Australian National University

Working Papers in Trade and Development

Digitalization and the performance of micro and small enterprises in Yogyakarta, Indonesia

Anna T. Falentina[1], Budy P. Resosudarmo[1], Danang Darmawan[2]
Eny Sulistyaningrum[3]

1. Arndt-Corden Department of Economics, Australian National University
2. Faculty of Political and Social Science, Gadjah Mada University
3. Faculty of Economics and Business, Gadjah Mada University

June 2019
Working Paper No. 2019/08

Arndt-Corden Department of Economics
Crawford School of Public Policy
ANU College of Asia and the Pacific

Digitalization and the performance of micro and small enterprises in Yogyakarta, Indonesia

Anna T. Falentina, Budy P. Resosudarmo, Danang Darmawan,
Eny Sulistyaningrum

Abstract

The world is going digital. Little is known about how this digitalization affects the performance of micro and small enterprises, one of the major foundations of the economy in developing countries but with relatively low productivity. This paper examines the causal impact of internet utilization, as a part of digitalization, on enterprise performance. We conducted a field survey among micro and small enterprises in Yogyakarta, the densest micro and small enterprise population province in Indonesia. The identification strategy exploits the fact that the differences in geographic topography produce conceivably exogenous variations in the strength of cellular signal that micro and small enterprises in various areas can receive to connect to the internet. We find that internet utilization has enabled micro and small enterprises to engage in the digital economy and has improved labor productivity and exports.

Keywords: digital technology, internet, micro and small enterprises, productivity, exports

JEL-codes: H54; L53; L96

Digitalization and the performance of micro and small enterprises in Yogyakarta, Indonesia

Anna T. Falentina[1], Budy P. Resosudarmo[1], Danang Darmawan[2],
Eny Sulistyaningrum[3]

1 Introduction

Micro and small enterprises (MSEs) play a significant role as a source of income and employment in many developing countries (Berry & Mazumdar, 1991; Berry, Rodriguez, & Sandee, 2001; Tambunan, 2009). Banerjee & Duflo (2011) show that small and medium enterprises (SMEs) have generated most of the new non-farm jobs in India, Indonesia, and China. Further, in some cases, MSEs are an important informal social safety net mechanism (Resosudarmo, Sugiyanto & Kuncoro, 2012). The contribution of MSEs might be underestimated since they are underrepresented in most countries' enterprises surveys (Li and Rama, 2015). Small enterprises also play a role in exports and the supply of products and services to larger enterprises (Asian Development Bank, 2015). Nevertheless, the productivity of MSEs remains low (Mead & Liedholm, 1998; Tybout, 2000) and is, as expected, lower than that of larger firms (Hill, 2001; Little, Mazumdar & Page, 1989; Organisation for Economic Co-operation and Development [OECD], 2015). It is also argued that MSEs constitute only a small share of exports (Anas, Mangunsong & Panjaitan, 2017).

Digitalization—typically means digital technology utilization, such as internet utilization—has been widely expected to improve firm performance in developing

---

[1] Arndt-Corden Department of Economics, Australian National University
[2] Faculty of Political and Social Science, Gadjah Mada University
[3] Faculty of Economics and Business, Gadjah Mada University
We thank Australia-Indonesia Centre (AIC) and Indonesia Education Endowment Fund (LPDP) for providing some funding for this research and PT. Telekomunikasi seluler (Telkomsel) for allowing us to use the BTS location data. We also thank to the FISIPOL-UGM team survey for helping us conducting the survey for this research. All mistakes are our responsibility.

countries. Over 40% of people globally have internet access, and this figure continues to rise as new users connect online everyday (World Bank, 2016). In 2015, 18.2 billion devices were connected to the internet; this number is predicted to increase threefold by 2020. Digitalization is considered the basis of the fourth industrial revolution, in which technologies are transforming almost every aspect of life, including the way we do business (Das, Gryseels, Sudhir & Tan, 2016). The rise of e-commerce, for instance, the Alibaba business-to-business site, in China has boosted the nation's economy with the creation of 10 million jobs in online stores and related services. M-Pesa, a digital payment platform, has enabled Kenyans to send low-cost remittances to their families in their hometowns.

The benefit of digitalization for firm performance has been acknowledged in several studies. The use of the internet as a general-purpose technology by various firms is associated to higher labor productivity and firm growth (Clarke, Qiang & Xu, 2015). Moreover, it is not only larger firms but also smaller firms with disadvantaged socioeconomic backgrounds are expected to benefit from the use of digital technologies in all aspects of business activities. The adoption of internet by medium, small enterprises has been predicted to help smaller firms achieve higher exports (Lal, 2004; Hagsten, Kotnik, 2017), better access to credit (Pellegrina, Frazzoni, Rotondi, Vezzulli, 2017). Similarly, the internet has been argued to become a facilitator of inclusive innovation for small businesses across nations (Paunov & Rollo, 2016). However, only a few studies show a causal impact of digitalization on firm productivity among MSEs (Bertschek & Niebel, 2016; Colombo, Croce & Grilli, 2013; Díaz-Chao, Sainz-González & Torrent-Sellens, 2015; Tadesse & Bahiigwa, 2015).

This paper is one of the first studies providing an evidence on the causal impact of digitalization on MSEs' productivity in developing countries. Using MSEs in Yogyakarta, Indonesia, as a case study, this paper investigates the causal impact of internet utilization, as a part of digitalization, on the performance of MSEs. Yogyakarta province is a relevant place to study MSEs in Indonesia. With nearly 470 MSEs per 1,000 households in 2016 (Badan Pusat Statistik, 2017a), Yogyakarta has the densest MSE population in Java island, Indonesia. Further, most of Indonesia's internet users are located on Java island (Jurriens & Tapsell, 2017). The primary identification strategy exploits the fact that the differences in geographic topography produce conceivably exogenous variations in the strength of cellular phone signal that MSEs in various areas can receive to connect to the internet.

We begin with a brief review of the current study on MSEs, digitalization and firm performance. Afterward, we discuss our survey data and descriptive statistics emerging from the survey. The subsequent section outlines the evidence from our survey. The paper concludes by deliberating on the wider implications of our findings for researchers and policy makers.

2 Digitalization and firm performance

A relatively large body of literature has recently developed showing the role of digital technology in promoting welfare in developing countries. For instance, Aker and Mbiti (2010) reveal that the staggering level of mobile phone coverage and adoption in sub-Saharan Africa greatly reduces search costs and improves markets. Muto and Yamano (2009) find that mobile phone coverage expansion induces market participation of farmers in remote areas, while Jensen (2007) reveals that the adoption of mobile phones by anglers and wholesalers in Kerala, India, reduces price dispersion and waste, and increases fishermen's profits and consumers' welfare. Moreover, Tadesse and Bahiigwa (2015) examine the impact of mobile phones on farmers' marketing decisions and the prices they achieve in rural Ethiopia.

Nevertheless, scarce evidence is available about the impact of digital technology utilization on MSEs. Colombo et al. (2013) investigate broadband internet technology adoption and its associated application among SMEs in Italy, utilizing the generalized method of moments approach to handle the endogeneity issue. They find that the adoption of basic or advanced broadband applications does not have any positive effect on SMEs' productivity. Nonetheless, the adoption of advanced broadband applications that are potentially relevant in SME operations produces productivity gains. The benefit appears only when the adoption is associated with the undertaking of extensive strategic and organizational changes to SMEs' current way of doing business. Similar results are also found in previous research focusing on larger enterprises (Bresnahan, Brynjolfsson, & Hitt, 2002). Díaz-Chao et al. (2015) analyze new co-innovative sources—including internet use—of labor productivity in small firms that sell products locally in Girona, Spain. In contrast with other studies, they find that co-innovation does not directly affect small local firms' productivity. However, they established an indirect relationship between co-innovation and productivity in firms that initiate international expansion. Bertschek and Niebel (2016) show that employees' mobile internet access causes labor productivity to be higher among German manufacturing and services firms in 2014.

Several mechanisms explain how digital technology promotes development. First, digital technology generates 'creative destruction'. Schumpeter (1934, 1950) introduced this term to describe how innovations might increase productivity and efficiency, thus revolutionizing economic structure, and at the same time destroy traditional industries and business models. Digitalization has transformed physical markets and physical transactions into virtual ones and converted corporate-centric systems into crowd-centric and collaborative economic systems, thus generating the digital economy (Pangestu & Dewi, 2017).

Second, digital technology greatly lowers the cost of economic and social transactions for firms, individuals, and the public sector by reducing information costs. The World Bank (2016) suggests three mechanisms via which the internet stimulates economic development. First, the internet has enabled automation and coordination, thus promoting efficiency. Second, the internet enables almost frictionless communication and collaboration, thus supporting new delivery models, encouraging collective action, and accelerating innovation owing to scale economies and platforms. Third, the internet creates the market effects of expanding trade, creating jobs, and increasing access to public services that previously were out of reach, thus promoting inclusion.

Nonetheless, in reality the positive effect of digitalization is not always reflected in productivity. Solow (p.36, 1987, July 12) stated, “You can see the computer age everywhere but in the productivity statistics”. This is known as the Solow paradox, a concept that scholars are still exploring (Acemoglu et al., 2014). Researchers have developed some possible explanations for the Solow paradox. First, digital technology is underutilized because of technical bottlenecks, for instance reliance on humans to input data (Triplett, 1999) or a lack of access to the latest computing equipment (Katz & Koutroumpis, 2012).

Second, it takes time for digital technology to have an impact on productivity. Basu and Fernald (2008) confirm that the digital technology-using sectors in the United States (US) have experienced a rise in productivity but with a long lag. Meanwhile, David (1990) reveals that it takes decades for the impact of the breakthrough in electrification to become visible in the productivity statistics.

Third, there is a possibility of flawed or incorrect measurement of the impact on aggregate output. It is possible that the increases in aggregate output resulting from digitalization are not well measured (Triplett, 1999). Brynjolfsson and Hitt (2000) argue that traditional macroeconomic measurement approaches do not capture complementary organizational investment well, which determines digital technology usage performance.

3 Micro and small enterprises and digitalization in Indonesia

In Indonesia, MSEs are one of the major foundations of the nation's economy. MSEs constitute 98% of all firms in various sectors and are the source of living for more than 53 million people, or provide 76% of employment (Badan Pusat Statistik, 2017b). Table 1 provides some statistical information about MSEs in Indonesia. Over two decades, the number of MSEs increased from 16 million in 1996 to 26 million in 2016. The sectoral distribution indicates that the share of MSEs in the mining sector decreased over time, from 2% to less than 1% in 2016. The proportion of MSEs in manufacturing was relatively constant, while that in the services rises. In 2016, the wholesale and retail trade dominated, accounting for more than 47% of MSEs, followed by accommodation and food services activities, and manufacturing at around 17%. Further, over 60% of MSEs are on Java island, where more than 55% of Indonesians live. Nonetheless, the productivity of MSEs is relatively low and constitutes a small portion of the nation's exports. In 2016, the contribution of MSEs to the nation's gross domestic product (GDP) and to exports was 46% and 3.8%, respectively.

-TABLE 1 HERE-

Internet connections have continued to grow since the arrival of the internet in Indonesia in the second half of the 1990s. The number of Indonesian people using the internet has followed an exponential growth trend, increasing sevenfold from 8.1 million (3.6%) in 2005 to 56.6 million (22.%) in 2015 (ITU, 2016). This was initialized by the internet café where people accessed the internet; since then, smartphones have been the main media facilitating people in accessing the internet. The percentage of those who connect to the internet through mobile phones rocketed from 29% in 2012 to 70% in 2016, because of the massive expansion of the smartphone (Balea, 2016; Jurriens & Tapsell, 2017). Indonesia is the fastest growing among neighboring countries in internet and mobile penetration rates (Pangestu & Dewi, 2017).

Nonetheless, digitalization is not yet widespread in Indonesia. The current penetration rate is below that of several Association of Southeast Asian Nations (ASEAN) immediate neighboring countries and far behind that of developed countries. In addition, data from the 2016 Economic Census listing shows only 5% of all firms in Indonesia accessed the internet in 2016 (Badan Pusat Statistik, 2017b). With almost 95% of all enterprises still not connected to the internet, this means the level of connectivity among transactors is still very low. Similarly, across Indonesia's entire key sectors, such as manufacturing, financial and business services, and social sectors, IT spending lags behind not only developed countries but also peer countries (Das, Gryseels, Sudhir & Tan, 2016).

4 Field survey

We conducted a field survey of MSEs in Yogyakarta province in January 2018. Undergraduate students from the Faculty of Social and Political Science, Gadjah Mada University, were trained as enumerators. The respondents were required to be the owner or the manager of the selected enterprise. We used a stratified sampling strategy to randomly sample 700 MSEs in Bantul district and Yogyakarta city in various sectors from manufacturing, to wholesale, to services (Figure 1). Details on the stratified sampling strategy used to determine our samples are provided in the appendix 1.

We developed a mobile survey utilizing the Survey Solutions application. Survey Solution is a computer-assisted personal interview (CAPI) technology developed by the World Bank that is used to conduct surveys with dynamic structures using tablet devices, such as smartphones. This mobile questionnaire was then installed in each smartphone provided to the enumerators. We provided each enumerator with a smartphone (Xiaomi Redmi 3) and Telkomsel (the main cellular operator in Indonesia) SIM card so that they could use the same standard equipment to collect the required data. The CAPI method enabled efficiency in data collection and data processing. Further, it enabled the collection of information on variables such as coordinate locations of samples and cellular signal strengths.

-FIGURE 1 HERE-

We explored internet utilization among MSEs in several possible utilization areas, such as website, emailing, social media and online trading platforms, for different intensities in business operations. The intensity of internet utilization concerned whether the MSEs used the internet to communicate with customers/suppliers, purchase inputs from suppliers, deliver services to clients, or advertise the products/services. Exports were categorized according to whether they were direct or indirect.

We managed to interview 576 MSEs out of 700 samples. Table 2 presents the descriptive statistics of our survey data. It appears that the mean revenue per worker was IDR 7.7 million, while profit per worker was only half of revenue per worker (IDR 3.4 million). The mean of exports proportion was 7%. The mean age of entrepreneurs was 46 years old and on average they had more than 21 years' working experience. Nearly one-third of MSEs possessed a license, and around 11–15% were members of business associations or cooperatives. On average, the strength of the Telkomsel cellular signal was 4.5 bars, with 77 units of Base Transceiver Station (BTS) per village. A BTS is a piece of network equipment that facilitates wireless communication between a device and a network (Technopedia, 2018).

-TABLE 2 HERE-

5 Empirical strategy

We used two measurements of firm performance, that is, labor productivity and exports. Labor productivity is represented by revenue per worker and profit per worker. Labor productivity is a vital element in assessing the living standards of those engaged in a production process in which labor is the most essential input (OECD, 2001). In this paper, we used revenue per worker as the gross output–based productivity and profit per worker as the value added–based productivity. Gross output–based productivity measures captured disembodied technical change, while value added–based productivity measures reflected an industry's capacity to contribute to economy-wide income and final demand. These two measurements were complements to each other.

Exports was considered a mean of accelerating MSEs by upgrading of MSEs in productivity, technology and managerial know-how (Sato, 2013). We expected the use of the internet by firms to have positive impacts on labor productivity and exports since it enables creative production processes in which enterprises find new efficient ways of doing business in place of the old methods, thus generating dynamism at the enterprise level.

The following estimation model was used to estimate the effect of internet adoption on firm performance:

$$y_{i,j,k,l} = \beta\ Internet_{i,j,k,l} + X'_{i,j,k,l}.\gamma + BTS_{j,l}.\delta + \theta_k + \theta_l + \varepsilon_i \quad (1)$$

where *i* represents an enterprise, *j* represents a village where enterprise *i* is located, *k* represents a sector of enterprise *i*, and *l* represents a district where enterprise *i* is located. *y* is a measure of labor productivity or the export proportion in total sales. We used *y* at level since some of our samples showed that they experienced a loss (negative value of profit), such that we would lose observations if we took the natural log of profit. Coefficient β is our variable of interest to identify the impact from the uptake of the internet. Internet is a dummy variable of internet utilization, which equals 1 if the enterprise utilizes the internet in business activities and 0 otherwise. *X* is a set of firm characteristics (firm age, association membership, cooperative membership, license, scale, home based, export status (for labor productivity only)), including the width of road as a proxy for physical access, and elevation, as well as entrepreneur characteristics such as gender, age, education, and experience. BTS is the number of BTSs in the village j. θ_k is industry fixed effects and θ_l is district fixed effects. ε_i is an idiosyncratic term. Details on how we constructed variables are available in the appendix 2. Estimations are weighted by sampling probability and standard errors are clustered at the sub-district level.

5.1 Identification strategy

To cope with potential endogeneity issues, for instance, while internet utilization might support labor productivity or exports, enterprises that are more productive also rely more on the internet, we did the following identification strategy.

We recorded Telkomsel signal strength at the location of our MSE samples. Telkomsel is documented as the cellular operator with the widest network coverage in Indonesia, as well as in Yogyakarta. To minimize the possibility of measurement errors, we recorded Telkomsel signal strength using the same type of SIM cards and similar type of smartphones.

To ensure that cellular signal reception was orthogonal to other characteristics that might also affect firm performance, we also recorded the placement of BTSs in a region. The placement of BTSs is determined primarily by the cellular company, based on certain factors—among others, the number of active subscribers, the usage capacity of the BTS, and location. In the specification, we included as control variables the number of BTSs in each village to capture further differences in cellular signal strength within villages and across enterprises. We also added district and sector-fixed effects. Including district fixed effects had the potential to remove most of the relatively subtle variations in the economic or infrastructure across Bantul and Yogyakarta. Similarly, sectoral fixed effects could remove sector-specific factors jointly affecting internet utilization and enterprise performance.

Once the proximity to the BTS site had been considered, geography was the main remaining determinant of cellular signal reception. In some areas, high buildings or mountains block cellular signal transmission, whereas in others they do not. MSEs located in areas where high buildings or a mountain block the 'line of sight' to a BTS might experience substantially less reception than nearby firms with a direct line of sight. Additionally, since MSEs located in mountainous areas might have different productivity or signal reception from those on the low plains, we controlled for elevation. Moreover, we included the width of the road to control for physical access. Having controlled these geographic aspects, our signal strength data would be driven largely by the happenstance of topography. We then used this cellular signal strength at the location of our samples as an arguably exogenous factor—an instrument variable—of internet adoption among our MSE samples.

This kind of approach that exploits difference in topography has been used in several previous studies. Olken (2009) examines the impact of media on local social interactions in Indonesia by exploiting mountains as the main source of television and radio signal reception. Once geographic factors, such as elevation, are taken into account, then the difference in signal reception is due to topography that varies randomly. A similar approach was adopted by Farré and Fasani (2013) to evaluate the impact of media exposure on internal migration in Indonesia, while Yanagizawa-drott (2014) uses the differences in radio signal coverage to examine the role of mass media on genocide in Rwanda.

There is a possibility that our instrument correlates with omitted variables. For instance, a more ambitious entrepreneur will choose a better location for his or her business. However, MSEs, who are notably financially more constrained compared with larger enterprises, would just use the resources they have to work with; for example, using the entrepreneur's house as the base for his or her business activities. Data show almost 60% of our sample were home based enterprises. Further, it would be very costly for MSEs to move to locations with better telecommunication signal to conduct their business, particularly in city or urban areas. Therefore, we argue that this concern is less likely to be an issue in the context of MSEs in Indonesia.

Another possibility is that entrepreneurs who experience weaker cellular signal strength might opt to use another cellular provider, instead of Telkomsel, to obtain a better signal. Telkomsel and Indosat are the two biggest cellular providers in Indonesia, and Telkomsel has a wider coverage compared with Indosat. Accordingly, if an internet user's objective is to achieve a better signal strength, then he or she would prefer to use the provider with the wider coverage, that is Telkomsel. Furthermore, cellular signal coverage in Yogyakarta is relatively good compared with other regions in the country. There is less reason not to use the provider with the wider coverage.

6 **The impact of internet utilization**

Table 3 presents the results of the first stage of our IV estimates; indicating that cellular signal strength is a relevant and a valid instrument for internet utilization. Cellular signal strength is positive and statistically significant at the 1% level, with around 60% of the variation in internet utilization explained by cellular signal strength. The signal strength also passed the weak instrument test easily.

Without controlling for other factors, the coefficient of signal strength is 0.095. The stronger the signal strength, the higher the probability of internet utilization. Column 2 adds entrepreneur, firm characteristics, district FE, sector dummy; here, we obtained a higher coefficient of signal strength (0.165). We find that the coefficients for signal strength are relatively the same in the case that the second stage are estimating revenue per worker, profit per worker, or exports.

Our instrument is significant in the first stage and powerful, as seen also in the heteroskedasticity-robust Keibergen-Paap *F* statistic range from 55.2 to 149.3. The

Kleibergen-Paap Wald rk *F* statistic is used to test weak instruments when standard errors are clustered. Once we control for other factors, the *F* statistic drops but our instrument still passes the weak instrument test easily. For comparison, the Stock and Yogo (2005) critical value for one instrument and one endogenous regressor is 16.38 for a maximum 10% bias.

-TABLE 3 HERE-

In Table 4, we present estimates of equation (1) computed using ordinary least squares (OLS) and IV for each dependent variable. The coefficients in the IV models can be interpreted as the causal impact of internet utilization on enterprise performance (labor productivity, exports) associated with stronger cellular signal strength. Further, this is a local average treatment effect (LATE) of utilizing the internet because of stronger cellular signal strength. We find positive and significant coefficients of internet utilization, suggesting that internet utilization contributes positively to labor productivity and exports.

Panel A of Table 4 illustrates labor productivity: revenue per worker and profit per worker. The estimated coefficients in Column 1 present the OLS coefficient without any control; we obtain a statistically significant positive effect at the 1% level (9.051). Similarly, the result holds when we add controls in Column 2, yet the magnitude of the coefficient reduces to 4.466. Internet utilization is associated with an IDR4.5 million rise in revenue per worker. Columns 3 and 4 provide results for the IV estimation. Adding no control in Column 3, we obtain a positive and statistically significant coefficient of internet uptake at the 1% level (16.15). Internet utilization, associated with stronger signal strength, increases revenue per worker by IDR16.15 million. The coefficient becomes smaller as we add controls in Column 4 (10.23). Analogously, using profit per worker as a measurement for labor productivity, we obtain positive and significant coefficients for all specifications of OLS and IV estimates in Columns 5–8.

Regarding export performance shown in Panel B of Table 4, our coefficients of internet adoption are positive and statistically significantly different from zero. Both OLS and IV estimates show a comparable magnitude. Our measurement of export proportion is in percentage; thus, the interpretation of the magnitude is by percentage point. The IV estimates controls in Column 12 show that using the internet in business activities related to greater cellular signal strength corresponds to, on average, a 1.729 percentage point increase in the proportion of exports.

Using the OLS estimation results, we calculate the monetary benefit MSEs obtain from internet utilization associated with stronger cellular signal strength. As shown in Table 4, internet uptake increases the revenue per worker by IDR4.466 million per month (or approximately 58% of average revenue per worker) and increases profit per worker by IDR1.141 million per month (or approximately 34% of average profit per worker). Please note that the local government regulation on minimum wage in Yogyakarta in 2018 was approximately IDR 1.454 million per month. The impact of internet use, hence, is significant for local people.

-TABLE 4 HERE-

7 Robustness checks

In Table 5, we present the reduced-form estimates of the effect of our instrument on firm performance. The cellular signal strength, as shown in the smartphones used to measure it, ranges from the zero bar (no signal), to one bar, and all the way up to five bars for the strongest signal strength, which captures the availability and strength of the cellular signal. If broader cellular coverage exerted a positive effect on firm performance, we would expect the coefficients on signal strength to be positive and significant. In other words, we would expect the enterprise that experienced a stronger signal strength to perform better. As the columns show, we see that the coefficients of signal strength are positive and statistically significantly different from zero, except that on profit per worker once we take into account other factors. This indicates that broader cellular coverage leads to better performance.

-TABLE 5 HERE-

Columns 1–2 of Table 5 present the effects on revenue per worker. Column 1 adds no control; we obtain a positive and significant coefficient of signal strength at the 1% level (1.533). This means that a one-unit increase in cellular signal strength—that is, for instance, from no signal to one bar of signal strength—is associated with an increase in revenue per worker by IDR1.5 million. Once we add controls in Column 2, the magnitude of coefficient becomes smaller (1.380) and is weakly significant. In Columns 3 and 4 of Table 5 we re-run the reduced-form with revenue per worker as the dependent variable. Columns 5 and 6 show exports proportion as the dependent variable. The results show that a wider and stronger cellular signal strength promotes better performance.

We also examine whether our results robust to different specifications. First, we exclude the context variables, i.e., elevation and the number of cell towers in the village. Second, we instrument internet utilization using cellular data type (e.g. 2G, 3G), instead of cellular signal strength. Third, we evaluate whether there are spatial spillovers in which enterprises located adjacent to villages might receive a cellular signal from their neighboring villages. Here, we add the weighted number of BTSs of neighboring villages. The weighting uses a contiguity matrix, in which the off-diagonal elements equal one if village *i* is adjacent to village *j*, and zero otherwise (Anselin, 1988). This matrix is then row normalized, that is, the sum of row elements is set equal to 1. If there are spatial spillovers, then the coefficient of this weighted neighboring BTS variable should be significant. Fourth, we remove outliers from our dataset to evaluate whether these drive our results.

In general, as shown in Table 6, we find that our estimation results are robust to these various specifications. The signs of the internet uptake coefficients are positive, and they are statistically significant. Nonetheless, depending on the specification, the magnitude is bigger or smaller than our main estimations. We find that there are no spatial spillovers for profit per worker and exports because the coefficients of the weighted neighboring BTS are statistically not significant. For our alternative IV estimation, the instruments are statistically significant in the first stage and pass the weak instrument test.

We also informally test whether our instrument fulfills the exclusion restriction by evaluating the correlations between our instrument and the error terms. For this validity to be satisfied, holding other variables constant, the cellular signal strength can have no relationship with the dependent variables, except through internet utilization. In other words, having controlled all relevant covariates in the specification, the validity requires the instrument to be not correlated with the residuals. The results can be seen in the appendix 3. First, we obtain the estimated internet utilization from the first stage of the IV estimation. Next, we place this estimated internet utilization on the right-hand side of equation (1) and estimate the residuals for each dependent variable. Finally, we evaluate the correlations between the residuals and our instrument, cellular signal strength. We find that there are no correlations between errors and the instrument for all dependent variables.

-TABLE 6 HERE-

8 Which internet platform help firms perform better?

As shown in our data, entrepreneurs use the internet to access various platforms, such as website launching, emailing, social media, and online shopping platform. To achieve a better understanding of what kind of platform is associated with better performance, that is, higher labor productivity and exports proportion, we regress our performance measurements on website launching, emailing, having a social media account, and online shopping platform using OLS estimation. We focus on those MSEs that use smartphones to connect to the internet. The estimation results from this restricted sample gives explanation of what type of platform that help those who connected to the internet through smartphone to have higher productivity.

-TABLE 7 HERE-

As shown in Table 7, we find that emailing and social media are the platforms that help enterprises to engage in the digital economy and gain benefits. Social media enables MSEs to advertise their products and sell them to customers in the wider domestic market, while emailing helps MSEs communicate and arrange sales with their customers abroad. This finding is similar to those of Damuri et al., (2018) and Melissa et al. (2015), which show that social media supports Indonesian business to be more productive. However, it appears that online shopping platforms are statistically not significantly linked to better performance. A possible explanation for this is that a very small proportion of MSEs in our sample use this online trading platform. Emailing and social media are relatively easy to access using smartphones and might require low skill technology savviness, whereas website launching requires more skill and/or access to a computer. Although the e-commerce platform in Indonesia is growing rapidly, those who can utilize it for their business are still limited, as indicated in the low use of e-commerce among MSEs (see supplement for more details).

9 Conclusion

In this paper, we have examined the causal impact of internet utilization on the performance of MSEs and explored the extent of digitalization among MSEs in Indonesia. Our identification relies on geographical differences, which generate variation in cellular signal reception by enterprises in various areas.

We found that internet utilization has helped MSEs to engage in the digital economy and improved their performance. The internet uptake increased labor productivity and exports. Our finding is robust even after excluding some of the context variables, i.e., elevation and the number of cell towers in the village, replacing cellular signal strength with cellular data type (e.g. 2G, 3G), and taking into account spatial spillovers from adjacent villages. Hence, this paper has been able to provide an evidence that digital economy, represented by access to and use of internet, has a significant potential to contribute to development and inclusiveness by expanding trade opportunities.

Among different types of digital related activities, we found that emailing and social media are the platforms that significantly help enterprises to engage in the digital economy and gain benefits. This result is encouraging since emailing and social media are relatively easy to access using smartphones and require low skill technology savviness. Hence, barriers to participate to digital economies are relatively low.

Evidence from this paper is expected to contribute in inducing a stronger justification for developing public policies aimed at boosting good quality internet availability as well as fostering firms' use of the internet in developing countries. With much higher penetration of decent quality internet, developing countries can expect the productivity of their MSEs can be significantly improved.

References

Acemoglu, D., Autor, D., Dorn, D., Hanson, Gordon. H., Price, B. (2014). Return of the Solow paradox ? IT , productivity, and employment in US manufacturing. *American Economic Review*, *104*(5), 394–399.

Aker, J. C., & Mbiti, I. M. (2010). Mobile phones and economic development in Africa. *Journal of Economic Perspectives*, *24*(3), 207–232. https://doi.org/10.1257/jep.24.3.207

Anas, T., Mangunsong, C., & Panjaitan, N. A. (2017). Indonesian SME participation in ASEAN economic integration. *Journal of Southeast Asian Economies*, *34*(1), 77–117. https://doi.org/10.1355/ae34-1d

Anselin, L. (1988). *Spatial Econometrics: Methods and Models*. Boston: Kluwer Academic Publishers.

Asian Development Bank. (2015). *Integrating SMEs into the global value chains: Challenges and policy actions in Asia*. (Asian Development Bank & Asian Development Bank Institute, Eds.). Manila. Retrieved from https://www.adb.org/sites/default/files/publication/175295/smes-global-value-chains.pdf

Badan Pusat Statistik. (2017a). *Result of Establishment Listing Economic Census 2016: DI Yogyakarta Province*. Jakarta: BPS.

Badan Pusat Statistik. (2017b). *Result of Establishment Listing Economic Census 2016*. Jakarta: BPS.

Balea, J. (2016). The latest stats in web and mobile in Indonesia (INFOGRAPHIC). Retrieved from https://www.techinasia.com/indonesia-web-mobile-statistics-we-are-social

Banerjee, A. V., & Duflo, E. (2011). *Poor Economics: A radical rethinking of the way to fight global poverty*. New York, NY: Public Affairs.

Basu, S., & Fernald, J. G. (2008). Information and communications technology as a general purpose technology: Evidence from U.S. industry data. *FRBSF Economic Review*, *8*(2), 1–15. https://doi.org/10.1111/j.1468-0475.2007.00402.x

Berry, A., & Mazumdar, D. (1991). Small-scale industry in the Asian-Pacific region. *Asian Pacific Economic Literature*, *5*(2), 35–67.

Berry, A., Rodriguez, E., & Sandee, H. (2001). Small and medium enterprise dynamics in Indonesia. *Bulletin of Indonesian Economic Studies*, *37*(3), 363–384. https://doi.org/10.1080/00074910152669181

Bertschek, I., & Niebel, T. (2016). Mobile and more productive? Firm-level evidence on the productivity effects of mobile internet use. *Telecommunications Policy*, *40*, 888–898. https://doi.org/10.1016/j.telpol.2016.05.007

Bresnahan, T. F., Brynjolfsson, E., & Hitt, L. M. (2002). Information technology, workplace organization, and the demand for skilled labor: Firm-level evidence.

The Quarterly Journal of Economics, *117*(1), 339–376.

Brynjolfsson, E., & Hitt, L. M. (2000). Beyond computation: Information technology, organizational transformation and business performance. *Journal of Economic Perspectives*, *14*(4), 23–48.

Clarke, G. R. G., Qiang, C. Z., & Xu, L. C. (2015). The Internet as a general-purpose technology: Firm-level evidence from around the world. *Economics Letters*, *135*, 24–27. https://doi.org/10.1016/j.econlet.2015.07.004

Colombo, M. G., Croce, A., & Grilli, L. (2013). ICT services and small businesses' productivity gains: An analysis of the adoption of broadband Internet technology. *Information Economics and Policy*, *25*, 171–189. https://doi.org/10.1016/j.infoecopol.2012.11.001

Damuri, Y. R., Perkasa, V. D., Hirawan, F. B., & Rafitrandi, D. (2018). *Rich-Interactive-Applications (RIA) in Indonesia: Value to the Society and the Importance of an Enabling Regularoty Framework*. Jakarta: Centre for Strategic and International Studies (CSIS) & Asia Internet Coalition (AIC).

Das, K., Gryseels, M., Sudhir, P., & Tan, K. T. (2016). Unlocking Indonesia's digital opportunity. Jakarta: McKinsey & Company.

David, P. A. (1990). The dynamo and the computer: An historical perspective on the modern productivity paradox. *The American Economic Review*, *80*(2), 355–361.

Díaz-Chao, Á., Sainz-González, J., & Torrent-Sellens, J. (2015). ICT, innovation, and firm productivity: New evidence from small local firms. *Journal of Business Research*, *68*, 1439–1444. https://doi.org/10.1016/j.jbusres.2015.01.030

Farré, L., & Fasani, F. (2013). Media exposure and internal migration—Evidence from Indonesia. *Journal of Development Economics*, *102*, 48–61. https://doi.org/10.1016/j.jdeveco.2012.11.001

Hagsten, Eva; Kotnik, Patricia. (2017). ICT as facilitator of internationalisation in small- and medium-sized firms. Small Business Economics, 48(2), 431-446. DOI:10.1007/s11187-016-9781-2

Hill, H. (2001). Small and medium enterprises in Indonesia: Old policy challenges for a new administration. *Asian Survey*, *41*(2), 248–270. https://doi.org/10.1525/as.2001.41.2.248

International Telecommunication Union. (2016). ICT Development Index. Retrieved from https://www.itu.int/en/ITU-D/Statistics/

Jensen, R. (2007). The digital provide: Information (technology), market performance, and welfare in the South Indian fisheries sector. *The Quarterly Journal of Economics*, *122*(3), 879–924.

Jurriens, E., & Tapsell, R. (2017). Challenges and opportunities of the digital “revolution” in Indonesia. In E. Jurriens & R. Tapsell (Eds.), *Digital Indonesia: Connectivity and Divergence*. Singapore: ISEAS-Yusof Ishak Institute.

Katz, R. L., & Koutroumpis, P. (2012). Measuring socio-economic digitization : A paradigm shift. *SSRN Scholarly Paper No. ID 2070035*, 1–31. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2070035&download=yes

Lal, K. (2004). E-business and export behavior: Evidence from Indian firms. *World Development*, *32*(3), 505–517. https://doi.org/10.1016/j.worlddev.2003.10.004

Li, Y., & Rama, M. (2015). Firm dynamics, productivity growth, and job creation in developing countries: The role of micro- and small enterprises. *The World Bank Research Observer*, *30*(1), 3–38. https://doi.org/10.1093/wbro/lkv002

Little, I. M. D., Mazumdar, D., & Page Jr., J. M. (1989). *Small Manufacturing Enterprises: A Comparative Analysis of India and Other Economies*. *World Bank Reseach Publication*. Oxford, United Kingdom: Oxford University Press.

Mead, D. C., & Liedholm, C. (1998). The dynamics of micro and small enterprises in developing countries. *World Development*, *26*(1), 61–74.

https://doi.org/10.1016/S0305-750X(97)10010-9

Melissa, E., Hamidati, A., Saraswati, M. S., & Flor, A. (2015). The internet and Indonesian women entrepreneurs: Examining the impact of social media on women empowerment. In C. Arul, J. May, & B. Roxana (Eds.), *Impact of Information Society Research in the Global South* (pp. 203–222). Springer Open. https://doi.org/10.1007/978-981-287-381-1_6

Muto, M., & Yamano, T. (2009). The impact of mobile phone coverage expansion on market participation: Panel data evidence from Uganda. *World Development*, *37*(12), 1887–1896. https://doi.org/10.1016/j.worlddev.2009.05.004

Organisation for Economic Co-operation and Development. (2001). *Measuring productivity—OECD manual: Measurement of aggregate and industry-level productivity growth*. Paris: OECD Publicing. https://doi.org/10.1787/9789264194519-en

Organisation for Economic Co-operation and Development. (2003). *ICT and economic growth: Evidence from OECD countries, industries and firms*. https://doi.org/http://dx.doi.org/10.1787/9789264101296-en

Organisation for Economic Co-operation and Development. (2015). *Innovation policies for inclusive growth*. Paris: OECD Publications. Retrieved from http://www.oecd.org/sti/innovation-policies-for-inclusive-growth-9789264229488-en.htm

Organisation for Economic Co-operation and Development Southeast Asia Regional Forum. (2017). *Opportunities and policy challenges of digitalisation in Southeast Asia* (Background Note [August]). Retrieved from https://www.oecd.org/southeast-asia/events/regional-forum/Forum_Note_Digital_Transformation_STI.pdf

Olken, B. A. (2009). Do television and radio destroy social capital ? Evidence from Indonesian villages. *American Economic Journal: Applied Economics*, *1*(4), 1–33.

Pangestu, M., & Dewi, G. (2017). Indonesia and the digital economy: Creative destruction, opportunities and challenges. In E. Jurriens & R. Tapsell (Eds.), *Digital Indonesia: Connectiviy and divergence*. Singapore: ISEAS-Yusof Ishak Institute.

Paunov, C., & Rollo, V. (2016). Has the Internet fostered inclusive innovation in the developing world ? *World Development*, *78*, 587–609. https://doi.org/http://dx.doi.org/10.1016/j.worlddev.2015.10.029

Pellegrina, Lucia Dalla; Frazzoni, Serena; Rotondi, Zeno; Vezzulli, Andrea. (2017). Does ICT adoption improve access to credit for small enterprises?. *Small Business Economics,* 48(3), 657-679. DOI:10.1007/s11187-016-9794-x

Purbo, O. (2017). Narrowing the digital divide. In E. Jurriens & R. Tapsell (Eds.), *Digital Indonesia: Connectivity and divergence*. Singapore: ISEAS-Yusof Ishak Institute.

Resosudarmo, B. P., Sugiyanto, C., & Kuncoro, A. (2012). Livelihood recovery after natural disasters and the role of aid: The case of the 2006 Yogyakarta earthquake. *Asian Economic Journal*, *26*(3), 233–259. https://doi.org/10.1111/j.1467-8381.2012.02084.x

Sato, Y. (2013). Development of small and medium enterprises in the ASEAN economies. In *Beyond 2015: ASEAN–Japan strategic partnership for democracy, peace and prosperity in Southeast Asia*. Tokyo, Japan: Japan Center for International Exchange. Retrieved from http://www.jcie.org/japan/j/pdf/pub/publst/1451/full report.pdf

Schumpeter, J. A. (1934). *The theory of economic development*. Cambridge, MA: Harvard University Press.

Schumpeter, J. A. (1950). *Capitalism, socialism, and democracy* (3rd editon). New York, NY: Harper Collins.

Solow, R. (1987, July 12). We'd better watch out. *The New York Times Book Review*, p. 36.

Stock, J. H., & Yogo, M. (2005). Testing for weak instruments in linear IV regression. In

W. K. A. Donald & H. S. James (Eds.), Identification and inference for econometric models: Essays in honor of Thomas Rothenberg. Cambridge, UK: Cambridge University Press.

Sukmadi, Budianti, S., Hardjo, H., & Purwanto. (2008). *Metode Survei MDGs Tingkat Kecamatan*. Jakarta, Indonesia: BPS-UNICEF.

Tadesse, G., & Bahiigwa, G. (2015). Mobile phones and farmers' marketing decisions in Ethiopia. *World Development*, *68*, 296–307. https://doi.org/10.1016/j.worlddev.2014.12.010

Tambunan, T. (2009). *SMEs in Asian* Developing Countries. London, United Kingdom: Palgrave Macmillan. https://doi.org/10.15713/ins.mmj.3

Technopedia. (2018). Base Transceiver Station (BTS). Retrieved July 26, 2018, from https://www.techopedia.com/definition/2927/base-transceiver-station-bts

Telkomsel. (2016). *PT Telekomunikasi Selular Annual Report 2016: Accelerating Digital For Indonesia*. (Telkomsel, Ed.). Jakarta.

Triplett, J. E. (1999). The Solow productivity paradox: What do computers do to productivity? *The Canadian Journal of Economics*, *32*(2), 309–334.

Tybout, J. R. (2000). Manufacturing firms in developing countries: How well do they do, and why? *Journal of Economic Literature*, *38*(March), 11–44. Retrieved from http://www.jstor.org/stable/10.2307/2565358

World Bank. (2016). *Digital Dividends*. Washington, DC: The World Bank.

Yanagizawa-drott, D. (2014). Propaganda and conflict: Evidence from the Rwandan genocide. *The Quarterly Journal of Economics*, *129*(4), 1947–1994. https://doi.org/https://doi.org/10.1093/qje/qju020

Table 1. Indonesian MSE statistics

	1996–1997	2004	2016
Number of MSEs	16,780,631	17,145,244	26,263,649
Sectoral distribution (%)			
Mining	2.13	1.50	0.65
Manufacturing	17.0	15.58	16.65
Wholesale, retail[4]	58.2	61.16	47.27
Accommodation and food services			16.93
Other services	22.59	21.76	36.43
Number of employment	28,876,422	30,547,132	53,641,524
Contribution to GDP[5] (%)	40.45	39.22	46.28
Share of non-oil & gas exports[3] (%)	2.79	5.18	3.85

Source: Data for 1996–1997 and 2004 are from Integrated survey of small- and micro-scale establishment (BPS); data for 2016 are from the 2016 Economic Census listing (BPS)

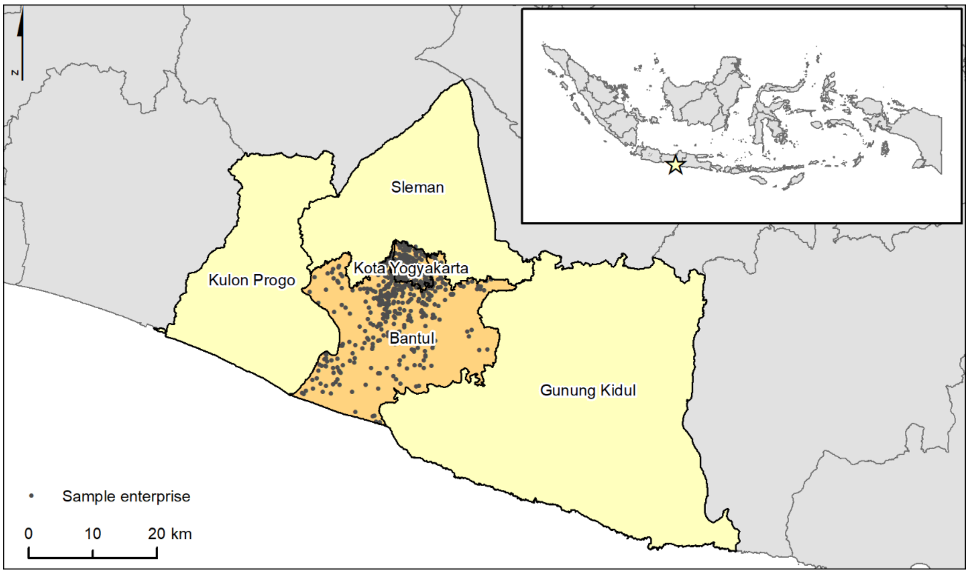

Figure 1. Map of survey location in Yogyakarta province

[4] Including accommodation and food services (1996–1997 and 2004) and repair of motor vehicles/ motorcycles (2016).
[5] Classification of MSEs is based on that of the Ministry of Cooperative and Small and Medium Enterprises

Table 2. Descriptive statistics

Variable	Obs	Mean	SD
Data at enterprise level			
Revenue per worker (IDR million)	567	7.70	17.89
Profit per worker (IDR million)	564	3.35	9.93
Proportion of exports (%)	576	7.03	19.61
Internet utilization (1 = yes)	576	0.62	0.49
Telkomsel cellular signal strength (0 = no signal, 1-5 bars)	576	4.56	0.82
Telkomsel cellular data type (0 = no signal, 1 = 2G, 2 = GPRS, 3 = EDGE, 4 = 3G, 5 = 4G, 6 = LTE)	576	4.92	0.44
Elevation (meters above sea level)	576	91.24	55.08
Width of road (1 = less than 2m, 2 = 2–4 m, 3 = 4–6 m)	576	2.10	0.71
Sector (1 = mining, 2 = manufacturing, 3 = service)	576	2.57	0.51
Home based enterprise (1 = yes)	576	1.40	0.49
Enterprise age (year)	576	15.37	14.10
Association membership (1 = yes)	575	0.15	0.36
Cooperative membership (1 = yes)	575	0.11	0.32
License (1 = yes)	576	0.37	0.48
Scale (1 = micro, 2 = small)	576	1.15	0.35
Gender (1 = male, 2 = female)	576	1.43	0.50
Education (0 = no educ, 1 = primary & secondary, 2 = higher educ)	576	1.62	0.57
Experience (year)	575	21.87	8.58
Age (year)	575	45.75	12.56
Data at village level			
Number of Telkomsel BTSs in village (unit)	107	50.17	59.21

The above statistics are unweighted.

Table 3. First stages for base IV estimates

Variables	Revenue per worker		Profit per worker		(%) Proportion of exports	
	(1)	(2)	(3)	(4)	(5)	(6)
Coefficient on instrument:						
Cellular signal strength	0.095***	0.165***	0.095***	0.170***	0.095***	0.165***
	(0.008)	(0.021)	(0.008)	(0.023)	(0.008)	(0.021)
Excluded *F* statistic	147.230	61.853	134.499	55.179	149.273	65.286
Controls & FE	N	Y	N	Y	N	Y
Observations	567	567	564	564	575	575
R squared	0.439	0.602	0.441	0.605	0.439	0.604

Note: Clustered standard errors by subdistricts in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Districts: Bantul and Yogyakarta; Sectors: mining, manufacturing, and services; Entrepreneur controls: gender, education, age, experience, Firm controls: home based, export status (unless exported goods), association membership, cooperative membership, license, scale, firm age, road width, elevation; number of cell towers in village. Weighted using sampling weight.

Table 4. Productivity effects of internet utilization

Variables	A. Labor productivity								B. Exports			
	Revenue per worker				Profit per worker				(%) Proportion of exports			
	OLS		IV: cellular signal strength		OLS		IV: cellular signal strength		OLS		IV: cellular signal strength	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Internet utilization	9.051***	4.466**	16.15***	10.23***	4.300***	1.141^	7.957***	5.459*	1.879***	1.364***	1.972***	1.729***
	(1.537)	(1.929)	(3.887)	(3.719)	(1.182)	(0.732)	(2.119)	(2.832)	(0.335)	(0.262)	(0.350)	(0.581)
Controls & FE	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
Observations	567	567	567	567	564	564	564	564	575	575	575	575
R squared	0.098	0.283	0.038	0.264	0.064	0.227	0.018	0.197	0.040	0.059	0.040	0.058

Note: Clustered standard errors by subdistricts in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Districts: Bantul and Yogyakarta; Sectors: mining, manufacturing, and services; Entrepreneur controls: gender, education, age, experience, Firm controls: home based, export status (unless exported goods), association membership, cooperative membership, license, scale, firm age, road width, elevation; number of cell towers in village. Fixed effects include district FE, and sector FE. Weighted using sampling weight.

Table 5. Reduced-form estimation results

Variables	Revenue per worker		Profit per worker		(%) Proportion of exports	
	(1)	(2)	(3)	(4)	(5)	(6)
Cellular signal strength	1.533***	1.380^	0.760***	0.769	0.187***	0.317***
	(0.323)	(0.840)	(0.186)	(0.583)	(0.0326)	(0.113)
Controls & FE	N	Y	N	Y	N	Y
Observations	567	567	564	564	575	575
R squared	0.138	0.267	0.097	0.223	0.019	0.050

Note: Clustered standard errors by subdistricts in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Districts: Bantul (base) and Yogyakarta; Sectors: mining, manufacturing (base), and services; Entrepreneur controls: gender, education, age, experience, Firm controls: home based, export status (for only productivity), association membership, cooperative membership, license, scale, firm age, road width, elevation; number of cell towers in village. Weighted using sampling weight.

Table 6. Further robustness tests

Variables	DV: Revenue per worker				DV: Profit per worker				DV: Proportion of exports (%)			
	Without context controls	IV = cellular data type	Spatial spillovers	Removing outlier	Without context controls	IV = cellular data type	Spatial spillovers	Removing outlier	Without context controls	IV = cellular data type	Spatial spillovers	Removing outlier
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Internet utilization	7.154^	8.371***	14.53***	6.332***	4.419	3.643*	4.821**	2.216***	1.596***	1.914***	1.621***	48.84***
	(4.573)	(2.355)	(4.002)	(1.291)	(3.213)	(2.021)	(1.908)	(0.574)	(0.568)	(0.506)	(0.593)	(15.82)
First stage												
Cellular signal strength	0.171***		0.152***	0.159***	0.175***		0.157***	0.160***	0.177***		0.158***	0.156***
	(0.019)		(0.026)	(0.020)	(0.020)		(0.028)	(0.025)	(0.019)		(0.025)	(0.023)
Cellular data type												
2G		1.205***				1.225***				1.240***		
		(0.108)				(0.105)				(0.103)		
GPRS		1.585***				1.598***				1.602***		
		(0.093)				(0.094)				(0.095)		
EDGE		1.257***				1.269***				1.306***		
		(0.107)				(0.110)				(0.119)		
3G		1.301***				1.327***				1.342***		
		(0.143)				(0.142)				(0.150)		
4G		1.344***				1.375***				1.367***		
		(0.087)				(0.096)				(0.086)		
LTE		0.922***				0.945***				0.921***		
		(0.159)				(0.163)				(0.166)		
Excluded F statistic	78.625	63.835	35.585	63.359	74.712	66.744	31.865	40.642	84.335	60.652	37.465	45.612
Neighboring BTSs			−0.062*				0.009				0.002	
(spatial spillovers)			(0.032)				(0.030)				(0.004)	
Controls & FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	567	567	567	505	564	564	564	498	575	575	575	127
R squared	0.262	0.275	0.235	0.203	0.197	0.217	0.206	0.278	0.057	0.057	0.058	0.526

Note: Clustered standard errors by subdistricts in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, ^$p < 0.11$. Districts: Bantul and Yogyakarta; Sectors: mining, manufacturing, and services; Entrepreneur controls: gender, education, age, experience, Firm controls: home based, export status (unless exported goods), association membership, cooperative membership, license, scale, firm age, road width. Context controls: elevation, number of cell towers in village.

Table 7. Platforms used and firm performance

Variables	Revenue per worker		Profit per worker		Proportion of exports	
	(1)	(2)	(3)	(4)	(5)	(6)
Website	3.394	5.669^	2.353	3.843	3.094	2.642
	(4.535)	(3.376)	(3.796)	(3.084)	(2.316)	(2.135)
Email	5.964	3.186	8.458*	3.604	3.966**	4.290**
	(5.206)	(3.728)	(4.408)	(2.557)	(1.488)	(1.893)
Social media	7.465***	4.985	3.136***	3.848**	0.929*	0.465
	(1.747)	(3.551)	(1.035)	(1.405)	(0.465)	(0.801)
Online shopping platform	−0.123	−0.441	−6.753	−4.859	−1.611	−3.283
	(6.381)	(5.807)	(4.448)	(3.699)	(1.655)	(1.984)
Controls & FE	N	Y	N	Y	N	Y
Observations	334	334	332	332	339	339
R squared	0.206	0.368	0.199	0.340	0.088	0.120

Note: Clustered standard errors by subdistricts in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Districts: Bantul and Yogyakarta; Sectors: mining, manufacturing, and services; Entrepreneur controls: gender, education, age, experience, Firm controls: home based, export status (except exports proportion), association membership, cooperative membership, license, scale, firm age, road width. Context controls: elevation, number of cell towers in villages. Weighted using sampling weight.

Appendix 1. Stratified sampling strategy adopted

Statistics Indonesia-BPS constructed the sampling frame, designed the sampling procedure, drew the MSE samples and calculated the sampling weight for this survey. The sample frame was constructed based on the MSE survey of September 2017, which was a more detailed sample survey of the 2016 Economic Census listing. This extended survey asked MSEs about internet utilization, and export and import activities undertaken by the enterprises.

The following is the sampling procedure to select our samples. In the first stage, we selected 2 districts out of 5 districts in Yogyakarta province, probability proportional to size randomly, where size is the number of MSEs in each district based on the 2016 Economic Census listing. Bantul district and Yogyakarta city are districts selected in the first stage. In the second stage, we constructed four MSE strata based on internet utilization (yes/no) and export or import activities (yes/no). Then, we selected n_s MSE samples in stratum *s*-th randomly. Samples in each stratum was allocated equally adjusted to total MSEs in each stratum in the sampling frame.

Appendix 2. Explanation of variables

Variable	Description	Source
Cellular signal strength (0,1–5 bars)	Telkomsel cellular signal strength measured using Telkomsel SIM card and Xiaomi Redmi 3 smartphones	Survey
Number of BTSs (unit)	Number of Telkomsel cell towers in village	PT. Telkomsel
Elevation (meters above sea level)	Altitude measured by GPS installed in Xiaomi Redmi 3 smartphones	Survey
Road width	Dummy variable equals to: 1 if < 2 m width (suits 1 car) 2 if < 2–4 m width (suits 1 car & 1 motorcycle) 3 if >4 m width (suits 2 cars or more)	Survey
Revenue per worker (IDR million per worker)	Revenue per worker	Survey
Profit per worker (IDR million per worker)	Profit (= revenue-expenses)	Survey
Proportion of exports to total sales (%)	Share of exports to total sales	Survey
Gender	Dummy value equals 1 if male, 2 if female	Survey
Education	Dummy variables equal 0 = no education 1 = primary or secondary junior school 2 = if senior high school, undergraduate, graduate	Survey
Age	Calculated as (2017–year of birth)	Survey
Experience	Calculated as (2017–age started working)	Survey
Home based	Dummy variable equals 1 if business site is the same unit of household residential, 0 otherwise	Survey
Export status	Dummy variable equals 1 if firm export products abroad directly or indirectly, 0 otherwise	Survey

Variable	Description	Source
Association membership	Dummy variable equals 1 if firm is a member of a business association, 0 otherwise	Survey
Cooperative membership	Dummy variable equals 1 if firm is a member of a cooperative, 0 otherwise	Survey
License	Dummy variable equals 1 if firm has a license, 0 otherwise	Survey
Scale	Dummy variable equals 1 if firm workers equal 1–4, or 2 if worker 5–19	Survey
Firm age	Calculated as (2017–year established)	Survey
Districts fixed effects	Bantul and Yogyakarta (base)	Survey
Sectors fixed effects	Mining, manufacturing (base) and services	Survey

Appendix 3. Correlation of between errors and the instrument

	Residual of revenue per worker	Estimated Internet utilization	Cellular signal
Residual revenue per worker	1.0000		
Estimated Internet utilization	0.0500	1.0000	
Cellular signal	0.0210	0.4822*	1.0000

	Residual of profit per worker	Estimated Internet utilization	Cellular signal
Residual profit per worker	1.0000		
Estimated Internet utilization	−0.0622	1.0000	
Cellular signal	0.0162	0.4822*	1.0000

	Residual of exports	Estimated Internet utilization	Cellular signal
Residual exports	1.0000		
Estimated Internet utilization	0.0843	1.0000	
Cellular signal	−0.0335	0.5531*	1.0000

* significant at 1%. Error terms are not correlated with signal strength.