Research Article

Use of the Internet and Productivity of Microbusinesses: Evidence from the Peruvian Case (2007–2010)[2]

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Abstract

The Internet is a tool that facilitates better and broader access to information, as well as a more efficient form of communication both inside and outside a business. According to the theory of ICT for development (ICT4D), the use of ICT helps business owners make better decisions (reducing transaction costs and the uncertainty associated with decision-making processes), which would, in turn, increase the business' productivity. In the case of Peru (and also for the Latin American case, in general), this effect would be especially relevant, since microbusinesses constitute not only the largest business group (98% of the total companies in the country), but also the group with the lowest productivity rates.

Based on a nationwide representative sample for the years 2007–2010, we used a first differences model which determined that a one-point increase in the adoption index (0–100 scale) results in a productivity increase of approximately 1.5% of the sample's average productivity.

Introduction

Information and communications technologies (ICTs), particularly the Internet, are technologies which, in general terms, allow for faster communication, as well as greater access to and use of information. A rapid expansion in the use of ICT in companies was recently observed (ITU, 2011). These ICTs are expected to transform, in the medium term, the productive and social relationships of the world in which we live.

1. Several people have collaborated in different ways to help me prepare this article, and I wish to convey my deepest thanks to them all. I would like to offer a special word of gratitude to Roxana Barrantes Cáceres, Fátima Ponce, and Aileen Agüero for the comments they made throughout the different research stages. Their input has been of invaluable importance for continuously improving my research. Moreover, I would like to thank those whose numerous comments I received during my internship at the Instituto de Estudios Peruanos (IEP) as part of the "Diálogo Regional sobre la Sociedad de la Información" program. I would also like to extend my most sincere thanks to all the people who, by agreeing to provide me with necessary information via e-mail, made a fundamental contribution to completing this work. Additionally, I would like to thank the valuable observations made by the many participants, attendees, and commentators of the VI Conference "ACORN-REDECOM" held in Valparaíso, Chile; the "I Workshop of Applied Economic Research" organized by the "Consorcio de Investigación Económica y Social (CIES)"; the XXIX Economists Symposium" organized by the Peruvian Central Bank; and the IV Symposium of Economics Students organized by the Economics Department of the Pontific Catholic University of Peru (PUCP). Furthermore, comments made by different researchers at the IEP and by colleagues specialized in Economics from the PUCP have enriched this study greatly. I assume full responsibility for any errors that may be found in this article.

2. I would like to express thanks for the economic support given by the CIES to conduct this research as part of the XII National Research Contest. Also, I would like to give special thanks to the Instituto de Estudios Peruanos (IEP) for the institutional support given to this project.

Recent reports and international studies have also described ICT as a great opportunity for the development of both small businesses and the poorest households in Latin America (see ECLAC, 2008; ITU, 2012; UNCTAD, 2011; WEF, 2011, among others). More important, it has been sustained that the Internet enables microbusinesses to reduce search and transaction costs, improve communications throughout the entire value chain, obtain better training, and enhance their relationships with the state through e-government.

The positive relationship between the use of the ICT and productivity has been broadly studied for different sectors and for diverse ICT tools. However, in Peru or even all of Latin America, no thorough or quantitative investigation has yet been made to determine the existence of a direct relationship between the use of the Internet and the productivity of businesses.

This lack of research takes greater relevance in the case of microbusinesses,[3] which represent 47% of the GDP of Peru, 57% of the sources of employment in cities, and 43% of the sources of employment in rural areas.[4] However, their productivity level is very low (they represent about 5% of the productivity of large and mega companies). This is clearly shown, for instance, by the fact that they only represent 2% of Peru's total exports.

Thus, the overall purpose of this article is to provide evidence that speaks to the question of whether the use of the Internet has an effect on the productivity of microbusinesses. Based on the conclusions of this article, we will be able to suggest policies to determine the feasibility of promoting the use of the Internet as a tool to improve the productivity of businesses.

To that end, we analyze the hypothesis that the use of the Internet by the microbusiness owner has a positive effect on the productivity of the owner's company. This is because business owners who use the Internet have a comparative advantage in terms of information and communications, since they are able to obtain information and communicate more frequently and effectively (e.g., with their employees, suppliers, and customers).

To verify our hypothesis, we will estimate how the use of the Internet by the business owner affects the productivity of his or her company (holding constant all other factors affecting productivity) in order to find a causal link between increased adoption of the Internet by business owners and greater productivity of microbusinesses. This is known as the potential outcomes approach, or the Rubin-Holland causal model.[5]

The above mentioned model is the most convenient one, since there are "unobservable variables" typical of each individual that may bias the results.[6] For this reason, we use a first differences (FD) model that enables us to correct this problem.

This article, furthermore, addresses the issue of the adoption of the Internet beyond the simple determination of whether it is "used or not used," since our purpose is to create an Internet adoption index. This allows for a measurement of the Internet's effect on the productivity that is more precise than the one that would be obtained if only a "used/not used" indicator were employed.

The results of our research show that an increase in the adoption index (which has a 0–100 range) has an average effect of 0.04 peruvian "nuevos soles"(PEN)[7] per worked hour. This represents 1.5% of the sample's average productivity, a clearly noteworthy effect.

The finding of a positive effect of the use of the Internet on the productivity of these companies enables us to design policies aimed at reducing the productivity gap between this important group of companies and larger companies, thus improving the overall economic development of Peru.

3. A microbusiness is one with less than 10 employees, including independent workers and excluding household workers and farmers. This definition is usually used in research papers on microbusinesses prepared in Peru. See, for example, Villarán (2007) and Chacaltana (2008).

4. Chacaltana (2008) and Villarán (2007).

5. For a more detailed analysis on this approach, see Angrist and Pischke (2009). The seminal works of Rubin (1974) and Holland (1986) are also recommended.

6. In this regard, although the endogeneity issue will be explained in greater detail in the "Methodology" section, it is important to clarify that the main effect of endogeneity is that, in this case, it prevents us from making a causal interpretation of the results because the decision to use or not use the Internet depends on such personal characteristics as the person's "ability" (which, in the literature, has an effect known as "ability bias.").

7. The exchange rate between United States dollars (USD) and Peruvian "nuevos soles" (PEN) is 2.63. So, in this case, if the effects are of 0.04 PEN per hour worked, then is equivalent to 0.015 USD per hour worked.

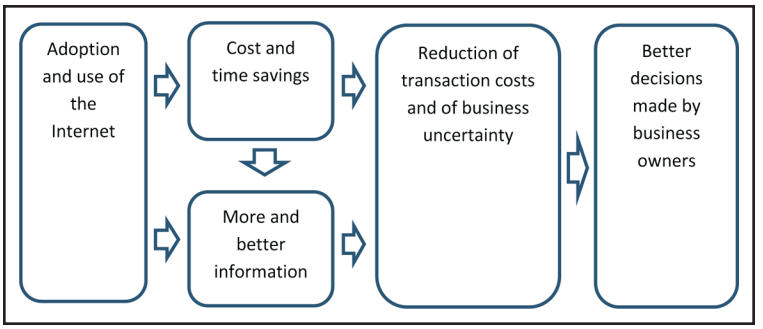

Figure 1. Causal relationship showing the effect of the use of the Internet in decision-making processes.

Source: Gi-Soon (2005), prepared by the author.

1. Analytical Framework and Hypothesis

1.1 Effect of ICT on the Economy

Katz (2009) points out that companies decide to adopt ICT to gain productivity (or competitiveness) to defeat their competitors. This works as an incentive for the other companies in the sector to adopt these technologies as well, thus causing them to compete on an equal level. This effect would translate, as Gi-Soon (2005) points out, into an improvement in the decision-making process undertaken by business owners, who would save both time and money when searching for information, since ICT would enable them to access more and better information. As we stated above, this ultimately helps the business owner make better-informed decisions in a faster way, thereby increasing the productivity of the owner's company.[8] This is shown in Figure 1.

This study thus seeks to find out in what way the use of the Internet by the business owner has a positive effect on the productivity of its business. The hypothesis under study is as follows:

Hypothesis:	A greater use of the Internet by a microbusiness owner has a positive effect on the work productivity of the owner's business, as it facilitates access to more and better sources of information and communication.

According to the above hypothesis, the use of the Internet facilitates access to better sources of information and communication, thereby reducing both transaction costs (most importantly, information search costs) and the uncertainty associated with decision-making processes (since information asymmetries would be reduced). This would enable the business owner to make better decisions, and as a result, the productivity of the owner's company would naturally improve. Additionally, the Internet also facilitates communication between the key people of the business, as well as with suppliers and customers. Furthermore, this improved communication helps to reduce both transaction costs (especially the costs resulting from coordination activities with customers, partners, and suppliers) and the uncertainty inherent in the decision-making process, since communication lowers the risk of making mistakes.

2. Review of Empirical Literature

Given the amplitude and variety of research studies conducted in connection with the issue under analysis, some clarifications should be made for this review of the empirical literature not to be too extensive. We will not include the studies analyzing the effect of the use of the Internet on microbusinesses in developed countries, since such businesses are not comparable with those in developing countries. Moreover, since this research is quantitative in nature, our review will not include those studies using exclusively a qualitative approach. Also, our work only takes into consideration those studies which consider the Internet to be part of the ICTs worthy of analysis, despite the existing abundant literature focusing on the use of mobile phones. This exclusion is deemed necessary because there are important differences between the referred technologies and the ways in which they affect productivity.

8. Other authors have drawn similar conclusions in the realm of microeconomics, and have related them, in particular, with the mentality of microbusinesses. Aker (2008) and Jensen (2007) state that the main advantages of ICTs is that they help to make small decisions which are critical for microbusiness owners.

2.1 Approaches to the Relationship Between the Use of the Internet and the Productivity of Businesses in Peru

Only a few studies have been carried out in Peru on the relationship between the use of the Internet and the productivity of microbusinesses. Further, the studies that address this issue do so using approaches with variables that measure productivity in an indirect manner (with values such as household income or salary), use small samples, or conduct only exploratory studies.

The studies of Rodríguez (2008), Tello (2011), De Los Ríos (2010), and Medina and Fernández (2011) are the latest research studies that have been conducted in Peru concerning the effect of the use of the Internet on such variables related with productivity as income, salaries, and profitability.

Although all these studies have found a positive and significant effect, their main limitations are that the variables used only capture productivity in an indirect manner. Moreover, the variable measuring use of the Internet in these studies does not distinguish among the different types of use of that tool; that is, these studies do not take into account the potential differences that using the Internet for different applications may have. This restricts the capacity of these studies to capture the effect of this service.

Kuramoto (2007), Agüero and Pérez (2010), and Proexpansión (2005) conducted exploratory studies on the relationship between the use of the Internet and the productivity of microbusinesses in Peru. Unlike the studies mentioned in the preceding paragraph, they do take into consideration the different types of uses of the Internet, remarking that it is important to acknowledge these different uses because their impact on businesses is, likewise, different. In spite of this, no causality relationships could be obtained from these studies' results.

2.2 Approaches in Other Developing Countries

Although scholars focusing on other developing countries may have done advanced research on the effect of the Internet on the productivity of microbusinesses, it should be noted that the characteristics of the companies analyzed in such countries may have significant differences with the subject matter under study in our research.

Esselaar, Stork, Ndlwalana, and Deen-Swarray (2007); Chowdhury and Wolf (2003); and Amorós, Planellas, and Batista-Foguet (2007) have studied, through diverse strategies, the effect of the use of the Internet on the productivity of microbusinesses. Amorós et al., in particular, have found that it is not productivity that is affected, but the size of the company involved.

Esselaar et al. (2007) and Chowdhury and Wolf (2003) focus their analysis on the African case and draw mixed conclusions on the effect of ICT. For example, Chowdhury and Wolf have found that the use of ICTs has no effect on the profitability of companies, but that it has a negative effect on productivity. However, they point out that maybe this is because the effects of the use of these technologies will only become evident in the days to come. Esselaar et al., who have found a positive effect in the use of ICTs, sustain that the negative results obtained by Chodwhury and Wolf are due to incorrect measurements of the characteristics of microbusinesses.

3. Methodology

The following equation (1) summarizes the relationship we intend to prove through this work:

$$\text{Productivity} = f(\text{Use of the Internet} \mid \text{Control variables}) + \text{error} \quad (1)$$

This equation contains four important elements for the correct application of the model:

i) Dependent variable: productivity of the microbusiness.

ii) Treatment variable: the use of the Internet by the business owner.

iii) Group of control variables: those variables included in the model to obtain a better measurement of the effect of the treatment variable.

iv) The white noise or "error term"

Since this article aims at finding a cause-effect relationship, we have selected the potential results approach, also known as the Rubin-Holland causal model.

As it relates to our problem, this approach consists of finding a causal link between a greater adoption of the Internet by the business (specifically, by the microbusiness owner) and a greater productivity rate.[9]

9. For a more detailed analysis of the nature of this model, see the introductory chapter by Angrist and Pishcke (2009), whose nomenclature was used for this work.

In simpler words, specific to this particular case, we wonder what the productivity rate would be if the business owner had used the Internet (in the case that the owner did not use it), and vice versa.

The main reason why this type of approach is used is that it enables us to treat directly the endogeneity that may exist between the productivity variable and the use of the Internet. For instance, we could mention a scenario where an observed increase in productivity might occur due to "unobservable" factors (where such increase, in turn, may affect the extent to which the Internet is used).

Thus, for example, one type of problem we intend to prevent is a situation where a third variable, "E," would be the one giving rise to a change in the adoption level and affecting productivity at the same time. This would cause the observed relationship between these variables to be biased, since the model would be capturing the effect of "E," and not the effect of the actual use of the Internet.

This is especially relevant since productivity is a variable which depends on the unobservable variable "ability" (the effect of which has been broadly studied by empirical authors and is known as "ability bias"). This means that there is a positive bias toward the adoption of the Internet and the productivity of those individuals who are more "skilled" or "intelligent."[10] Failing to take this problem into consideration results in an incorrect measurement of the relationship, since doing so causes us to overrate the true causal link between the use of the Internet and the productivity rate. In the next section, we describe the econometric model we have selected.

3.1 Econometric Model

We have decided to work with the first differences (FD) model.[11] The reason for this choice is that ability is an individual characteristic that does not change over time. By applying this methodology, we prevent the model from containing the referred ability bias and obtain a consistent estimator.[12]

Thus, the first differences model is represented by the following equation (2):[13]

$$\Delta y_{i,t,t-1} = \beta_0 + \Delta X_{i,t,t-1}'\beta_1 + X_{i,t-1}'\beta_2 + y_{i,t-1}'\beta_3 + \Delta\varepsilon_{i,t,t-1}, \quad (2)$$

where y_{it} is the vector that observes the productivity of the business owned by individual i during period t. Naturally, the variable expressed as $\Delta y_{i,t,t-1}$ represents the variation between period t and $t-1$. X_{it} is the control variables matrix of the model (such as the education of the business owner and the employees, the number of employees, their age, etc.). Based on the periods matrix, we built matrix $\Delta X_{i,t,t-1}$, which contains the variations of the variable adoption of the Internet by businesses, as well as the rest of the control variables between periods t and $t-1$. Vector β_1 contains the coefficients vector for this matrix. Matrix $X_{i,t-1}$ represents the lagging values of this matrix (that is, the original period with respect to which the difference is obtained), and vector β_2 represents the coefficients for that matrix.

Vector y_{it-1} contains the values of the dependent variable in the period elapsing before the difference,

10. Although the term "ability" has several connotations, it may be sustained that "able" persons have the skill to learn how to use new technologies, are more curious about learning them, or identify more quickly the competitive advantage of adopting them. In addition, these people represent the most productive group. There is plenty of relevant literature that discusses the effects and nature of the "ability bias," although such literature is mainly focused on the estimations of the return on education, not on the particular context of the use of the Internet. The study conducted by DiNardo and Pischke (1997)—who have analyzed the "ability bias" issue in the case of the effect of the use of computers on workers' salaries—is the research work that most closely resembles our study. As in this article, it analyzes the existing endogeneity problem in the relationship between productivity and ICT use.

11. For a mathematical proof of how the FD model solves the "unobservable" variables problem, see Woolridge (2002), pp. 279–284.

12. There is another potential endogeneity problem. This problem is known as "simultaneous causality" or "bicausality," which consists of the occurrence of two causal effects at the same time. The only way to solve it is through the use of some experimental method or the instrumental variables method (IV), but this requires that there be some exogenous "instrument" that randomly "assigns" the use of the Internet. By doing that, the estimated effect might be known in one direction only. In this case, unfortunately, we do not have such an instrument, and it is therefore preferable to not use that methodology, since the results might feature an even greater bias (for more detailed information, see Angrist & Pischke, 2009).

13. It is worth mentioning that the variable levels are also included in the previous period, since, according to Wooldridge (2002, p. 284), when the difference is associated with lagging values, including them in the regression is the most recommended alternative.

also to control—by means of a differentiated effects approach (depending on where the variable is placed)—the value of the dependent variable in the initial period. Coefficient β_3 estimates the effect of having different initial productivity levels in the future variation of productivity.[14]

3.2 Database

The data used for this study were obtained from the National Household Survey (ENAHO) for 2007–2010, which presents economic information on microbusinesses, such as the company's activity years, the number of employees, their qualifications and expertise, and the company's expenses. The survey also contains information on the use of the Internet by the business owner, as well as his or her socioeconomic characteristics.

The survey is a cross-sectional survey, but it contains a panel data sub-sample. The original cross-sectional sample consists of 11,211 observations for 2007; 11,047 for 2008; 11,383 for 2009; and 11,378 for 2010.[15]

Of the total, 1,994 panel data observations were made for 2007–2008, 1,920 were made for 2008–2009, and 2,020 were made for 2009–2010. Using these three periods as a difference pseudo-panel, we obtain 5,920 observations formed by 10,970 cross-sectional observations (approximately 25% of the original cross-sectional sample).

3.3 Model Variables

3.3.1 Result variable

Unfortunately, we cannot observe the productivity of the company's employees, and calculating it directly would be very difficult (if not impossible).[16] For this work, we use the "proxy" variable to measure the value added per average worked hour in the company, which we express as: $\frac{VA}{H_{it}}$

Where *VA* is the total value added (which comprises both the output for the company's own consumption and the output for sale), and *H* is the total worked hours in the business owned by individual *i* in year *t*. We use this variable as an approximate value of the productivity per worker. However, in order for the results not to be biased by the use of this proxy variable, another two variables[17] will be used to test the robustness of the results.

3.3.2 Control variables

We subdivide the control variables group into four parts: Z_{it}, W_{it}, γ_t and δ_{it}.

Matrix Z_{it} contains 11 variables typical of the business owned by *i* for each period *t*. These variables are the salaries paid to workers, the experience (or activity years) of the business, the percentage of workers who are related to the business owner,[18] the percentage of unpaid workers, a dichotomous variable that indicates whether the business is located in a city or rural location,[19] three dichotomous variables that indicate the business' economic sector (production, services, or trade), and three dichotomous variables that indicate the business' payroll.[20]

Matrix W_{it} contains nine variables related to the business owner's characteristics and labor in business *i* for period *t*. As part of this matrix, we find the following data points: the workers' average edu-

14. It should also be noted that the FD model will be estimated using the least squares methodology corrected with White's variance-covariance matrix, which helps to prevent the potential problem of heteroscedasticity between the model's variables. For more detailed information on the issue of heteroscedasticity, see White (1980).

15. Moreover, it is worth noting that this article only takes into consideration the microbusiness owners who have indicated that their business is their main economic activity. This is because those who conduct it as a secondary activity are not as comparable as those who, in a certain way, obtain their main source of income from this activity.

16. Productivity is a directly unobservable variable that is not constant in time and is difficult to identify when the productivity of workers is a homogeneous variable within a company and, especially between different companies.

17. The other variables are the gross output per worked hour (VBPxh) and the total profitability per worked hour (RTxht). This will be discussed again in the "Results" section. However, for the sake of brevity, the results of these two variables are not shown.

18. It is important to note that all "percentage" and "average" variables were weighted by the number of hours worked by each worker at the company.

19. To determine the "city" or "rural" location, we used a dichotomous variable that takes the value of 1 when the company is located in a city (that is to say, if the business is located in an area with a population of 4,000 or more) and a value of 0 when the company is in a rural location (that is, if the business is located in an area with a population of less than 4,000).

20. The first variable determines whether there are independent contractors working for the business, the second vari-

cation,[21] the square of such education value, the workers' average years of expertise, the square of such average expertise value, the workers' average years of age, the square of such average age, if the business owner is a head of household, if the owner is an entrepreneur,[22] and the mother tongue of the business owner.[23]

Matrix γ_t contains two dichotomous variables used to distinguish the year intervals in the model for the three years of the sample.[24]

Matrix δ_{it} contains the dichotomous variables used to distinguish the geographic area where the business owned by *i* was located during period *t*. Eight dichotomous variables were created for the eight Peruvian areas.[25]

3.3.3 Interest variable

The interest variable "use or adoption of the Internet" will be measured in this work using the Lefebvre and Lefebvre index (ILL), which measures the extent to which the Internet is adopted for each business owner.[26]

Using this methodology, we created equation (3), where we find eight applications of the Internet that business owners may use. Each of these applications has a weighting p_j, with *j* being the variable indicating what application is shown in the weight factor. This score is higher for the applications considered to be more useful to improve the productivity of businesses. Thus, variable *A* is a dichotomous variable for each application *j*. It is assigned a value of 1 if the microbusiness owner adopts the technology, and a value of 0 if the owner does not.

Although this allows us to simplify the object under analysis, it also leads to the problem of determining what weight factors should be used.[27] For this study, we have chosen to use *ad hoc* weight factors specific to this project. By doing this, we avoid problems resulting from the use of weight factors from prior studies that may lead us to make incorrect assumptions. For this reason, the new weight factors must be selected in an arbitrary way, since there is no previous work indicating how to assign those weightings for the Peruvian case.

The value of index ILL_{it} is the sum of the eight dichotomous variables weighted by relevance. Thus, with this definition, the formula of the treatment variable is:

$$ILL_{it} = [p_1 * A_1 + p_2 * A_2 + \ldots + p_7 * A_7 + p_8 * A_8]_{it} = \left[\sum_{j=1}^{n=8} p_j * A_j\right], \quad \text{for } j = 1, 2, \ldots, 8 \tag{3}$$

In selecting the weight factors, we are unavoidably assuming the risk of being arbitrary and biased. For this reason, we have decided to conduct electronic surveys among specialists in the field of ICTs. The results of the estimation of these weight factors are described in the following section.

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able indicates whether the number of employees is between one and five, and the third one indicates whether there are more than five employees working for the business.

21. We proxy this variable by using the average schooling years of the workers.

22. This is a dichotomous variable which assigns a value of 1 to those business owners who replied in the survey that they started their business because it was a more profitable alternative than working as employees for other companies, or because they preferred to be independent. Other answers, such as lack of opportunities, obligation, or support for a relative, were assigned a value of 0. This definition allows us to distinguish between survival microbusinesses (or non-enterprising businesses) and those microbusinesses which did start as a convenience decision (that is, businesses which have come to be as a result of the efforts of an entrepreneur).

23. This is measured as a dummy variable that takes the value of 1 if the mother language of the business owner is Spanish or some other non-indigenous one (that is, not Quechua or Aymara).

24. That is to say, three dichotomous variables are included which assign a value of 1 to observations between the following intervals: 2007–2008, 2008–2009, or 2009–2010. This is aimed at controlling variations, both those given in all observations within each interval and those arising from generalized characteristics (i.e., level of economic growth, inflation, etc.).

25. The ENAHO subdivides them into eight areas: North Coast, Center Coast, South Coast, North Highlands, Center Highlands, South Highlands, Jungle, and the Metropolitan area.

26. This index was created by Lefebvre and Lefebvre (1996) and subsequently applied by Monge, Alfaro, and Alfaro (2005) to the Central American case.

27. This is particularly relevant, since using weight factors of previous studies is not recommendable (as indicated by Lefebvre & Lefebvre, 1996, and Monge et al., 2005), as we would risk assuming that the Peruvian reality is similar to that of other countries, and even more important, that the weight factors effective at that time are still in effect today (which is very unlikely, due to the dynamism of this sector).

Table 1. Statistics from Electronic Surveys.

Use of the Internet	Minimum	Maximum	Mean	Median
Obtaining information	3.5	7	6.15	6.5
Communication (e-mail, chat, etc.)	3.5	7	6.15	6.5
Purchasing products or services	2	7	4.8	5
Electronic banking and/or other financial services	2	7	5.05	5.5
Obtaining formal education and/or conducting or participating in training activities	1	6.5	4.35	4.5
Conducting transactions (or interacting) with state entities or public authorities	2	7	4.8	5
Entertainment (playing video games, watching movies, listening to music)	0	7	2.45	2

4. Results

4.1 The Internet Adoption Index

For this article, we conducted surveys among specialists in the field. Between September and November 2010, we prepared and sent the electronic survey to approximately 40 potential respondents. To select them, we used the bibliographical section of this study (only those who have done research on ICT involving the Peruvian case were selected) and also included representatives of the MTC (the ministry in charge of telecommunications issues), OSIPTEL (the telecommunications regulatory agency), and a consulting firm specializing in telecommunications with a main focus on economic issues.

As a result, we obtained 10 completed surveys. Among the specialists who completed the survey were professional researchers of the economic and social effects of ICTs, consultants in telecommunications who advise public and private entities, and MTC and OSIPTEL officers. A summary of these surveys is included in Appendix 1.[28]

Figure 2 is a box graph (where the maximum, minimum, median and mean answers are presented) which shows that the applications "obtaining information" and "communication" are the ones deemed by specialists to be the most important ones to improve the productivity of microbusinesses. This is consistent with the theoretical and empirical literature, which describes these two uses of the Internet as the ones with the greatest potential for improving productivity.

There is a marked variety in the responses obtained, which can be observed in Appendix 1 and Table 1: The mean value is biased towards the extreme values of the survey. For this reason, we have decided to work with the median value. Table 2 shows a list with the weight factors chosen. In order to simplify the interpretation of coefficients, the weight factors in that table were standardized for them to be within the 0–100 range and not between 0–35.

28. Although the representativeness of our sample of 10 surveyed people may be questioned, it is worth noting that, given the voluntary nature of the survey, it was impossible to receive more answers within the necessary time to complete this study. Furthermore, the background distribution of the answers was satisfactory: Of the surveyed people, five were from academic institutions, two were from the public sector (MTC or OSIPTEL) and three were from consulting firms. It should also be noted that the surveyed people are recognized for their experience in more than one of these three sectors.

Moreover, this survey did not intend to find a representativeness of the kind required for household surveys. Its purpose was to obtain some variety in the responses, and to find representatives of the public, private, and academic sectors as a way to prevent the assigned weight factors from being biased. Naturally, we admit that the results may be biased to some extent, but such bias is most probably smaller than what would have if we had used our own weight factors or weight factors from prior studies.

Additionally, the weightings have a secondary role, since, regardless of their values, the hypothesis of a positive effect will be validated with any group of weight factors having values higher than zero. This occurs because there are correlations beyond the value of the weight factors.

Table 2. Weight Factors of the Adoption Index.

Applications	ILL index weight factors (0–35)	Standardized index weight factors (0–100)
Obtaining information	6.5	18.57
Communication (e-mail, chat, etc.)	6.5	18.57
Purchasing products or services	5	14.29
Electronic banking and/or other financial services	5.5	15.71
Obtaining formal education and/or conducting or participating in training activities	4.5	12.86
Conducting transactions (or interacting) with state entities or public authorities	5	14.29
Entertainment (playing video games, watching movies, listening to music)	2	5.71
Total	35	100

4.2 Econometric Results

Table 3 presents the result of the FD model. Column 1 shows the coefficient of the effect of a variation in the use of the Internet by the business owner, further controlled by the *dummies* of variable γ_t, which control the data pool for a certain period. Column 2 includes, also, the variations in the control variables of matrix *Z* (characteristics of the business). Column 3 presents the results as it includes the model of column 1 only with the variations in the variables of matrix *W* (characteristics of the business owner and labor). Column 4 shows the results including both variable groups (*Z* and *W*). Finally, column 5 presents the results of the model including both matrixes (*Z* and *W*), as well as geographical control variables of matrix δ_{it}.[29]

The coefficient of the variation in the adoption of the Internet by the business owner is very closely related with the variation in the productivity of its business within the same period. It can also be noted that this coefficient is relatively constant, since its value ranges between 0.044 and 0.040, which shows that the inclusion of control variables does affect the estimator, although not in a very significant manner.

This is initial evidence of the robustness of our estimator, and furthermore, it shows that including a larger number of control variables will probably not have a significant effect on the results obtained.

The coefficient can be interpreted as follows: For each one-point increase in the ILL adoption index within the same time period, the value added per worked hour increases approximately PEN 0.04[30] (all other variables held constant). If this value is compared with the productivity mean of the sample, we note that it is equivalent to 1.5% of the total. This means that each one-point increase in the ILL index has an average effect similar to an increase of 1.5% of the average productivity of the microbusinesses in the sample.

Although this value may seem modest at a first glance, a clarification should be made with respect to both the estimator based on the weight factors table and multiplying such value by the number of worked hours. Table 4 presents a conversion table which may be useful to that end. However, it is worth noting that this table shows information for reference purposes only, since the "potential effects" shown in the table have not been directly estimated in a regression. Rather, using the values obtained from the surveys, we intend to "rebuild" the effect that each of these applications would have.

The aim of Table 4 is to provide information on

29. To see the complete results, see the table in Appendix 2.
30. It is important to remember, at this point, that 0.04 PEN is equivalent to 0.015 USD as mentioned in the introduction.

Table 3. Results of the First Differences (FD) model.

Dependent variable: Annual variation of the value added per worked hour					
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Variation of the Internet adoption index (ILL)	0.044*** (3.09)	0.044*** (3.08)	0.044*** (3.11)	0.044*** (3.08)	0.040*** (2.80)
Var. effects controls per scale and pseudo-panel[1]	Yes	Yes	Yes	Yes	Yes
Controls per characteristics of the business (matrix Z)		Yes		Yes	Yes
Controls per characteristics of the business owner and labor (matrix W)			Yes	Yes	Yes
Controls per geographic area and mother tongue (matrix Delta)					Yes
Constant	1.528*** (10.00)	1.525*** (9.82)	1.569*** (9.41)	1.531*** (9.05)	1.952*** (5.95)
Observations	5,925	5,925	5,925	5,925	5,925
R2-Adjusted	0.453	0.461	0.453	0.461	0.464

*Note: ***p < 0.01; **p < 0.05; and *p < 0.1. The value between parentheses represents the value of the student's t-statistic for the estimated coefficient.*
[1]Included among the control variables per scale are the value added per worked hour within the initial period and the Internet adoption level within the original period.

the effect of the Internet that is easier to understand. Thus, as we rebuild the applications for which the index was created, we can show the "potential effect" of each of those applications but assuming that the coefficient will not vary when each application is treated separately.

Columns 1 and 2 of the table show the applications and the standardized weight factors for each application, respectively. Column 3 shows the effect of each of those applications on the value added per worked hour at the business. Finally, column 4 shows the potential effect as a percentage of the average productivity of the sample.

The table shows, for example, that the use of the Internet for communication purposes has a weight factor of 18.57. This means that the use of that application improves productivity in that value multiplied by the estimated coefficient (since it measures the effect of a one-point increase of the index).

This means that this application has the potential effect of increasing the productivity of the business by PEN 0.74 in terms of the value added per worked hour. This can also be calculated with respect to all the other applications. The potential effects would therefore prove to be relevant, since the average productivity of businesses represented PEN 2.5 and PEN 3.18 in 2007 and 2010, respectively. Moreover, as shown in column 4, the relative magnitude of the use of one of these applications ranges between 8.6% (for "entertainment") and 28% for "obtaining information" and "communication."

4.3 Measuring the Robustness of the Results

As a way to validate the selection of the FD method, we used a least squares approach to study the relationship between the use of the Internet by business owners and productivity. Through this model, we obtained a coefficient higher than the one estimated using the FD model. This higher value verifies our concerns described in the preceding chapter regarding the issue of endogeneity between both variables as a result of an "ability bias" (which, if not corrected, would have caused us to overestimate the effect).[31]

On another note, the potential problem that the results of this estimation may be biased to some extent due to the selection of the result variable is solved through the implementation of the same

31. For the sake of brevity, these results are not shown in this study.

Table 4. Results Conversion Table.

Coefficient value estimated under the FD model			
Estimated effect of a one-point increase of the index as a percentage of the average productivity of the sample**			**1.5%**
Applications	**Standardized weight factors**	**"Potential effect" of each application on the value added per worked hour (PEN)**	**"Potential effect" of each application as % of the average productivity of the sample****
Obtaining information	18.57	0.74	27.9%
Communication (e-mail, chat, etc.)	18.57	0.74	27.9%
Purchasing products or services	14.29	0.57	21.4%
Electronic banking and/or other financial services	15.71	0.63	23.6%
Obtaining formal education and/or conducting or participating in training activities	12.86	0.51	19.3%
Conducting transactions (or interacting) with state entities or public authorities	14.29	0.57	21.4%
Entertainment (playing video games, watching movies, listening to music)	5.71	0.23	8.6%

*Note: **We use the productivity mean of the sample, PEN 2.65 per worked hour, to calculate this percentage.*

model, with two alternative proxy variables for the productivity of the business.[32] The results are equally meaningful in statistical terms. This clearly shows that the results previously obtained with the "value added per worked hour" variable are reliable, and that the methodology applied was adequate.

5. Conclusions

The purpose of this article was to test the hypothesis that greater use of the Internet by business owners leads to greater productivity of their microbusinesses. To prove this, we used a data sample of Peruvian microbusiness owners from 2007–2010.

Although there are previous research studies which have addressed the importance of ICTs for small companies, there are no adequate previous studies in Peru which directly analyze the effect of the use of the Internet on the productivity of microbusinesses. Those who have attempted to do so have not succeeded in showing that their results can be interpreted as the outcome of a cause-effect relationship. To fill this gap, this article aims to estimate the causal relationship between the use of the Internet and the productivity of microbusinesses.

With the above purpose in mind, we built an Internet adoption index using the Lefebvre and Lefebvre (1996) index. This has allowed us to grasp more thoroughly the potential of the Internet to improve productivity.[33]

Using the aforementioned index, we calculated the effect of the use of the Internet on the productivity through the first differences (FD) method. The results indicate that a one-point increase in the ILL index improves, in turn, the productivity of the business (approached as the value added per worked hour) in PEN 0.04.[34] Although at a first glance the effect may seem insignificant, it should be noted that the index ranges between 0 and 100 (that is, it

32. The two alternative productivity proxy variables were gross output per worked hour and total profitability per worked hour. For the sake of brevity, these results are not included in this document.
33. This index was created with the collaboration of a panel of public officers, scholars, and members of the private sector, who completed electronic surveys.
34. The results have proven to be statistically meaningful and robust, considering the change of model and of the result variable. For more details, see the preceding section.

can increase up to 100 points). Thus, the effect is significant if we compare it with the average productivity of the sample, which is equivalent to PEN 2.7 per worked hour. Each one-point increase in the index has an effect that is approximately equivalent to 1.5% of the average productivity of the sample.

From the observations gathered in this study, we suggest the design of policies aimed at promoting and increasing the use of the Internet by microbusiness owners. Moreover, conducting more research on the specific characteristics of the effect on different sectors and different business contexts is also of the utmost importance. ■

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APPENDIX 1

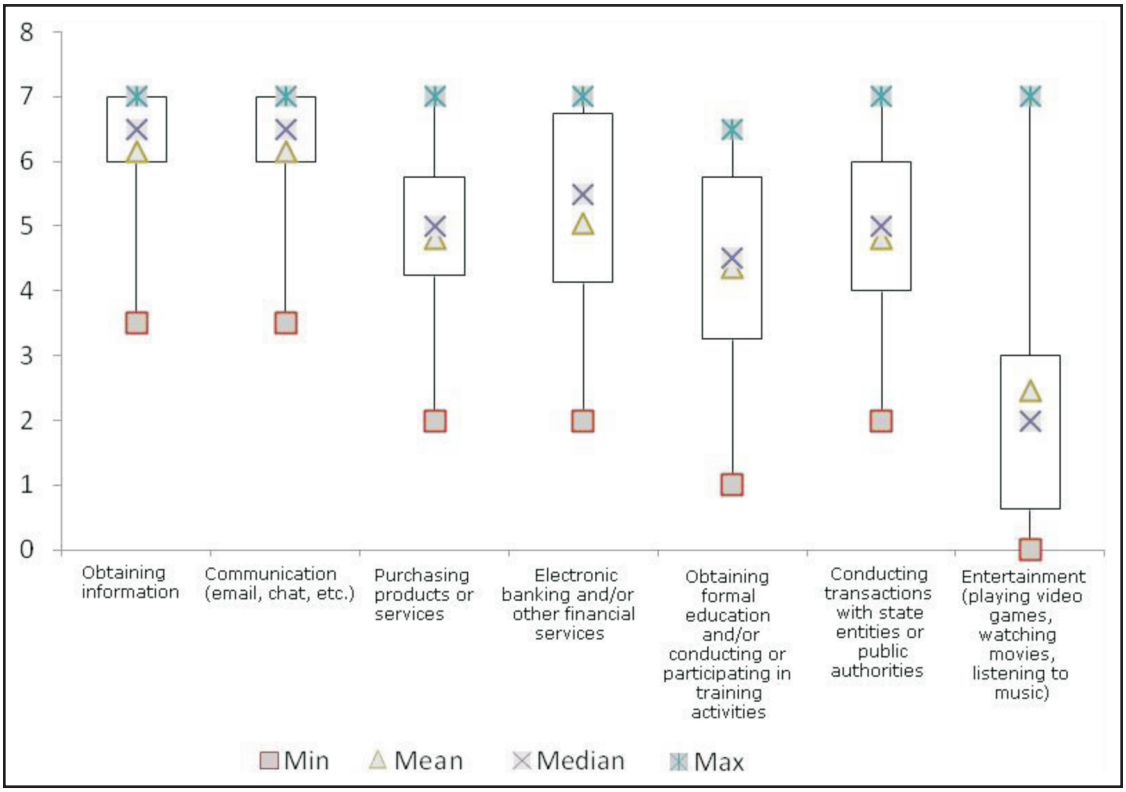

Figure 2. Distribution of the answers to the surveys conducted among specialists on the effect of the use of the Internet.

Source: Prepared by the author based on surveys conducted among specialists.

APPENDIX 2

Table 5. Complete Results of the FD Model for the Sample in Differences.

Dependent variable: First difference in the value added per worked hour					
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
First difference in the Internet adoption index—ILL (t-stat)	0.044*** (3.658)	0.044*** (3.756)	0.044*** (3.681)	0.044*** (3.766)	0.040*** (3.521)
Lagging value of the adoption index	0.243***	0.235***	0.243***	0.140***	0.218***
Lagging value of the dependent variable	−0.786***	−0.77***	−0.783***	−0.773***	−0.778***
Dichotomous variable indicating if the period in question is 2008–2009[b]	0.057	0.063	−0.133	0.039	0.046
Dichotomous variable indicating if the period in question is 2009–2010[b]	0.401	0.446*	0.315	0.436	0.444
Annual variation of the wages paid per worked hour		0.365***		0.372***	0.373***
Variation in the business' activity years		−0.026*		0.026	0.028
Annual variation of the percentage of relatives working for the business		1.529*		1.276*	1.292*
Annual variation of the percentage of unpaid workers in the business		3.946***		3.651***	3.679***
Dichotomous variable indicating if the business is in the production sector		−0.855**		−0.839**	−0.795**
Dichotomous variable indicating if the business is in the services sector		0.278		0.249	0.269
Dichotomous variable indicating if the business is in the trade sector		−0.846		−0.847	−0.849
Dichotomous variable indicating if the business has between 1 and 5 employees[c]		−0.98***		−1.024***	−1.016***
Dichotomous variable indicating if the business has more than 5 workers[c]		−1.36***		−1.367***	−1.367***
Annual variation of the workers' average education			−0.093	−0.054	−0.063
Annual variation of the square of the workers' average education			0.007	0.003	0.003
Annual variation of the workers' average expertise			−0.073*	−0.105**	−0.106**
Annual variation of the square of the workers' average expertise			0.001*	0.001*	0.001*
Annual variation of the workers' average age			0.029	0.015	0.016
Annual variation of the square of the workers' average age			0.000	−0.000	−0.000
Dichotomous variable indicating if the business owner is the head of household within the period under analysis			0.553	0.525	0.527
Dichotomous variable indicating if the business owner is an entrepreneur (1 if it is)			0.093	0.069	0.069

Table 5. (Continued)

Dependent variable: First difference in the value added per worked hour					
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Dichotomous variable indicating if the business is in the North Coast area[d]					−1.233***
Dichotomous variable indicating if the business is in the Central Coast area[d]					−1.017***
Dichotomous variable indicating if the business is in the South Coast area[d]					−0.464
Dichotomous variable indicating if the business is in the North Highlands area[d]					−1.245*
Dichotomous variable indicating if the business is in the Central Highlands area[d]					−0.676*
Dichotomous variable indicating if the business is in the South Highlands area[d]					−0.582*
Dichotomous variable indicating if the business is in the Jungle area[d]					−0.790*
Constant (t-stat)	2.913*** (13.96)	2.880*** (13.50)	2.976*** (13.51)	2.886*** (12.94)	2.980*** (8.194)
Observations	5,925	5,925	5,925	5,925	5,925
R2-Adjusted	0.341	0.352	0.343	0.352	0.354

*Note: ***p < 0.01; **p < 0.05; and *p < 0.1.*

[a]*The variables of the model presented in the "Methodology" section as "dichotomous variable indicating if the business is in a city or rural location" and "dichotomous variable indicating if the business owner speaks a native mother tongue" were not included in the results table, since they do not present any temporal variations and thus have no effect on the dependent variable.*

[b]*The dichotomous variable indicating if the period in question is 2007–2008 was not included to avoid dealing with the issue of perfect collinearity.*

[c]*The dichotomous variable indicating whether the business has independent contractors was not included to avoid dealing with the issue of perfect collinearity.*

[d]*The dichotomous variable indicating whether the business is in the Metropolitan Lima area was not included to avoid dealing with the issue of perfect collinearity.*