlation between education and mobile phone ownership than first suggested.

Mobile Ownership	Mean of unexpected non-owners (residual < -0.9)	Mean of unexpected owners (residual > 0.9)
Wealth	4.76	3.10
Landline	0.17	0.13
Time to water	5.18	19.99
Education	7.32	5.28
Rural	0.55	0.75
Male hhold head	0.85	0.44
Age of hhold head	41.26	52.94

Table 12: Swaziland Household Demand Regression Residual Analysis

The Household Productivity Regression was run with the residual and a host of other explanatory variables, as well as in a simpler model containing just the wealth, household size, rural, land, residual and regional variables. The results are seen in Table 14, with both models producing similar results. The discussion below deals with Model A for the sake of continuity.

The key result is the significant and positive coefficient for the residual variable. This suggests that some factor of the error term of mobile phone demand is affecting the number of cattle owned by a household, the proxy used for productivity. If this random factor is indeed related to the productive properties of mobile telephony, then it could be inferred that mobile phone ownership is leading to more productive households, which in turn is leading to greater investment in cattle as productive assets and stores of wealth. While one

cannot rule out an omitted variable bias causing something else correlated with mobile phone and cattle ownership to blur the outcomes, the findings are certainly very encouraging for the hypothesis that mobile phones do add significant value.

In the productivity regression, wealth is positively correlated with the number of cattle owned, and a movement of one standard deviation up the wealth index results in the ownership of nearly one more head of cattle per household. This is logical given the financial expense incurred to purchase and look after such livestock. At the top end of the wealth index, an opposite effect may be expected, as the very wealthy might tend to diversify away from livestock to more modern assets. However, because the wealthy make up such a low proportion of this survey, the effect probably goes unseen. Household size performs as expected, with an increase in the number of people in a household by one standard deviation causing the number of cattle owned to increase by just under two. African agriculture is very labor intensive, due to low levels of capital investment and the marginality of the land, and so it would be easier for larger households to handle larger herds of cattle. The rural coefficient is equally unsurprising, suggesting that rural households own 3.1 more head of cattle than their urban counterparts. This may be as a result of the rural economy being dominated by agriculture, whereas the urban economy is more varied. Rural areas are also more suited to raising cattle than urban ones, and they tend to have more space in which to do this. However, this is more than likely accounted for by the square meters for agriculture variable, which finds that an increase in agricultural land by one standard deviation increases the head of cattle owned by approximately one.

Households with male heads are likely to own over two more head of cattle than female-headed households. This may be to do with a traditional dominance in livestock farming by males, while female-headed households may tend towards other forms of agriculture. Alternatively, female-headed households may have seen their husbands leave the home to work in the cities or the mines, leaving them unreliant on agriculture as their first means of income. Having an older household head also increases the number of cattle owned, which may be due to the fact that older generations tend to stick to traditional forms of agriculture, as well as having higher levels of built up capital, some of which will be invested in cattle. Education is positively correlated with the number of cattle owned, and while one might expect this effect to be more significant, its effect may be tied into other

variables like wealth. Furthermore, the dataset only takes into account formal education, and not necessarily the acquisition of informal knowledge that is useful in farming.

As an indication of household remoteness, time to water has a limited impact. However, the presence of a landline raises the head of cattle owned by 0.6, which may be a result of higher landline density closer to major centers or in areas of gentle topography where it would be easier to lay telephone lines. Households in these areas should be able to farm more effectively and could therefore own higher levels of cattle. Topography is also a likely explanation for why regions perform differently. The Shiselweni region in the south of Swaziland returns a negative coefficient in the regression, probably because it is in a more mountainous area of the country and not in the more favorable plains where other regions are situated.

Model	Rural				Urban			
Mobile Ownership	**Coef.**	**Std. Error**	**t-stat**	**S.D. x Coef.**	**Coef.**	**Std. Error**	**t-stat**	**S.D. x Coef.**
Wealth	0.6240	0.0114	54.50	0.8974	0.6988	0.0279	25.07	1.0049
Landline	-0.5009	0.0454	-11.02	-0.1743	-0.2032	0.0539	-3.77	-0.0707
Time to water	0.0001	0.0003	0.43	0.0045	-0.0008	0.0016	-0.48	-0.0231
Education	0.0106	0.0030	3.59	0.0213	0.0360	0.0041	8.70	0.0725
Male hhold head	0.1421	0.0227	6.27	0.0710	0.1947	0.0425	4.58	0.0973
Age of hhold head	-0.0028	0.0007	-3.99	-0.0444	-0.0009	0.0017	-0.51	-0.0135
Constant	-1.2797	0.0510	-25.08	-	-2.4422	0.1408	-17.35	-
Observations	15435				5458			
Pseudo R Squared	0.2128				0.2081			

Table 14: Swaziland Household Demand

Model	A				B			
Cattle Owned	**Coef.**	**Std. Error**	**t-stat**	**S.D. x Coef**	**Coef.**	**Std. Error**	**t-stat**	**S.D. x Coef**
Wealth	0.6421	0.0703	9.13	0.9234	0.7043	0.0709	9.93	1.0128
Household Size	0.4218	0.0228	18.53	1.6844	0.5131	0.0209	24.58	2.0491
Rural	3.1345	0.3587	8.74	1.3769	2.7989	0.3533	7.92	1.2295
Male hhold head	2.0022	0.1571	12.74	1.0011	-	-	-	-
Age of hhold head	0.0645	0.0050	12.90	1.0246	-	-	-	-
Landline	0.6322	0.3453	1.83	0.2201	-	-	-	-
Time to water	0.0022	0.0028	0.78	0.0678	-	-	-	-
Education	0.0516	0.0201	2.58	0.1039	-	-	-	-
Sq. m for agriculture	0.0004	0.0000	12.32	0.9643	0.0004	0.0000	13.00	1.0349
Residual	1.3771	0.1678	8.21	0.5547	1.1351	0.1678	6.76	0.4572
Hhohho region	0.8949	0.2349	3.81	0.3872	1.0523	0.2380	4.42	0.4554
Manzini region	0.1127	0.2355	0.48	0.0510	0.0892	0.2329	0.38	0.0403
Shiselweni region	-0.3844	0.2130	-1.80	-0.1614	-0.2194	0.2161	-1.02	-0.0922
Constant	-10.0458	0.4381	-22.93	-	-6.2159	0.3628	-17.13	-
Observations	14451				14451			
R Squared	0.1124				0.0912			

Table 13: Swaziland Household Productivity Regression – Models A & B Regression – Rural v Urban

Cambodia

Similar regressions were run with the 2005 DHS data for Cambodia, however this time the type of livestock used in the Household Productivity Regression was either pigs or chickens. Also the Cambodian dataset was not as comprehensive as the Swazi equivalent, lacking variables for landline and time to water. However, these missing variables were not deemed to negatively affect the regression with their absence. The results of the Household Demand Regression can be seen in Table 15 below.

(1) Household Demand Regression:

$Mobileownership = a + \beta_1 wealth + \beta_2 education + \beta_3 rural + \beta_4 malehholdhead + \beta_5 agehholdhead + \varepsilon$

(2) Household Productivity Regression:

$Chickensowned = a + \beta_1 wealth + \beta_2 householdsize + \beta_3 rural + \beta_4 malehholdhead + \beta_5 agehholdhead + \beta_6 education + \beta_7 sqmetersforagriculture + \beta_8 residual + regionaldummies + \varepsilon$

Mobile Ownership	Coef.	Std. Err.	t-stat	S.D. x Coef
Wealth	1.2547	0.0132	95.00	1.7827
Education	0.0391	0.0021	18.56	0.0683
Rural	-0.2649	0.0168	-15.72	-0.1105
Male hhold head	0.2369	0.0208	11.37	0.0908
Age of hhold head	-0.0026	0.0007	-3.96	-0.0328
Constant	-5.6328	0.0716	-78.66	-

Number of obs	72190
Wald chi2(5)	12312
Prob > chi2	0.000
Pseudo R2	0.553

Table 15: Cambodia Household Demand Regression

Most of the variables produce similar outcomes to what is seen in Swaziland. Wealth is very highly correlated with mobile ownership at an extremely high level of significance. Education's impact is once again small and male-headed households have high levels of mobile ownership, while the age of household head is negatively correlated to it. However, unlike in Swaziland, the rural coefficient for Cambodia is negative and very statistically significant. It was argued for Swaziland that the rural coefficient may have been positive

because the rural areas were so consistently poor that the effect of being rural was lost in the wealth variable. However, the wealth gap is smaller in Cambodia, with an average wealth score of 2.64 in rural areas and 3.85 in urban areas, much less of a differential than is seen in Swaziland. This may have caused the rural variable to fall more into line with expectation in the Cambodian results.

The results from the Household Productivity Regression, run twice using either chickens or pigs as proxies for investment assets, can be seen in Tables 16 and 17. These regressions tell a similar story to that of Swaziland, with matching signs for all variables except for age of household head, which is negative in both instances for Cambodia. This may be a result of younger households bring better able to cope with the demands of raising pigs and chickens in a Cambodian setting than they are with raising cattle in Swaziland, where the entry costs are much higher.

Most importantly, the residual coefficient is positive and statistically significant in each model for each type of livestock in the Household Productivity Regression. Under Model A, an increase of the residual by one standard deviation would see chicken ownership increase by 0.7 heads per household and pig ownership by 0.1 heads per household. Just as in Swaziland, if we assume that these livestock are used as productive assets and stores of value, then this positive correlation with the residual indicates that something related to it is improving household productivity.

Wealth has a large impact on livestock ownership once more, with a one standard deviation increase in wealth resulting in approximately one more chicken and 0.4 more pigs being owned per household. The square meters for agriculture variable is also significant, with a one standard deviation increase seeing 1.3 more chickens and 0.3 more pigs owned per household. The household size and rural variables are also positive for both types of livestock, while the impact of education is low but more significant that it was for Swaziland.

Model	A				B			
Pigs Owned	**Coef.**	**Std. Error**	**t-stat**	**S.D. x Coef**	**Coef.**	**Std. Error**	**t-stat**	**S.D. x Coef**
Wealth	0.2902	0.0111	26.07	0.4123	0.2967	0.0108	27.38	0.4216
Household size	0.0755	0.0061	12.39	0.1808	0.0736	0.0060	12.33	0.1764
Rural	0.2542	0.0384	6.62	0.1061	0.2491	0.0386	6.46	0.1039
Male hhold head	0.0981	0.0247	3.97	0.0376	-	-	-	-
Age of hhold head	-0.0070	0.0007	-9.86	-0.0892	-	-	-	-
Education	0.0192	0.0044	4.40	0.0336	-	-	-	-
Sq. m for agriculture	0.0000	0.0000	11.43	0.2508	0.0000	0.0000	11.39	0.2492
Residual	0.4281	0.0695	6.16	0.1380	0.4259	0.0694	6.13	0.1373
Constant	-0.1897	0.0726	-2.61	-	-0.3847	0.0664	-5.79	-
Observations	52642				52642			
R Squared	0.0539				0.0518			

Table 16: Cambodia Household Productivity Regression – Chickens Owned*

Model	A				B			
Chickens Owned	**Coef.**	**Std. Error**	**t-stat**	**S.D. x Coef**	**Coef.**	**Std. Error**	**t-stat**	**S.D. x Coef**
Wealth	0.7106	0.0437	16.24	1.0096	0.7903	0.0415	19.03	1.1229
Household size	0.3299	0.0340	9.71	0.7905	0.3586	0.0331	10.83	0.8592
Rural	1.5580	0.1480	10.53	0.6500	1.5456	0.1482	10.43	0.6448
Male hhold head	1.3880	0.1134	12.23	0.5322	-	-	-	-
Age of hhold head	-0.0092	0.0033	-2.76	-0.1165	-	-	-	-
Education	0.1062	0.0176	6.03	0.1854	-	-	-	-
Sq. m for agriculture	0.0001	0.0000	18.73	1.2751	0.0001	0.0000	19.23	1.3090
Residual	2.1114	0.2554	8.27	0.6805	2.0427	0.2557	7.99	0.6584
Constant	-3.3241	0.3145	-10.57	-	-2.7339	0.2868	-9.53	-
Observations	52636				52636			
R Squared	0.0651				0.0619			

Table 17: Cambodia Household Productivity Regression – Pigs Owned*

**For extended results with regional outcomes included, see tables in Appendix Two*

Honduras

The following regressions were run with the 2005 DHS data for Honduras, with the results of the first regression on display in Table 18.

(1) Household Demand Regression:

$Mobileownership = a + \beta_1 wealth + \beta_2 landline + \beta_3 timetowater + \beta_4 education + \beta_5 rural + \beta_6 malehholdhead + \beta_7 agehholdhead + \varepsilon$

(2) Household Productivity Regression:

$Landforagriculture = a + \beta_1 wealth + \beta_2 householdsize + \beta_3 rural + \beta_4 malehholdhead + \beta_5 agehholdhead + \beta_6 landline + \beta_7 timetowater + \beta_8 education + \beta_9 residual + regionaldummies + \varepsilon$

Mobile Ownership	Coef.	Std. Err.	t-stat	S.D. x Coef.
Wealth	0.8616	0.0066	130.28	1.2087
Landline	-0.4997	0.0162	-30.77	-0.1897
Time to water	0.0010	0.0005	1.84	0.0110
Education	0.0188	0.0012	15.14	0.0815
Rural	0.2774	0.0143	19.44	0.1333
Male hhold head	-0.0638	0.0125	-5.11	-0.0266
Age of hhold head	-0.0002	0.0004	-0.58	-0.0030
Constant	-3.2061	0.0325	-98.66	-

Number of obs	93511
Wald chi2(7)	29414
Prob > chi2	0.000
Pseudo R2	0.348

Table 18: Honduras Household Demand Regression

These results follow the trends witnessed in the other two countries for the most part. Wealth is highly correlated with mobile ownership and this is extremely significant, as expected. It is certainly the main driver of mobile phone ownership, as the effect of a one standard deviation shift in wealth far outweighs the combined effect of a one standard deviation shift in all of the other variables. It should be noted that the rural coefficient is positive, as it was in Swaziland but not in Cambodia. Wealth may once more be accounting for some of the rural effect and this could be causing the rural coefficient to be positive, as was suggested in Swaziland. The male household head variable has a negative coefficient in

the Honduran regression where it had a positive one in the others. Although it is small, this may infer that variations in gender roles across these nations lead to different consumptive outcomes.

In the Household Productivity Regression, wealth has a strong and positive relationship with the productivity measure once more, which in this case is the amount of land used for agriculture. Also, as witnessed in the two countries examined prior, the household size and education variables are positively correlated with the productivity measure. The age of household head variable is also positively correlated with it, as it was in Cambodia but not in Swaziland. This could be due to the fact that old family ties have remained relatively entrenched in these two nations, whereas circumstances like civil war in Cambodia may have eroded traditional social organizations and allowed younger households to start off on a more level playing field. The time to water and landline variables are both statistically significant for the first time in the Honduras regression, with an increase of one standard deviation in time to water decreasing land for agriculture by 0.25ha, and the lack of a landline decreasing it by 5.14ha. This indicates that proximity to towns and infrastructure may be more important in Honduras, which makes sense given the logistics of growing crops and getting them to market. Alternatively, this could be a commentary on the topography of the country, in that the land most suited for agriculture is closer to major centers, typically on the coastal plains.

The rural variable is negative in this regression, for the first time. As mentioned earlier and demonstrated in Table 10, this may be because urban households own more than twice the amount of land on average that their rural counterparts do. Part of the reason for this is that land is an asset readily acquired by the wealthy, who tend to live around urban areas. Furthermore, the best agricultural land in Honduras tends to be close to the main urban centers. Strikingly, the rural coefficient is even more negative in Model B, where landline and time to water variables are absent. This suggests that the more remote a household is, the less land that is suitable for agriculture it is likely to have.

Importantly, the coefficient of the residual factor of mobile phone ownership is positive and statistically significant, marking the third straight country in which this has been the case. The fact that such results have occurred across multiple countries with different economic structures adds great confidence to the argument that mobile phones do have real and quantifiable impacts on productivity in developing nations.

Model	A				B			
Ha. for agriculture	**Coef.**	**Std. Error**	**t-stat**	**S.D. x Coef**	**Coef.**	**Std. Error**	**t-stat**	**S.D. x Coef**
Wealth	1.9751	0.1347	14.66	2.7708	2.7298	0.1227	22.24	3.8294
Household size	0.1011	0.0358	2.82	0.2786	0.1075	0.0360	2.98	0.2962
Rural	-0.9213	0.5117	-1.80	-0.4427	-2.5733	0.4650	-5.53	-1.2365
Male hhold head	-0.1719	0.3110	-0.55	-0.0717	-	-	-	-
Age of hhold head	0.0202	0.0069	2.90	0.3004	-	-	-	-
Landline	5.1390	0.7148	7.19	1.9549	-	-	-	-
Time to water	-0.0221	0.0056	-3.94	-0.2536	-	-	-	-
Education	0.1532	0.0354	4.33	0.6644	-	-	-	-
Residual	0.7837	0.3525	2.22	0.2848	0.8785	0.3524	2.49	0.3193
Atlantida region	-0.2262	1.1056	-0.20	-0.0475	-0.7510	1.1165	-0.67	-0.1576
Colon region	0.3874	0.8880	0.44	0.0839	-0.0736	0.8963	-0.08	-0.0159
Comayagua region	-4.6913	0.7492	-6.26	-1.1104	-5.0812	0.7601	-6.68	-1.2027
Copan region	-3.7265	0.7541	-4.94	-0.8779	-4.0154	0.7636	-5.26	-0.9460
Cortes region	-4.3326	1.0679	-4.06	-1.3019	-5.0327	1.0810	-4.66	-1.5123
Choluteca region	-3.3354	0.8019	-4.16	-0.7569	-3.2773	0.8085	-4.05	-0.7437
El Paraiso region	-0.7633	0.7816	-0.98	-0.1741	-0.7967	0.7876	-1.01	-0.1817
Francisco Morazan region	-1.9633	0.8377	-2.34	-0.6223	-1.7859	0.8417	-2.12	-0.5661
Intibuca region	-4.6845	0.7056	-6.64	-1.1865	-4.7009	0.7121	-6.60	-1.1907
La Paz region	-5.1432	0.7040	-7.31	-1.2440	-5.0586	0.7108	-7.12	-1.2236
Lempira region	-4.2937	0.7045	-6.09	-1.0572	-4.2665	0.7110	-6.00	-1.0505
Ocotepeque region	-6.6188	0.6950	-9.52	-1.4125	-6.6966	0.7008	-9.56	-1.4291
Olancho region	1.3762	0.7893	1.74	0.3286	1.3161	0.7971	1.65	0.3142
Santa Barbara region	-4.6910	0.7513	-6.24	-1.0467	-5.1498	0.7611	-6.77	-1.1490
Valle region	-1.0762	0.8941	-1.20	-0.2289	-1.1978	0.8991	-1.33	-0.2548
Constant	4.8604	1.0473	4.64	-	6.5170	0.9556	6.82	-
Observations	36860				36860			
R Squared	0.0648				0.0604			

Table 19: Honduras Household Productivity Regression

6. Policy Implications and Conclusion

A strong correlation is identified in this study between the residual factor of mobile phone ownership and the proxies used for productivity– livestock and land. Assuming that these proxies do indeed act as productive assets, and that this residual factor is not correlated with any factor affecting output other than mobile phone ownership, then it would appear that mobile phones do indeed have positive impacts on the productivity of their owners. In simpler terms, if a phone figuratively fell out of the sky and a household began to use it, an increase in productivity would be expected regardless of the household's other attributes.

Despite the strong results, there is still the risk of an omitted variable bias that is not accounted for in these equations, which would prevent the residual term from representing the productive effects of a mobile phone accurately. The use of household capital, labor and income statistics instead of livestock ownership in future studies may help reduce such issues. Additionally, multi-observation panel data would be needed to firmly establish causality. Regardless, the findings of this study are still significant given the strong coefficients produced across multiple examples.

The results point to real productivity benefits from the prevalence of mobile phones in developing nations. Such findings imply that national leaders should look to promote their telecommunications industries so that more of their people can enjoy better services that will ultimately improve their productivity, and that of their country. Previous studies have suggested that economies with more government intervention have seen greater benefits from increases in mobile telephony. Indeed, substantial government involvement in building an integrated, national mobile network may be instrumental to its success. However, doing so would also threaten the reigns of dictatorial and corrupt governments, as the increased information flows may jeopardize their longevity in power. For this reason, some nations may encounter friction in their attempts to build successful telecommunications networks. However, as further pieces of evidence regarding the positive impacts of mobile phones emerge, one can only imagine that telecommunications networks will be more readily implemented, as in the long run it appears certain that they are helping developing economies to catch up with the rest of the world.

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8. Appendices

Appendix One: Variable Definitions

Mobile ownership: binary variable for owning a mobile phone, ownership being 1

Wealth: discrete wealth score on a five point scale, 1 being the lowest and 5 the highest

Landline: binary variable for household owning a landline, ownership being 1

*Time to water**: time taken to reach household water source, in minutes

Education: highest year of education in household, from 0 to 20

Rural: binary variable for physical setting of household, rural being 1

Male hhold head: binary variable for sex of hhold head, male being 1

Age of hhold head: variable for age of hhold head

Household size: number of household members

*Square meters / hectares for agriculture**: amount of land available for agriculture

*Cattle owned**: head of cattle owned per household

*Chickens owned**: chickens owned per household

*Pigs owned**: pigs owned per household

**It should be noted that these variables had reporting ceilings – levels at which a household was assigned a maximum value (9600 minutes for time to water, 95 for number of cattle/chickens/pigs owned, 9500m^2 / 70 ha. for agricultural land). The vast majority of data points fell under these caps, but it could be fair to assume that the presence of these caps may cause the effects estimated in the regressions to be under-reported in comparison to reality.*

Model	A				B			
Chickens Owned	**Coef.**	**Std. Error**	**t-stat**	**S.D. x Coef**	**Coef.**	**Std. Error**	**t-stat**	**S.D. x Coef**
Wealth	0.7106	0.0437	16.24	1.0096	0.7903	0.0415	19.03	1.1229
Household size	0.3299	0.0340	9.71	0.7905	0.3586	0.0331	10.83	0.8592
Rural	1.5580	0.1480	10.53	0.6500	1.5456	0.1482	10.43	0.6448
Male hhold head	1.3880	0.1134	12.23	0.5322	-	-	-	-
Age of hhold head	-0.0092	0.0033	-2.76	-0.1165	-	-	-	-
Education	0.1062	0.0176	6.03	0.1854	-	-	-	-
Sq. m for agriculture	0.0001	0.0000	18.73	1.2751	0.0001	0.0000	19.23	1.3090
Residual	2.1114	0.2554	8.27	0.6805	2.0427	0.2557	7.99	0.6584
Banteay Mean Chey region	1.7021	0.2638	6.45	0.3636	1.8388	0.2633	6.98	0.3928
Kampong Cham region	2.4320	0.3092	7.86	0.5128	2.4707	0.3086	8.01	0.5209
Kampong Chhnang region	3.4738	0.2078	16.72	0.7612	3.5663	0.2067	17.26	0.7815
Kampong Speu region	1.1439	0.1910	5.99	0.2572	1.2001	0.1903	6.31	0.2698
Kampong Thom region	2.6303	0.2088	12.60	0.5985	2.7345	0.2075	13.18	0.6222
Kandal region	2.4754	0.2550	9.71	0.5537	2.5144	0.2524	9.96	0.5624
Kratie region	3.7620	0.2443	15.40	0.8289	3.8425	0.2430	15.81	0.8467
Phnom Penh region	-2.7001	0.4630	-5.83	-0.5949	-2.6330	0.4597	-5.73	-0.5801
Prey Veng region	3.2270	0.2584	12.49	0.7138	3.3453	0.2570	13.01	0.7400
Pursat region	4.3683	0.2220	19.68	0.9445	4.3953	0.2215	19.85	0.9503
Siem Reap region	2.7575	0.2068	13.34	0.6207	2.7913	0.2065	13.52	0.6283
Svay Rieng region	4.3767	0.2258	19.38	0.9376	4.4659	0.2232	20.01	0.9568
Takeo region	4.3117	0.3058	14.10	0.9669	4.4328	0.3060	14.49	0.9940
Otdar Mean Chey region	2.7233	0.1968	13.84	0.6256	2.7114	0.1970	13.76	0.6229
Battambang & Krong Pailin region	2.9286	0.2847	10.29	0.6994	2.9592	0.2855	10.37	0.7067
Kampot & Krong Kep region	8.2318	0.2458	33.50	1.8122	8.3629	0.2451	34.11	1.8410
Krong Preah Sihanouk & Kaoh Kong region	3.9460	0.3699	10.67	0.8183	3.8852	0.3698	10.51	0.8056
Preah Vihear & Steung Treng region	2.4724	0.1936	12.77	0.5754	2.5756	0.1937	13.30	0.5994
Constant	-3.3241	0.3145	-10.57	-	-2.7339	0.2868	-9.53	-
Observations	52636				52636			
R Squared	0.0651				0.0619			

Table 20: Cambodia Household Productivity Regression – Chickens Owned (Extended)

Model	A				B			
Pigs Owned	**Coef.**	**Std. Error**	**t-stat**	**S.D. x Coef**	**Coef.**	**Std. Error**	**t-stat**	**S.D. x Coef**
Wealth	0.2902	0.0111	26.07	0.4123	0.2967	0.0108	27.38	0.4216
Household size	0.0755	0.0061	12.39	0.1808	0.0736	0.0060	12.33	0.1764
Rural	0.2542	0.0384	6.62	0.1061	0.2491	0.0386	6.46	0.1039
Male hhold head	0.0981	0.0247	3.97	0.0376	-	-	-	-
Age of hhold head	-0.0070	0.0007	-9.86	-0.0892	-	-	-	-
Education	0.0192	0.0044	4.40	0.0336	-	-	-	-
Sq. m for agriculture	0.0000	0.0000	11.43	0.2508	0.0000	0.0000	11.39	0.2492
Residual	0.4281	0.0695	6.16	0.1380	0.4259	0.0694	6.13	0.1373
Banteay Mean Chey region	-0.2494	0.0532	-4.69	-0.0533	-0.2240	0.0528	-4.24	-0.0479
Kampong Cham region	-0.3746	0.0613	-6.11	-0.0790	-0.3734	0.0611	-6.11	-0.0787
Kampong Chhnang region	-0.1673	0.0535	-3.13	-0.0367	-0.1494	0.0526	-2.84	-0.0327
Kampong Speu region	-0.2779	0.0544	-5.11	-0.0625	-0.2589	0.0541	-4.79	-0.0582
Kampong Thom region	0.0409	0.0501	0.82	0.0093	0.0555	0.0492	1.13	0.0126
Kandal region	-0.6838	0.0621	-11.01	-0.1530	-0.6910	0.0608	-11.36	-0.1546
Kratie region	-0.0330	0.0592	-0.56	-0.0073	-0.0215	0.0588	-0.37	-0.0047
Phnom Penh region	-1.3106	0.2045	-6.41	-0.2888	-1.2602	0.2027	-6.22	-0.2776
Prey Veng region	0.1615	0.0511	3.16	0.0357	0.1825	0.0502	3.63	0.0404
Pursat region	0.1694	0.0774	2.19	0.0366	0.1921	0.0772	2.49	0.0415
Siem Reap region	-0.1321	0.0495	-2.67	-0.0297	-0.1093	0.0493	-2.22	-0.0246
Svay Rieng region	0.1733	0.0495	3.50	0.0371	0.1951	0.0484	4.03	0.0418
Takeo region	0.0341	0.0535	0.64	0.0076	0.0617	0.0526	1.17	0.0138
Otdar Mean Chey region	-0.2728	0.0442	-6.18	-0.0627	-0.2463	0.0438	-5.63	-0.0566
Battambang & Krong Pailin region	-0.6056	0.0766	-7.91	-0.1446	-0.5938	0.0761	-7.80	-0.1418
Kampot & Krong Kep region	-0.0996	0.0557	-1.79	-0.0219	-0.0695	0.0554	-1.25	-0.0153
Krong Preah Sihanouk & Kaoh Kong region	-0.1278	0.0735	-1.74	-0.0265	-0.1108	0.0728	-1.52	-0.0230
Preah Vihear & Steung Treng region	0.0880	0.0436	2.02	0.0205	0.1066	0.0432	2.47	0.0248
Constant	-0.1897	0.0726	-2.61	-	-0.3847	0.0664	-5.79	-
Observations	52642				52642			
R Squared	0.0539				0.0518			

Table 21: Cambodia Household Productivity Regression – Pigs Owned (Extended)