The Effect of Communication Technologies on Firm Productivity in a Difficult Business Environment: Evidence from Kenya

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Version: July 1, 2011

Abstract

Kenyan firms rely on communication technologies such as email, websites, and the internet to overcome obstacles associated with excessive regulations, poor infrastructure, rampant insecurity, an uneducated workforce, widespread corruption, and inadequate finance. This study shows that such reliance has significant positive impacts on productivity mainly for firms with one or more female owners. Using a sample of enterprises in relatively low-skilled industries with few barriers to entry, the exogenous component of technology use is isolated by using information on the regional presence of mission, private, and government schools from colonial Kenya, as well as a geographical indicator which measures rainfall shocks. These instruments pass a series of robustness checks on relevance, and they satisfy the exclusion restriction. Results indicate that for firms with female owners, a 10% increase in technology use results in a 1.69 percentage point increase in value-added per worker. For male-owned firms, a positive effect is evident but significantly more muted.

Keywords: Communications Technology, Obstacles, Colonial Education, Kenya, Firms, Female Owners
JEL Classification Codes: O14, O33, L22, N37

Thanks to Jenny Aker, Kristin Butcher, Judith Dean, Marcel Fafchamps, Kathryn Graddy, Martin Laffin, Phillip Levine, Isaac Mbiti, Rachel McCulloch, Dilip Mookherjee, Steven Pischke, John Ritchie, and participants at the 2011 Center for Study of the African Economies Conference at Oxford University, and seminar participants at Boston University, Brandeis University, Wellesley College, Durham University, UK, and the Indira Gandhi Institute for Development Research, Mumbai. Jing Ren provided excellent research assistance. The usual disclaimer applies.
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Section 1: Introduction

It is difficult to start a firm in Kenya. Recent estimates indicate that in terms of the number of procedures required to start an enterprise, the number of procedures required to register property, and the overall expenses of enforcing contracts, Kenya ranks 136th or lower in a global rank of 188 countries (Doing Business in Kenya, 2010). Moreover, once in existence, firms in Kenya continue to face large operation costs due to regulatory and infrastructural hurdles. These include long delays in gaining access to telephone land-lines, electricity, and water connections, informal payments and gifts that are required in order to expedite and obtain licenses and government contracts, and insecure, unstable operating environments. When such obstacles to business exist, firms may rely on technology to overcome many of the hurdles faced. For example, if there are significant delays in obtaining mainline telephone connections, firms may opt to use email and the internet for communication and advertisement purposes. These examples illustrate that the use of communication technologies such as email and the internet are endogenous to obstacles posed by excessive regulations and poor infrastructure.

In dealing with the constraints presented by business obstacles, it may be argued that firms with female owners are at an even greater disadvantage. This is because women-owned businesses tend to be more credit-constrained that those run by men. Moreover, unlike firms operated by men, women-owned businesses are often isolated from formal and informal networks that provide information and support. Women-run businesses also tend to be small scale. For these reasons, giving gifts or making informal payments to expedite licenses for operating businesses or accessing telephone land-lines may pose a greater hardship for them.

Since women-owned firms face higher costs of operation, intuitively, one should expect different patterns in their reliance on communications technologies as compared to male-owned businesses. Menon (2011) analyzes the effect of business obstacles and finds that while all firms rely on technologies such as computers, cell-phones, and generators in the face of obstacles related to regulations, infrastructure, workforce, security, and corruption, firms with female principal owners experience net effects that are statistically different from those experienced by firms with only male principal owners. In particular, estimates from the full sample of firms indicate that the probability of technology ownership is 0.15 higher for firms with female owners as compared to all other firms. Furthermore, Menon (2011) uses a gender-of-owner disaggregated Oaxaca-Blinder type decomposition of differences in technology ownership to reveal that up to 18% of the total gap is due to differences in preferences (residual component). This suggests that female-run firms invest in technology to a higher level than is warranted by the level of their observed characteristics.

Following from Menon (2011), the aim of this study is to analyze whether conditional on business obstacles, region, firm, and industry covariates, the use of email, a website, or the internet for communication with clients and suppliers (heretofore referred to as “communications technologies”), has significant impacts on firm productivity. This is an important question since evidence of the productivity-enhancing effects of technology use provides a compelling rationale for why firms choose to invest in such tools in difficult business circumstances. Menon (2011) documents a behavior – reliance by establishments, especially female-owned ones, on technologies such as computers and cell-phones in the restrictive business climate of Kenya. This study provides evidence that facets of this reliance such as the use of email, a website, or the internet for communication purposes, has important measurable effects on firm productivity. That is, firms that choose to invest in these communication technologies are successful in circumventing the restraining influences of the harsh business ethos in Kenya.

Using the World Bank’s Enterprise Survey data from 2007 on Kenyan manufacturing firms, retail firms, and micro-enterprises, this research demonstrates that reliance on communications technologies has beneficial impacts on firm productivity as measured by value-added per worker, especially for establishments that are female-headed. More explicitly, the communication technologies considered here are whether the firm uses email, its own website, or a high-speed broadband internet connection to communicate with clients and suppliers. Using an instrumental variables methodology where rainfall shocks and historical measures of education from Kenya’s colonial past are used as identifying instruments (we implement a range of robustness tests to ensure that these instruments are relevant and satisfy the exclusion restriction), this research demonstrates that conditional on obstacles, regional, firm, industry, and top manager covariates, use of communications technologies has positive and significant effects on value-added per worker in Kenyan firms. For all firms, a one unit increase in the average measure of technology increases value-added per worker by about 34 percentage points. However, most of this is for firms that are female-headed, where the effect of technology is positive and significant at 43 percentage points. This translates into a 10% increase in technology use resulting in a 1.69 percentage point increase in value-added per worker. Strikingly, the effect of technology use is positive but of significantly smaller magnitude in the sample of firms with male-only owners (a 10% increase in technology use results in only a 0.26 percentage point increase in value-added per worker). This is evidence in favor of the assertion that given the difficult business background, female-owned firms stand to gain the most from technology adoption in Kenya. The use of an alternate Nearest Neighbor Matching Estimator method confirms these results.

Section 2: Review of previous research

The literature on the effect of regulatory obstacles on technology adoption in developed and developing countries have mainly been theoretical in nature for advanced countries (Acemoglu and Autor, 2010, Alesina and Zeira, 2009, and Acemoglu *et al*., 2007), and in terms of the developing world, have concentrated on the adverse economic impacts of restrictive labor legislations (Almeida and Carneiro, 2009, Lall and Mengistae, 2005, Sanyal and Menon, 2005, and Besley and Burgess, 2004, Amin, 2009).

The effect of technology adoption (as embodied in computers) on firm productivity in advanced countries is well documented. Stoneman and Kwon (1996) uses data on firms from the UK to study the diffusion of technology and shows that non-adopters experience lower profits as other firms adopt new technologies such as computer controlled machine tools. Brynjolfsson and Hitt (2000) notes the wider applicability of the computer as being a tool that is effective in many things other than just the ability of computing quickly. In particular, the study notes the productivity enhancing effects of computer-controlled machinery that is documented in Keller (1994), and the improvement in productivity of government services such as toll collections that has resulted from increased computerization (Mukhopadhyay *et al*., 1997). Further, Black and Lynch (2001) shows that plant productivity is higher when a larger proportion of non-managerial staff use computers, whereas Bresnahan, Brynjolfsson, and Hitt (2002) finds that use of technologies such as computers and telecommunications equipment works in a complementary manner with workplace reorganization to increase productivity and the demand for skilled labor.

There is little previous work in developed countries that has considered the adoption of technology as a means of mediating the effects of constraints such as excessive regulations. The few studies that have looked at technology, productivity, and regulations in the same context either consider only the negative effects of regulations on productivity (Scarpetta and Tressel, 2002), or why technology adoption has been low in industrial countries other than the US. Gust and Marquez (2004) in particular attributes the low technological adoption to stringent regulations.

In the developing world, the impact of technological innovation has mainly been studied in the context of research and development (R&D) and foreign direct investment. For example, Basant and Fikkert (1996) finds that an Indian firm's returns to internal R&D expenditures are often low and insignificant, whereas its returns to technology purchases have large, statistically significant impacts on output. Vishwasrao and Bosshardt (2001) finds that an Indian firm's probability of adopting new technology is largely dictated by foreign ownership and firm size. Using data on firms from China, Hu *et al*. (2005) documents that the effect of foreign technology transfer on firm's productivity depends on the manner in which such transfers interact with internal R&D. One of the few studies that consider the impact of technology on firm productivity in developing countries is Commander *et al*. (2011), which documents that the adoption of information and communication technologies (ICTs) in Brazil and India is constrained by labor market policy and poor infrastructure, especially power disruptions. In the context of Africa, a few studies have analyzed the association between technology and productivity (Harding and Rattso, 2005, Goedhuys *et al*. 2006), but none have considered the role of technology in mitigating the constraining influences of regulations.

This research contributes to the literature by highlighting the role that communications technologies play in alleviating the costs of excessive regulations and poor infrastructure in a developing country. More specifically, it considers regulations, technology adoption, and firm productivity within the same framework, and assesses the impact of the use of email and the internet on firm productivity in a difficult business environment. The results indicate that such technologies have large positive effects on value-added per worker, conditional on business obstacles related to regulations, infrastructure, workforce, security, corruption, and finance, as well as region, firm, and industry characteristics. A disaggregation of effects by gender-of-owner shows that female-headed firms have the most to gain from owning such technologies. To the best of our knowledge, this research is the first to document the assuaging role of communications technologies on productivity in the face of business obstacles in Africa.

Section 3: Theoretical framework

This section formulates a theoretical model for understanding the manner in the use of communications technologies affects a firm's value-added in environments with obstacles to business.[1] This is a relatively straightforward model since the objective is to provide a basic framework for the estimations that follow. The intuition is the following: in the case of a restricted value-added function (Varian, 1992) without adjustments in output price, quantity, and choice of inputs (as in the short-run), value-added is higher when total cost is lower. We consider the short run case since in the long-run it is possible that choice of technologies directly affects the production process.[2] Total costs are lower with use of email or the internet since use of such technologies reduces the cost of inputs. Consider communication, which is different from traditional inputs such as labor and capital, but clearly important in a firm's production process. The costs of communication can be high in environments with excessive regulations and long delays in obtaining basic services such as mainline telephone connections. Using email, own website, or the internet to communicate with clients and suppliers decreases this cost.[3] Consider a firm with the following production function:

$$y = x_1^a x_2^b \qquad (1)$$

Where y is output, x_1 is a conventional input such as labor, and x_2 is another input important for production such the ability to communicate easily with clients and suppliers. For ease of exposition, we assume that the presence of obstacles in the environment affects only the price of good x_2, the communications input. This means that where w_1 and w_2 are the factor prices associated with x_1 and x_2 respectively, w_2 is higher than its value associated with maximizing productivity. In this set-up, the firm's cost minimization problem before it owns any technology is:

$$\min w_1\, x_1 + w_2\, x_2$$

$$\text{such that } x_1^a x_2^b = y \qquad (2)$$

It is straightforward to see that the conditional demand for the conventional factor is:

$$x_1 = \left[\frac{aw_2}{bw_1}\right]^{\frac{b}{a+b}}\ y^{\frac{1}{a+b}}$$

and conditional demand for the communications factor is:

$$x_2 = \left[\frac{aw_2}{bw_1}\right]^{\frac{-a}{a+b}}\ y^{\frac{1}{a+b}}$$

Substituting these values into the cost function, we obtain:

$$C_1^* = \left[\left(\frac{a}{b}\right)^{\frac{b}{a+b}} + \left(\frac{a}{b}\right)^{\frac{-a}{a+b}}\right] w_1^{\frac{a}{a+b}} w_2^{\frac{b}{a+b}}\ \ y^{\frac{1}{a+b}} \qquad (3)$$

In the case of a constant returns to scale Cobb-Douglas production function, (3) reduces to

$$C_1^* = a^{-a}(1-a)^{a-1} w_1^a w_2^{1-a} y \qquad (4)$$

since $a + b = 1$.[4] If adopting technology reduces the cost of communication for a firm, then equation (2) may be re-written as:

$$\min w_1\, x_1 + (w_2 - \tau)\, x_2$$

$$\text{such that } x_1^a x_2^b = y \qquad (5)$$

Where τ is the "price-offset" that technology brings, with $\tau > 0$ and $\tau < w_2$. The $\tau < w_2$ assumption states that firms still have some costs associated with the communications input; these are not driven to zero by virtue of technology ownership.[5] It is relatively straightforward to show that solving the problem in (5) leads to the following optimal cost function:

$$C_2^* = a^{-a}(1-a)^{a-1} w_1^a (w_2 - \tau)^{1-a} y \qquad (6)$$

In order to demonstrate formally that the costs in (6) are lower than those in (4), consider the following restricted value-added functions faced by a firm without $(\pi_1(p,w))$ and with $(\pi_2(p,w))$ the use of communications technologies:

$$\pi_1(p,w) = py - C_1^* \qquad (7)$$

$$\pi_2(p,w(\tau)) = py - C_2^* \qquad (8)$$

where p is the sale price of output, and w is a vector of input prices. Adoption of technology has a positive effect on value-added if $\pi_2(p,w(\tau)) \geq \pi_1(p,w)$, which occurs if $\left(\frac{C_1^*}{C_2^*}\right) \geq 1$. In order to obtain the ratio of costs, we use equations (4) and (6) to get:

$$\left(\frac{C_1^*}{C_2^*}\right) = \left(\frac{w_2}{(w_2-\tau)}\right)^{1-a} \qquad (9)$$

It is clear that $\left(\frac{w_2}{(w_2-\tau)}\right)^{1-a} \geq 1$ since $\tau < w_2$ and $a < 1$. That is, firm productivity increases with technology adoption. Conditional on regulatory, infrastructural, and other business obstacles, as well as region, firm, and industry covariates, we test the productivity enhancing effect of communications technologies below.

Section 4: Empirical methodology

The theoretical framework developed above shows that by alleviating costs associated with obstacles to business, use of technology increases value-added. Hence, conditional on observables, firms that use email, their website, or the internet for communication purposes, experience positive impacts on value added per worker. However, evaluating the effect of technology use on firm value-added is not straightforward since as noted before, technology use is endogenous in the business environment of Kenya. This implies that estimating the effect of technology on value-added per worker by OLS will result in biased estimates. Indeed, if firms are more likely to use technology when the business climate is poor, then OLS will underestimate the impact of technology on firm productivity.[6]

In the empirics that follow, we instrument for technology use in order to isolate its exogenous component and ascertain whether use of communications technologies has positive effects on firm productivity. We accomplish this using instrumental variables (IV) models in which the first stage is of the following form:

$$T_{ij} = \gamma_0 + \gamma_1 Z_{ij} +_{\vartheta_{ij}} \qquad (10)$$

where *i* denotes a firm and *j* denotes a region, T_{ij} is the average of an indicator for whether firm *i* in region *j* uses email, its website, or the internet for communication with clients and suppliers (why we take an average is explained below), and Z_{ij} are the identifying instruments. We discuss these identifying instruments in detail below but in general, they emanate from the theoretical framework developed above and represent measures of current and "historical price" of operating the technologies considered here. Results of the first stage in equation (10) and tests for the strength of instruments are reported in Table 5.

In the second stage, we estimate the reduced form counterpart to the value-added function in equation (8) by formulating a model which includes the orthogonal component of T_{ij}:

$$V_{ij} = \beta_0 + \beta_1 \hat{T}_{ij} + \beta_2 O_{ij} + \beta_3 F_{ij} + \beta_4 (F_{ij} * O_{ij}) + \beta_5 R_j$$

$$+\beta_6 X_{1ij} + \beta_7 X_{2ij} + \varepsilon_{ij} \qquad (11)$$

Where V_{ij} is value-added per worker, $\hat{T}_{ij}$ is the orthogonal component of the dependent variable in (10), O_{ij} is a vector of variables that represents six obstacles faced by the firm (those related to regulations, infrastructure, workforce, security, corruption, and finance), F_{ij} is an indicator for whether the firm has one or more female principal owners, R_j are regional dummies, X_{1ij} represents firm and industry characteristics, X_{2ij} represents the firm's top manager's characteristics, and ε_{ij} is the standard error term. Note the symmetry between the theoretical section above and equation (11) – the labor-related variables in (11) pertain to the conventional labor input x_1 , and $\hat{T}_{ij}$ and O_{ij} in (11) pertain to the communications input x_2.

For the full sample of firms, β_1 in equation (11) is the impact of technology on value-added per worker. β_3 indicates how value-added per worker differs between firms with female owners and those that have only male owners, and the net amplified effect of obstacles for firms with female owners is measured by $(\beta_2 + \beta_4)$. We disaggregate the firm-level data by gender-of-owner and estimate equation

(11) separately in order to ascertain the relative size of β_1 for firms that have female principal owners and those that do not. The results of these models are reported in Table 9.

Section 5: Data and descriptive statistics

Data used in this research are from the Enterprise Survey which was implemented by the World Bank in Kenya in 2007. In Kenya, the firms that were targeted were located in the capital city of Nairobi which is in the central part of the country, the coastal city of Mombasa, Nakuru in the Rift Valley, and Kisumu which is located on Lake Victoria in the Western region of the country (see Map 2). Nairobi, Mombasa, Nakuru, and Kisumu were selected since they collectively contain the largest share of economic activity in Kenya. Firms in all manufacturing sectors, construction, retail and wholesale services, hotels and restaurants, transport, storage, and communications, and computer and related activities were administered the survey. Those that had five or more full-time permanent paid employees were stratified into five groups: manufacturing (food and beverages), manufacturing (garment), manufacturing (other), retail trade, and “rest of the universe” (RoU) which included construction, wholesale trade, hotels, bars and restaurants, transportation, storage, and communications, and computer related activities. Firms having fewer than five full-time permanent paid employees (“micro establishments”) were also sampled; however, these were not stratified according to industry.

The Enterprise Survey asks detailed questions on the environment faced by firms in conducting business within their regions of operation. These questions include those related to firm characteristics, gender participation, sales, costs of inputs, and obstacles related to telecommunications, crime, licensing, infrastructure, trade, competition, land and permits, taxation, access to finance, zoning restrictions, and other restrictions on hours of operation and pricing and mark-ups. Given the level of detail in the survey, these data are particularly apt for purposes of this study.

The sampling methodology employed is stratified random sampling with replacement, where the strata are firm size (number of employees), business sector (manufacturing, retail, and other services), and geographic region within the country. All estimations as well as summary statistics are adjusted with sampling weights provided in the data to account for the differing probabilities of selection across the different strata.

Menon (2011) indicates that firms with female owners in chemicals or machinery and equipment manufacturing industries may be less representative of the average women-owned firm in the economy. A way to improve representativeness is to restrict the analysis to firms in industries where barriers to entry for women are comparatively low. These industries include manufacturing industries such as garments, food, textiles, and non-metallic minerals (these include gemstones and gold, which is mainly processed by small-scale artisanal workers in the Western and South-Western regions of the country near Lake Victoria), retail industries, and service industries such as hotels and restaurants, and construction and transport. We also exclude all firms that are legally classified as “public” since public firms are mostly large enterprises, whereas the majority of firms in Kenya are small and medium enterprises. With the restrictions, our estimation sample has 499 firm-level observations of which 213 firms (42.7%) have one or more female owners and 286 firms (57.3%) have only male owners.

Figure 1 depicts the percentage of firms with female principal owners and those without, by industries. The figure is arranged such that classifications that have the largest difference between female-owned and male-owned firms appear first. In our sample, the largest difference by gender of firm owner is found in manufacturing garment industries (22.5% female, 15% male-only) followed by retail industries (32.4% female, 31.8% male-only). Textiles have relatively the same proportion of female and male headed firms, and the proportion of firms with only-male owners exceeds that of female-owned firms in non-metallic minerals, construction and transport, and hotels and restaurants. Figure 1 shows that the fewest relative number of firms with female owners is found in manufacturing food industries.

Figure 2 portrays the breakdown of firms by gender-of-owner and use of email, own website, or the internet for communication purposes. As noted above, about 43% of firms in these data have one or more female principal owners. Given this, it is remarkable to note that firms with female owners rely on communications technologies to such a disproportionately large extent. Figure 2 shows that the proportion of female firms that use technologies of the form considered here is about 87% of the proportion of male firms that also use such technologies. The pattern in Figure 2 indicates that in Kenya, of the firms that rely on email, website, and the internet for communication purposes, the proportion of female-owned ones are comparable with the proportion of male-owned ones.

Figure 3 is a plot of the median value-added per worker (in 2006 US $) for firms with female principal owners and for those without.[7] It is apparent from this figure that value-added per worker in male and female firms is about the same in garments, food, and textile industries, and comparable, although to a lesser degree, in retail firms and firms in the hotels and restaurants industry. Value-added per worker is significantly different between male and female owned firms in two industries - non-metallic minerals (higher for female-owned firms) and construction and transport (higher for men-only owned firms). Figure 3 conveys that net of disadvantages that tend to work against female-owned firms (credit-constraints, small-scale, and relative isolation from support-providing networks), their value-added per worker is comparable to that of male-only owned firms for the majority of industries in our sample. The question of interest is how much of this parity may be attributed to the use of communication technologies.

Figures 1 – 3 provide a graphical description of characteristics of firms in Kenya, disaggregated by gender-of-owner. They make clear that firms with female owners are relatively more present in manufacturing garment and retail industries, and rely on the technologies to a larger degree than indicated by their presence in the estimation sample. Next, we focus on the obstacles that are perceived by firms in the business environment of Kenya.

The Enterprise Survey data report constraints related to twenty different types of obstacles. For expositional purposes, the twenty separate types of constraints are combined into six categories – regulations, infrastructure, security, workforce, corruption, and finance. The regulations group includes the following obstacles: labor regulations, licensing and permits, customs and trade regulations, regulations on hours of operation, regulations on pricing and mark-ups, zoning restrictions, tax rates, and tax administration. The infrastructure group includes obstacles related to telecommunications, electricity, transportation, and access to land. The security category includes constraints related to crime, theft, and disorder, political instability, macroeconomic instability, and functioning of the courts. The workforce group includes obstacles related to an inadequately educated workforce, and the corruption group includes obstacles related to corruption and practices of competitors in the informal sector. The last group (finance) includes obstacles related to access to finance.

In the Enterprise Survey data from Kenya, firms are asked to rank obstacles on a scale of five – no obstacle, minor obstacle, moderate obstacle, major obstacle, and very severe obstacle. Tables 1 - 3 report weighted proportions of firms characterizing obstacles as moderate, major, or very severe, by industry and technology use. Table 1 shows that over 90% of firms report regulations, infrastructure, and finance to be binding constraints; this pattern is also true upon disaggregation by gender of firm owner. Table 2 shows weighted proportions by industrial groupings, and for firms with female headship, regulations continue to be the most widely cited obstacle across all industrial categories. Such firms in manufacturing and construction and transport are also particularly concerned with security and corruption, whereas firms that are all male-owed in manufacturing are less likely to cite security as a major concern. Amongst firms with male-ownership, access to finance is the most widely cited obstacle after regulations. Finally, estimates in Table 3 show that firms who report using technology are also more likely to report regulations, security, and infrastructure to be binding obstacles. This remains mostly true upon disaggregation by gender of firm owner.

Tables 1 – 3 provide descriptive evidence that firms perceive excessive regulations, poor infrastructure, and lack of security, as imposing significant burdens in the business environment of Kenya. There are also correlations evident between the perception of these constraints and use of communications technologies such as email and the internet.

We conclude this section by reporting differences in obstacles and other firm and industry-level variables between female-headed and male-only headed firms. Obstacles measured in the data and discussed in tables 1 – 3 reflect a firm’s perceptions of its operating environment. In order to eliminate possible measurement errors and other endogeneity issues that may contaminate these variables, we take averages of these variables at the region, industry, legal status, and firm size level (Angrist and Krueger

2001, Dethier *et al*. 2008, Amin 2009). The estimations discussed in the following tables are conducted on constructed mean values of the obstacles rather than on an individual firm's perceptions of them.

Table 4 provides weighted means and standard deviations of the characteristics of firms with female owners and those without, and an indication of whether there is a statistical difference in the characteristics. The characteristics reported include value-added per worker, use of communications technologies, obstacles related to regulations, infrastructure, security, workforce, corruption, and finance, the variables used as identifying instruments (discussed below), regional indicators, firm and industry characteristics including firm size, value of property and machinery, industrial classification, and finally, characteristics of the firm's top manager including education and number of years of experience in the sector. Estimates in this table indicate that on average, firms with female owners have lower value-added per worker and lower percentage values in terms of technology use as compared to male-only owned firms, although only the former difference is statistically significant. The reported differences in obstacles for female-headed and male-only headed firms in Table 4 shows that the weighted average value is somewhat higher for female-owned firms in five of the six categories (regulations, infrastructure, security, workforce, and finance); however, these differences are not statistically significant.

Statistical differences in instruments and regional indicators by gender of firm owner are absent; however, average values indicate that there are relatively fewer female-owned firms in Nairobi and relatively more of such firms in Mombasa. In terms of firm and industry characteristics, although female-owned firms have lower machinery and property values, a higher value of percentage of establishment owned by largest shareholders, and relatively fewer proportions of manufacturing, retail, permanent full-time paid employees, the difference is measured precisely only in the case of property values. There are no other instances of measurable statistical differences in characteristics between female and male-owned firms in the remaining variables of Table 4.

Results in Table 4 indicate that firms with female owners are not very different from firms with all-male owners in levels of technology use, or in terms of many of the firm, industry, and top manager characteristics considered. These sub-categories of firms are thus comparable in terms of observed covariates in the more representative sample of industries we consider in this study.

Section 6: Impact of technology use on firm productivity

A study of whether technology use increases firm productivity is complicated by the fact that technology is endogenous in contexts where obstacles exist. To correct for the endogeneity, instruments are required that are correlated with technology use, but conditional on technology use, do not affect firm productivity. The instruments that we use are derived from the theoretical framework and affect τ, the extent of the price-offset that technology adoption brings. We argue that τ is influenced by the "historical price" of technology adoption which was determined retrospectively by the distribution of mission, private, and government schools from Kenya's colonial past. The regional historical distribution of schools in colonial Kenya is correlated to current technology use and adoption, but conditional on technology, does not directly affect firm productivity – that is, regional distribution of schools in colonial Kenya provides the exogenous variation required for identifying the effects of technology on firm productivity in 2006. We also use a geographical variable, the deviation in annual rainfall from the 1910-2000 rainfall average, as an additional instrument. Our instruments and tests for their validity are discussed in detail below.

Instruments for technology use

Regional distribution of schools in Kenya from 1844 - 1935

The use of email and the internet requires a basic amount of skills associated with recognizing letters from the English language, understanding Arabic numerals, and competence associated with elementary vocational training. The earliest foundations for such knowledge was laid by mission organizations in Kenya, primarily the Church Mission Society (CMS) which was founded in England in 1799, and which established the first school in Rabai Mpia near Mombasa in 1844. Starting from 1844 through 1935, CMS and other missionary groups (primarily the Holy Ghost Mission, Church of Scotland Mission, Seventh Day Adventists, Quakers, Mill Hill Mission, and the Protestant Alliance of Missionary Societies) enjoyed a virtual monopoly in educating Kenyans of African origin (Furley and Watson, 1978).

Such schools taught basic facts about the Christian religion, and “secular” subjects that lead to apprenticeships in trade or teacher training. Mission schools also enjoyed a monopoly over girl’s education as other schools either did not exist, or were reluctant to educate girls’ for fear of clashing with local cultural traditions. By the time of the Fraser Report (1919) that urged greater government role in the education of Africans, mission schools were dominant in the coastal, central, and western provinces of Kenya.

Using primary sources (archives of the CMS housed at the University of Birmingham in the UK) and information in Furley and Watson (1978), we compiled a list of all main mission schools that existed in Kenya from 1844 to 1935. 1935 is the end-point of our data since after that year, mission schools came under the control of the British government (Kenya became a British protectorate in 1895), and although still present in the delivery of education throughout the colony, were no longer active in their original autonomous form. From 1844 until 1919, all schools that we have information on are missionary schools that provided access to girls as well as boys, administered knowledge of Christianity and vocational education, and primarily “targeted” Africans. From 1919 until 1935, government schools (segregated by race – European and Asian), and private schools (also segregated by race) began to be established. Government and private schools engaged relatively little in educating Africans and girls, and amongst the two, private schools were particularly elitist and rigid in their educational policies. The data that we collected over the 1844-1935 time-span has information on 80 schools including their year of establishment and original location. Among these, 56 are mission schools, 17 are government schools, and 7 are private schools. We use information on location to allocate schools to each of the four regions in our data – Nairobi, Mombasa, Nakuru, and Kisumu.

Mission schools in Kenya were the first to provide elementary education and vocational training, were unique in providing access to girls, and African education was primarily in their hands until 1919. This is important from our point of view since over 70% of firms in our sample have African principal owners. Gender-based equality in education that mission schools afforded is also important from our view-point since we are interested in how firms with female owners respond differently as compared to their all-male counterparts. We argue that mission schools in this time period (and government and private schools to a lesser extent) laid the foundations for historical regional differences in basic skills.

In order to be a valid instrument, we require that the location of schools in the 1844 to 1935 time-period be random and uncorrelated with regional economic characteristics which might influence firm productivity in 2006. We contend that this is indeed the case. The establishment of mission schools solely reflected Christian evangelical zeal in the nineteenth century (Furley and Watson, 1978), and the religious motives that fueled the creation of such schools had few economic underpinnings. In fact, the main objective of establishing mission schools in the 1844 to 1935 period was to counter the growing influence of Islam in colonial East Africa (Strayer, 1973).[8]

Following Lewis (2010) which uses exogenous variation in the area-specific supply of skills as an instrument for technology, we argue that the location of schools as of 1935 provides regional exogenous variation from history in the supply of skilled labor which may be used to instrument technology use. In the terminology of our theory, the location of schools as of 1935 affects the price-offset that technology adoption affords. Only those firms with sufficiently large τ use communications technologies (since they experience a larger net input price reduction), and the regional average value of τ is likely to be historically determined by the regional location of schools in colonial Kenya. Using this intuition and information on the location of schools as of 1935, we allocate each school by distance to the closest point in our data (Nairobi, Mombasa, Nakuru, or Kisumu), and then use this information to construct the number of mission, private, and government schools in each of the four regions. Each firm in the data is then allocated a value for the number of schools based on its regional location and co-incidence of start dates of the firm and the schools. In the discussion that follows, we denote these instruments "number of mission schools", "number of private schools", and "number of government schools".

Deviation in region-year rainfall level from the 1910-2000 rainfall average

In addition to the instruments described above, we construct one more instrument. This is geographical in nature and relates to rainfall shocks as proxied by deviations in annual region-year rainfall from the 1910-2000 rainfall average. Our use of rainfall shocks as an instrument comes from the observation that use of email or the internet most likely depends on the presence of a computer, the operation of which requires a power source such as electricity. In Kenya, 60% of the electricity is generated from hydropower (Kirai, 2009). Kenya Electricity Generating Company (KENGEN), a state-owned national generation company at the time these data were collected, is the main power generator, and controls all publicly owned power plants in Kenya to produce about 80% of the power consumed in the country (Kirai, 2009). As of 2007, there were fourteen hydro-power plants, three thermal plants, two geo-thermal plants, one wind power plant, and two plants that were off-grid in Kenya (see Map 1 for a location of these plants). For each of the plants, we have information on district of location, capacity in megawatts, year of commissioning, river/lake on which the plant is located, and distance to Nairobi.[9]

A facet of hydro-electricity is that the quantity of power generated is heavily dependent on climate, in particular, rainfall. Twelve of the fourteen hydro-plants are located on rivers; six of them on the Tana river in central Kenya - the remaining two hydro-plants are located near lake Victoria and lake Turkana (see Map 1). During times of drought (negative rainfall shocks), plants are unable to operate at their peak capacity and the supply of electricity is insufficient. Alternatively, excess rainfall (positive rainfall shocks) is also a problem because it causes landslides and flooding which destroys power lines.

Using information on year of commissioning, district of location of the power plant, and deviations in annual rainfall from the 1910-2000 average level of rain in the four regions of our data, we construct a measure of rainfall shocks in the region in which a firm is located. This variable is constructed to allow for a firm's exposure to the rain shocks to be dependent on year of origin of the firm and commissioning year of the power plant(s) in the region of the firm's location. This is because the rain shocks that a firm may "avail" of depend on the year of commissioning of the power plant and the year in which the firm began operations. For example, the earliest plant that was commissioned near Mombasa is Lamu in 1989. Thus firms in Mombasa that had a start year before 1989 get a value of zero for the rainfall deviations variable since no plant existed before that date. Firms with start year of 1989 were affected by shocks received only at Lamu – they thus receive a value of rainfall deviations equal to that in the region in 1989. Two other plants (Kipevu I and Kipevu II) were commissioned near Mombasa in

1999, thus firms that had a start year of 1999 or after are affected by rainfall shocks received by the three plants in the Mombasa region as of 1999.

Information on historical rainfall from 1901 to 1990 for four stations in Kenya (Machakos (close to Nairobi), Malindi (close to Mombasa), Nakuru, and Kisumu – see map 2 for locations) are available from the Global Historical Climatology Network (GHCN) precipitation data which is part of the National Oceanic and Atmospheric Administration's (NOAA) national climatic data center. Since the Enterprise Survey has information on firms as of 2006, the remaining years of rain data were obtained from UNDP Climate Change Country Profile for Kenya which is available from Oxford University's School of Geography and the Environment. A combination of these two data sources allowed the creation of a historical time series from 1901 to 2006 of annual precipitation data for each of the four regions in our study. These data were then used to construct a firm-level measure of rainfall deviations (in mm) in the region of location of the power plants, conditional on the coincidence of the starting year of the firm and commissioning year of the power station. We denote this variable "rainfall shocks" in the discussions that follow.

Thus, mission schools, private schools, government schools, and rainfall shocks are the identifying instruments used to analyze whether use of communications technologies has beneficial impacts on firm productivity. These instruments are correlated to regional historical determinants of basic skills and the regional geographical environment of a firm, and thus likely to influence the use of the forms of technologies we consider. Statistical evidence for this is provided in Table 5 which reports the first stage regression results.

First stage regression results

The first column of Table 5 shows results for all firms in our sample where the indicator of email, website, or internet usage for communication purposes is averaged at the region, industry, legal status, and firm size levels.[10] All instruments are significant and explain about 8% of the variation in technology use. Mission schools and to a smaller extent, government schools have strong positive effects on technology use, consistent with our hypothesis that the historical presence of schools (predominantly mission schools) in the region significantly increased the regional historical stock of basic skills of the African population. An indicator for the absence of rain shocks (no deviation in region-year rainfall from the 1910-2000 rainfall average) has a positive effect on the communications technology measure, suggesting that technology usage is least disrupted when annual rainfall is neither too heavy nor too light.

The remaining two columns of Table 5 show separate first stages for firms with female principal owners and for firms with only male owners. For firms with female headship, mission schools have a particularly pronounced effect on technology use. Together with the fact that the magnitude of the effect of mission schools in this sub-sample is almost the same as in the full sample of all firms, there is strong evidence that variables related to mission schools have power in explaining a sizeable proportion of the variation in the use of technology by female-owned firms. For the male-only sample, mission schools still matter although to a smaller extent. The F-statistics in the three columns of Table 5 are all above 10, the rule-of-thumb threshold value for sufficiently strong identifying instruments. The results in Table 5 demonstrate that our identifying instruments are significant determinants of technology use.

Robustness checks on instruments

Validity of the instruments rests on their satisfying the exclusion restriction. This evidence is presented in Table 6, and follows the methodology of the overidentification tests developed in Acemoglu *et al*. (2001). The overidentification tests assume that one set of instruments, say the schooling variables are exogenous, and then tests the exogeneity of the rain shock instrument (and vice versa). As noted in Acemoglu et al. (2001), the test will reject the validity of the procedure if the instrument that is assumed to be exogenous has a direct effect on firm productivity, or if the instrument whose exogeneity is being tested affects productivity through omitted variables.

The results of the overidentification tests presented in Table 6 are divided into four panels. Column (1) of panel A reports the IV estimates of the impact of communication technology use on the log of value-added per worker using the absence of rain shocks as an instrument, while Panel B presents the corresponding first stage estimates. The first column of panel D reports the corresponding IV estimate with the schooling instruments added as exogenous regressors. If the schooling instruments have a direct effect on our measure of firm productivity, then these variables should be significant. Column (1) of Table 6 shows that the schooling variables are all measured imprecisely, thus, the effect of these variables is likely to operate through their impact on technology use. Panel C reports the *p*-value for the corresponding χ^2 overidentification test that the IV coefficients on technology use estimated in Panel A and Panel D are equal. The p-value in column (1) of panel C indicates that at we cannot reject the hypothesis that these coefficients are the same at the 5 percent significance level. The estimates reported in panels A – D of column (2) of Table 6 test the exogeneity of the rainfall shock instrument assuming that the schooling variables are truly exogenous.[11] These results are in keeping with those in column (1). Taken together, the estimates in Table 6 indicate that our instruments satisfy the exclusion restriction. That is, there is no evidence that they directly (or indirectly through omitted variables) affect our measure of firm productivity.[12]

Results in Table 6 demonstrate that the schooling and rain shock instruments satisfy the exclusion restriction. As another test for the absence of direct effects on our measure of productivity, we check to ensure that the regional historical distribution of the number of mission, private, and government schools is not correlated to a firm's top manager's education.[13] Since the manager's educational level may conceivably affect a firms' value-added, any correlation between the number of schools and a manager's educational level would invalidate these instruments. We conduct this test in two steps. First, we rank order the regional means of the schooling variables and compare these to a rank order of the regional means of an indicator for top manager's educational level.[14] This comparison reveals that there is no correspondence between the regional share of colonial schools and the regional educational level of managers. Second, we note that the top manager's education is already controlled for in the second stage of the IV models. Although the coefficient is not reported in our main results presented in Table 9 (discussed below), we note here that despite its significance (primarily in the sample of firms with female owners), the positive impact of technology use on log of value-added per worker is still evident across all columns of Table 9.

Thus, the schooling instruments do not influence firm productivity through the top executives' highest educational level.

Another manner in which the schooling instruments might directly affect firm productivity is by influencing the education of the workforce, that is, workers might be better educated in regions that had a large historical presence of mission, private, and government schools. We re-iterate that in order to maintain racial separation and distance from non-whites, the education imparted to the native population by mission schools (the majority of the schools in the historical sample) was of low quality. Mission schools "transferred to Africa a curriculum and a method designed to meet the needs of the British working class" (Strayer, 1978). Thus, lasting influences on the education of the workforce in terms of affecting firm productivity in 2006 are unlikely. However, in order to address this more rigorously, we approach the concern in two ways – first, we note that the industries in our sample are those in which skills and education of the worker are likely to matter less in determining overall productivity (these are not highly skill-intensive industries). These industries are primarily retail firms or firms in garments and textiles where average education and skills are likely to be lower as compared to firms in information and technology (IT) industries, or manufacturing industries such as those in machinery and equipment or chemicals. A basic comparison of skills and education for workers across industries confirms this intuition. In our sample of industries, the mean weighted share of unskilled production workers is about 32%, whereas mean weighted share of such workers in more skill-intensive industries is lower at 28% (using the full sample of firms).

The second route by which we control for possible influences of the school instruments on the education of the workforce is to include indicators for the average education of a typical production worker directly in the second stage. Results of this model are reported in Appendix Table 2. It is clear that although indicators for the average education of production workers have a significant effect on productivity, this effect is negative. More importantly, the positive impact of technology use on productivity is still evident[15]. The estimates in Appendix Table 2 indicate that even with controls for workers' educational levels, our main IV results remain intact.

Next, our rain shocks instruments are open to the claim that they might affect firm productivity directly by influencing firm location. That is, different firms might locate in areas with different geographic characteristics and this could independently affect value-added. We note first that it is not easy for firms to migrate to other regions in search of greener pastures, and our data confirm this. If there were no costs associated with moving, we should expect to see most, if not all firms located in Nairobi and Mombasa (the financial and commercial hubs). This does not seem to be the case – although Nairobi does have a large share of firms (57%), the remaining are equitably distributed across Mombasa, Nakuru, and Kisumu (about 14-15% each). Next, evidence for certain industries originating only in certain areas would be present if we saw "bunching" of firms by industry in certain regions. Again, this does not appear to be the case. We have seven industries in our sample and tabulation exercises reveal that all seven are present in each of the four regions in roughly the same proportions. Moreover, we control for industrial classification categories in the second stage in order to adjust for possible correlation with the rainfall instruments. Finally, the contention that rainfall might affect production directly through its effect on the availability of power or through the fact that water is an important intermediate input in some industries is addressed by noting that the rain shocks variable satisfies the exclusion restriction as demonstrated in column (2) of Table 6.

Another robustness check we undertake is to examine the impact of sub-sets of our instruments on the measure of firm productivity. The instrumental variables models that we estimate with alternative specifications of the instrument set are reported in Table 7. The main results for the full sample of firms (discussed in detail below) are presented in the first column. The following two columns report results for two sub-sets of instruments: schooling variables only (have time and regional variation), and rain variable only (has time and regional dimensions). In sum, the coefficient on technology use is positive and significant across the columns in Table 7, and overidentification tests (Hansen's J statistic) in the first two columns cannot reject the hypothesis that the respective sub-sets of instruments are valid.

Our final set of robustness tests involves ensuring that the instruments have no indirect effects on firm productivity through their correlation with omitted variables. For example, historical schooling measures might influence whether the firm acquired technological innovations recently, which could, in turn, affect value-added. Or firms in regions that are better endowed in terms of retrospective schooling and geographic attributes might have easier access to credit, which might directly influence productivity. Overidentification tests presented in Table 6 above already provide evidence that the instruments do not affect firm productivity through their correlation with omitted variables. The set of tests presented here further corroborate the estimates reported in Table 6 by demonstrating that the instruments are randomly assigned. In Table 8, we ascertain the lack of correlation between our instruments and a wide range of observed variables that could potentially determine value-added. These include the number of skilled production workers, whether the firm acquired technological innovations in the last three years, the proportion of working capital borrowed from commercial banks, from state-owned banks and/or government agencies, and from non-bank financial institutions, whether the firm distributed HIV prevention messages to employees, and the proportion of the workforce that is unionized. As clear from Table 8, our instruments are not significantly correlated with any of the variables they are tested against.

The different robustness tests in this section provide reassuring evidence that our instruments influence technology use, but conditional on technology use, have no independent effects on firm productivity. That is, our instruments are relevant and satisfy the exclusion restriction.

Second stage regression results

Before we discuss the instrumental variables results in Table 9, we re-iterate that obstacles are averaged at the region, industry, legal status, and firm size level, in order to avoid bias that might result from using individual perception data. Technology use is also similarly averaged in order to avoid having a first stage with a binary dependent variable. Such a transformation allows us to use linear two stage least squares (TSLS) models to identify effects.

Table 9 reports the instrumental variables results for technology use for all firms, for firms with female owners, and for firms with only male owners. We begin by noting that a test of over-identifying restrictions which tests the joint null hypothesis that the instruments are valid (that is, not correlated with the error term and that the identifying instruments are correctly excluded from the estimated second stage), cannot be rejected in all models of Table 9 (Hansen's J statistic). Column (1) of Table 9 shows that the establishment's use of communications technology has strong, positive, and significant effects on value-added per worker; estimates indicate that a unit increase in the average measure of technology use increases value-added per worker by about 34 percentage points. This means that for a 10% increase in technology use, value-added per worker increases by 1.45 percentage points. As expected, many obstacles have a negative effect on firm productivity although only lack of a skilled workforce is measured precisely. Finance has a counter-intuitive positive effect; however, this might indicate that firms with high productivity want to borrow more and thus are also likely to report inadequate finance as a binding obstacle. The indicator variable for whether the firm has one or more female principal owners in column (1) is positive but insignificant, indicating that conditional on technology use and obstacles, firms with female owners are not consistently different from their counter-parts in terms of effects on value-added per worker. The *p*-value of the joint test of the interaction of the female-headship variable with different types of obstacles indicates that the null hypothesis cannot be rejected. That is, as compared to male-owned firms and conditional on the use of communications technologies, differential patterns in the effects of obstacles do not exist for female-owned firms. Finally, the *p*-value of the joint test of significance on obstacles indicates that the null hypothesis can be rejected at the 10 percent significance level. This implies that conditional on technology use, obstacles still exert a non-zero effect on value-added per worker in the full sample of firms.

The second column of Table 9 reports results for the female-owned sample of firms. Technology use has significant positive impacts on productivity as measured by value-added per worker. The coefficient indicates that a unit increase in the average measure of technology use increases value-added per worker by approximately 43 percentage points. This translates into a 10% increase in technology use resulting in a 1.69 percentage point increase in value-added per worker. Interestingly, obstacle related to security is negative and significant in this sub-sample when it was not in the full data. This is consistent with the general observation that female owned firms are relatively more vulnerable in developing countries. Column (2) indicates that such constraints have measurable limiting effects on productivity.

Technology use has a positive effect on value-added per worker in the male-only sub-sample of firms, although the magnitude of the coefficient is roughly one-seventh that in the sub-sample of female-owned firms. The estimate for male-owned firms indicates that for a 10% increase in technology use, value-added per worker increases by only 0.26 percentage points.

The results in Table 9 emphasize the fact that the beneficial impact of technology use on firm productivity in the data arises mainly from the sub-sample of firms with female principal owners. For such firms, the use of email, own website, or the internet for communicating with clients and suppliers is particularly effective in mitigating the costs associated with business obstacles. For male-owned firms, similar patterns are evident but in appreciably smaller magnitudes.

Robustness checks on main results using an alternate method

As a robustness check for the main results in Table 9, we evaluate the effect of communications technology use on value added per worker using an alternative technique: the nearest neighbor matching estimator (NNME). Based on the value of covariates, firms self-select to use technology. In addition to the instrumental variables method above, another method to control for the endogeneity of technology adoption that results from such self-selection is to match observable characteristics of firms that use technology and those that do not. This allows the creation of a counterfactual that answers the following question: what would value-added per worker have been if the firm had not opted to use email or the internet for communication purposes? If the decision to use technology is assumed to be random for firms with similar measures of the pretreatment covariates, then an approach to create such a counterfactual would be to use the average outcome of a few firms who chose not to use technology (Abadie and Imbens, 2002, Imbens, 2003). This is the concept that underlies the formulation of matching estimators. We report the result of the NNME method in Appendix Table 3.

Appendix Table 3 reports the average treatment effect and the average treatment effect for the treated (those firms that use such technologies) for the full sample of firms, for firms with female owners, and for firms with only male owners. The NNME conditions on matching regional variables as well as firm, industry, and manager characteristics. The results show that for the firms in our sample, the average effect of using communications technologies is an increase in value added per worker of about 34 Kenyan shillings (almost 0.50 US dollars in 2006); approximately 11% of the average of value added per worker in the full sample of firms. The effect of technology use on those firms that use such technologies is higher at 111 Kenyan shillings (about 2 US dollars in 2006). Estimates specific to the sample of firms with female owners are broadly similar and show that both the average treatment and the average treatment for users is positive and strongly significant. More specifically, for firms with female owners, the effect of technology use for those firms that use is an increase in value added per worker of about 570 Kenyan shillings (approximately 8 US dollars in 2006). For firms with male owners, the NNME returns negative average effects of technology use on productivity. This finding is broadly in keeping with those reported in Table 9 where male-owned firms did not benefit as much in terms of increases in value added per worker from technology use. The results in Appendix Table 3 show that use of an alternative method leads to conclusions that are generally consistent with those of the main results reported in Table 9.

Section 7: Conclusion and implications for policy

This study demonstrates that the use of communication technologies has important measurable effects on firm productivity in environments with excessive regulations, poor infrastructure, and rampant insecurity. An instrumental variables method reveals that net of obstacles, regional, firm, industry, and top manager characteristics, the use of email, own website, or the internet for communication with clients and suppliers has large, positive, and significant effects on value-added per worker. Strikingly, this is largely true for establishments with female principal owners. The magnitude of estimates indicates that for firms with female-headship, a 10% increase in technology use results in a 1.69 percentage point increase in value-added per worker. This suggests that given their relative disadvantages in the economy (smaller-scale, relative isolation from support networks), the use of communications technologies is a particularly effective means of improving productivity for such firms. For male-owned firms, technology use is positive but of significantly smaller magnitude. This leads to the conclusion that the use of communications technologies is important, but not critically so, for this sub-set of firms. A reason for why this might be the case is that male-owned firms are relatively more likely to belong to business associations where information flows are likely to help in circumventing constraints associated with business obstacles.

Our findings indicate that in addition to removing regulatory hurdles, improving physical infrastructure, and curbing crime and corruption, Kenyan firms may benefit from policies that enable greater use of communication technologies. A way of fostering this would be to extend access to loans that are relatively low-cost for purposes of purchasing computers and cell-phones for business use. Improving access to loans may be especially relevant for female-owned firms for whom finance is likely to be a binding constraint. For example, such loans could be in keeping with the spirit of "Mwamba" loans that are currently provided to women business owners for acquiring machinery by the Kenya Women's Finance Trust, Ltd., but could now also be used for the purchase of communication technologies. Mwamba loans are provided to large businesses at present; the results of this study suggest that widening access of such loans to medium and small firms would be especially fruitful. Furthermore, since operation of technologies is facilitated by a minimum stock of basic skills, the provision of government subsidized vocational training and computer literacy courses would also be of value. Finally, policies that build formal and informal networks among female-owned businesses would help diffuse expertise on how to use communications technologies to mitigate regulatory burdens in the difficult business environment of Kenya.

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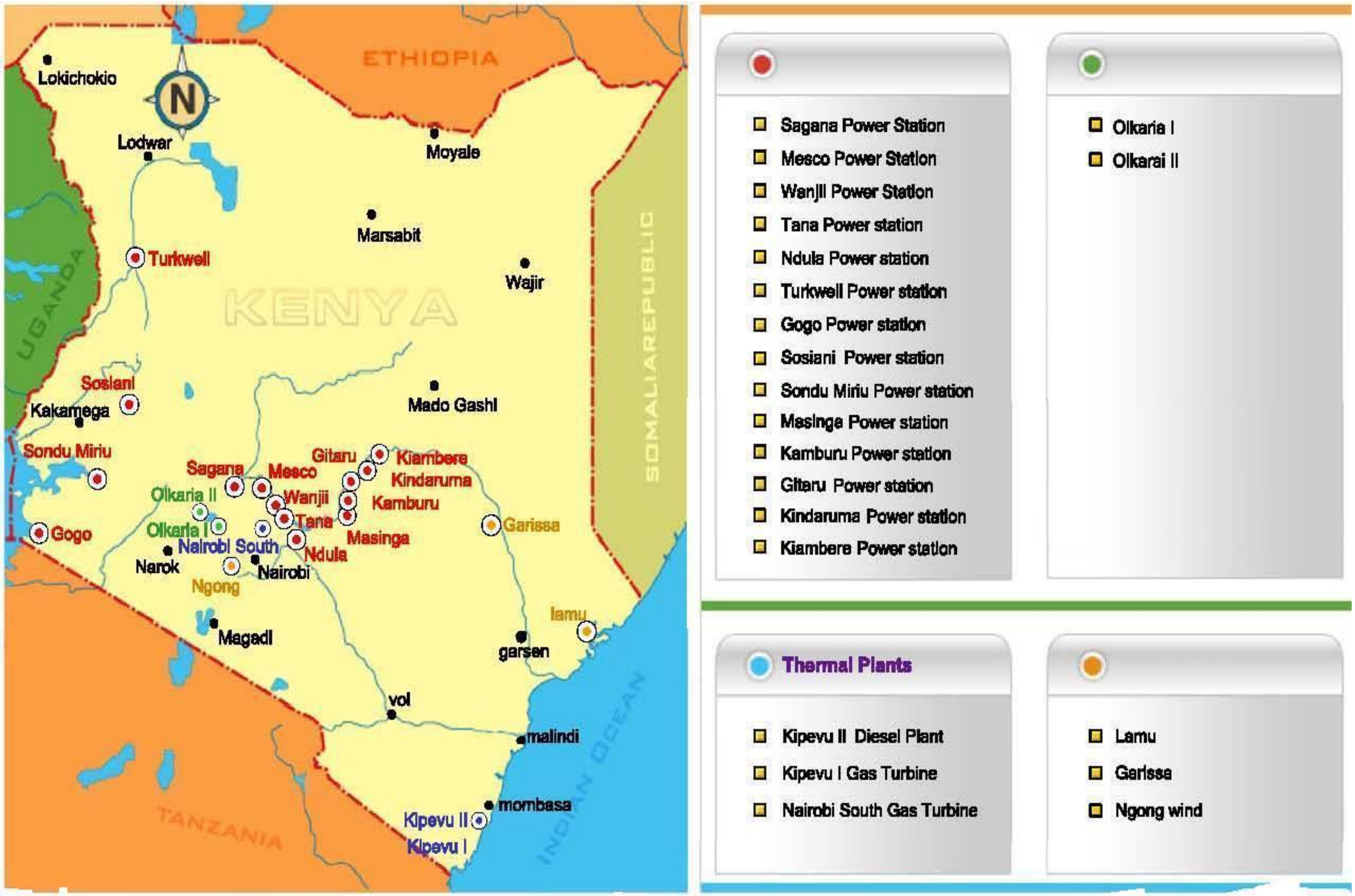
Map 1: Map of power plants in Kenya

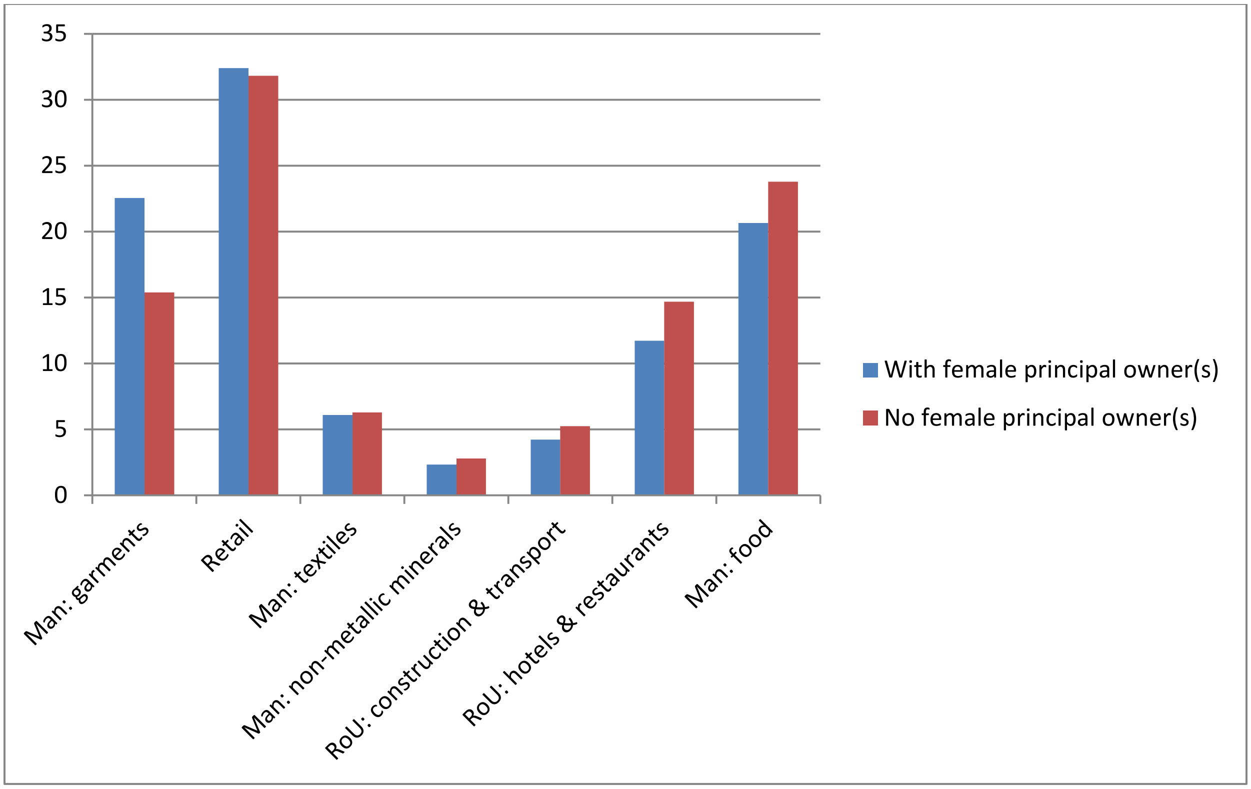


Source: http://www.kengen.co.ke/index.php?page=business&subpage=powerplant. Accessed on August 17, 2010.

Map 2: Political map of Kenya

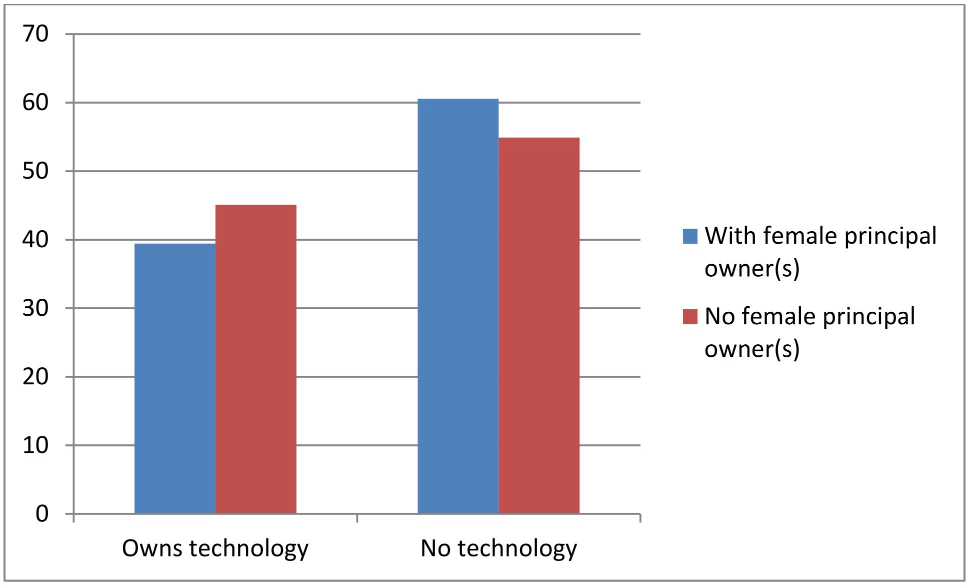
Source: http://www.nationsonline.org/oneworld/map/kenya_map.htm. Accessed on August 12, 2010.

Figure 1: Percentage of firms with female principal owners and without, by industry



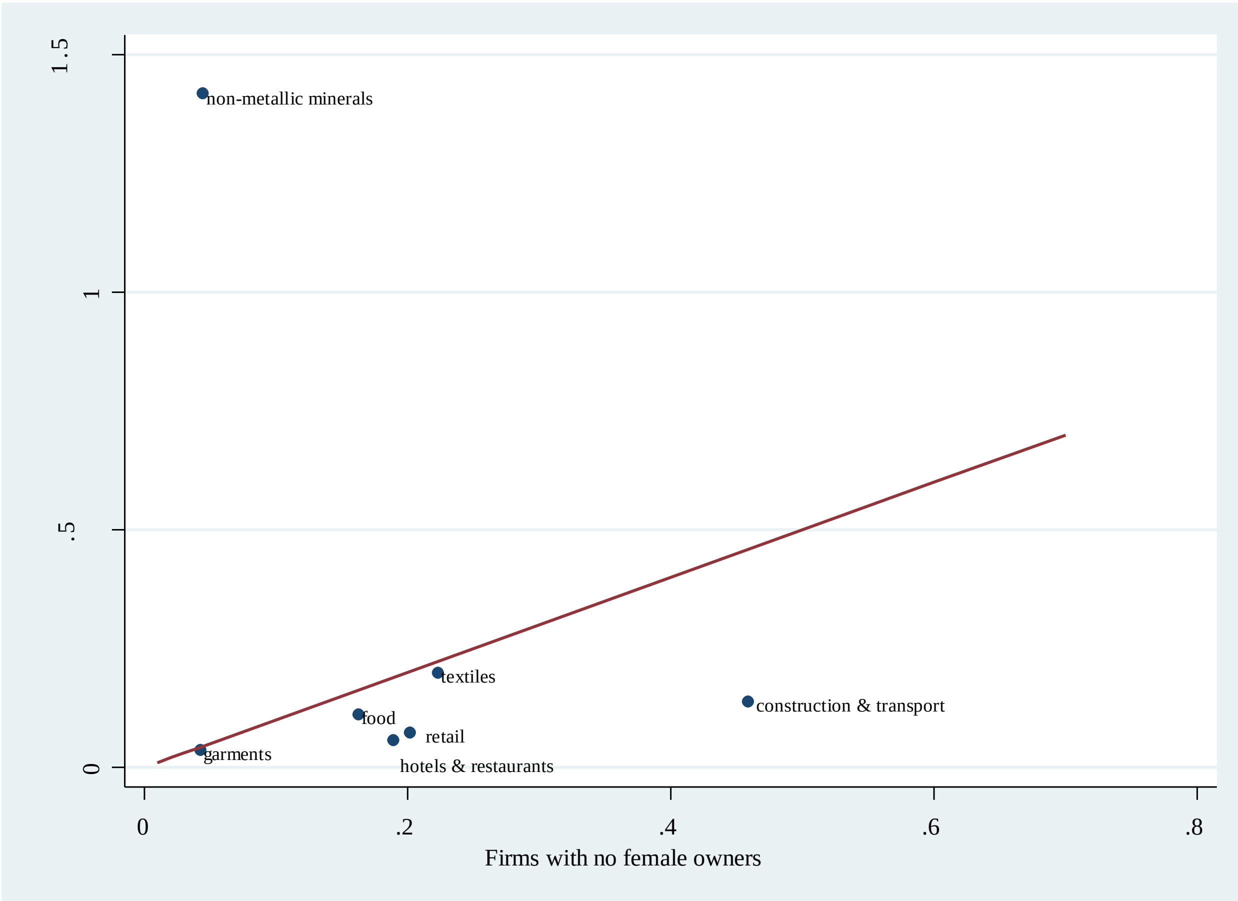
Notes: Industries are arranged by order of the difference between firms with female principal owners and firms with no female principal owners (from largest to smallest), within each industry grouping.

Figure 2: Percentage of firms with female principal owners and without, by use of communications technology



Notes: "Communications technology" implies that the firm uses email, its website, or the internet to communicate with clients and suppliers.

Figure 3: Median value-added per worker, by gender of firm owner (2006 US $)



Notes: Author's calculations. Value-added per worker is in 10,000 Kenyan Shillings before being converted to 2006 US $.

Table 1: Weighted proportions of firms characterizing obstacles as moderate, major, or very severe

	Total	*With female principal owners*	*No female principal owners*
Obstacles related to			
regulations	0.997	0.998	0.999
	(0.001)	(0.002)	(0.00002)
infrastructure	0.930	0.954	0.907
	(0.004)	(0.034)	(0.037)
security	0.728	0.725	0.730
	(0.095)	(0.143)	(0.050)
workforce	0.180	0.236	0.126
	(0.082)	(0.127)	(0.021)
corruption	0.842	0.835	0.850
	(0.059)	(0.053)	(0.068)
finance	0.965	0.947	0.983
	(0.020)	(0.036)	(0.006)

Notes: There are 499 total firms in the sample of which 213 firms have female principal owners and 286 have only male principal owners. Weighted to national level with weights provided by the Enterprise Survey of Kenya. Table reports percentage values. Robust standard errors in parenthesis.

Table 2: Weighted proportions of firms characterizing obstacles as moderate, major, or very severe, by industry

	With female principal owners				No female principal owners			
	Manufacturing	*Retail*	*Construction & Transport*	*Hotels & Restaurants*	*Manufacturing*	*Retail*	*Construction & Transport*	*Hotels & Restaurants*
Obstacles related to								
regulations	1.000	0.996	1.000	1.000	1.000	0.999	1.000	1.000
	(0.000)	(0.003)	(0.000)	(0.000)	(0.000)	(0.0001)	(0.000)	(0.000)
infrastructure	0.982	0.926	0.976	0.995	0.691	0.991	0.674	0.972
	(0.020)	(0.052)	(0.025)	(0.005)	(0.336)	(0.005)	(0.009)	(0.012)
security	0.997	0.639	0.995	0.714	0.771	0.645	0.995	0.967
	(0.002)	(0.120)	(0.008)	(0.259)	(0.111)	(0.095)	(0.008)	(0.010)
workforce	0.006	0.334	-	0.193	0.228	0.078	0.328	0.039
	(0.003)	(0.187)		(0.130)	(0.114)	(0.074)	(0.006)	(0.038)
corruption	0.983	0.927	0.992	0.536	0.979	0.774	1.000	0.993
	(0.021)	(0.052)	(0.013)	(0.126)	(0.027)	(0.134)	(0.000)	(0.003)
finance	0.955	0.924	0.967	0.987	0.983	0.988	0.989	0.937
	(0.045)	(0.051)	(0.033)	(0.010)	(0.010)	(0.007)	(0.006)	(0.027)

Notes: There are 499 total firms in the sample of which 248 are in manufacturing firms, 160 are retail firms, 24 are Construction and Transport firms, and 67 are Hotels and Restaurant firms. Weighted to national level with weights provided by the Enterprise Survey of Kenya. Table reports percentage values. Robust standard errors in parenthesis.

Table 3: Weighted proportion of firms characterizing obstacles as moderate, major, or very severe, by use of communications technology

	With female principal owners *Firm uses email, website, or an internet connection for communication with clients and suppliers*	**No female principal owners** *Firm uses email, website, or an internet connection for communication with clients and suppliers*
Obstacles related to		
regulations	0.912	0.996
	(0.061)	(0.001)
infrastructure	0.643	0.919
	(0.051)	(0.055)
security	0.878	0.935
	(0.044)	(0.052)
workforce	0.041	0.786
	(0.017)	(0.113)
corruption	0.641	0.946
	(0.092)	(0.057)
finance	0.336	0.835
	(0.056)	(0.103)

Notes: There are 499 total firms in the sample of which 212 firms use email for communications with clients and suppliers, 57 firms use their own website for communications with clients and suppliers, and 18 firms use high-speed, broadband internet connection to communicate with clients and suppliers. Weighted to national level with weights provided by the Enterprise Survey of Kenya. Table reports percentage values. Robust standard errors in parenthesis.

Table 4: Weighted means and standard deviations disaggregated by gender of principal owners

	Firm has at least one female principal owner	*Firm has no female principal owner*	*Difference (column 1 - column 2)*
Endogenous variable			
Natural log of value added per worker	1.412	2.757	-1.346***
	(0.330)	(0.287)	(0.438)
Firm uses email, its website, or the internet to	0.019	0.072	-0.052
communicate with clients and suppliers	(0.006)	(0.051)	(0.051)
Obstacles related to			
Regulations	0.999	0.998	0.0003
	(0.0004)	(0.0004)	(0.001)
Infrastructure	0.950	0.911	0.039
	(0.024)	(0.028)	(0.036)
Security	0.749	0.706	0.043
	(0.041)	(0.047)	(0.063)
Workforce	0.190	0.170	0.020
	(0.039)	(0.036)	(0.053)
Corruption	0.819	0.865	-0.046
	(0.033)	(0.029)	(0.044)
Finance	0.968	0.962	0.006
	(0.007)	(0.007)	(0.009)
Instruments			
Number of mission schools as of 1935 in region	13.932	16.810	-2.878
in the year the firm was established	(1.416)	(1.301)	(1.923)
Number of private schools as of 1935 in region	2.466	2.672	-0.206
in the year the firm was established	(0.101)	(0.093)	(0.137)
Number of government schools as of 1935 in region	5.923	7.542	-1.619
in the year the firm was established	(0.808)	(0.742)	(1.097)
Indicator for no deviation in region-year rainfall	0.050	0.048	0.001
from 1910-2000 rainfall average	(0.047)	(0.046)	(0.066)
Regional indicators			
Nairobi	0.488	0.692	-0.203
	(0.101)	(0.093)	(0.137)
Mombasa	0.490	0.289	0.201
	(0.102)	(0.093)	(0.138)
Nakuru	0.013	0.010	0.003
	(0.004)	(0.003)	(0.005)
Kisumu	0.009	0.009	-0.001
	(0.003)	(0.003)	(0.004)

Table 4: Weighted means and standard deviations disaggregated by gender of principal owner (continued)

	Firm has at least one female principal owner	*Firm has no female principal owner*	*Difference (column 1 - column 2)*
Firm and industry characteristics			
Natural log of value of machinery (machinery, vehicle equipment new and/or used)	6.329 (0.977)	6.866 (0.889)	-0.537 (1.321)
Natural log of value of property (land and buildings)	0.012 (0.006)	1.075 (0.554)	-1.064* (0.554)
Percent of firm owned by largest shareholders	97.162 (1.814)	95.723 (2.464)	1.440 (3.060)
Dummy for manufacturing firm	0.133 (0.067)	0.159 (0.071)	-0.026 (0.097)
Dummy for retail firm	0.552 (0.101)	0.647 (0.090)	-0.095 (0.135)
Firm has 20 – 99 employees ("medium" firm)	0.006 (0.002)	0.010 (0.003)	-0.004 (0.003)
Firm has 5 – 19 employees ("small" firm)	0.020 (0.005)	0.029 (0.006)	-0.009 (0.008)
Firm has African-origin principal owner	0.956 (0.036)	0.991 (0.003)	-0.034 (0.036)
Firm has Indian-origin principal owner	0.006 (0.002)	0.007 (0.002)	-0.001 (0.003)
Number of skilled production workers	69.727 (30.509)	65.175 (13.841)	4.551 (33.502)
Acquired technological innovation in past 3 years	0.530 (0.055)	0.562 (0.047)	-0.032 (0.072)
Proportion of working capital borrowed from private commercial banks	12.593 (2.394)	13.353 (1.952)	-0.759 (3.089)
Proportion of working capital borrowed from state-owned banks and/or government agencies	0.725 (0.349)	1.328 (0.779)	-0.603 (0.853)
Proportion of working capital borrowed from non-bank financial institutions	0.680 (0.484)	0.692 (0.448)	-0.012 (0.660)
Establishment distributed HIV prevention messages to employees	0.615 (0.054)	0.566 (0.048)	0.050 0.072)
Proportion of workforce that is unionized	28.648 (3.923)	33.834 (3.695)	-5.185 (5.388)

Table 4: Weighted means and standard deviations disaggregated by gender of principal owner (continued)

	Firm has at least one female principal owner	*Firm has no female principal owner*	*Difference (column 1 - column 2)*
Top manager's characteristics			
Illiterate	-	0.00004	-0.00004
		(0.00004)	(0.00004)
Some primary or primary school graduate	0.341	0.224	0.117
	(0.097)	(0.081)	(0.126)
Some secondary or secondary school graduate	0.591	0.618	-0.027
	(0.099)	(0.092)	(0.135)
Vocational training	0.013	0.098	-0.085
	(0.004)	(0.056)	(0.056)
Some university training or graduate degree	0.051	0.057	-0.006
	(0.036)	(0.035)	(0.050)
MBA or PhD from Kenya or another country	0.004	0.003	0.001
	(0.002)	(0.001)	(0.002)
Years of managerial experience in this sector	7.598	7.326	0.272
	(1.027)	(1.289)	(1.648)

Notes: Weighted to national level with weights provided by the Enterprise Survey for Kenya. Table reports percentage values. Standard errors in parentheses. The notation *** is p<0.01, ** is p<0.05, * is p<0.10. Significance denoted on the basis of respective *p*-values.

Table 5: First stage regressions for identifying instruments

	Firm uses email, its website, or the internet to communicate with clients and suppliers		
	All firms (1)	*Firms with female owners* (2)	*Firms with no female owners* (3)
Instruments			
Number of mission schools as of 1935 in region	0.011***	0.014***	0.009***
in the year the firm was established	(0.00001)	(0.00002)	(0.00003)
Number of private schools as of 1935 in region	-0.142***	-0.161***	-0.122***
in the year the firm was established	(0.0002)	(0.0003)	(0.0006)
Number of government schools as of 1935 in region	0.003***	0.0008***	0.003***
in the year the firm was established	(0.00003)	(0.00007)	(0.0001)
Indicator for no deviation in region-year rainfall	0.008***	0.008**	0.004***
from 1910-2000 rainfall average	(0.0008)	(0.002)	(0.00004)
R-squared	0.083	0.130	0.050
F	110e+07***	420e+04***	310e+03***
Observations	499	213	286

Notes: Weighted to national level with weights provided by the Enterprise Survey for Kenya. Table reports OLS regressions. Standard errors, clustered by region, in parentheses. The notation *** is p<0.01, ** is p<0.05, * is p<0.10. Significance denoted on the basis of respective *p*-values. F-statistics reported in the table are for all identifying instruments. Regressions include a constant term.

Table 6: Overidentification tests of the exclusion restriction

	(1)	(2)
Panel A: Two-stage least squares		
Firm uses email, its website, or the internet to communicate with clients and suppliers	128.057*	8.544*
	(66.946)	(4.392)
Panel B: First stage for firm uses email, its website, or the internet for communications		
Indicator for no deviation in region-year rainfall from 1910-2000 rainfall average	0.009***	
	(0.001)	
Number of mission schools as of 1935 in region in the year the firm was established		0.011***
		(0.00001)
Number of private schools as of 1935 in region in the year the firm was established		-0.141***
		(0.0001)
Number of government schools as of 1935 in region in the year the firm was established		0.002***
		(0.00003)
R^2	0.026	0.083
Panel C: Results from overidentification test		
p-value (from χ^2 test)	[0.209]	[0.420]
Panel D: Second stage with excluded instrument(s) as exogenous variables		
Firm uses email, its website, or the internet to communicate with clients and suppliers	132.356**	13.881***
	(66.589)	(2.814)
Number of mission schools as of 1935 in region in the year the firm was established	23.348	
	(15.050)	
Number of private schools as of 1935 in region in the year the firm was established	136.531	
	(114.696)	
Number of government schools as of 1935 in region in the year the firm was established	-17.307	
	(17.539)	
Deviation in region-year rainfall from 1910-2000 rainfall average		-14.772
		(18.796)

Notes: Panel A reports the two-stage least-squares estimates with natural log of value added per worker as the dependent variable. Panel B reports the corresponding first stage. Panel C reports the *p*-value for the null hypothesis that the coefficient on the endogenous communications technology variable is Panel A is the same as in Panel D. Weighted to national level with weights provided by the Enterprise Survey for Kenya. Standard errors, clustered by region, in parentheses. The notation *** is p<0.01, ** is p<0.05, * is p<0.10. Significance denoted on the basis of respective *p*-values. Regressions include a constant term. The first stage regressions have 500 observations, the remaining regressions have 464 observations.

Table 7: Robustness of subsets of the instruments: Natural log of value added per worker

	All firms		
Model	*IV*	*IV*	*IV*
Instrument set	*Schooling variables + deviation of rain variable*	*Schooling variables only*	*Deviation of rain variable only*
Firm uses email, its website, or the internet to communicate with clients and suppliers	33.996**	8.064*	129.505**
	(16.964)	(4.351)	(66.093)
χ^2 *value of joint test of significance of obstacles*	6.31	93.94	4.46
	[0.098]	[0.000]	[0.216]
χ^2 *value of joint test of significance of female principal owner interactions with obstacles*	5.54	152.48	0.71
	[0.137]	[0.000]	[0.870]
Hansen's J Statistic	1.689	1.397	-
	[0.430]	[0.237]	
Includes region, firm, industry, and manager chars.	YES	YES	YES
Observations	464	464	464

Notes: Weighted to national level with weights provided by the Enterprise Survey for Kenya. Table reports two stage least squares estimates. Standard errors, clustered by region, in parentheses. *p*-values in square brackets. The notation *** is p<0.01, ** is p<0.05, * is p<0.10. Significance denoted on the basis of respective *p*-values. Regressions include a constant term. Other regressors included but not reported in the table are obstacles, indicator for female headship, and interactions of obstacles with the indicator for female headship.

Table 8: Robustness of the instruments with respect to other variables that might be correlated with natural log of value added per worker

Dependent variable	*Number of skilled production workers*	*Acquired technology innovation in past 3 years*	*Proport. of working K borrowed from private commer. banks*	*Proport. of working K borrowed from state-owned banks*	*Proport. of working K borrowed from non-bank inst.*	*Establish. distributed HIV prev. messages to emp.*	*Percent of workforce that is unionized*
Instruments							
Number of mission schools as of 1935 in region	36.882	0.150	3.876	1.164	-0.695	-0.056	9.284
in the year the firm was established	(22.977)	(0.121)	(2.770)	(0.838)	(0.513)	(0.077)	(13.085)
Number of private schools as of 1935 in region	53.201	0.728	-9.333	4.186	-1.885	-0.608	81.300
in the year the firm was established	(71.341)	(1.655)	(12.202)	(6.199)	(2.223)	(0.549)	(86.339)
Number of government schools as of 1935 in region	2.261	-0.101	2.693	-0.716	-0.006	0.122	-14.774
in the year the firm was established	(7.119)	(0.310)	(2.054)	(0.896)	(0.251)	(0.085)	(13.242)
Indicator for no deviation in region-year rainfall	-41.222	0.021	5.909	0.024	-0.616	0.086	9.274
from 1910-2000 rainfall average	(26.561)	(0.065)	(6.913)	(0.484)	(0.824)	(0.153)	(6.267)
Includes region, firm, industry, and manager chars.	YES	YES	YES	YES	YES	YES	YES
Observations	229	229	421	421	430	305	224

Notes: Weighted to national level with weights provided by the Enterprise Survey for Kenya. Table reports OLS regressions. Standard errors, clustered by region, in parentheses. The notation *** is p<0.01, ** is p<0.05, * is p<0.10. Significance denoted on the basis of respective *p*-values. Regressions include a constant term. Other regressors included but not reported in the table are obstacles, indicator for female headship, and interactions of obstacles with the indicator for female headship. Number of skilled production workers, technological innovation, and unionized questions are asked only of manufacturing firms.

Table 9: IV results for the effect of communications technology on natural log of value added per worker

	All firms	*Has female owners*	*No female owners*
Firm uses email, its website, or the internet to communicate with clients and suppliers	33.996**	42.824***	5.808***
	(16.964)	(8.450)	(1.663)
Obstacles related to regulations	13.804*	5.388	14.794***
	(7.129)	(6.627)	(1.682)
Obstacles related to infrastructure	-5.360	-4.177	-0.876
	(4.033)	(3.763)	(0.661)
Obstacles related to security	-10.198	-10.382***	-0.327
	(6.694)	(2.306)	(1.057)
Obstacles related to workforce	-5.698*	-6.881***	0.306
	(3.062)	(2.351)	(0.785)
Obstacles related to corruption	10.189	4.688	1.468
	(6.866)	(2.981)	(1.734)
Obstacles related to finance	17.269**	16.214***	2.764***
	(8.149)	(4.728)	(0.747)
Firm has one or more female principal owners	10.730		
	(6.695)		
Female principal owner interactions with:			
Obstacles related to regulations	-16.329**		
	(7.681)		
Obstacles related to infrastructure	3.051		
	(3.030)		
Obstacles related to security	9.096*		
	(5.203)		
Obstacles related to workforce	-1.582		
	(3.478)		
Obstacles related to corruption	-3.086		
	(6.425)		
Obstacles related to finance	-1.568		
	(2.185)		
χ^2 *value of joint test of significance of Obstacles*	6.310	32.560	168.990
	[0.098]	[0.000]	[0.000]
χ^2 *value of joint test of significance of female principal owner interactions with obstacles*	5.540		
	[0.137]		
Hansen's J Statistic	1.689	2.594	0.155
	[0.430]	[0.273]	[0.693]
Includes region, firm, industry, and manager chars.	YES	YES	YES
Observations	464	200	264

Notes: Weighted to national level with weights provided by the Enterprise Survey for Kenya. Table reports two stage least squares estimates. Standard errors, clustered by region, in parentheses. *p*-values in square brackets. The notation *** is p<0.01, ** is p<0.05, * is p<0.10. Significance denoted on the basis of respective *p*-values. Regressions include a constant term.

Appendix Table 1: OLS results for the effect of communications technology on natural log of value added per worker

	All firms	*Has female owners*	*No female owners*
Firm uses email, its website, or the internet to communicate with clients and suppliers	1.573*	1.293	-0.217
	(0.612)	(0.819)	(0.355)
Obstacles related to regulations	3.776	-8.337	10.784**
	(5.684)	(4.251)	(2.430)
Obstacles related to infrastructure	-1.703*	-1.247	-0.738
	(0.607)	(0.688)	(0.422)
Obstacles related to security	-4.815	-3.808	-0.342
	(3.114)	(2.932)	(0.334)
Obstacles related to workforce	2.691	1.866	2.801***
	(1.289)	(0.988)	(0.365)
Obstacles related to corruption	4.661	4.484*	0.300
	(4.042)	(1.425)	(0.809)
Obstacles related to finance	1.876*	0.192	0.647
	(0.688)	(0.528)	(0.618)
Firm has one or more female principal owners	9.221**		
	(2.861)		
Female principal owner interactions with:			
Obstacles related to regulations	-11.990**		
	(2.509)		
Obstacles related to infrastructure	3.049*		
	(1.102)		
Obstacles related to security	4.783		
	(3.259)		
Obstacles related to workforce	-3.555		
	(1.681)		
Obstacles related to corruption	-2.140		
	(4.054)		
Obstacles related to finance	-2.718*		
	(1.091)		
χ^2 *value of joint test of significance of Obstacles*	18.290	2.720	15.83
	[0.020]	[0.216]	[0.024]
χ^2 *value of joint test of significance of female principal owner interactions with obstacles*	95.160		
	[0.002]		
Includes region, firm, industry, and manager chars.	YES	YES	YES
Observations	464	200	264

Notes: Weighted to national level with weights provided by the Enterprise Survey for Kenya. Standard errors, clustered by region, in parentheses. *p*-values in square brackets. The notation *** is $p<0.01$, ** is $p<0.05$, * is $p<0.10$. Significance denoted on the basis of respective *p*-values. Regressions include a constant term.

Appendix Table 2: IV results for the effect of communications technology on natural log of value added per worker with inclusion of average educational attainment of typical production worker in the second stage

	All firms
Firm uses email, its website, or the internet to communicate with clients and suppliers	3.908***
	(1.318)
Obstacles related to infrastructure	-2.498***
	(0.661)
Obstacles related to security	2.688***
	(0.734)
Obstacles related to workforce	-0.447
	(0.999)
Obstacles related to corruption	3.512***
	(0.311)
Obstacles related to finance	-0.135
	(0.338)
Firm has one or more female principal owners	-3.924***
	(0.955)
Typical production worker has between 0-6 years of education	-0.849***
	(0.169)
Typical production worker has between 7-12 years of education	-0.732***
	(0.177)
Female principal owner interactions with:	
Obstacles related to infrastructure	4.315***
	(0.916)
Obstacles related to security	0.160
	(0.769)
Obstacles related to workforce	0.004
	(1.179)
Obstacles related to corruption	-1.561**
	(0.701)
Obstacles related to finance	2.082**
	(0.851)
χ^2 *value of joint test of significance of Obstacles*	38.960
	[0.000]
χ^2 *value of joint test of significance of female principal owner interactions with obstacles*	22.230
	[0.0001]
Includes region, firm, industry, and manager chars.	YES

Notes: Weighted to national level with weights provided by the Enterprise Survey for Kenya. Table reports two stage least squares estimates. Standard errors, clustered by region, in parentheses. *p*-values in square brackets. The notation *** is $p<0.01$, ** is $p<0.05$, * is $p<0.10$. Significance denoted on the basis of respective *p*-values. The excluded education category is the indicator for whether a typical production worker has 13 years and above of education. Obstacles related to regulations (and its interaction) is dropped from the model with the inclusion of indicators for the education level of the typical production worker. Number of observations is 230 since the average education level of production workers is asked only of manufacturing firms. Regressions include a constant term.

Appendix Table 3: Matching estimator results for the effect of technology on value added per worker

	All firms	*Firm has at least one female owner*	*Firm has no female owners*
Average treatment effect	34.231*	170.874***	-230.324***
	(19.687)	(38.638)	(21.430)
Average treatment effect for the treated	111.013*	570.027**	-49.627***
	(57.303)	(258.658)	(17.886)
Includes region, firm, industry, and manager chars.	YES	YES	YES
Observations	464	200	264

Notes: Weighted to national level with weights provided by the Enterprise Survey for Kenya. Estimates are as reported by the bias corrected matching estimator which uses the inverse variance weighting matrix. Table reports robust standard errors in parentheses. The notation *** is p<0.01, ** is p<0.05, * is p<0.10. Significance denoted on the basis of respective *p*-values.

Endnotes

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[1] We assume that the decision to invest in communications technologies is economically rational for firms that choose to use email or the internet for communication purposes. Given data constraints, we do not model this choice in the paper.
[2] As noted in Bresnahan *et al*. (2002). In so far as the general effect of technology is likely to be beneficial on the whole (increase the efficiency of production and reduce input costs), we consider the magnitude of the short-run effects measured here to be an underestimate of long-run adjustments in the future.
[3] Modeling technology adoption as a reduction in price is similar to the intuition provided in Rosenzweig and Wolpin (1986).
[4] We assume that the total factor productivity parameter equals one. One way to incorporate long run effects of technology ownership on production process and input choice would be to condition total factor productivity as a function of technologies owned, similar to Hu *et al*. (2005).
[5] For example, if the firm owns a computer for emailing purposes, there is still an electricity bill to be paid.
[6] The OLS counterparts of the main IV results in Table 9 are reported in Appendix Table 1. It is clear that in comparison to the preferred IV estimates, the OLS estimates are smaller in magnitude and measured with error.
[7] Value-added per worker is measured in 10,000 Kenyan Shillings.
[8] Furthermore, we check to ensure that there is no systematic correlation between the regional distribution of such schools as of 1935 and the regional distribution of firms in our data. The earliest firm in our data was established in 1920 in Mombasa and as of 1935, only 4 of the 499 firms in our sample had been established. Only 10% of firms had been established by 1975, forty years after the end-point of the schools data (the majority of firms in our sample was established in 2000).
[9] These data are available from the KENGEN website at http://www.kengen.co.ke/.
[10] Without this averaging, the dependent variable in the first stage is non-linear. Angrist and Krueger (2001) show that estimating a two-stage model where the first stage is non-linear is invalid, since the model is identified from the non-linearity in the first stage.
[11] In panel D, the variable denoting deviations in region-year rainfall is used. This is the source variable from which the indicator for no deviation in region-year rainfall is created.
[12] We note that information on value-added per worker is available for 464 of the 499 firms since value-added is exactly zero for 10 firms (these values are dropped with the natural log transformation), and is not defined for 25 firms (these are micro firms that do not employ any permanent full-time paid employees; these firms are dropped upon dividing by 0 in order to obtain value-added per worker).
[13] We note here that mission schools espoused a notion of "trusteeship" which implied that non-white races were considered to be biologically inferior (Strayer, 1978). Thus, although such schools engaged in educating native populations, the education imparted was of low quality and consistent with that provided to the "lower social orders in England" (Strayer, 1978).
[14] This variable is binary in nature and represents whether the manager has some school (primary or secondary or vocational training) or whether he/she has advanced schooling (some graduate training or holds an M.B.A. or Ph.D.)
[15] The magnitude of the coefficient on technology use is somewhat diminished.