

# Digital Technology Uses among Informal Micro-Sized Firms

Productivity and Jobs Outcomes in Senegal

*İzak Atiyas*  
*Mark A. Dutz*



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## Abstract

This paper explores the use of digital technologies among informal micro-sized firms in Senegal, their association with productivity, sales, exports and jobs, and the role of age and gender dimensions of enterprise owners. The study uses a new national sample of over 500 firms, of which over 90 percent are not fully formal and over 95 percent are micro-sized, employing five or fewer full-time employees. The analysis finds that using a 2G mobile phone is significantly positively correlated both with productivity and sales, and using a smartphone is associated with an additional premium relative to using a 2G. The largest statistically significant conditional correlate of productivity, sales and

jobs is a more specialized internal-to-the-firm management technology proxying for management capabilities more generally, namely inventory control/point of sales (POS) software. Use of digital technologies to facilitate external-to-the-firm transactions, namely using mobile money to pay suppliers and to receive payments from customers are also statistically significant conditional correlates of productivity and sales. Using a smartphone is also positively correlated with exporting (while using only a 2G phone is not). Finally, there are significant digital divides in the use of digital technologies across age and gender groupings.

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# Digital technology uses among informal micro-sized firms: Productivity and jobs outcomes in Senegal

İzak Atiyas and Mark A. Dutz<sup>1</sup>

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<sup>1</sup> Affiliations: Atiyas (Economic Research Forum and TUSIAD-Sabanci University Competitiveness Forum), Dutz (World Bank). Corresponding author: [mdutz@worldbank.org](mailto:mdutz@worldbank.org). This research has received funding from the World Bank analytical and advisory services task “Senegal Digital Sources of Growth Study: Productivity and Inclusion Opportunities from Adoption of Digital Technologies (DTs)” (project ID: P168247) and the joint Africa Chief Economist-Digital Development Research Program on Digital Transformation for Africa (project ID: P170151). The authors are grateful to Alison Gillwald and Onkokame Mthobi for making available the RIA (Research ICT Africa) ICT Access business data for 2017-18 and for their support in the use of these data.

## I. INTRODUCTION

This paper presents findings on the adoption and use of digital technologies (DTs) by informal micro-sized firms in Senegal. The paper explores associations between enterprise and entrepreneur (owner) characteristics, uses of smartphones as internet access technologies and more specialized DTs enabled by the internet, and business outcomes linked to productivity, sales, exports and the generation of better jobs for more people. It explicitly focuses on age and gender dimensions of business owners, their differential use of smartphones and more specialized DTs and associated digital divides, and their associations with business performance. The findings are based on a national sample of over 500 firms, of which over 90 percent are not fully formal and over 95 percent are micro-sized, employing five or fewer full-time employees—with over half of the sample being self-employed household enterprises with no full-time paid employees.

The paper provides new evidence, both with respect to correlates of adoption and with respect to associations between adoption of various DTs and firm performance. The paper uses smartphones as the main DT providing access to the internet. Information on whether the firm uses only 2G phones or no mobile phone at all is also provided, allowing to compare the differential association between different mobile access technologies and firm performance. With respect to adoption, the paper explores the correlates of adoption of smartphones controlling for firm level characteristics such as the degree of informality, being in urban versus rural locations, the level of education of the owners, access to finance, and whether the owner had any vocational training. In addition, the paper explores whether adoption is significantly correlated with age and gender.

As indicators of general business performance, the paper uses labor productivity, sales and whether the firm has customers abroad (a proxy for exports). The paper also measures the performance of enterprises against the objective of creating more and better jobs: as a measure of more jobs the number of full-time employees plus owners generated by each firm, and as income-related measures of better jobs wages per full time workers and profits per owner. The latter variable is likely to be especially important to assess whether entrepreneurial firms generate sufficient profits to support the well-being of their owners.

The paper explores the associations between these performance variables and the use of access technologies as well as additional more specialized DTs enabled by access to the internet. The distinction between adoption of an access technology such as smartphones and specialized DTs is important: a smartphone can be used in ways that have no productive bearing on firm performance (e.g. watching videos or engaging in communications with friends). Only when the access technology is used for purposes that are relevant for business performance is a positive association between use of DTs and performance to be expected. Fortunately, the data set provides a rich set of information on various types of DTs as well as different uses of internet, unavailable elsewhere, especially for the type of largely informal micro firms covered in the survey. The paper explores the use of DTs that are especially useful for the firms' external transactions with upstream and downstream product providers and consumers, financial intermediaries, labor markets and government: for example, whether the firm uses the internet to look for suppliers and pay suppliers, to better understand and market to customers and receive payments from them, or to access the financial system, to recruit workers, and to interact with government entities as well as to pay taxes. The paper also explores uses of DTs to enhance internal-to-firm transactions, including to improve the internal management of the firm, namely by using accounting and inventory control/point of sales software, and to communicate with and pay workers with mobile money. As such, the paper explores some dimensions of management practices that are related to those that have been shown to improve firm performance (e.g. Bloom et. al. 2014, 2012).

The data are available only as a single cross-section. As such, the findings are restricted to statistically significant associations and do not generally allow inferences to be made about causality, neither with respect to adoption of technologies nor with respect to the impact of their use on business performance. However, a detailed description of the incidence of DTs among microenterprises and an assessment of statistically significant associations between firm characteristics, use of DTs and firm performance—both unconditional and conditional—provide valuable inputs to enrich the existing understanding of the micro-entrepreneurial environment in SSA countries. This analysis also highlights the desirability to generate and analyze better panel data in the future.

Some of the key hypotheses with respect to smartphone adoption, use of DTs and business performance, and other correlates of business performance that are tested in the paper are as follows:

- Adoption of smartphones is expected to be positively correlated with businesses located in urban areas, having access to electricity, higher levels of owner education, and having access to finance. Firms with younger owners are more likely to adopt smartphones. Firms with a female owner are expected to have a negative association with smartphone adoption, based on widespread evidence of a gender gap in digital access.
- Specific DTs that provide services beyond access are expected to have stronger positive correlations with firm performance relative to adoption of smartphones. DTs that are primarily used to reduce the cost of operations and improve efficiency within the firm (such as accounting or inventory control/point of sales software) are expected to be more strongly positively correlated with better firm performance relative to DTs that are useful for firms' external transactions. This is because DTs used primarily within the firm are less subject to network effects while those that are especially useful for firms' external transactions can generally only be effective if similar DTs are extensively used by firms' external counterparts.
- Having access to finance, having higher levels of human capital, being in urban areas, having some degree of formality and larger firm size are expected to be associated with better firm performance. Firms owned by "transformative" owners, namely in the business because of a perceived profit opportunity rather than because they cannot find alternate employment are expected to be associated with better performance.

The main findings of this paper include:

- Using a 2G mobile phone is significantly positively correlated both with productivity and sales, and using a smartphone is associated with an additional premium relative to using a 2G, based on conditional correlations from regression analysis. Having a smartphone per se does not matter for generating more jobs (or larger firm size). The largest statistically significant conditional correlate of productivity, sales and jobs is a more specialized internal-to-the-firm management technology proxying for management capabilities more generally, namely inventory control/point of sales (POS) software—which facilitates documenting and tracking the changing levels of inventories and customer purchases over time, the lifeblood of small companies, rather than writing them on pieces of paper and not being able to consider what they mean for company profits and growth. Use of DTs to facilitate external-to-the-firm transactions, namely using mobile money to pay suppliers and to receive payments from customers are also statistically significant conditional correlates of productivity and sales. Having a loan, electricity, and more full-time workers, being owned by men, not being fully informal and the owners having vocational training (at the 10 percent level) are also significantly positively correlated with productivity and sales. For generating more jobs, having a loan and electricity and not being fully informal continue to matter; in addition, the owners having vocational training

now becomes highly significant (at the 1 percent level), while women-owned firms, both youth and older owners, are as likely to generate more jobs as men-owned firms.

- Using a smartphone (using a 2G phone is no longer sufficient) is also positively correlated with exporting. Exporting is conditionally correlated not with DTs internal to the firm, but with the use of a wide range of DTs to facilitate external-to-firm transactions: in addition to using the internet to look for suppliers online, the full range of DTs associated with better understanding customers and marketing, using e-commerce to sell goods and services online, and using mobile money to receive payments from customers are all statistically significant. The gender and age of the owner is not a statistically significant correlate of exporting—suggesting that young women and men are equally likely to be exporting. While having a loan and not being fully informal is positively correlated with exporting, having more full-time workers and using electricity are not.
- Analysis of unconditional means suggests that there are significant digital divides in the use of DTs across age groups and gender. The difference between youth-owned and older-owned firms is stark regarding the use of a smartphone: the share of youth-owned firms that use a smartphone is twice as large as that of older-owned firms (27% vs 14%). While women-owned firms on average are slightly less likely to use a smartphone relative to men-owned firms, the highest share of usage overall is among younger women-owned firms, at over 27 percent, almost twice the overall share of smartphone users—versus older women-owned firms at only 10 percent. This divide likely reflects the fact that firms owned by older women are disproportionately in agriculture, in rural areas, fully informal and with lower access to electricity. The highest percentage usage of several key specialized DTs is by young women-owned businesses, and this is where the digital divide is also the largest, relative to older women-owned businesses. This includes: two management-related DTs, inventory control/POS and accounting software, with over 12 and 13 percent of younger women-owned businesses using them (relative to 4.6 and 9.6% of younger men-owned firms, respectively, and only 3.7 and 4.7% for older women-owned firms); using internet to better understand customers, with almost 24 percent of younger women-owned businesses using it (relative to 21.4% of younger men-owned firms, and only 6.4% for older women-owned firms); and using mobile banking, with 12 percent of younger women-owned businesses using it (here, the divide with older women-owned businesses is starkest, with less than 2% of them using it). Analysis of conditional correlations shows that once industrial sector, firm size, degree of informality, location (urban vs rural), having electricity and education of the owner are controlled for, firms owned by men have higher productivity and sales and the difference between older and younger women disappears.

The rest of the paper is organized as follows. Section II presents an overview of the relevant literature. Section III presents an analysis of patterns in the Senegal data relative to similar informal micro-sized firms across eight other sub-Saharan African countries as a group and relative to a nationally representative sample of larger-sized Senegalese firms. To understand the extent and correlates of specific digital divides in Senegal, Section IV presents an analysis of the patterns of adoption and use of DTs and selected general business outcomes—productivity, sales and export outcomes—by exploring the gender and age dimensions of business owners. It presents unconditional means disaggregated by women- versus men-owned informal micro-sized firms, and youth- versus older-aged-entrepreneur-owned micro businesses; it then presents regression analyses conditional on these gender and age dimensions and other correlates of firm performance. Section V presents an analysis of associations between the adoption and use of DTs and jobs-specific business outcomes. Two broad dimensions of jobs outcomes are explored, namely “jobs for more people”, the extent to which there is a positive association between use of specific DTs and firm employment, and “better jobs”, the extent to which there is a positive association between DTs and higher wages and higher per-owner/entrepreneur profits. Again,

the analysis controls for any significant differences between micro-sized firms owned by women and youth relative to those owned by men and older-aged entrepreneurs as well as other correlates of firms' job market performance.

## II. LITERATURE REVIEW

The literature on firms' use of DTs focuses on two general questions. First, what are the drivers of adoption? This body of work as applied to emerging markets so far has largely focused on adoption of broadband internet, mainly through smartphones. There is a broader and important follow-on issue of what specific productive purposes broadband internet is used for, which includes the adoption and use a variety of more specialized DTs enabled by broadband—which this paper seeks to explore in greater detail. Second, what are the economic consequences of adoption on dimensions such as productivity, production, export orientation, employment, and the skills composition of employment? The answer to the first question generally emphasizes two factors: first, the business environment, including policies affecting the degree of competition, and second, firm characteristics, and in particular firm capabilities. For example, using data for 25 industries in 25 European countries and a difference-in-difference methodology, Andrews, Nicoletti and Timilotis (2018) find that both market incentives (for example, administrative burdens on start-ups and barriers to entry in services, both measured from the OECD product market regulation index, and barriers to exit and reallocation, as measured by their employment protection Index) as well as firm capabilities (low managerial quality, lack of ICT skills and poor matching of workers to jobs) explain cross-industry-country variations in adoption of various DTs such as enterprise resource planning and customer relationship management software, and cloud computing.

Regarding the impact of adoption and use, the recent literature has provided much evidence that the adoption of DTs by enterprises generally leads to reductions in various types of costs and frictions (e.g. search, replication, transport and monitoring costs as well as networking and organization costs). These efficiencies, in turn are expected to generate better economic outcomes, including higher productivity, higher sales and/or better and more jobs (Goldfarb and Tucker, 2019). However, the materialization of these economic benefits may require some time as well as complementary investments (Brynjolfsson and McAfee, 2014, Brynjolfsson et. al 2020). There is also evidence that the impact of DTs exhibits heterogeneity across different types of technologies as well as across characteristics of localities. For example, DeStefano et. al. (2019) find that while conditional correlations between broadband adoption and various firm performance variables are positive and significant, there is no causal effect of broadband on plant exit, productivity, sales growth, employment or employment growth. They find weak evidence of impact on sales, but this finding is not robust to variations in the specification of econometric approach. The finding of a positive causal impact of DT adoption on productivity is also not universal. For example, DeStefano et al. (2018) find that DTs causally affect firm size (captured by either sales or employment) but not productivity.<sup>2</sup>

While until recently most research focused on developed countries, a few papers have begun to explore the use of DTs in emerging markets, including in Latin America, Asia and more recently, in Sub-Saharan Africa (SSA). Reporting results from studies on Argentina, Brazil, Chile, Colombia, and Mexico, Dutz, Almeida, and Packard (2018) show that low-skilled workers can also benefit from the more intensive use of the internet due to the output expansion effect from increases in productivity and consequent lower prices: while firm investments in

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<sup>2</sup> Moreover, they also find evidence of larger effects for small as opposed to large firms. Their explanation is that "ADSL broadband provided small and medium sized firms low cost access to internet technologies for the first time allowing them to create websites, develop e-commerce sales and extend their market reach". For productivity, they find a positive correlation in the OLS estimates but that this is no longer significant when correcting for endogeneity bias

information and communication technologies (ICT) capital and firm-level use of faster internet result in a substitution effect whereby some low skilled workers are replaced by the new technology, a sufficiently strong output effect results in a net increase in the use of low skilled labor as well as higher skilled labor. More generally, as long as adoption of DTs expands production volumes and doesn't totally eliminate the need for lower-skilled workers including through new tasks, it results in more jobs over time, including both higher and lower-skilled jobs. The output expansion effect requires sufficient responsiveness of demand to the lower prices, which is more likely in lower-income countries where demand for most products is still far from being satiated and therefore more likely to be highly price-elastic (Bessen 2019); the output expansion effect is additionally facilitated through exports. Iacovone et al. (2016) show that over the period 2008-2012, firms that increase ICT use in Mexico between the years 2008-2012 have higher growth in productivity. They also find that firms that face higher competition and make more intensive use of ICT have a better performance. Fernandes et. al (2019) find that the rollout of internet (captured by the availability of internet interacted with intensity of use) in China increases a firm's likelihood of exporting and its export-output ratio. Further, rollout of internet also results in increases total factor productivity and use of labor. They also find that increased availability and use of online services leads to a higher increase in exports in industries more reliant on an online presence.

More recent work on SSA includes Hjort and Poulsen (2019), who examine the impact of availability of faster internet made possible by the arrival of submarine cables on jobs by skill and education levels in twelve countries. They find that arrival of fast internet causes an overall increase in the probability of holding a job as well as an increase in the probability that an individual will hold a skilled job. The probability of holding an unskilled job does not decrease. Most important, an examination of the impact of faster internet arrival on workers by educational attainment rather than by job categories highlights that the estimated increase in the employment rate is of comparable magnitude for those with primary school, secondary school, and tertiary education in all samples studied. Cusolito and Pena (2020) look at correlations between adoption of websites and email on skill composition in manufacturing and services in SSA. They show that DT adoption is correlated with a scale effect for skilled and unskilled labor. For email adoption, they find a skill biased correlation in both manufacturing and service industries. However, for website adoption, there is a skilled biased correlation in manufacturing and a bias towards unskilled workers in services. For larger firms with five full-time employees or more in Senegal, Cirera, Comin, Cruz and Lee (2020) find that, on average, those that have adopted more sophisticated levels of technologies have higher levels of labor productivity, generate more jobs, and increase the share of unskilled workers in their payroll. Interestingly, the uses of internal-to-the-firm DTs for business administration, production planning and quality control have an association with higher average jobs growth than the uses of external-to-the-firm DTs for upstream sourcing and for downstream marketing, sales and payment methods, partly no doubt because the latter require a more widespread ecosystem of adoption to be effective, including other upstream firms and downstream firms and individuals as users.

Few studies explicitly focus on micro-sized informal firms in SSA. Bahia et. al (2020) investigate the causal effect of increases in broadband coverage on household consumption and poverty in Nigeria, using three waves of nationally representative longitudinal household surveys on living standards and detailed information on deployment of mobile broadband between 2010 and 2016. They find large and positive impacts on household consumption as well as a reduction in the poverty headcount. The main channel is an increase in labor force participation and wage employment, and not through an increase in self-employment jobs. The impact is larger for households who are initially poorer. They also find that the impact is significant and positive for rural households, but not significant for urban households. This finding suggests that informal labor demand by enterprises in rural areas was especially positively affected by increases in broadband coverage.



In their study on the consequences of using mobile phones on the performance of informal firms in Dakar, Berrou et. al. (2020) find that results depend on the characteristics of the firms and entrepreneurs. Specifically, they find that digital small business entrepreneurs (consisting of the largest size and entrepreneurs who are older, more educated and have more experience) have more revenues than the disconnected own-account entrepreneurs (consisting of largely uneducated self-employed owners with no employees, and firms having no registration). While the former generally have smartphones and use the internet for marketing and selling, the latter generally have only a feature phone and have minimal use of the internet for business purposes. Using data from Living Standards Measurement Study-Integrated Surveys on Agriculture data sets for Ethiopia, Malawi, Niger, Nigeria, Tanzania and Uganda, Hounghbonon et. al. (2020) show that access to high speed internet increases the probability that a household operates a non-farm enterprise. More detailed analysis shows that this effect is relevant in services but not in agribusiness or manufacturing.

Beyond these studies, evidence on the incidence, adoption and impact of DTs among micro-sized firms in general and especially among micro firms in SSA is still relatively scarce. This is unfortunate from a policy perspective, as micro enterprises are economically important in SSA, including in Senegal. According to the most recent 2016 enterprise census, 94 percent of all plants in Senegal have less than 5 full-time employees, and they account for over half of total employment (52%). And almost all of these firms are categorized as informal according to the ANSD definition: 92.8 percent of all plants and 51.2 percent of all workers.<sup>3</sup> In the broader SSA context, micro-sized firms acquire an additional importance as it is generally believed that small-scale entrepreneurial activities provide livelihoods to a large proportion of the youth population and that entrepreneurship may provide an important policy area to handle the problem of youth unemployment.<sup>4</sup> Given that the age profiles of SSA countries are tilted towards the young and given the critical challenge of reducing youth unemployment, information on the age, productivity and employment characteristics of micro-enterprises is needed to help provide data-based guidance to policy. In addition, micro-enterprises are generally located in areas where poor people are relatively more concentrated. Hence evidence on the incidence of DTs by micro-sized firms and how they are associated with various measures of performance may provide important information to policy makers in designing policies to address issues of entrepreneurship, productivity and employment.

### III. DATA

#### 3.1 Senegalese firms relative to other Sub-Saharan African countries and to larger firms

The Senegal findings are based on the analysis of a Business Survey compiled by Research ICT Africa (RIA) in 2017-18. The survey was administered in Ghana, Nigeria and Senegal in western Sub-Saharan Africa (SSA), Kenya, Rwanda, Tanzania and Uganda in eastern SSA, and Mozambique and South Africa in southern SSA. The focus of the survey is informal micro-sized businesses.<sup>5</sup> Of the 517 firms that answered the survey in Senegal,

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<sup>3</sup> See Cruz, Dutz and Rodriguez-Castelan (2021), based on ANSD (2017). ANSD, Senegal's National Agency for Statistics and Demography, classifies formal firms as those that have a formal accounting system according to SYSCOA (West African Accounting System) standards or an alternate formal harmonized accounting system. Of the 407,882 economic units in the 2016 census, 395,665 or 97% are classified as informal according to this definition.

<sup>4</sup> For the promise of micro-entrepreneurship for the youth and the challenges it faces see, for example, the discussion in GEM (2015) and UNDP (2018).

<sup>5</sup> Because RIA did not have independent information on the distribution of informal firms, sampling for the business survey was done in parallel to the sampling for the RIA household survey examined in Atiyas and Dođanođlu (2020). Specifically, the national census sample frames were split into urban and rural Enumerator Areas (EAs). Then EAs were sampled for each stratum using probability proportional to size. For each EA, two listings were compiled, one for households and one for firms; these listings served as the sampling frames. 24 households and 10 firms were selected randomly from each EA. See Mothobi et al. (2020) for a descriptive analysis of these data.

over 90% are not fully formal in the sense that they do not have all four indicators of formality, namely being registered with any local authority or municipality, being registered with the national revenue authority, paying local or municipal taxes (tax stamps), and being registered for national VAT or sales tax: more specifically, 56% are fully informal in the sense that they have none of these indicators of formality, 37% are semi-formal, namely they have from one to three of these indicators, while only 7% are formal.<sup>6</sup>

**Table 1: Characteristics of RIA and FAT firms – sectoral distribution, size and age**

	Sample sector shares (%)			Firm size (FT workers)			Firm age (years)		
	RIA-Sen	RIA-SSA	FAT	RIA-Sen	RIA-SSA	FAT	RIA-Sen	RIA-SSA	FAT
ALL FIRMS [total no of firms]	[517]	[3 889]	[1 786]	1.3 (0)	0.7 (0)	29.0 (6)	8.0 (6)	10.1 (7)	16.9 (14)
Agriculture	13	10	11	0.7 (0)	0.8 (0)	39.2 (7)	8.4 (6)	12.9 (8)	20.5 (19)
Manufacturing	3	5	38	2.0 (1)	1.3 (0)	35.1 (7)	7.1 (5)	12.8 (9)	15.9 (14)
Trade (wholesale/retail)	57	63	21	0.8 (0)	0.5 (0)	19.1 (6)	7.9 (6)	9.7 (6)	16.8 (14)
Other services	27	22	30	2.6 (1)	1.1 (0)	24.3 (10)	8.5 (6)	10.5 (7)	17.1 (14)

Note: The table reports totals, shares and means based on unweighted data; medians are reported in parentheses. RIA-SSA covers the other eight SSA countries. FAT covers the 2019-20 Senegal Firm-level Adoption of Technology survey. Square brackets contain the total number of firms in each of the samples. Sample sector shares for RIA firms are based on a larger total number of responses, as firms are not asked their primary activity but rather separately whether they produce agricultural products, manufacturing products, whether they trade or sell goods, and whether they are providing another service (with a total of 603 responses for Senegal, 4,321 for non-Senegal SSA).

To gain general insights about Senegalese micro-sized firms, this sub-section compares Senegal RIA firms with the comparable group of eight other SSA countries' RIA firms and with those larger businesses in the new "Firm-level Adoption of Technology" (FAT) survey implemented in Senegal (Cruz et. al. 2020).<sup>7</sup> The firms in the RIA business survey across all SSA countries are much smaller in terms of number of full-time paid employees than those in the FAT survey: the average number of employees is 1 and the median firm is almost always a self-employed household enterprise with no full-time employees across all RIA survey countries and sectors, while the FAT survey covers firms with at least 5 employees and the average number of employees is 29 (Table 1). In the Senegal RIA sample, over 95 percent of firms are micro-sized, employing five or fewer full-time employees: 52 percent of firms are self-employed firms with no employees,<sup>8</sup> 33 percent employ one or two full-time employees, a further 11 percent employ three to five full-time employees, and only 4 percent of firms (or 20 firms) employ more than five employees.<sup>9</sup> The sectoral composition is also very different: 57 percent of RIA firms are involved in trade activities (primarily retail, also wholesale), while only 21 percent of Senegalese FAT firms are in trade; conversely, the largest share of FAT firms are in manufacturing (with a focus on food processing and wearing apparel). The RIA firms are also younger: the average age of Senegalese micro-sized firms is 8 years (it is 10 for the rest of SSA), while it is 17 for Senegalese FAT firms. Both samples are representative based on their strata of focus.<sup>10</sup>

<sup>6</sup> The corresponding numbers across all 9 countries are similar: 56% fully informal, 35% semi-formal, and 7% formal (2% of firms did not reply to these questions). The questionnaire does not ask about the formality status of workers, namely if firms are complying with social protection responsibilities for their workers regarding health, social security and pension benefits.

<sup>7</sup> The authors are grateful to Marcio Cruz and Kyungmin Lee for generating the comparative statistics for FAT firms.

<sup>8</sup> Of these 268 firms with no full-time employee, 60 or 22% have unpaid family members, so can justifiably be called household enterprises.

<sup>9</sup> There was one observation with 800 full-time employees, the next largest number being 60. This was treated as an error and the number of full-time employees for this firm was treated as missing.

<sup>10</sup> The RIA and FAT data contain sampling weights, yielding nationally-representative data for FAT and EA-level representative data for RIA. These are included in the subsequent descriptive regression analyses wherever appropriate. As clarified for instance by Cameron and

Managers of RIA firms in Senegal are less educated than those in other SSA countries as well as those of FAT firms: the manager of the median Senegalese RIA firm has no formal education while the median manager in RIA firms in other SSA countries has primary education and 9 years of education in the larger Senegalese FAT trade sector firms, and tertiary (bachelors level) education in other services (Table 2). The share of firms with women owners is lower in Senegal RIA firms than in other SSA countries except for agriculture, likely driven by the larger number of household agriculture firms owned by women in Senegal; the share of women owners is higher in the Senegal micro-sized firms than the larger FAT firms, except for other services. Finally, a larger share of RIA firms in Senegal have electricity compared to non-Senegal SSA firms, but a smaller share relative to the larger FAT firms.

**Table 2: Characteristics of RIA and FAT firms – manager's education, owner's gender and electricity**

	Manager's education (years)			Firms with female owner (%)			Firms with electricity (%)		
	RIA-Sen	RIA-SSA	FAT	RIA-Sen	RIA-SSA	FAT	RIA-Sen	RIA-SSA	FAT
ALL FIRMS	4.8 (0)	7.4 (6)	10.7 (6)	35	51	28	64	54	82
Agriculture	5.2 (0)	7.1 (6)	8.1 (6)	56	50	43	34	28	35
Manufacturing	4.7 (6)	7.5 (6)	9.0 (6)	29	39	20	76	47	92
Trade	5.0 (0)	7.0 (6)	11.6 (9)	34	54	33	64	53	86
Other services	4.4 (0)	8.5 (6)	13.1 (16)	28	43	31	80	71	85

Note: The table reports means and shares based on unweighted data; medians are reported in parentheses. Manager's education is measured in years based on: "What is the highest level of education of the business manager?" The coding is as follows: "None" =0, Primary=6, "Secondary"=13, "Tertiary: Diploma /Certificate"=15, "Tertiary: Bachelors"=16, "Tertiary: Masters"=19 (owner's education is not available in FAT). Firms with electricity are based on a yes/no answer to "Does the business premises have electricity?"

Table 3 presents evidence on the extent of access to internet through smartphones, use of internet/social media for general business purposes, and two more specialized uses of internet, namely better understanding customers (marketing) and selling goods or services on-line through e-commerce.<sup>11</sup> Smartphone use among RIA firms in Senegal (16% of firms) is four times higher than among RIA firms in other SSA countries (4%).<sup>12</sup> On the other hand, and not unexpectedly, smartphone usage rates are lower for RIA firms compared to FAT firms in Senegal: roughly twice the share of larger FAT firms use a smartphone (31%) than the smaller informal RIA firms. For Senegal RIA firms, the shares of firms that use internet/social media for business purposes are almost identical to the shares of firms having a smartphone, with the instances where social media usage is higher than smartphone usage due to alternative internet access available through public internet (for example an internet café), a fixed broadband connection, or a friend's smartphone.<sup>13</sup> Use of internet/social media for business purposes is consistently higher in Senegal than in other SSA countries, in line with higher smartphone usage.

Trivedi (2005), "If one takes a structural approach and assumes that the model of  $E[y|x]$  is correctly specified, there is no need to use sample weights. Results can be used to analyze effects of changes in  $x$  on  $E[y|x]$ . If one instead takes a descriptive or data summary approach then weights should be used. Regression is then interpreted as estimating census coefficients... Here using sample weights in OLS regression is appropriate to permit estimates to be interpreted as measuring associations in the population, rather than merely those in a possibly unrepresentative sample. Even though no causal interpretation is possible, these estimates can be useful as they do measure how dependent variables vary across sub-groups of specific explanatory variables after controlling for some other key socioeconomic variables. After all, a major goal of statistics is data summary" (pp 820-21).

<sup>11</sup> See Cirera, Cruz and Comin (2020) on the distinctions between general and sector-specific business functions, and the uses of different DTs and other technologies to improve the productivity of these functions.

<sup>12</sup> Understanding why the adoption of smartphones is so much higher in Senegal relative to other RIA SSA countries is the subject of ongoing research taking advantage of country-by-country data from the other RIA SSA countries complemented by other country-level indicators.

<sup>13</sup> Of the 93 Senegalese micro-sized businesses who have internet access, 84 report doing so through a smartphone, 23 have a fixed broadband (ADSL or fiber) connection, 13 use a public connection, and 26 also use "other" (including through a friend's smartphone).

Interestingly, use of social media is higher among RIA than FAT firms in Senegal in agriculture, manufacturing and other services though it is lower in trade, where most micro-sized firms are operating.

**Table 3: Uses of comparable DTs across RIA and FAT firms by sector**

	Using smartphone			Using internet/social media			Understanding customers			Using e-commerce		
	RIA-Sen	RIA-SSA	FAT	RIA-Sen	RIA-SSA	FAT	RIA-Sen	RIA-SSA	FAT	RIA-Sen	RIA-SSA	FAT
ALL FIRMS	16	4	31	18	7	21	12	4	38	7	1	15
Agriculture	8	2	16	9	3	5	4	2	13	3	0	4
Manufacturing	29	6	36	29	9	23	24	7	49	18	2	17
Trade	12	3	32	13	4	18	8	3	34	6	1	15
Other services	32	8	29	35	15	27	24	11	37	12	2	17

Note: All responses are shares (%) of firms responding based on unweighted data. In RIA, smartphone adopters are identified as those respondents who answer “yes” to the question: “How does the business access the internet: Mobile broadband (3G/4G, wireless).” In FAT, smartphone usage was asked in the computer coverage part of the questionnaire through the question “How many tablets or smartphones does this establishment use for business purposes?” RIA firms that use social media are those that respond “yes” to the question “are you using internet/social media for business purposes?”, with a zero response indicating no use. In FAT, social media usage was asked in the internet service and coverage part of the questionnaire via “At the present time, does this establishment use an account on an online social media for business purposes?” Understanding customers for RIA is an “agree” (as opposed to “not sure” or “disagree”) response to the question “Regarding the internet/social media use, it helps to understand our customers better”. For FAT firms, use of internet to understand customers was asked in the marketing and product development business function part of the questionnaire, and includes separate responses to the use of (i) online chat, (ii) CRM or equivalent specialized software, and (iii) ML algorithms with big data. Finally, RIA firms that use “e-commerce” are those that respond yes to the question: “What do you use the internet for: e-commerce (selling products and services online)”. For FAT firms, using e-commerce includes separate responses to the use of the following sales methods: (i) sales through social media platforms or apps, (ii) online sales through digital platforms such as Amazon or Alibaba, (iii) online sales through the business’ own platform, and (iv) e-orders integrated to specialized supply chain management systems.

The use of internet to better understand customers is a more specialized DT usage for marketing purposes, to expand existing markets and build new ones; it is almost as common as using social media for more general, unspecified business purposes among Senegalese micro-sized firms. It is again much more common in Senegal than in other SSA countries. Interestingly, it is more common in larger FAT firms than the more generic use of smartphones or the use of internet/social media for business purposes on average and across most sectors (except for smartphone use in agriculture). This is no doubt due to the broader use of different types of DTs for understanding customers: in addition to social media (online chat such as WhatsApp) for collecting and analyzing information about customers for marketing purposes and product development, a number of the larger FAT firms also use more specialized Customer Relationship Management (CRM) software and some even use machine learning algorithms with big data. Finally, the use of e-commerce, a more specific DT usage for online sales typically requiring internet, is also much more frequent in RIA firms in Senegal relative to other SSA countries. Usage of e-commerce among micro-sized RIA firms is typically lower than usage by the larger FAT firms in Senegal, except for agriculture and manufacturing where usage frequency is almost identical. Using e-commerce for sales is less common than the use of internet (and more specialized software) for understanding customers across all sectors for both RIA and FAT firms.

Table 4 compares selected general business outcomes of RIA firms with Senegal FAT firms—labor productivity, exporting, and total profits. RIA firms in Senegal are less productive on average than those in the rest of the SSA region (measured as monthly value added divided by the sum of full-time workers and the number of owners, in US dollars). This is the case across all sectors except manufacturing, and particularly so in agriculture. The smaller firms in the Senegal RIA data have lower labor productivity than FAT firms, except for agriculture, where productivity is the same, and manufacturing, where it is higher for RIA firms; these are surprising findings, with

manufacturing productivity in both Senegalese and non-Senegal SSA RIA firms higher than in the larger FAT firms.

**Table 4: Selected general business outcomes of RIA and FAT firms**

	Labor productivity			Exporting			Total profits		
	RIA-Sen	RIA-SSA	FAT	RIA-Sen	RIA-SSA	FAT	RIA-Sen	RIA-SSA	FAT
ALL FIRMS	564	761	663	9	4	18	1 579	1 279	47 996
Agriculture	266	626	168	4	5	8	1 010	3 014	50 115
Manufacturing	828	627	405	24	4	25	5 090	1 630	46 127
Trade	668	851	984	6	4	18	1 298	1 301	70 338
Other services	492	640	1 076	16	5	13	2 351	922	33 745

Note: All values are based on unweighted data. Labor productivity is measured as value added (total sales minus raw materials & intermediate inputs plus water & electricity used in production) divided by the sum of full-time workers and the number of owners. Exporting reflects shares of firms active in each sectoral area that report having international customers or non-zero exports (in RIA, in response to the yes/no question “Does the business have customers located in other countries (selling goods or services abroad)?” Profits is measured as value added minus salary & wages. Labor productivity and profits values are monthly (based on expenses in a typical month) and in US dollars (to allow comparison across SSA countries).

A higher share of RIA Senegal firms export than comparable SSA firms, on average (9 percent versus 4 percent) and across all sectors except agriculture. Senegalese micro-sized firms are particularly likely to export in the manufacturing sector, with 22 percent of manufacturing firms exporting, more than five times the share in the rest of SSA, and 17 percent of firms active in (non-trade) services exporting, more than three times the share in the rest of SSA.<sup>14</sup> Strikingly, roughly the same share of Senegalese micro-sized manufacturing firms export as larger FAT firms, with this share being actually larger for other (non-trade) services. A more detailed examination of the 56 sectoral activities sold to customers located in other countries by the 46 Senegal RIA exporting firms reveals that the 3 agricultural exporters involve cereals and coffee, the 4 manufacturing exporters involve school materials, metal and wood fabrication, the 22 traders are sellers ranging from food, fabrics, shoes, cosmetics to tires and cars, and the 27 non-retail service exporters range from fashion-related services (sewing, embroidery and tailor services), to car repair and delivery services and also include 3 small hotels. Overall, it is striking how many Senegalese micro-sized firms export—indicating possible competitiveness advantages that could be built upon.

Finally, RIA firms in Senegal have higher total profits than similar firms in other SSA countries (measured as monthly value added minus salary and wages, also in US dollars), except for agriculture; the latter is linked no doubt to the much lower agriculture productivity numbers in Senegal. RIA firms have much lower profits than the larger FAT firms, with average profit differences between the smaller RIA firms and the larger FAT firms ranging between roughly 13 times (for manufacturing) and 76 times (for agriculture). It is striking that agriculture has the highest average profitability across informal micro-sized firms in the other SSA countries, and the second-highest average profitability for larger FAT firms, but the lowest average profitability (and average productivity) for Senegalese micro firms.

**3.2 Senegalese micro-sized firms by age and gender of owner**

To understand the extent and correlates of digital divides in Senegal, this sub-section explores in greater detail the patterns of firm characteristics, firm assets, uses of DTs, and business outcomes between youth- versus

<sup>14</sup> It is important to note that 22% of manufacturing firms only accounts for 4 of the 18 firms that are manufacturing products in the sample.

older-aged-micro-entrepreneur-owned and women- versus men-owned informal micro-sized firms.<sup>15</sup> Since there is no need to constrain or adjust for similar but not exactly-worded questions posed across RIA and FAT surveys, this sub-section and the rest of the paper take advantage of the rich set of questions posed in the RIA survey.

**Table 5: Firm characteristics by age and gender**

	No of firm-activities	Agri	Manuf	Trade	Other services	Have electricity	Urban	Fully informal
ALL	603	79	17	342	165	68.5	65.7	53.2
youth	180	19	5	90	66	71.3	75.8	40.1
older	413	60	12	246	95	66.7	61.1	60.2
women	211	44	5	116	46	49.4	62.0	65.8
men	392	35	12	226	119	78.7	67.7	46.5
younger women	67	8	3	33	23	52.8	70.8	50.0
older women	139	36	2	80	21	46.0	56.4	72.0
younger men	113	11	2	57	43	82.0	78.7	34.5
older men	274	24	10	166	74	77.3	63.5	52.4

Note: The table reports the number of firms active in each sectoral activity based on unweighted data, and the shares of all firms within each category having electricity, being in urban locations, and being fully informal based on weighted data. Youth are owners that are aged 30 years or younger (9 firms across 10 firm-activities did not report the owner's age, with the convention that the owner's age is the age of the youngest owner if there are multiple owners, so there is a downward bias inherent in the owner's age variable).

Table 5 presents a description of the sectoral areas of economic activity of youth and women entrepreneurs relative to older and men entrepreneurs in the underlying unweighted data, as well as the shares of firms having electricity, being in urban locations, and being fully informal based on weighted data, again broken down by these age and gender dimensions. Youth-owned firms are those whose youngest owner (if multiple) is aged 30 years or younger. The first part of table disaggregates the numbers underlying the sectoral shares in Table 1. Since businesses can indicate more than one area of activity, Table 5 includes multi-sectoral businesses in whatever sectors they are active—for instance the operator of a small petrol station (trade) also being a mobile money agent (other services), or a household enterprise producing vegetables (agriculture) also trading and selling fresh produce as a street vendor (trade). Of the 515 businesses responding to this question, 74 firms report being in two broad sectors of activities, with the most common combinations being trade and other services (39 firms) and agriculture and trade (27 firms).<sup>16</sup>

All owner types are most likely to be active in retail or wholesale trade, given that 57 percent of all businesses in the sample are active in this sector (Table 1). Relative to older-owned businesses, youth-owned micro-entrepreneurs are more active in other services (41% or 66/(66+95) versus less than 30% in the other sectors); older entrepreneurs are relatively more active in agriculture (76% (60/79) versus 73% or less in the other sectors). Relative to men-owned businesses, women-owned enterprises are more likely to be farms (56% versus less than 35% in the other sectors); firms in all other sectors are more likely to be owned by men. While it is much more likely for older women than any of these other owner categories to be active in agriculture, younger

<sup>15</sup> The only gender-related variable in the RIA data is the gender of the owners of these businesses. While an age variable is available for both the owner (or youngest owner if more than one) and the manager (or youngest manager if more than one), this analysis uses the age of the owner to be consistent with the available gender variable. Youth business owners are defined as those aged 30 or less. They account for 30 percent of all businesses.

<sup>16</sup> Four firms are active in 3 of the 4 sectors, while one firm is active across all 4 sectors.

women are more likely to own businesses in manufacturing and other services, relative to other owners of these sectors (18% of manufacturing businesses and 14% of other services, versus 10% of agriculture and trade businesses)—recalling that relative to other sectors, young women are still most likely to be owners of retail or wholesale trading businesses. The data suggests that businesses owned by older women are disproportionately farms in more remote rural areas possibly with less infrastructure.

As reported in the second half of Table 5, there are not significant differences comparing youth-owned to older-owned businesses in terms of having electricity, with both relatively close to the sample average of 69 percent. However, women-owned businesses on average are significantly less likely to have electricity than men-owned firms. In line with this electricity gender divide, the starkest difference across age and gender dimensions is between younger men-owned businesses, with 82 percent having electricity, and older women-owned businesses, with less than 50 percent having power. So women-owned firms are more likely to be constrained, to the extent that having electricity is an important correlate of adopting smartphones and using more specialized DTs. Regarding business location, there is a larger difference between youth and older-owned firms than between women and men-owned firms, with a higher share of older-owned firms in rural locations relative to youth-owned firms: over three quarters of youth-owned firms are in urban locations. So older-owned firms are more likely to be constrained, to the extent that being in a rural location makes affordable access to the internet as well other infrastructure elements such as electricity more problematic. Finally, in terms of formality status, there is again a similar pattern, with older-owned firms and women-owned firms being more likely to be fully informal (60 relative to 40% for age, and 66 relative to 47% for gender). Again, the starkest difference is between younger men-owned firms, with only 35 percent being fully informal, versus older women-owned firms, with more than double that share, namely 72 percent, being fully informal. So older women-owned enterprises are again more likely to be constrained regarding performance outcomes by their formality status, to the extent that firms that are fully informal on average exhibit poorer performance, not being able to take advantage of possible capability-upgrading benefits including financing offered to semi-formal and fully formal firms.

Table 6 presents available variables related to the aptitudes and capabilities of the business owners, as well as their available soft assets. It again presents a breakdown of unconditional means disaggregated by the age and gender dimensions of these variables. Regarding aptitudes of the business owners, whether the owner is a “transformational” entrepreneur is a proxy for their inherent aptitude for productive entrepreneurship; this corresponds to owners selecting themselves as entrepreneurs due to the profit-making opportunity that owning a business provides as opposed to a necessity or subsistence choice to supplement earnings or because there is no preferred wage job available. The number of years of formal schooling and whether the owner holds any vocational training certificates are proxies for the capabilities of the owner. Regarding the firm’s available soft assets, whether the firm ever had a business loan from a bank and whether it has a line of credit or credit facility from any supplier are indicators reflecting access to financing. And whether the firm has large formal businesses as main suppliers, its most important suppliers located abroad, big enterprises as customers, and its most important customers located non-locally are all indicators of soft assets reflecting opportunities of learning from likely more knowledgeable business partners upstream and downstream in the firm’s value chain.

As reported in Table 6, women-owned firms have a lower share of transformational entrepreneurs than men-owned firms, 27 versus 45 percent. Regarding schooling, women owners have more years of schooling than men, with the median firm for both younger and older women-owned firms having six years of schooling (primary schooling completed), while the median firm for both younger and older men-owned firms has no years of schooling. Interestingly, youth entrepreneurs have less formal schooling than older entrepreneurs, both

for women and men: younger men owners in particular have the lowest average level of schooling across age and gender dimensions, at less than 4 years of schooling on average—a stark finding suggesting the need for greater policy attention to human capital formation. On the other hand, young entrepreneurs are more than twice as likely to have vocational training as older entrepreneurs, with a similar magnitude of gap for both women and men.

**Table 6: Firm assets by age and gender**

	Transform.	School	Vocational	Had loan	Supplier credit	Large suppliers	Foreign suppliers	Large buyers	Non-local buyers
ALL FIRMS	38.7	5.3 (0)	15.4	5.7	24.2	13.1	9.1	9.8	10.3
youth	37.7	4.5 (0)	24.3	7.4	33.7	18.7	13.4	12.0	15.6
older	39.1	5.8 (0)	11.4	5.1	20.2	10.9	7.4	8.4	8.1
women	27.3	6.1 (6)	13.3	6.2	18.2	7.8	11.5	4.8	8.0
men	44.7	4.9 (0)	16.4	5.5	27.7	16.2	7.7	12.4	11.5
younger women	25.1	5.9 (6)	22.6	8.8	23.9	14.3	13.2	7.6	12.3
older women	27.2	6.4 (6)	9.2	5.2	16.1	4.9	11.0	2.0	6.2
younger men	44.9	3.7 (0)	25.4	6.7	40.1	21.5	13.5	14.6	17.6
older men	45.1	5.5 (0)	12.6	5.1	22.5	14.1	5.4	11.7	9.1

Note: The table reports shares of all firms within each category based on weighted data, except for the manager’s years of schooling variable which are means, with medians reported in parentheses. Entrepreneurs are labeled “transformational” if they answered “My own business pays more than being employed” to “What was the main reason to start a business for you? while the remaining (subsistence) entrepreneurs answered either “To make additional money to my salary” or “Otherwise I would have been unemployed”. For vocational training, respondents answered yes to “Do business owners have vocational training certificates?” Had loan is in response to “Has the business ever had a business loan from a bank?” Supplier credit is in response to “Does the business have a line of credit/ credit facility with suppliers?” Large suppliers are firms that responded “large formal businesses” to “Who are your main suppliers?” Foreign suppliers are firms that responded “abroad” to “Where are your most important suppliers located? (if more than one response and they are at different locations, take the furthest away),” with the other possible responses being “locally (surrounding towns and villages)” and “from all over the country”. Large buyers are firms that responded “big enterprises” to “Who are your customers?”. Non-local buyers are firms that responded “from all over the country” to “Where are the most important customers of the business located”, with the other possible response being “locally (surrounding towns and villages).”

In terms of financing, it is striking how few firms have received a bank loan: less than 6 percent of all firms, or 30 firms out of 517 based on the nationally weighted sample received a loan.<sup>17</sup> Youth-owned firms are more likely to receive a loan than older-owned firms. Interestingly, women are more likely to have had a bank loan than men, though the difference in means is not statistically significant. However, younger women are almost twice as likely to have had a business loan than older women and older men (9 versus 5%). Having a line of credit or a credit facility from suppliers is more than four times as likely a form of financing as getting a loan from a bank across all firms.<sup>18</sup> Both younger men and younger women are more likely to receive supplier credit than older entrepreneurs (24 relative to 16% for women-owned firms, 40 relative to 23% for men-owned firms).

In terms of relationships with value chain partners, youth-owned firms are more likely to have relationships with all four types of value chain partners than older-age-owned firms. In particular, younger women-owned firms are about three times as likely to have relationships with large suppliers and large buyers than older women-owned firms. Interestingly, while men-owned firms are more likely to have relationships with large suppliers,

<sup>17</sup> Based on the underlying unweighted data, only 5.0% or 26 firms reported ever having received a bank loan.

<sup>18</sup> This is particularly surprising since the loan question refers to ever having had a loan while the supplier credit question is about current ongoing financing.



large buyers and non-local buyers than women-owned firms, women-owned firms are more likely to have relationships with foreign suppliers than men-owned firms.

**Table 7: Uses of DTs by age and gender**

	ACCESS TECHNOLOGIES				EXTERNAL-TO-FIRM TRANSACTIONS									INTERNAL-TO-FIRM		
	Use any mobile	Use s-phone	Use computer	Have website	Upstream and downstream products				Finance	Labor	Government		Management		Workers	
					Look for suppliers	Pay suppliers	Understand customers	Use e-commerce	Receive payments	Use online banking	Recruit workers	Interact w govt	Pay taxes	Accounting software	Inventory / POS s/w	Pay workers
ALL FIRMS	89.4	18.3	9.0	4.6	5.8	25.0	12.8	8.1	25.9	4.1	2.2	1.7	4.2	6.8	5.3	6.1
youth	92.1	27.1	12.0	7.9	10.4	27.7	22.2	11.6	30.6	9.0	3.1	2.2	5.4	10.9	7.5	8.8
older	88.6	14.1	7.9	3.2	3.9	23.8	8.2	6.7	22.9	1.9	1.3	1.5	3.8	5.0	4.4	5.1
women	83.5	15.5	8.3	3.6	5.6	19.9	11.9	6.6	20.3	3.8	2.2	2.0	3.8	7.1	6.4	3.6
men	92.6	19.8	9.4	5.1	5.9	28.7	13.3	8.9	29.0	4.2	2.2	1.6	4.5	6.6	4.7	7.5
younger women	88	27.4	13.1	7.0	9.6	25.7	23.7	9.1	25.0	6.7	3.9	3.0	3.7	13.1	12.4	4.2
older women	82.1	10.1	6.2	2.0	3.8	14.7	6.4	5.6	16.9	2.4	1.5	1.5	4.0	4.4	3.7	3.4
younger men	94.4	26.9	11.4	8.3	10.9	28.8	21.4	13.0	33.8	10.3	2.6	1.7	6.4	9.6	4.6	11.4
older men	91.9	16.2	8.7	3.8	3.9	28.5	9.1	7.3	26.0	1.6	1.2	1.5	3.7	5.4	4.8	5.9

Note: All responses are shares (%) of firms based on weighted data. Use any mobile is in response to “Does the business manager have a mobile?”, irrespective if it is for private, business use or both. Smartphone users answered “yes” to “How does the business access the internet: Mobile broadband (3G/4G, wireless).” Use computer is a non-zero response to “How many computers does your business have?” Website is in response to “Does your business have a website?” Reported answers to “What do you use the internet for?” include “looking for suppliers online”, “e-commerce (selling products and services online)”, “internet/online banking”, “recruitment”, and “interacting with government organizations”. Reported answers to “Does the business use mobile money for...” include “paying suppliers”, “receiving payments from customers”, “paying taxes”, and “paying employees”. Understanding customers is an “agree” (as opposed to “not sure” or “disagree”) response to the question “Regarding the internet/social media use, it helps to understand our customers better”. The management-related questions are “Does your company use accounting software?” and “Does your company make use of inventory control/point of sale (POS) software?” (both asked in the computer section of the questionnaire).

Table 7 reports unconditional means of the use of DTs by businesses for all enterprises and disaggregated by age and gender of firm owners. There are three sets of variables. A first set relates to general access technologies, namely what type of handset the firm has, whether the firm has at least one business mobile phone (irrespective of whether it is a basic 2G phone, a 2.5G featurephone, or a smartphone) and whether the firm accesses the internet via a mobile broadband-enabled smartphone (3G or 4G). It also includes whether the firm uses one or more computers as well as whether the firm has a website—both of these are also access technologies for internet, with websites being a more general DT to access and get the attention of upstream and downstream companies, end-use customers, financial institutions, workers and government, and are often the location for more specialized DTs such as apps for marketing and payment. A second set of variables covers more specialized uses of DTs for external-to-the-firm transactions enabled by the adoption and use of access technologies, largely driven by the lower search costs, cheaper and expanded market coordination, and by the lower transportation costs enabled by these DTs. This includes five uses of DTs for upstream transactions with suppliers and downstream transactions with customers related to product markets: using the internet to look online for suppliers, using mobile money to pay suppliers (which doesn’t require a smartphone), using the internet to better understand customers and for marketing, using e-commerce to sell goods and services online to customers, and using mobile money to receive payments from customers (which again doesn’t require a smartphone). It also includes using online banking for more efficient relationships with financial intermediaries,<sup>19</sup> using the internet to recruit workers in the labor market, using the internet to interact with

<sup>19</sup> There is unfortunately no question on whether the firm has received a loan based on a credit score linked to its digital transaction records (history of its output sales and input purchases), though these digital financial service technologies hold great promise for smaller firms that lack sufficient traditional collateral or resources from family and friends.

government organizations, and using mobile money to pay taxes—with in principle reductions in the time required as well as increased transparency of these transactions. A third set of variables relates to the adoption and more specialized uses of DTs to undertake internal-to-the-firm functions that reduce costs, create efficiencies and allow users to enhance their capabilities. This includes management functions, in particular whether the firm uses accounting software and inventory control/point of sale (POS) software,<sup>20</sup> as well communication and payment transactions with the firm’s workers, through the use of mobile money to pay employees. Whereas DTs facilitating external-to-firm transactions require not only the using firm but the upstream or downstream counterpart for product market transactions, bank, workers and government to be using these digital tools, the advantage of specialized DTs facilitating internal-to-firm transactions linked to business management is that they do not require another external party to also be using these tools for them to be able to yield maximum impact for the user firm; this is not the case for DTs enabling the digital payment of the firm’s workers, as these require the workers also to have a digital device to receive payments.

Regarding access technologies, nine of ten businesses use a mobile phone, including 2G to 4G. Slightly larger shares of youth-owned and men-owned firms use them, slightly lower shares of older-owned and women-owned firms. However, the difference in usage between youth-owned and older-owned firms is much starker regarding smartphones: almost twice the share of youth-owned firms use a smartphone, at 27 relative to 14 percent. While women-owned firms on average are slightly less likely to use a smartphone relative to men-owned firms, the highest share of usage overall are younger women-owned firms, at over 27 percent, not that far from twice the overall share of smartphone users overall. Significantly fewer micro-sized businesses use a computer, with the highest usage share overall again by younger women-owned firms at 13 percent. And even fewer businesses have a website, with the highest share overall by younger men-owned firms at just over 8 percent—no doubt replaced by related uses of social media such as Whatsapp, as highlighted in Table 3 (where usage was at the same levels as smartphone usage).

Regarding the more specialized uses of DTs for product-related transactions with upstream supplier businesses and downstream business buyers and end-use customers, the most commonly-used DTs are using mobile money to pay suppliers and to receive payments from customers, likely because these are the only uses that do not require an internet-enabled smartphone. The other three DT uses are all intermediated through the internet, with the most frequently used to better understand customers for marketing. The pattern by youth-owned relative to older-owned firms is similar across all five DTs with more youth-owned firms using them; the pattern by men-owned relative to women-owned firms is also similar, with more men-owned than women-owned firms using them on average. However, regarding the use of internet for better understanding customers, the highest share of usage overall is again by younger women-owned firms, at almost 24 percent—more than three times the share of older women-owned firms, and more than two-and-a-half times the share of older men-owned firms. Younger women-owned firms also use DTs to look for suppliers and for e-commerce more than the average frequency of usage by men-owned firms.

Regarding the use of DTs for finance, it is striking how few micro firms make use of online banking: only 4 percent of all firms, or 21 firms (on a weighted basis). Youth-owned and men-owned firms are again the largest

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<sup>20</sup> The questions “does your company use accounting software” and “does your company make use of point of sale software/ inventory control software” are asked in the computer module of the questionnaire and only to firms that have responded that they have at least one computer. However, there is nothing in the question that prevents the accounting or POS/inventory control software to be accessed as well on a smartphone instead of on a computer, or even exclusively so.

users relative to older-aged and women owners as aggregate groups.<sup>21</sup> Again, younger women-owned firms use online banking not only more than older women-owned firms but also more than the average frequency of usage by men-owned firms. Regarding transactions between businesses and the labor market to recruit workers, only a small number of firms are taking advantage of the internet for this purpose: only 12 businesses (with weights) use internet to recruit. This is not surprising since internet will only be used by the subset of firms that are not self-employed with no full-time employees, that have access to internet, and only by those firms not relying on informal local contacts, including family members and friends; it also requires a greater number of lower-income households to have access to internet before recruitment will be effective through this medium. Finally, only 9 businesses use internet to interact with government organizations and only 22 businesses use mobile money to pay taxes. This also is not surprising given that 93 percent of firms are informal or semi-formal and therefore are expected to have a lesser inclination to interact with government and to pay taxes; in this light, it is a positive finding for fiscal domestic resource mobilization that 4 percent of these micro-sized firms already pay taxes using mobile money.

Regarding more specialized uses of DTs to undertake internal-to-the-firm functions, a larger share of youth-owned firms use accounting and inventory control/POS software relative to older-owner firms. Strikingly, these two types of management software are the only DTs that are on average used by a higher share of women than men owners (other than the low frequency of firms that use the internet to interact with government). The combination of these two usage patterns results in the highest share of usage overall being by younger women-owned firms relative to all other owner types: three times the share of younger women-owned firms use accounting software than older women-owned firms (13.1 vs 4.4 percent), with men-owned firms at 6.6 percent, and over three times the share of younger women-owned firms use POS/inventory control software than older women-owned firms (12.4 vs 3.7 percent), with men-owned firms at 4.7 percent. Finally, only 32 businesses use mobile money to pay their workers; this low number is again restricted to the subset of firms that are not self-employed with no full-time employees, though it does not require workers to have access to internet as such payments are feasible with only a 2G phone.

**Table 8: Business outcomes by age and gender**

	GENERAL BUSINESS OUTCOMES			JOBS OUTCOMES		
	Labor productivity	Total sales	Exporting	Firm size	Average wages	Entrepreneurial profits
ALL FIRMS	331 982 (90 000)	1 293 909 (200 000)	10.3	2.7 (2)	61 589 (16 667)	906 263 (130 000)
youth	376 616 (85 000)	1 924 819 (250 000)	15.6	3.7 (2)	58 597 (17 500)	1 370 470 (136 667)
older	318 754 (95 000)	1 025 007 (200 000)	8.1	2.3 (1)	66 507 (16 667)	711 017 (125 000)
women	155 181 (50 000)	991 147 (100 000)	8	3.1 (1)	72 509 (11 667)	481 954 (50 000)
men	427 306 (120 000)	1 456 448 (300 000)	11.5	2.6 (2)	57 920 (17 500)	1 134 055 (195 000)
younger women	231 891 (60 000)	1 880 567 (150 000)	12.3	4.7 (2)	21 389 (11 667)	974 282 (63 000)
older women	117 787 (49 000)	553 944 (100 000)	6.2	2.2 (1)	128 310 (13 000)	243 461 (49 000)
younger men	461 473 (113 333)	1 950 401 (360 000)	17.6	3.0 (2)	74 062 (20 000)	1 599 507 (200 000)
older men	421 037 (125 000)	1 264 755 (300 000)	9.1	2.3 (2)	49 750 (16 667)	948 980 (190 000)

Note: Labor productivity is measured as value added (total sales minus raw materials & intermediate inputs plus water & electricity used in production) divided by the sum of full-time workers and the number of owners. The value of total sales is also asked as turnover or “revenues money received by the business”. Exporting reflects shares of firms active that report having international customers or non-zero exports, in response to the yes/no question “Does the business have customers located in other countries (selling goods or services

<sup>21</sup> There are two other related questions in the survey: “Have you used online banking for business?” and “Have you used mobile phone banking for business”, both in the banking section of the questionnaire. The reported question was used since it was posed in the internet section of the questionnaire, in a similar way as questions on suppliers, e-commerce, worker recruitment and interaction with government.

abroad)?” Firm size is the number of full-time employees plus owners. Average wages reflect salary & wages divided by full-time employees. Entrepreneurial profits are measured as value added minus salary & wages, and water & electricity costs. Labor productivity, total sales, average wages and profits are means of monthly values (based on earnings and expenses in a typical month, with total sales based on annual audited statements if available and divided by 12), in local currency (FCFA); medians are reported in parentheses.

Finally, Table 8 presents selected business outcome variables disaggregated by age and gender of the owner. A first set of general business outcomes includes labor productivity (measured as monthly value added divided by the sum of full-time workers and the number of owners), total sales (measured as monthly turnover and proxying as well for the production gains that are enabled by higher productivity)<sup>22</sup> and exporting (measured as the share of firms with customers located in other countries, selling goods or services abroad). In contrast to Table 4, labor productivity is reported in local currency (CFCA) and based on weighted data. A second set of variables focus on jobs-specific outcomes. Two dimensions of jobs outcomes are explored: “jobs for more people”, namely firm size as a proxy for generating more jobs beyond the owner (measured as the number of full-time employees plus owners, namely the number of good jobs created), and “better jobs”, both higher wages (measured as averaged wages of all full-time employees who are paid a salary or wage) as an indicator of better jobs for workers, and higher profits (measured as per-owner profits, with profits measured as value added minus salary and wages and water and electricity costs for the RIA-specific analyses) as an indicator of better jobs for entrepreneurs.

In terms of general business outcomes, enterprises owned by younger entrepreneurs and owned by men are on average more productive. Businesses owned by younger women are on average more productive than those owned by older women; the same relationship holds for men. In terms of total sales, businesses owned by young entrepreneurs and by men on average generate more sales revenues than those owned by older entrepreneurs and by women, aligned with the productivity pattern. In line with youth-owned businesses generating more sales, the enterprises owned by both younger women and men on average generate more sales than their older counterparts. Interestingly, younger-women-owned businesses generate more sales not only than older women-owned businesses but also than older men-owned businesses. While younger women-owned businesses on average generate almost as much sales revenues as younger men-owned firms, older women-owned businesses generate significantly fewer sales, less than a third of the level of younger women-owned firms. Finally, exporting as an outcome variable aligns relatively closely with productivity and sales: youth-owned and men-owned businesses are more likely to export than older-owned and women-owned ones, with the businesses owned by both younger women and men more likely to export than their older counterparts. Younger women-owned businesses are also more likely to export not only than older women-owned businesses but also than older men-owned ones. Notably, dispersion is generally high in these performance variables. Hence the only difference in means of all these comparisons that is statistically significantly different from zero at the 1% level is the labor productivity of women- vs men-owned firms. The difference in exporting between youth and older owners, the difference in the productivity between younger female and older men and the difference in sales between older and younger women are statistically different from zero only at the 10% level.

In terms of jobs-related outcomes, youth-owned enterprises are likely to be larger (employing on average almost 3 people, with the median firm employing 2 people) than older-owned enterprises (employing on average just over 2 people, with the median firm a self-employed business with only the owner and no full-time

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<sup>22</sup> In terms of total sales as a proxy for production, differences across firms also will include differences due to differential quality and levels of mark-ups (reflecting differences in market power), as well as changes in inventories of final products (in response to changes in market demand for products produced).

employees). This pattern holds for both younger women-owned and younger men-owned firms, with both generating jobs for more people on average than their older counterparts. So youth-owned firms are less likely to be constrained by size, to the extent that the smallest zero-employee businesses are likely to be less productive and generate fewer sales. Interestingly, women-owned enterprises as a group are larger and create jobs for more people than men-owned businesses, driving up their average relative to the median, largely due to younger women-owned firms. The average size of women-owned firms is over 3 people (relative to about 2 ½ people for men-owned firms) even though the median woman-owned firm is a self-employed business with no full-time employees; the women group average is driven up by the average 5 person size of young women-owned firms, the largest size of all the age-gender groups.

The patterns of wages and per-owner profits across age and gender dimensions reflect how average labor productivity translates into total sales revenues, and in turn—after covering other costs—is jointly shared between full-time workers and owners: the higher average productivity of younger men-owned firms is associated with higher total sales, including both domestic sales as well as a higher share of exporting firms, slightly larger firm sizes in terms of employment than the average across all firms, and higher incomes especially for business owners.<sup>23</sup> The monthly wage figures highlight that the wage paid by the median firm across all businesses is significantly below the moderate poverty line of 27,787 FCFA. Strikingly, the wage paid by the median woman-owned firm is below the extreme poverty line: at least 50 percent of those women-owned businesses that hire one full-time employee or more do not enable their employees to earn sufficient income to rise above the extreme poverty line, without supplementing these wage payments with other income sources.<sup>24</sup> On the other hand, the better-paying firms pull the average up, so that the mean wage paid across all age and gender groups is above the moderate poverty line for all businesses except those owned by younger women. Surprisingly, while the lowest median wage is paid by older women-owned businesses, this group also pays the highest average wage of all age and gender groups.<sup>25</sup> It is remarkable how much higher the income levels are accruing to owners: the biggest differential is for younger women-owned businesses, where owners earn on average 45 times the income of full-time workers, while the smallest differential is for older women-owned businesses, where owners earn on average less than twice what full-time workers do. So entrepreneurial firms generate sufficient profits on average to support the well-being of their owners. How these outcomes—including the translation of productivity into higher production as proxied by sales, and into more jobs and higher incomes for both workers and owners—are affected by business use of different types of digital technologies is the focus of the next two sections.

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<sup>23</sup> Of all the selected business outcome variables, average wages are reported only for the subset of businesses with one full-time employee or more, and not for any of the self-employed businesses with no employees—so it is important when comparing labor productivity, total sales, exporting and firm size to take into account how incomes are jointly shared between workers and owners.

<sup>24</sup> The annual national poverty line per person according to the 2018-19 household survey is set at 333,440.5 FCFA while the extreme poverty line is set at 186,869 FCFA. Converted to monthly levels, the respective moderate and extreme poverty lines are 27,787 FCFA and 15,572 FCFA. Since the RIA survey was implemented in fall 2018, no deflation or inflation of these latest poverty lines by the annual CPI is required.

<sup>25</sup> Since there are only 32 older women-owned firms in the weighted sample reporting paying wages (vs 27 younger women-owned firms, 69 younger men-owned firms and 114 older men-owned firms reporting paying wages), it is not that unusual for a few higher-paying firms to pull up the average.

## IV. ADOPTION OF SMARTPHONES AND GENERAL BUSINESS OUTCOMES FROM DT USES

### 4.1 Adoption of smartphones

This sub-section presents findings on correlates of smartphone adoption, the main access technology for internet and enabler of adoption and use of more specialized and productive DTs. Table 9 presents marginal effects from probit regressions exploring the correlates of smartphone adoption—including any significant conditional associations with youth-owned and women-owned firms. The analysis is in three parts: a basic model exploring individual variables as correlates of adoption; two models with additional interacted terms for youth and for women included separately; and a final model including interacted terms for both youth and women. Only variables that are statistically significant at the 10 percent level in at least one of the models are reported.

**Table 9: Conditional correlates of mobile broadband adoption by age and gender**

	Adopt smartphone			
	Basic	Youth	Women	Both
Having electricity	0.19***	0.20***	0.22***	0.22***
Vocational training	0.07*	0.12**	0.13***	0.17***
Schooling	0.004	0.006*	0.0005	0.003
Urban	0.09**	0.09**	0.08**	0.09**
Informal	-0.06	-0.06	-0.07*	-0.08*
Loan	0.23***	0.29***	0.20**	0.25***
Other services	0.13***	0.13***	0.14***	0.14***
Youth-owned	0.05	0.09	0.05	0.10
Women-owned	0.02	0.03	0.01	-0.01
Women*vocational			-0.22***	-0.20**
Women*schooling			0.12**	0.01**

Note: Results of probit regressions (with marginal effects reported), based on weighted data: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Coefficients of youth- and women-owned firms are reported even though they are not significant in any of the specifications since interactive terms are sometimes significant. Additional control variables included in the regressions that are not statistically significant at the 10% level include: transformational entrepreneurship (and interacted with youth and women), youth and women interacted with having a loan, youth interacted with vocational training and schooling, firm sizes (large (3+ employees) and mid-sized (1-2 employees) relative to self-employed with no full-time employees), and manufacturing and trade (relative to firms in the agriculture sector).

Across the four models, having electricity, having vocational training (business owners having vocational training certificates), being in an urban location (relative to a rural location) and being active in other (non-trade) services (relative to agriculture) are all statistically significantly associated with a higher probability of smartphone adoption. Critically, whether the firm had a loan is statistically significant across all models and is the most important correlate of smartphone adoption in terms of magnitude across three of the four models. In the underlying data, having a loan is strongly correlated with firm size, and its inclusion likely is linked to firm size not being statistically significant as an independent explanatory variable in these adoption models.<sup>26</sup> It is interesting that even though being a youth-owned business is positively associated with smartphone use on the basis of unconditional correlations (with almost twice the share of youth-owned businesses using a smartphone

<sup>26</sup> While 3 of 7 or 43% of larger firms (10 or more full-time employees) reported having a loan based on the underlying unweighted data, the corresponding ratios for mid-sized (6 to 9 employees), small (3 to 5 employees), micro (1 or 2 employees) and household enterprises (zero employees) are 15%, 11%, 6% and 2%; only 5 of the 268 zero-employee firms received a loan. A simple OLS regression of employment (defined as number of full-time workers plus the number of owners) on a dummy variable that reflects firms that have a loan shows that firms with loans have on average 4 more working people than those that do not.

relative to older-owned firms, 27 relative to 14%, as reported in Table 7), age is not a statistically significant conditional correlate of smartphone adoption once additional controls are introduced.

In the model with the addition of variables interacted with youth-owned businesses, there are no interactive terms that are statistically significantly associated with smartphone adoption. However, in the models with the addition of interactive terms with women-owned businesses and interactive terms with both youth-owned and women-owned businesses, both years of schooling and having vocational training are statistically significant. While schooling does not have a statistically significant association with increasing the likelihood of adoption across the population, it is a positive inducement for women. On the other hand, while vocational training increases the likelihood of smartphone adoption across the population, its net effect on women seems closer to zero or negative. The statistically significant findings of schooling for women-owned businesses and of vocational training for men-owned businesses can be interpreted as having a causal impact on adoption, as education and vocational training are variables that are longer-term investments in the acquisition of capabilities, and it would strain credulity to argue that adoption of smartphones leads to schooling and vocational training—though smartphones and more specialized DTs are clearly important enablers that can facilitate and increase the quality of schooling and vocational training.

## 4.2 Unconditional associations of DT uses

This sub-section is a first step in exploring whether the adoption and use of the smartphone as an access technology, of nine more specialized DTs facilitating external-to-firm transactions, and of three more specialized DTs facilitating internal-to-firm functions, matter in terms of their association with general business outcomes. Table 10 presents unconditional means of labor productivity (measured as monthly value added divided the sum of full-time workers and the number of owners), total sales (measured as monthly turnover and proxying as well for the production gains that are enabled by higher productivity) and exporting (measured as the share of firms with customers located in other countries, selling goods or services abroad) disaggregated by adopters and users versus those businesses that have not adopted and do not use each of these DTs.

For each adopted DT, its use matters based on the unconditional means of productivity, sales and exporting: in each instance, values are higher for users than non-users. For labor productivity, the greatest difference between unconditional means for users and non-users is for the internal-to-firm management-related DTs: users of inventory control/POS software have over 5 times higher average labor productivity than non-users, while users of accounting software have over 4 times higher average labor productivity.<sup>27</sup> Importantly, the businesses that have adopted and use these specialized internal-to-firm DTs also have significantly higher average labor productivity than the larger number of businesses that generically use a smartphone as an access technology: the average productivity of inventory control/POS and accounting software users is 2.2 and 1.8 times that of smartphone users, respectively. For total sales, the top 5 DTs with the greatest difference between users and non-users are inventory control/POS and accounting software, as well as use of DTs to interact with government, to recruit in the labor market, and to conduct on-line banking: the average sales of users is over 10 times the level of non-users for each of these DTs. And relative to the more generic use of smartphones, the users of all 5 of these DTs have average sales that are at least 2.5 times higher. However, the number of businesses using the external-to-the-firm transaction-facilitating DTs for interacting with government, recruiting in the labor market, and using online banking is significantly smaller than for users of the management-related internal-to-firm DTs: there are only 7, 9 and 16 businesses, respectively, using these DTs out of 517 firms. And

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<sup>27</sup> Out of 517 firms, 25 use inventory control software and 33 use accounting software, versus 83 businesses that use a smartphone.

there is a stronger established causal link in the literature between upgraded management capabilities and productivity and increased production and sales than for the facilitation of business-government interactions, labor market recruitment, and online banking.<sup>28</sup> Finally, for exporting, the top DTs with the greatest difference between users and non-users include e-commerce and using internet to better understand and market to customers, both uses that overcome traditional geographic distance and facilitate local producers to reach and sell to customers in other countries. Both of these DTs, together with interacting with government and online banking, are associated with the share of using businesses exporting being roughly 10 times or more the share of non-using businesses exporting.<sup>29</sup> Again, the businesses that have adopted and use these specialized DTs have higher exporting shares than the businesses that generically use a smartphone, though the differences are not as large as with productivity and sales, given that they are bounded by 100 percent: they range between 2.5 times for interacting with government to 1.2 times for using internet to better understand customers.

**Table 10: General business outcomes by use of DTs** (average labor productivity and sales in local currency, and % of firms selling goods or services abroad)

	Labor productivity		Total profits		Share of exporters	
	DT users	Non-users	DT users	Non-users	DT users	Non-users
Use smartphone	635 841 (178 750)	294 474 (90 000)	3 022 483 (421 000)	687 005 (135 000)	37.8	4.5
Look for suppliers	637 036 (195 000)	313 055 (85 000)	5 430 860 (550 000)	784 328 (130 000)	58	7.3
Pay suppliers	459 244 (135 000)	287 984 (73 500)	944 730 (240 000)	1 093 020 (100 000)	16	8.3
Understand customers	637 723 (195 000)	286 974 (82 500)	3 898 527 (475 000)	637 767 (120 000)	45.4	5.1
Use e-commerce	682 669 (295 000)	301 016 (82 500)	3 203 469 (550 000)	865 891 (125 000)	62.3	5.7
Receive payments	513 978 (140 000)	267 985 (74 000)	1 164 008 (320 000)	1 016 851 (100 000)	23.6	5.6
Use online banking	706 544 (446 875)	316 063 (87 500)	9 094 222 (1 270 000)	714 349 (130 000)	77.7	7.4
Recruit workers	596 660 (107 500)	325 914 (87 500)	13 402 555 (510 000)	772 722 (130 000)	73.7	8.8
Interact w government	762 341 (446 875)	324 496 (87 500)	17 467 115 (13 300 000)	770 351 (130 000)	93	8.9
Pay taxes	767 795 (290 000)	312 658 (85 000)	2 049 276 (565 000)	1 011 071 (130 000)	29.5	9.4
Accounting s/w	1 146 152 (896 500)	272 729 (85 000)	8 660 300 (5 855 000)	503 186 (126 000)	53	7.2
Inventory/POS	1 400 435 (1 407 407)	272 315 (85 000)	10 989 778 (6 900 000)	501 856 (126 000)	56.1	7.7
Pay workers	796 354 (193 000)	301 658 (85 000)	2 445 788 (380 000)	964 478 (127 000)	40.7	8.3

Note: Labor productivity is measured as value added (total sales minus raw materials & intermediate inputs plus water & electricity used in production) divided by the sum of full-time workers and the number of owners. Total sales is also asked as turnover or “revenues money received by the business”. Exporting reflects shares of firms active that report having international customers or non-zero exports. Labor productivity and total sales are means of monthly values, in local currency (FCFA); medians are reported in parentheses. No use of smartphone represents use of 2G phones rather than no use of any mobile phone.

### 4.3 Conditional associations of DT uses

Tables 11, 12 and 13 present the results of regressions exploring whether the separate uses of DTs are associated with better firm performance, explicitly controlling for other relevant variables—including whether firm ever had a loan, has electricity, is fully informal, and whether the owner had vocational training and self-reports being a transformational entrepreneur (relative to being a subsistence entrepreneur). The performance variables are labor productivity in Table 11, total sales in Table 12, and exporting in Table 13. Categorical variables are included to control for possible statistically significant differences across older and younger men-

<sup>28</sup> Reference to Bloom et al.

<sup>29</sup> The fact that 93% of firms using the internet to interact with government organizations are exporting, or 6.5 firms on a weighted basis, suggests that international trade and associated compliance with regulations is an important reason that businesses choose DTs to interact with government (for instance, interacting with customs or reporting online foreign tourists visiting local hotels). Conversely, on an unweighted basis, 46 firms have customers abroad, of which only 6 are using internet to interact with government organizations—suggesting that only the larger and more sophisticated of these exporting firms use this DT.



owned and younger women-owned firms relative to older women-owned firms. The DTs are grouped into three sets, as in Table 7.<sup>30</sup> First, a general access technology reflects whether the firm uses a mobile broadband-enabled smartphone (3G or 4G) or only uses a 2G phone, relative to not using any mobile phone. Second, more specialized DTs for external-to-the-firm transactions include using the internet to look online for upstream suppliers, using mobile money for paying suppliers, using the internet for better understanding downstream customers (marketing), using e-commerce to sell goods and services online to customers, and using mobile money to receive payments from customers, as well as using online banking, using the internet to recruit workers in the labor market, and using the internet to interact with government organizations.<sup>31</sup> Third, more specialized uses of DTs to undertake internal-to-the-firm functions include management functions, in particular whether the firm uses accounting software and inventory control/point of sale (POS) software, as well as the use of mobile money to pay employees.

**Table 11: DT conditional correlates of performance – labor productivity**

	Labor productivity											
	ACCESS	EXTERNAL-TO-FIRM TRANSACTIONS								INTERNAL-TO-FIRM		
	S-phone	Look for suppliers	Pay suppliers	Marketing	Use e-commerce	Customer payments	Online banking	Recruit workers	Govt.	Accounting software	Inventory ctrl/POS	Pay workers
S-phone	1.06***											
..only 2G	0.59***											
Find supply		0.51										
Pay supply			0.35**									
Marketing				0.48								
e-comm					0.55*							
Get pmnts						0.46***						
Online bank							0.64					
Recruit								-0.24				
Govt.									-0.06			
Accounting										0.74		
Invent./POS											1.47***	
Pay workers												0.13
Having loan	1.25***	1.30***	1.41***	1.23***	1.26***	1.34***	1.26***	1.47***	1.43***	1.07**	0.75**	1.43***
Electricity	0.83***	0.97***	0.90***	0.94***	0.95***	0.88***	0.96***	0.97***	0.97***	0.95***	0.94***	0.96***
Vocational	0.17	0.24	0.23	0.17	0.17	0.22	0.22	0.27	0.26	0.15	0.16	0.23
Transform.	0.25*	0.23	0.24*	0.24*	0.22	0.22	0.26*	0.25*	0.25*	0.24*	0.25*	0.24*
Young men	0.70***	0.70***	0.71***	0.69***	0.71***	0.70***	0.69***	0.70***	0.70***	0.70***	0.75***	0.71***
Older men	0.70***	0.71***	0.69***	0.71***	0.71***	0.71***	0.70***	0.69***	0.69***	0.70***	0.71***	0.70***
Large (3+)	-0.15	-0.12	-0.06	-0.12	-0.09	-0.10	-0.10	-0.10	-0.10	-0.11	-0.18	-0.11
Med.(1-2)	-0.21	-0.16	-0.16	-0.15	-0.15	-0.17	-0.15	-0.16	-0.16	-0.15	-0.17	-0.17
Informal	-0.36**	-0.41**	-0.39**	-0.39**	-0.41**	-0.40**	-0.39**	-0.43***	-0.43***	-0.39**	-0.38**	-0.42***
Services	-0.15	-0.09	-0.13	-0.09	-0.08	-0.13	-0.07	-0.06	-0.06	-0.07	-0.08	-0.06

Note: This table reports 12 separate sets of regressions on the log of labor productivity (defined as value added divided by the sum of full-time workers and the number of owners). OLS regression coefficients are reported with robust standard errors using weighted data: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Only control variables where at least one of the coefficients is statistically significant at least at the 10% level are reported; additional non-reported control variables are: schooling of owner, young female owners (all age-gender variables are relative to old female owners), urban (relative to rural location), and manufacturing and trade sectors (relative to agriculture).

<sup>30</sup> The results are similar when all the variables are used together but there is some loss of statistical significance with a few variables most likely due to collinearity. These results are available upon request.

<sup>31</sup> Using mobile money to pay taxes was not statistically significant for any of the outcome variables except for sales nor for any of the jobs-related outcome variables reported in the next section, and therefore was not included in the remainder of these tables.

Using a smartphone, relative to using no digital access device at all, is a large and highly statistically significantly conditional correlate of higher labor productivity; there also is a statistically significant and large productivity premium of using a smartphone over a 2G phone (Table 11). Importantly, the largest statistically significant conditional correlate of productivity is a more specialized internal-to-the-firm management function, namely inventory control/POS software. The other statistically significant (at least at the 5% level) conditional correlates of productivity are DTs to facilitate two external-to-the-firm transactions, namely using mobile money to pay suppliers and to receive payments from customers; using internet for e-commerce is only statistically significant at the 10% level. The finding that use of inventory control/POS software is a large significant conditional correlate of productivity aligns with its strong unconditional association with productivity (as highlighted in Table 10, users of inventory control/POS software have over 5 times higher average labor productivity than non-users, the largest difference among all DTs).

Regarding other variables, having a loan is the largest highly statistically significant conditional correlate of productivity, followed by having electricity and not being fully informal. Both younger and older men-owned businesses also have higher productivity, relative to older women-owned firms. All these variables are highly statistically significant across all regressions.

**Table 12: DT conditional correlates of performance – total sales**

	Total sales											
	ACCESS	EXTERNAL-TO-FIRM TRANSACTIONS								INTERNAL-TO-FIRM		
	S-phone	Look for suppliers	Pay suppliers	Marketing	Use e-commerce	Customer payments	Online banking	Recruit workers	Govt.	Accounting software	Inventory ctrl/POS	Pay workers
S-phone	0.95***											
..only 2G	0.60***											
Find supply		0.26										
Pay supply			0.42***									
Marketing e-comm				0.23								
Get pmnts					0.28							
Online bank						0.41**						
Recruit							0.49					
Govt.								0.53				
Accounting									0.85			
Invent./POS										0.77*		
Pay workers											1.44***	-0.10
Having loan	1.44***	1.50***	1.55***	1.47***	1.48***	1.49***	1.44***	1.47***	1.42***	1.19***	0.91***	1.56***
Electricity	0.77***	0.90***	0.82***	0.89***	0.89***	0.83***	0.90***	0.91***	0.91***	0.89***	0.88***	0.90***
Vocational	0.34	0.40*	0.37*	0.36*	0.36*	0.37*	0.38*	0.37*	0.36*	0.29	0.31	0.43*
Transform.	0.18	0.16	0.15	0.16	0.15	0.14	0.17	0.18	0.18	0.16	0.17	0.17
Young men	0.46*	0.46*	0.47*	0.45*	0.46**	0.46**	0.45*	0.47**	0.48**	0.46*	0.51**	0.47*
Older men	0.57***	0.57***	0.55***	0.57***	0.57***	0.57***	0.57***	0.57***	0.56***	0.57***	0.58***	0.56***
Large (3+)	1.42***	1.45***	1.51***	1.45***	1.47***	1.46***	1.47***	1.46***	1.45***	1.45***	1.38***	1.47***
Med.(1-2)	0.51***	0.56***	0.57***	0.57***	0.57***	0.55***	0.57***	0.57***	0.57***	0.57***	0.56***	0.57***
Informal	-0.41***	-0.46***	-0.43***	-0.45***	-0.46***	-0.45***	-0.45***	-0.46***	-0.46***	-0.44***	-0.42***	-0.47***
Services	-0.08	-0.02	-0.08	-0.01	-0.01	-0.06	-0.004	-0.02	-0.01	-0.01	-0.01	0.01

Note: This table reports 12 separate sets of regressions on the log of total sales. OLS regression coefficients are reported with robust standard errors using weighted data: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Only control variables where at least one of the coefficients is statistically significant at least at the 10% level are reported; additional non-reported control variables are: schooling of owner, young female owners (all age-gender variables are relative to old female owners), urban (relative to rural location), and manufacturing and trade sectors (relative to agriculture).

Table 12 reports on a similar set of conditional correlates for total sales. Using a smartphone, relative to using no digital access device at all, is again highly statistically significantly associated with higher total sales, and with a relatively large magnitude; there also is a statistically significant and large sales premium of using a

smartphone over a 2G phone. Importantly, the largest statistically significant correlate of sales is again the same more specialized internal-to-the-firm management function, namely inventory control/POS software; accounting software is now also statistically significant, but only at the 10% level. The other statistically significant (at least at the 5% level) correlates of productivity are again the same two DTs that facilitate external-to-the-firm transactions, namely using mobile money to pay suppliers and to receive payments from customers. The finding that inventory control/POS software—but not using internet to interact with government organizations or to recruit in the labor market, nor using online banking (as these also were strong unconditional correlates of sales, as highlighted in Table 10)—is a large significant conditional correlate of sales suggests that the latter variables are unconditionally associated with sales more due to their association with firm size rather than an association with productivity or other factors captured through the introduction of additional control variables. A plausible interpretation of the finding that use of inventory control/POS software is a large significant conditional correlate of both productivity and sales is that a similar set of firms are both more productive and better able to take advantage of their greater efficiency to increase production and sales than less efficient competitor firms.<sup>32</sup>

Regarding other control variables, having a loan is the largest highly statistically significant conditional correlate of sales, followed by having electricity and not being fully informal. Both younger and older men-owned businesses also have higher sales, relative to older women-owned firms. An additional highly significant set of variables, not present in the productivity regressions, is firm size, with especially large-sized firms with 3 or more full-time employees, as well as medium-sized firms with one or two full-time employees being important conditional correlates of firm sales: it is consistent with standard production theory that higher levels of production, as proxied by higher sales, on average require more workers. All these variables are highly statistically significant across all regressions.

Finally, Table 13 reports on a similar set of conditional correlates for exporting. Using a smartphone, relative to using no digital access device at all, is again statistically significantly associated with exporting; while there is also again a statistically significant exporting premium of using a smartphone over a 2G phone, this is now because using a 2G phone has no statistically significant association with exporting—so using a smartphone is statistically equally better for exporting than either using a 2G phone or not using any mobile phone at all. While using inventory control/POS software was a statistically significant correlate of both productivity and total sales, it has no significant association with exporting; a plausible interpretation is that using this management technology is as useful for local sales as for exporting. Importantly, the use of a wide range of DTs to facilitate external-to-firm transactions are statistically significant conditional correlates of exporting: in addition to using the internet to look for suppliers online, the full range of DTs associated with better understanding customers and marketing, using e-commerce to sell goods and services online, and using mobile money to receive payments from customers are all highly statistically significant correlates of exporting. This is plausible, as all of these customer-focused DTs facilitate business interactions with customers abroad, where geographical distance arguably is a bigger constraint. Users of these DTs also had much larger unconditional average exporting shares than non-users (Table 10). DTs for online banking, recruiting in the labor market, interacting with government

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<sup>32</sup> An equally plausible interpretation is that these firms have higher market power, and are able through higher markups to have both higher value added (and hence productivity) as well as higher sales revenues, and that their greater cash flow in turn allows them to purchase and make use of accounting software/POS digital solutions. Without more detailed data on quantities and prices to disentangle market power effects, and panel data to explore the direction of causality, it is not possible to differentiate between these interpretations.

organizations, and paying employees, on the other hand, are all used by a small number of larger firms that also are overwhelmingly exporting.

Regarding other control variables, having a loan is again the largest highly statistically significant conditional correlate of exporting, followed by not being fully informal. However, in contrast to labor productivity and sales, having electricity, larger firm size in terms of full-time employees, and the age and gender of business owners are not statistically significant correlates of exporting. One positive implication of these findings, in terms of gender equality, is that women-owned firms are just as likely to export as men-owned businesses.

**Table 13: DT conditional correlates of performance – exporting**

	Exporting											
	ACCESS	EXTERNAL-TO-FIRM TRANSACTIONS								INTERNAL-TO-FIRM		
	S-phone	Look for suppliers	Pay suppliers	Marketing	Use e-commerce	Customer payments	Online banking	Recruit workers	Govt.	Accounting software	Inventory ctrl/POS	Pay workers
S-phone	0.13**											
..only 2G	0.02											
Find supply		0.11***										
Pay supply			0.01									
Marketing				0.11***								
e-comm					0.16***							
Get pmnts						0.08***						
Online bank							0.19***					
Recruit								0.22***				
Govt.									0.29***			
Accounting										0.07		
Invent./POS											0.06	
Pay workers												0.09**
Having loan	0.13***	0.14***	0.17***	0.12***	0.12***	0.16***	0.13***	0.15***	0.15***	0.14***	0.14***	0.18***
Electricity	0.01	0.04	0.04	0.02	0.02	0.01	0.03	0.04	0.05	0.04	0.04	0.03
Vocational	0.01	0.01	0.03	0.01	-0.003	0.02	0.02	0.01	0.01	0.02	0.03	0.01
Transform.	0.03	0.03	0.04	0.03	0.01	0.03	0.04	0.04	0.04	0.03	0.04	0.03
Young men	0.03	0.03	0.04	0.03	0.03	0.04	0.02	0.04	0.04	0.04	0.04	0.04
Older men	-0.01	-0.004	-0.02	-0.004	-0.01	-0.01	-0.009	-0.02	-0.02	-0.01	-0.01	-0.01
Large (3+)	0.07*	0.06	0.07	0.06	0.08*	0.08*	0.07	0.07	0.07	0.07	0.06	0.06
Med.(1-2)	-0.01	-0.02	-0.02	-0.02	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.03
Informal	-0.05*	-0.06**	-0.07**	-0.06**	-0.05**	-0.06**	-0.04	-0.06**	-0.06**	-0.06**	-0.06**	-0.07**
Services	0.03	0.05	0.06*	0.05	0.05	0.04	0.05	0.06*	0.06*	0.06*	0.06*	0.05*

Note: This table reports 12 separate sets of regressions on exporting (defined as firms that report having customers located in other countries or selling goods or services abroad). Probit regression coefficients (marginal effects) are reported, with robust standard errors using weighted data: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Only control variables where at least one of the coefficients is statistically significant at least at the 10% level are reported; additional non-reported control variables are: schooling of owner, young female owners (all age-gender variables are relative to old female owners), urban (relative to rural location), and manufacturing and trade sectors (relative to agriculture).

In summary, it is the more specialized DTs facilitating management-related internal-to-the-firm functions, in particular software facilitating inventory control and the tracking of customer purchases at their point of sales that matter most in terms of a significant and sizable association with productivity and sales. Of the uses of DTs to facilitate external-to-the-firm transactions, the use of mobile money to pay suppliers and to receive payments from customers also matter in terms of their significant though less sizable association with productivity and sales. These external-to-the-firm DTs matter for productivity and sales as they allow a broader range of upstream supplier companies and downstream customer business and end-use customers to use any type of mobile phone, including 2G phones that are still much more widespread in their adoption across the population.

Importantly, it is the more specialized DTs facilitating internal-to-the-firm functions, and secondarily those that facilitate external-to-the-firm transactions through mobile money that matter much more so than the adoption and use of a smartphone for productivity and sales. While smartphones matter, it is largely through their role as enablers of more specialized uses of DTs. Exporting, on the other hand, is facilitated equally by having a smartphone, as well as by using external-to-the-firm DTs that facilitate understanding and marketing, selling to, and receiving payments from customers, as it is these DTs that are likely to most help to overcome traditional geographical distance barriers.

## V. JOBS-SPECIFIC BUSINESS OUTCOMES FROM DT USES

### 5.1 Unconditional associations of DT uses

This sub-section is a first step in exploring whether the adoption and use of the smartphone as an access technology, of nine more specialized DTs facilitating external-to-firm transactions, and of three more specialized DTs facilitating internal-to-firm functions, matter in terms of their association with jobs-specific business outcomes. The data allow two dimensions of jobs outcomes to be explored: “jobs for more people”, namely the extent to which there is a positive association between the use of specific DTs and larger firms (measured by the number of full-time employees plus owners), and “better jobs”, namely the extent to which there is a positive association between DTs and higher wages (averaged across all full-time employees who are paid a salary or wage) and higher profits (per owner-entrepreneur), as indicators of better jobs for workers and owners, respectively.

**Table 14: Jobs outcomes by use of DTs** (% of firms using DTs that are larger, and average wages and average profits per owner in local currency)

	More jobs: firm size		Better jobs: average wages		Better jobs: entrepreneur profits	
	DT users	Non-users	DT users	Non-users	DT users	Non-users
Use smartphone	4.7 (3)	2.4 (2)	107 545 (30 000)	46 322 (15 000)	2 343 481 (361 000)	657 806 (130 000)
Look for suppliers	6 (3)	2.5 (2)	192 883 (70 000)	47 239 (15 000)	4 089 560 (475 000)	709 335 (125 000)
Pay suppliers	3.4 (2)	2.5 (1)	84 635 (30 000)	50 643 (11 667)	879 218 (219 000)	915 578 (98 500)
Understand customers	5.6 (3)	2.3 (1)	131 351 (33 333)	43 865 (30 000)	2 935 845 (400 000)	608 437 (115 000)
Use e-commerce	4.4 (3)	2.6 (2)	165 870 (38 750)	47 182 (15 000)	2 042 990 (475 000)	806 191 (119 000)
Receive payments	2.9 (3)	2.7 (1)	77 612 (25 000)	53 140 (12 500)	1 071 457 (290 000)	848 392 (90 000)
Use online banking	9.5 (3)	2.5 (2)	58 408 (33 333)	61 815 (15 000)	6 752 918 (1 270 000)	658 496 (126 000)
Recruit workers	14.6 (6)	2.5 (2)	27 693 (33 333)	63 134 (15 000)	9 420 440 (510 000)	711 599 (126 000)
Interact w government	17.5 (21)	2.5 (2)	20 160 (4 500)	62 911 (16 667)	12 249 042 (6 650 000)	709 515 (126 000)
Pay taxes	2.5 (3)	2.8 (2)	32 753 (20 000)	63 346 (15 000)	1 695 832 (510 000)	871 354 (125 000)
Accounting s/w	8.1 (4)	2.7 (2)	130 028 (16 667)	52 498 (16 667)	6 840 849 (1 783 000)	475 646 (120 000)
Inventory/POS	8.7 (4)	2.4 (1)	158 572 (20 000)	51 370 (15 000)	8 694 908 (6 650 000)	472 586 (120 000)
Pay workers	7.1 (3)	2.5 (1)	60 213 (50 000)	61 767 (15 000)	2 283 909 (275 000)	816 566 (126 000)

Note: Firm size is the number of full-time employees plus owners. Average wages reflect salary & wages divided by full-time employees. Entrepreneurial profits are measured as value added minus salary & wages and water & electricity costs. Average wages and profits are means of monthly values, in local currency (FCFA); medians are reported in parentheses. No use of smartphone represents use of 2G phones rather than no use of any mobile phone.

According to the unconditional means reported in Table 14, (with a few exceptions, see below) firms that use DTs are more likely to be larger and generate more full-time jobs, are more likely to pay higher average wages, and are more likely to pay owners higher income than firms that are non-users. For each DT, values are higher for users than non-users for jobs and entrepreneur profits. For jobs (proxied by firm size), the top 5 DTs with the greatest difference between unconditional means for users versus non-users are inventory control/POS and

accounting software, as well as the use of DTs to interact with government, to recruit in the labor market, and to conduct on-line banking—similar to the unconditional means for sales in Table 10: the average firm size of users is over 3 times the level of non-users for each of these DTs. And relative to the more generic use of smartphones, the users of all 5 of these DTs have average firm sizes that are at least 1.7 times higher. It is important to note again that the number of businesses using the external-to-the-firm transaction-facilitating DTs for interacting with government, recruiting in the labor market, and using online banking is significantly smaller than for users of the management-related internal-to-firm DTs. And critically, there is a stronger established causal link in the literature between upgraded management capabilities and productivity and increased production and sales, and the generation of more jobs than between the latter and external-to-the-firm-DTs such as those used for the facilitation of business-government interactions, labor market recruitment, and online banking.<sup>33</sup>

For average wages, the top DT with the greatest difference between users and non-users is using internet to look for suppliers online: businesses that use internet to look for suppliers pay over 4 times higher average wages than non-user businesses. And the businesses that use internet to look for suppliers also pay significantly higher average wages than the larger number of businesses that generically use a smartphone as an access technology: the average wage of users that look for suppliers online is 1.8 times that of smartphone users, and 4.2 times that of 2G users.<sup>34</sup> Interestingly, firms that use online banking, use internet to recruit workers and to interact with government, and use mobile money to pay taxes pay lower average wages than those that do not use these DTs (though these variables are not as directly linked to productivity as management-related internal-to-the-firm DTs). Importantly, the use of DTs in all cases raises the average and median wage above the extreme monthly poverty line; in contrast, the median firm that does not use each of the available DTs—except for using the internet to better understand customers and to interact with government, and using accounting software—is only able to pay an average wage that is below the extreme poverty line.<sup>35</sup> Finally, for average profits per owner, the top 5 DTs with the greatest difference between unconditional means for users versus non-users are inventory control/POS and accounting software, as well as use of DTs to interact with government, to recruit in the labor market, and to conduct on-line banking—similar again to the unconditional means for sales in Table 10 and for firm size above. Notably, the differences between unconditional means for users versus non-users are largest for per-owner income, relative to all the other investigated general and jobs-specific business outcomes: the average per-entrepreneur profit of users is over 10 times the level of non-users for each of these DTs, with the difference in average income for inventory control software users starkest at over 18 times the income level for non-users. Again, the businesses that have adopted and use these specialized DTs have higher per-owner incomes than the businesses that generically use a smartphone, with differences ranging between 3.7 times for use of inventory control/POS software to 2.9 times for use of online banking.

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<sup>33</sup> See the studies on Argentina, Brazil, Chile, Colombia and Mexico highlighting the link between DT adoption, productivity and jobs summarized in Dutz et al. (2018).

<sup>34</sup> It is not obvious from economic theory why the firms using internet to look for suppliers online would be expected to be those that pay higher average wages. It should be clarified that of the 517 firms in this survey, only 248 report paying wages to their employees (52% of all firms are self-employed with no full-time employees, hence pay no wages), and of these, only 20 firms report using the internet to look for suppliers online.

<sup>35</sup> Senegal's moderate and extreme monthly poverty lines for the 2017-18 period that this survey was implemented are 27,787 FCFA and 15,572 FCFA – see footnote 23 for additional details.

## 5.2 Conditional associations of DT uses

There are large differences in unconditional averages of labor market outcomes depending on whether firms have adopted and are using DTs for specific business purposes or not (as highlighted in Table 14). However, it could be the case that other variables are more strongly associated with “jobs for more people” and “better jobs” than adopting a smartphone or using DTs for business functions like inventory control. To explore the strength of the association of these DT variables conditional on other drivers of labor outcomes including firm characteristics such as having a loan, having electricity, location and formality status, and owner characteristics such as age and gender, entrepreneurial aptitude and vocational training, Tables 15, 16 and 17 report findings on conditional correlations between DTs and more jobs, and better incomes for workers and owners, respectively.

**Table 15: DT conditional correlates of performance – firm size**

	More jobs: firm size											
	ACCESS	EXTERNAL-TO-FIRM TRANSACTIONS								INTERNAL-TO-FIRM		
	S-phone	Look for suppliers	Pay suppliers	Market.	Use e-commerce	Customer payments	Online banking	Recruit workers	Govt.	Account. software	Inventory ctrl/POS	Pay workers
S-phone	0.20											
..only 2G	0.15***											
Find supply		0.18										
Pay supply			-0.12									
Marketing				0.09								
e-comm					-0.06							
Get pmnts						-0.05						
Online bank							0.32					
Recruit								0.84**				
Govt.									0.87**			
Accounting										0.25		
Invent./POS											0.44**	
Pay workers												0.21
Having loan	0.46**	0.44**	0.49***	0.44**	0.50***	0.49***	0.40***	0.34**	0.33**	0.36**	0.28*	0.49***
Electricity	0.09	0.12*	0.14**	0.12*	0.12*	0.13*	0.12*	0.12*	0.13**	0.11*	0.12*	0.12*
Vocational	0.55***	0.56***	0.57***	0.54***	0.57***	0.56***	0.55***	0.50***	0.51***	0.52***	0.53***	0.51***
Transform.	0.004	-0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.004	0.002	-0.01
Young men	0.11	0.11	0.11	0.11	0.12	0.12	0.10	0.13	0.11	0.12	0.13	0.11
Older men	0.05	0.06	0.06	0.06	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06
Urban	-0.18***	-0.19***	-0.19***	-0.19***	-0.18***	-0.19***	-0.20***	-0.20***	-0.19***	-0.19***	-0.19***	-0.18***
Informal	-0.33***	-0.34***	-0.35***	-0.34***	-0.35***	-0.35***	-0.33***	-0.33***	-0.35***	-0.33***	-0.33***	-0.34***
Trade	-0.19**	-0.19**	-0.17**	-0.19**	-0.18**	-0.18**	-0.18**	-0.16**	-0.16**	-0.17**	-0.18**	-0.19**
Services	0.27***	0.27***	0.31***	0.28***	0.29***	0.29***	0.27***	0.27***	0.31***	0.28***	0.28***	0.28***

Note: This table reports 12 separate sets of regressions on the log of firm size. OLS regression coefficients are reported with robust standard errors using weighted data: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Only control variables where at least one of the coefficients is statistically significant at least at the 10% level are reported; additional non-reported control variables are: schooling of owner, young female owners (all age-gender variables are relative to old female owners), and manufacturing sector (relative to agriculture).

Table 15 reports on conditional correlates of generating more jobs, proxied by firm size including both full-time employees and owners. Using a smartphone, relative to using no digital access device at all, is not statistically significantly associated with higher firm size. However, there is a statistically significant association between using a 2G phone and firm size, relative to not using any mobile phone. Importantly, one of the three other statistically significant (at least at the 5% level) correlates of firm size is again the same more specialized internal-to-the-firm management function, namely inventory control/POS software. The other significant correlates of firm size are specialized DTs to facilitate external-to-the-firm transactions, namely using internet to interact with government and to recruit on labor markets. These findings roughly align with the unconditional means, where the greatest difference between unconditional means for users versus non-users of DTs included

inventory control/POS software, as well as the use of DTs to interact with government and to recruit in the labor market. The findings from section 3.3 that inventory control/POS software is a large significant conditional correlate of productivity and sales suggest that it is those firms that have higher productivity and sales that correspondingly also generate more jobs. Conversely, using the internet to interact with government and to recruit workers are not significant conditional correlates of productivity and sales; this suggests that the finding that these variables are statistically significant here is more likely due a strong unconditional correlation with firm size that remains after the introduction of additional control variables, with the direction of causality likely going the other way, namely that it is larger firms that need to interact with government and choose to recruit workers online.

Regarding other control variables, vocational training is a highly statistically significant and large in magnitude conditional correlate of larger firm size across all regressions (it was not a statistically significant correlate across any of the regressions on productivity, sales, and exporting). This is an important finding, particularly since vocational training, like education, requires a longer-term period of investment, and therefore the direction of causality is more likely to run from business owners that have invested in vocational training to larger firms that generate more jobs.<sup>36</sup> Being in an urban location is also a statistically significant conditional correlate of larger firm size, though smaller in magnitude and of a negative sign (it was again not a statistically significant correlate across any of the regressions on productivity, sales, and exporting, and therefore was not reported in those tables). It suggests that, controlling for all other correlates of firm size, that firms in urban locations are smaller than those in rural locations. Having a loan is also a highly statistically significant conditional correlate of firm size, followed by not being fully informal; not having electricity is most often only statistically significant at the 10% level. Interestingly in terms of sectors, being active in retail or wholesale trade is negatively associated with firm size relative to agriculture, suggesting that businesses active in trading are smaller in size than farms (based on the unweighted data reported in Table 1, the median firm in both trade and agriculture was a zero full-time employee self-employed business). Firm size as a categorical variable, namely large-sized firms with 3 or more full-time employees, as well as medium-sized firms with one or two full-time employees, are not included in these regressions given that the dependent variable is firm size as a continuous variable.

Table 16 reports results on conditional correlations between use of DTs and better incomes for workers, proxied by average wages (defined as salary & wages in a typical month divided by the total number of full-time employees). Among the available DT variables, only using the internet to find suppliers is positively associated with average wages at the 1 percent level. This finding aligns with the unconditional means analysis, where the top DT with the greatest difference between users and non-users is using internet to look for suppliers online. Using mobile money to pay suppliers is the only other DT variable that is significant, just at the 10 percent level. It is interesting to note that while using inventory control software is positively correlated with labor productivity, such conditional correlation does not carry through to average wages.

Regarding other control variables, having transformative owners and being located in urban areas are positively correlated with average wages. Interestingly, average wage is the only business outcome that has a statistically significant association (at least at the 5% level) with being a transformational entrepreneur, across all regressions. This suggests that owners that have an inherent aptitude for productive entrepreneurship, namely owners selecting themselves due to the profit-making opportunity that owning a business provides (as opposed

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<sup>36</sup> It is of course conceivable that larger firms that have survived for a number of years have over time given the business owners of these firms the opportunity to invest in vocational training, so the suggestion of a possible direction of causality must remain tentative and requires confirmation once better panel data become available.



to a necessity or subsistence choice to supplement earnings), are more likely to pay higher wages, perhaps as efficiency wages to motivate workers to work well and remain with the business.<sup>37</sup> Finally, the largest and strongest statistically significant association is a negative one with firm size: larger firms (those employing 3 or more workers) are likely to pay lower wages relative to medium-sized firms (employing 1 or 2 full-time workers).

**Table 16: DT conditional correlates of performance – average wages**

	Better jobs: average wages											
	ACCESS	EXTERNAL-TO-FIRM TRANSACTIONS								INTERNAL-TO-FIRM		
	S-phone	Look for suppliers	Pay suppliers	Marketing	Use e-commerce	Customer payments	Online banking	Recruit workers	Govt.	Accounting software	Inventory ctrl/POS	Pay workers
S-phone	0.23											
..only 2G	0.05											
Find supply		0.88***										
Pay supply			0.40*									
Marketing				0.39								
e-comm					0.43							
Get pmnts						0.09						
Online bank							-0.18					
Recruit								-0.57				
Govt.									-0.78			
Accounting										-0.55		
Invent./POS											0.32	
Pay workers												0.08
Having loan	-0.40	-0.53*	-0.31	-0.47*	-0.43	-0.35	-0.28	-0.20	-0.15	-0.06	-0.50	-0.33
Electricity	0.87	0.94*	0.83	0.86	0.87	0.87	0.88	0.87	0.86	0.88	0.88	0.88
Vocational	-0.04	-0.04	-0.04	-0.09	-0.11	-0.03	-0.02	0.02	0.02	0.04	-0.04	-0.04
Transform.	0.45**	0.39**	0.45**	0.42**	0.41**	0.45**	0.47**	0.46**	0.46**	0.50***	0.45**	0.46**
Young men	0.09	0.09	0.06	0.04	0.10	0.07	0.07	0.04	0.02	0.05	0.09	0.06
Older men	0.24	0.28	0.16	0.23	0.21	0.21	0.20	0.20	0.19	0.19	0.23	0.20
Large (3+)	-0.75***	-0.79***	-0.68***	-0.75***	-0.73***	-0.74***	-0.74***	-0.72***	-0.71***	-0.72***	-0.76***	-0.74***
Med.(1-2)												
Urban	0.47**	0.39*	0.56**	0.46**	0.46**	0.51**	0.52**	0.54**	0.55**	0.52**	0.49**	0.50**
Informal	0.17	0.17	0.16	0.18	0.16	0.17	0.15	0.13	0.13	0.10	0.19	0.17
Services	-0.02	-0.11	-0.12	-0.05	-0.02	-0.01	0.03	0.03	0.04	-0.001	0.02	0.01

Note: This table reports 12 separate sets of regressions on the log of average wages. OLS regression coefficients are reported with robust standard errors using weighted data: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Only control variables where at least one of the coefficients is statistically significant at least at the 10% level are reported; additional non-reported control variables are: schooling of owner, young female owners (all age-gender variables are relative to old female owners), and manufacturing sector (relative to agriculture).

Finally, Table 17 reports on a similar set of conditional correlates between uses of DTs and better incomes for owners, proxied by entrepreneurial profits per owner, the owner counterpart to worker wages. Using a smartphone, relative to using no digital access device at all, is highly statistically significantly and positively associated with per-owner profits; there is a significant profit premium of using a smartphone over a 2G phone, with using a 2G phone also an independent conditional correlate of per-owner profits relative to not using any mobile phone. Importantly, the largest statistically significant correlate of per-owner profits is again inventory control/POS software. The other statistically significant (at least at the 5% level) correlates of productivity are two DTs that facilitate external-to-the-firm transactions, namely using mobile money both to pay suppliers and

<sup>37</sup> On efficiency wages, see the seminal paper by Shapiro and Stiglitz (1984).

to receive payments from customers. Regarding other control variables, having a loan is again the largest highly statistically significant conditional correlate of per-owner profits, followed by having electricity, larger firm sizes in terms of full-time employees (large firms with 3 or more employees being of a greater magnitude than medium firms with 1 or 2 full-time employees), and men-owned firms, with almost identical coefficients for younger and older men-owned firms. Being fully informal is negatively correlated with per-owner profits, but only at the 5 percent level of significance.

**Table 17: DT conditional correlates of performance – entrepreneurial profits**

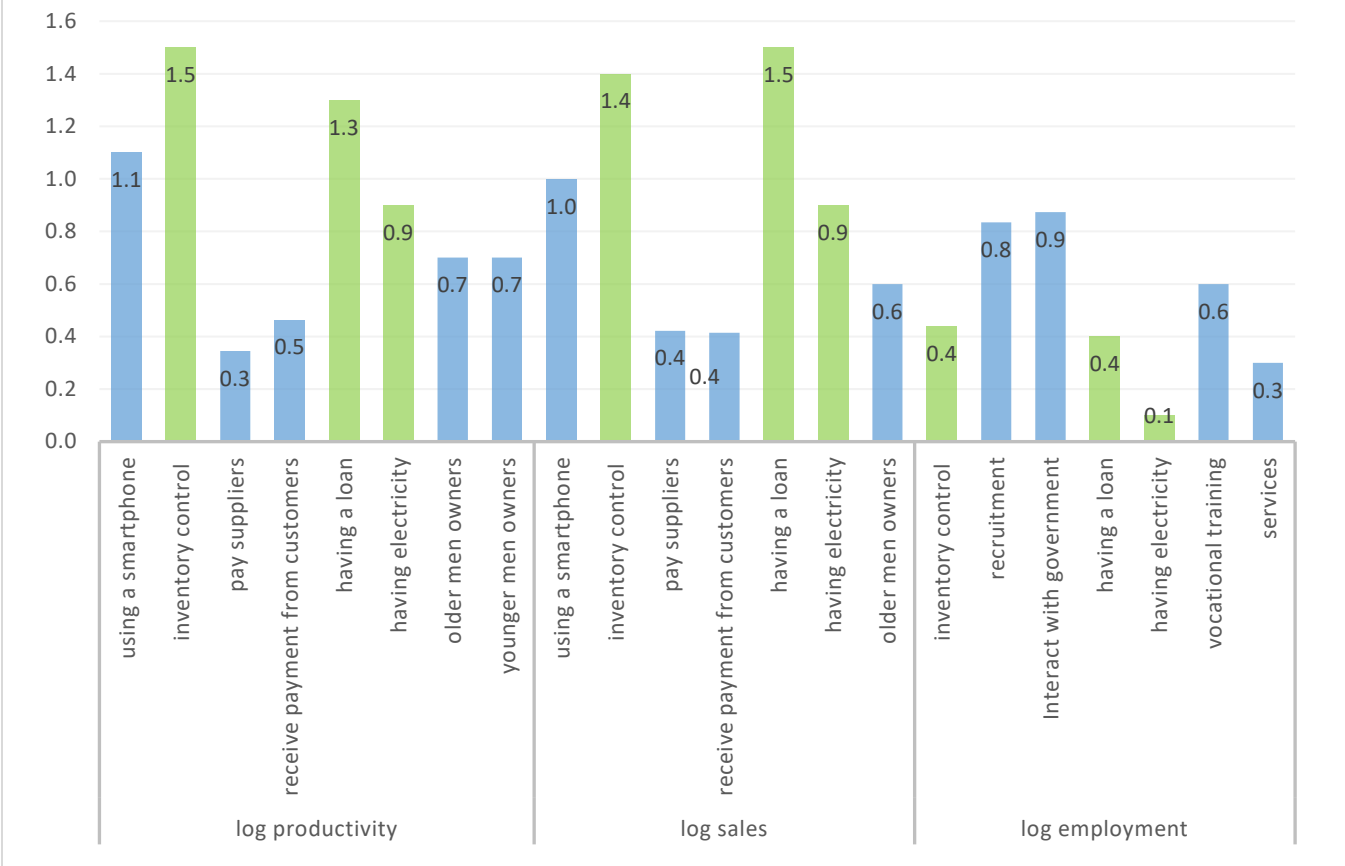
	Better jobs: entrepreneur profits											
	ACCESS	EXTERNAL-TO-FIRM TRANSACTIONS								INTERNAL-TO-FIRM		
	S-phone	Look for suppliers	Pay suppliers	Marketing	Use e-commerce	Customer payments	Online banking	Recruit workers	Govt.	Accounting software	Inventory ctrl/POS	Pay workers
S-phone	0.98***											
..only 2G	0.61***											
Find supply		0.47										
Pay supply			0.25									
Marketing				0.46								
e-comm					0.35							
Get pmnts						0.35**						
Online bank							1.29***					
Recruit								1.01				
Govt.									1.30**			
Accounting										0.73		
Invent./POS											1.56***	
Pay workers												0.07
Having loan	1.78***	1.81***	1.91***	1.74***	1.82***	1.86***	1.60***	1.76***	1.71***	1.56***	1.19***	1.92***
Electricity	0.72***	0.86***	0.81***	0.84***	0.85***	0.79***	0.85***	0.86***	0.87***	0.84***	0.83***	0.86***
Vocational	0.20	0.26	0.25	0.19	0.22	0.24	0.20	0.21	0.2	0.16	0.17	0.26
Transform.	0.18	0.15	0.16	0.16	0.15	0.15	0.2	0.18	0.18	0.16	0.17	0.17
Young men	0.84***	0.84***	0.85***	0.83***	0.85***	0.84***	0.82***	0.85***	0.86***	0.84***	0.89***	0.84***
Older men	0.86***	0.86***	0.84***	0.86***	0.86***	0.86***	0.87***	0.86***	0.85***	0.86***	0.87***	0.85***
Large (3+)	1.30***	1.33***	1.38***	1.33***	1.35***	1.34***	1.34***	1.33***	1.34***	1.34***	1.26***	1.34***
Med.(1-2)	0.44**	0.43***	0.49***	0.50***	0.50***	0.48***	0.52***	0.50***	0.50***	0.50***	0.49***	0.49***
Urban	-0.07	-0.09	-0.08	-0.09	-0.08	-0.06	-0.11	-0.08	-0.09	-0.07	-0.07	-0.07
Informal	-0.31*	-0.36**	-0.35**	-0.34*	-0.36**	-0.36**	-0.31*	-0.36**	-0.36**	-0.34**	-0.32*	-0.37**
Services	-0.07	-0.01	-0.04	-0.01	0.001	-0.03	-0.01	-0.01	-0.01	-0.003	-0.01	0.01

Note: This table reports 12 separate sets of regressions on the log of per-owner profits. OLS regression coefficients are reported with robust standard errors using weighted data: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Only control variables where at least one of the coefficients is statistically significant at least at the 10% level are reported; additional non-reported control variables are: schooling of owner, young female owners (all age-gender variables are relative to old female owners), and manufacturing sector (relative to agriculture).

In summary, it is again the use of a more specialized DT facilitating a management-related internal-to-the-firm function—namely software facilitating inventory control and the tracking of customer purchases at their point of sales, as a proxy for more general management support DTs—that matters most in terms of its significant and sizable association with more jobs as proxied by larger firm size and with higher incomes to owners as reflected in per-owner profits. This is plausible in terms of economic theory and recent empirical work in some emerging markets, namely that the output expansion effect from higher productivity generates demand for more workers to produce the additional sales and higher incomes enabled by the adoption of this DT (as summarized in Dutz et al, 2018, based on associated conceptual and empirical work). Of the uses of DTs to facilitate external-to-the-

firm transactions, the use of internet to interact with government entities also matters in terms of its significant and sizable association with both more jobs and higher incomes to owners (as well as using internet to recruit workers for more jobs, and using internet for online banking for higher incomes to owners). These external-to-the-firm DTs could plausibly be interpreted as being important for more jobs and higher owner incomes; however, the explanation most aligned with basic economic theory is that higher jobs and incomes would be enabled by higher productivity and higher sales, but there are no significant associations of these DT uses with these business outcomes. The implication is that the direction of causality for these variables likely goes in the other direction, with the larger firm size and higher entrepreneurial profits, driven by other factors, most likely enabling these firms to adopt these DTs, including in the case of business-government interactions to enable the few larger firms that use this DT to facilitate their required exporting and other related transactions. Importantly, it is the more specialized DT facilitating inventory control/POS tracking, and secondarily those that facilitate external-to-the-firm transactions that matter more than the adoption and use of a smartphone for more jobs and higher owner incomes. Higher average wages, on the other hand, are not associated either with using a smartphone, nor with internal-to-the-firm or most external-to-the-firm uses of DTs; rather, it is the urban location of businesses, and the transformational quality of entrepreneurs that are the main variables associated with higher wages.

**Figure 1: Significant conditional correlates of productivity, sales and jobs**



Note: This figure represents those conditional correlates of productivity, sales and jobs that are significant at least at the 5% level across all regressions, not including economic sectors of activity. Green bars highlight those variables that are similarly significant across all 3 business outcomes: inventory control software, having a loan, and having electricity.

Figure 1 summarizes the main statistically significant findings of the conditional correlation regressions of DT use and additional control variables across productivity, sales (as a proxy for production), and jobs. It highlights that for lower-income micro-sized informal firms, using a smartphone per se doesn't matter to generate more jobs. What matters consistently across productivity, sales and jobs are the variables indicated by the green bars, namely more specialized internal-to-the-firm management functions, as proxied by inventory control/ point of sales (POS) software, in addition to having a loan and having electricity.

## VI. CONCLUSIONS

The main findings of the paper can be summarized as follows:

- 16 percent of micro-sized firms in Senegal use smartphones as a general internet access technology, four times more than the average across micro-sized firms in other SSA countries (4%) but only half the level of larger firms with five or more workers (31%). The use of social media or internet, the use of internet to understand customers, and its use for e-commerce are also more widespread in Senegal relative to other SSA countries, but lower than larger firms.
- In Senegal, the digital divide is less between firms owned by women and those owned by men than between younger women-owned and older women-owned firms. The difference between youth-owned and older-owned firms is stark regarding the use of a smartphone: the share of youth-owned firms that use a smartphone is twice as large as that of old-owned firms (27% vs 14%). While women-owned firms on average are slightly less likely to use a smartphone relative to men-owned firms, the highest share of usage overall is among younger women-owned firms, at over 27 percent, almost twice the overall share of smartphone users—versus older women-owned firms at only 10 percent, indicative of a large digital divide. This divide likely reflects the fact that firms owned by older women are disproportionately in agriculture, in rural areas, fully informal and with lower access to electricity. The use of any mobile phone is almost universal (2G phones being the default), with over 94 percent of young men-owned businesses using a mobile on the upper end versus 82 percent of older women-owned businesses on the lower end.
- Regarding the range of more specialized uses of DTs used by micro-sized firms in Senegal—divided into management, upstream and downstream transactions, finance, worker and government transactions uses—receiving payments from customers via mobile money is the most commonly used by businesses, as it does not require a smartphone: it is used by 34 percent of young men-owned businesses but only 17 percent of older women-owned businesses. Using mobile money to make payments to suppliers is also widespread and is used by 25 percent of all firms, with a higher share among firms owned by men relative to those owned by women (29 percent versus 20 percent). Remarkably, the highest percentage usage of several key specialized DTs is by young women-owned businesses, and this is where the digital divide is also the largest, relative to older women-owned businesses. This includes: the two management-related DTs, inventory control/point of sales (POS) software and accounting software, with over 12 and 13 percent of younger women-owned businesses using them (relative to 4.6 and 9.6% of younger men-owned firms, respectively); using internet to better understanding customers, with almost 24 percent of younger women-owned businesses using it (relative to 21.4% of younger men-owned firms); and using mobile banking, with 12 percent of younger women-owned businesses using it (here, the divide with older women-owned businesses is starkest, with less than 2 percent of them using it).
- The main conditional correlates of mobile broadband adoption by Senegalese micro-sized firms are having a loan, having electricity, and producing services (other than retail or wholesale trade, and relative to agriculture), as well as being in an urban location. The education and age of the owner (whether the owner

is younger than 30 years or not) and whether the firm has a woman owner are not significantly associated with adoption. The vocational training of owners is associated with a higher probability of adoption (on average by 7-17 percentage points) but this association disappears for the case of firms with women owners. On the other hand, for firms with women owners, a unit increase in schooling increases the probability of adoption by 1 or 12 percentage points, depending on the specification, though this association does not hold for men owners.

- For all the indicators of DT used in this paper, firms that use the DT have higher labor productivity and sales and are more likely to export relative to firms that do not use the DT. Firms that go beyond using a smart phone and use specialized DTs have in general even higher productivity, sales and are more likely to be exporters than firms that only use a smartphone. For labor productivity, internal-to-firm DTs (inventory control/POS and accounting software) seems to matter most: users of these technologies have 4-5 times higher labor productivity relative to non-users, and have average labor productivity that is twice as high as that of firms that only use a smart phone. For sales, in addition to these two technologies, use of DTs to interact with government, to recruit in the labor market, and to conduct on-line banking are most important: firms using these 5 technologies have 2.5 or higher sales compared to firms that only use smartphone. However, DTs internal to the firm are more widespread, in other words, the number of businesses using the external-to-the-firm transaction-facilitating DTs for interacting with government, recruiting in the labor market, and using online banking is significantly smaller than the number of firms using management-related internal-to-firm DTs.
- Examination of conditional correlations resulting from regression analysis shows that using mobile phone is significantly positively correlated with productivity, and using a smartphone is associated with an additional productivity premium relative to using a 2G. The largest statistically significant conditional correlate of productivity is a more specialized internal-to-the-firm management function, namely inventory control/POS software. Use of DTs to facilitate two external-to-the-firm transactions, namely using mobile money to pay suppliers and to receive payments from customers are also statistically significant conditional correlates of productivity (at the 5 percent level). Similar results are obtained for when sales is used as the performance variable. Having a loan, having electricity being large and not being fully informal are also significantly positively correlated with productivity and sales.
- Using a smartphone (but not using a 2G phone) is also positively correlated with exporting. Interestingly, Rather than DTs internal to the firm, the use of a wide range of DTs to facilitate external-to-firm transactions are statistically significant conditional correlates of exporting: in addition to using the internet to look for suppliers online, the full range of DTs associated with better understanding customers and marketing, using e-commerce to sell goods and services online, and using mobile money to receive payments from customers are all highly statistically significant correlates of exporting.
- Being owned by young and old men is positively associated with higher labor productivity and higher sales relative to being owned by women across all uses of DTs. However, there is no statistically significant association between owners' gender-age and the probability that a firm is an exporter, suggesting that women and men, youth and older owners are all as likely to be exporting, conditional on other available control variables.
- An examination of conditional correlates of generating more jobs, proxied by firm size including both full-time employees and owners shows that using a smartphone, relative to using no digital access device at all, is not statistically significantly associated with higher firm size. However, there is a statistically significant association between using a 2G phone and firm size, relative to not using any mobile phone. Importantly, one of the three other statistically significant (at least at the 5% level) correlates of firm size is again the

same more specialized internal-to-the-firm management function, namely inventory control/POS software. The other significant correlates of firm size are specialized DTs to facilitate external-to-the-firm transactions, namely using internet to interact with government and to recruit on labor markets. Among other control variables, vocational training is a highly statistically significant and large in magnitude conditional correlate of larger firm size, whereas being fully informal and being located in urban areas is negatively associated with firm size.

- With respect to average wages, which is used as an indicator of better jobs, among the available DT variables, only using the internet to find suppliers is positively associated with average wages at the 1 percent level. While using inventory control software is positively correlated with labor productivity, such conditional correlation does not carry through to average wages. Being owned by a transformative entrepreneur is positively associated with average wages, whereas larger firm size (in terms of employment) is negatively correlated.
- Profits per owner, another proxy for better jobs, this one relevant for micro-entrepreneurs rather than workers, is significantly positively correlated with using a mobile phone, and using a smartphone rather than a 2G phone is associated with an additional premium of per-owner profits. Importantly, the largest statistically significant correlate of per-owner profits is again inventory control/POS software, again possibly reflecting its managerial use to reduce costs and increase revenues. The other statistically significant (at least at the 5% level) correlates of productivity are two DTs that facilitate external-to-the-firm transactions, namely using mobile money both to pay suppliers and to receive payments from customers. Having a loan, having electricity, larger firm sizes and having male owners are also significant positive correlates of per-owner profits.

In summary, using a smartphone is often significantly correlated with better firm performance across a range of performance measures and is often associated with a premium of performance over and above using a 2G. Among the various more specialized DTs available in the data set, inventory control/POS software, which is taken as a proxy for a broader set of management-related technologies relevant for the internal operations of the firm, comes out as the variable that exhibits the most frequent positive correlations with a variety of performance measures—importantly including productivity, sales and the generation of more jobs. By contrast, exports are more associated with DTs that focus on transaction between the firm and external counterparts.

As was emphasized in the introduction, while the data set used in this paper provides a wealth of information on very small enterprises difficult to find elsewhere and useful to help provide insights for policy formulation, the fact that it consists of a single cross section limits the amount of causal inference that can be extracted; importantly, it precludes any analysis of firm dynamics. Repeats of the same survey, in particular by following the same enterprises over time, would increase the amount of information for causal inference of the impact of DTs on performance and firm growth, as well as on determinants of firm exit. Given that one of the major problems faced by microenterprises in SSA is that few of them grow into competitive mid-sized or large companies, such a panel data set would provide valuable information to understand why this is so and whether DTs can be effectively used to circumvent the associated barriers. Providing support for such future additional surveys would be a valuable investment to the World Bank's and SSA's knowledge capital.

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