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Engendering Digital Capabilities in Indonesia: Closing the Gender Divide Through Employment Effects

NAMIRA SAMIR & DAVID LAWSON

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Publisher: ***Centre for Digital Development***
Global Development Institute, SEED
University of Manchester, Arthur Lewis Building, Manchester, M13 9PL, UK
Email: cdd@manchester.ac.uk Web: https://www.cdd.manchester.ac.uk/

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Table of Contents

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Namira Samir & David Lawson[1]
Global Development Institute, University of Manchester, UK

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Abstract

Using a mixed methods approach we investigate cross sector employment effects of the gendered digital capabilities divide in Indonesia. Conceptualising independent digital connectivity (IDC) by integrating digital device ownership and access to internet, and identifying its five main drivers – i) trend and profitability, ii) connecting with prospective buyers, iii) the presence of local online marketplaces, iv) loss prevention and v) low market saturation – we find that there is a need to move from an access-based policy to an ownership-driven agenda where individuals no longer rely on public goods, other people or resources to have digital connections. Disaggregating IDC into zero, low, medium, and high levels we find that informal agricultural self-employment has a higher discouraging effect in medium IDC among men and high IDC among women. In commerce, women are significantly less likely to have medium IDC, while men are significantly less likely to have high IDC. In services, men are significantly less likely to have medium levels of IDC, while women are significantly less likely to have high IDC.

[1] Corresponding author: david.lawson@manchester.ac.uk

A. Introduction

Digital capabilities relate to the ability to have the skills and attitudes that enables individual digital capacity which can further aspirations and achievements, including improved representation and participation in the public sphere (UNECA, 2021). Globally, significant gendered divides in digital capabilities exist, particularly within and across low-middle-income countries (Sey and Hafkin, 2019). Digital capabilities can enhance women's economic participation, through several mechanisms such as increasing the probability of becoming owners of medium-sized and large-sized enterprises, that can contribute to job creation through information and communications technology (ICT) (McAdam *et al.,* 2020). However, women are less likely to own and use digital devices due to social, economic, and cultural restrictions (Demirgüç-Kunt *et al.* 2021). Failures to address such divides can hinder future economic growth and development (Fantom and Serajuddin, 2016).

In this paper, we conceptualise digital capabilities related to the use and ownership of a digital device, with the capabilities developed through ownership of resources and active participation in the labour force. Ownership of resources refers to both tangible and intangible resources such as education and general knowledge, whilst labour force participation can be associated with increased digital capabilities through the increased digitalisation of economic activities (Ruiner and Klumpp, 2022).

We extend the prior literature, that restricts the employment and digital capabilities focus to income effects (Balgobin and Dubus, 2022; Forenbacher *et al.*, 2019; Galperin and Arcidiacono, 2021; Hasbi and Dubus, 2020). Equally, several studies have examined the role of employment in digital capabilities through lenses such as precarity (Gebrial, 2022), job insecurity (Brougham and Haar, 2020; Heyes, 2011), and adaptability (McArdle, 2007). However, we extend the prior research by disaggregated the impact of working in different economic sectors and job formality.

The paper makes three main contributions to the literature. First, we add to the emerging discourse analysing how employment is associated with the gendered digital capabilities divide (Balgobin and Dubus, 2022; Campos *et al.,* 2017; Forenbacher *et al.,* 2019; Galperin and Alciridiacono, 2021). We extend one of Martha Nussbaum's universal capabilities – control over one's environment (Nussbaum, 2000; 2003) – to conceptualise independent digital connectivity (IDC) as a form of digital capability, measured in terms of an individual's ownership and use of a digital device as a form of communication, transaction, and economic activity.

While prior studies focus on digital connectivity (Balgobin and Dubus, 2022; Forenbacher *et al.,* 2019; Galperin and Alciridiacono, 2021), we utilise the capability approach, emphasising the need to observe the independence aspect of digital connectivity – enabling an investigation into who has the freedom to be digitally connected. Second, by considering informality of employment, we can further understand gendered digital capabilities divides. This is particularly important for areas such as Southeast Asia, where informality of employment is extremely prevalent (Bonnet *et al.,* 2019; Fagertun, 2017). Third, we identify the drivers of digital capabilities for individuals in the informal economic sectors (Gebrial, 2022), and generate policy implications on how to ensure digital capabilities in middle-income countries, such as Indonesia.

The remainder of this paper is structured as follows. Section B discusses the conceptualisation of digital capabilities. Section C presents the contribution of prior literature regarding employment and digital capabilities. Section D describes the datasets and model specifications. Section E presents the results and discussion. Section F concludes the paper.

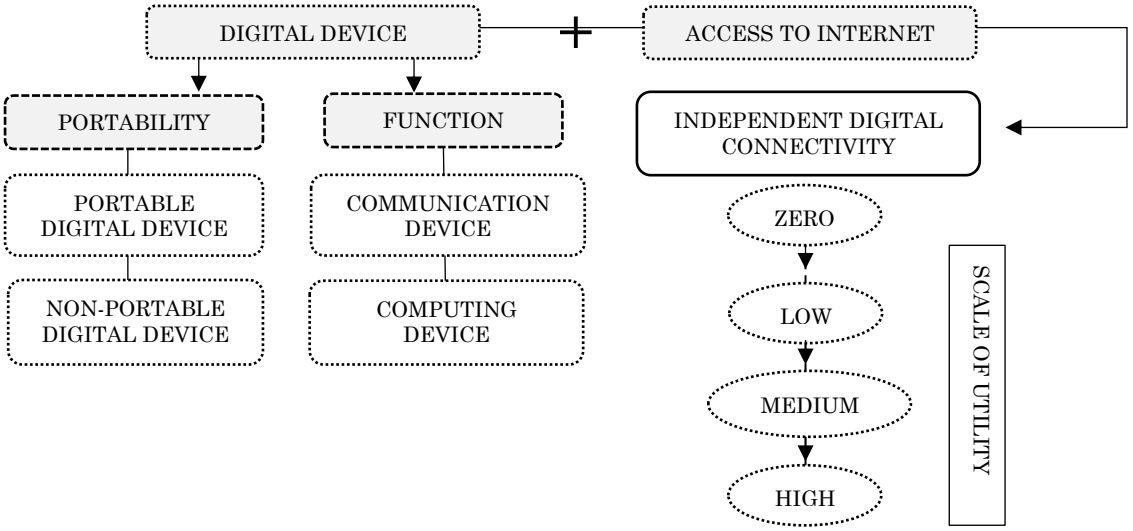
B. Digital Capabilities: Independent Digital Connectivity (IDC) and Scale of Utility

There is a lack of consensus regarding the term 'digital capabilities'. Cortoni and Presti (2015) and Sey and Hafkin (2019) equate digital capabilities with digital competence (i.e. knowledge, basic skills), such as ability to use the internet, send e-mails, access financial accounts, and attitudes needed to perform activities in the digital sphere, to reap the impact of ICT operations. However, the digital capabilities literature is limited by excluding the value associated with digital sphere participation as a digital capability. Equally, prior work tends to restrict capability to whether a person uses digital device data (usage of the internet, transactions, economic activity, *et cetera*) (Campos *et al.,* 2017; Galperin and Arcidiacono, 2021). or owns a digital device (e.g. mobile phone, basic mobile phone, smartphone) (Balgobin and Dubus, 2022, Forenbacher *et al.,* 2019).

Adopting a realised functioning approach (Sen, 1999) we construct an independent digital connectivity (IDC) capability framework,[2] that reflects differences in the quality of digital participation. To illustrate further – if two individuals both had internet access, with one owning a smartphone and another a computer, these individuals would have different levels of capability. Both independence of access and the types of communications, transactions, and economic activities they can execute would differ. IDC requirements include the need to possess both access to internet and a personal digital device (*Figure* 1). Access to internet alone cannot be equated with digital capability because utility derived is zero if there is no access to a digital device, thus IDC has four combinations of digital device ownership and internet access in our framework: 1) Zero IDC, 2) Low IDC (Simple Mobile Phone with Internet Access), 3) Medium IDC (Smartphone or Computer with Internet Access), 4) High IDC (Smartphone + Computer with Internet Access).

[2] According to Sen (1999), human capabilities can be measured in terms of 1) valuable functionings: a set of beings and doings that individuals would have access to and 2) realised functionings: a set of beings and doings that individuals already have access to. To study the capability to own and use a digital device as a valuable functioning, a researcher might ask whether the respondent can purchase and use a personal digital device with internet should they wish to, based on their current circumstances. The response might be in binary (yes/no) or a scale on how likely they can acquire the form of capability. Meanwhile, measuring realised functioning is based on current ownership and usage.

***Figure* 1** Conceptual Framework of Independent Digital Connectivity



Source: Authors

Within the framework, we recognise that the scale of utility is also an important facet of capabilities and thus conceptualise based on the digital device's portability and function (*see:* Shruti, 2017). Portability refers to whether the digital device can be easily transported, whilst function refers to the main purpose of the digital device, such as whether it is designed as a communication or computing device. For example, smartphones cannot necessarily perform the same scale of activities as desktop computers, yet the level of portability associated with smartphones is not possessed by a desktop computer (Chen *et al.,* 2019).

The conceptualisation of scale of utility differs from utilitarianism that merely concerns numbers. Owning ten laptops would not expand the scale of utility in the way that the ownership of a smartphone and a desktop computer would since the latter combines the values of portable and non-portable digital devices and the functions of an advanced communication device and a computing device, which can help enhance an individual's ability to participate in digital social, economic, and political spheres (UNECA, 2021).

A study by Hirai (2021) on capabilities measurement used a seven-point Likert scale to calculate the weight of the attainment level of Nussbaum's ten universal human capabilities in BRIC countries *(Brazil, Russia, India, and China).* In our study, we do not assign weights to IDC because the four combinations of digital device ownership and internet access in our study are not the only combinations that could exist for IDC. Thus, our categorisation of IDC as zero, low, medium, and high should be seen as the initial stage of the scale of utility of IDC and this could be further expanded or reduced depending on the number of combinations of digital devices and internet access that a study could have.

C. Independent Digital Connectivity and Employment

Digital capabilities effects on employment vary according to the type of capability. For example, digital skills, such as the ability to produce digital content, can positively influence

employment opportunities overall (Reljic *et al.,* 2021), whilst the ability to partake in digital-based activities, with a digital device, is associated with the different types of employment. Considering the employment and gender digital divide literature, Galperin and Arcidiacono (2021) found, for four Latin American countries, that women tend to be overrepresented in the informal economy. For Uganda, Balgobin and Dubus (2022) differentiated employment and self-employment and found no positive effects of mobile phone use. However, neither of the aforementioned studies considered the legal status, formal or informal, of employment which has long been established to have an impact on vulnerability (Chen, 2001; Gallin, 2001; Rankin, 2001; Samir, 2021).

However, the existing digital technologies literature has more commonly considered the reverse relationship – considering employment as one of the primary drivers of digital demand (Balgobin and Dubus, 2022; Forenbacher *et al.*, 2019; Galperin and Arcidiacono, 2021), and in particular focused on how internet access and digital device demand are determined by the sector of employment (Campos *et al.,* 2017; Galperin and Arcidiacono, 2021). The role of consumer demand and interaction with IDC have been less frequently considered as factors that prompt an individual to own a digital device (Elyachar, 2010; Justman and Van Der Beek, 2015).

Hasbi and Dubus (2020) examined the effect of types of job classified by activities, such as farmers, craftsmen (self-employed), white collars or manual workers, military, unemployed, and students on mobile broadband adoption in Nigeria, Kenya, Tanzania, and Uganda. Being a farmer was negatively associated with mobile broadband use in Nigeria and Tanzania. Meanwhile, white collar workers were positively associated with mobile broadband use across all countries, except in Uganda. Although the findings are of interest, the lack of sectoral identification limits detailed policy inference. In this paper, we therefore extend the analysis and examine the interaction between employment and sectoral activities and its association with independent digital connectivity.

D. Data and Empirical Strategy

We adopt a mixed-methods research design and analysis to investigate the association between employment and IDC. The work here has several methodological and analytical advantages over prior work as we use an Indonesia Survey on Financial Inclusion and Access (SOFIA) containing 13,085 individual level observations (BAPPENAS, 2017) which we complement with fieldwork interview data from *Koperasi Mitra Dhuafa* (KOMIDA), a credit and savings institution located in rural East Java (Barada and Garda), collected in 2022. The combined methods approach that follows-up the first survey wave data with mixed methods provides the advantage of ensuring a robust econometric modelling. Furthermore, through thematic qualitative analysis, we are able to provide the reasons behind informal self-employment (ISE) actors' investments in IDC - which could not otherwise be holistically uncovered if SOFIA data was used in isolation.

Three stages of econometric analysis are adopted: firstly, we examine the employment effects on IDC in relation to employment status, the formality of employment, and economic sectors; secondly, we provide a gendered disaggregation; thirdly, we disaggregate by rural and urban areas and consider the gender effects whilst controlling for the province of residence. We combine the econometric and qualitative analysis, enabling us to evaluate

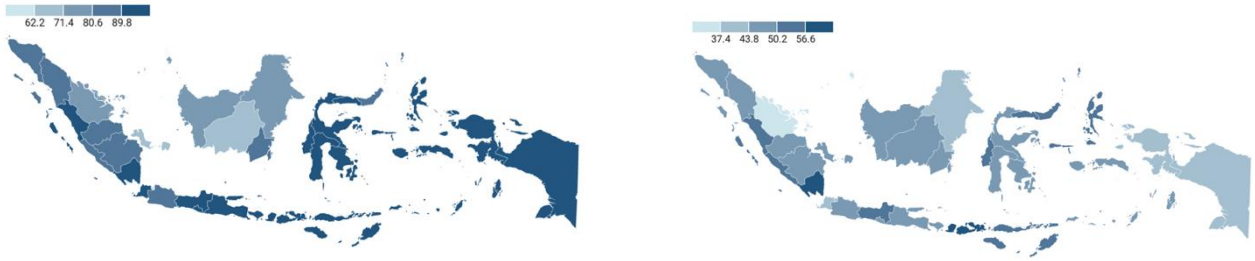
the drivers of digitalisation across informal self-employment activities among female KOMIDA borrowers.

D1. Indonesian Data

Indonesia is dominated by informal work, with 63 (57) per cent of working-age women (men) working in the informal economy in 2021 (BPS, 2022a). Informal employment (*Figure* 2) is higher in agriculture than in non-agriculture and provinces with a higher share of informal agricultural employment have a lower share of informal employment in non-agriculture. *Figure* 3 shows that only a few provinces (Java, Kalimantan, and Sumatra) have high shares of formal employment with Eastern Indonesia dominating the low rate of formal employment. This is particularly important given that women's lack of formal labour market participation has long been established as a transmission mechanism that leads to lower levels of economic growth, low productivity, and slower progress in the adoption of technology, amongst other factors (Blackden *et al.,* 2006).

***Figure* 2** Share of Informal Employment in Indonesia (2021)

Agriculture **Non-Agriculture**



***Source*:** BPS (2022d; 2022e), computed and mapped by the authors.

***Figure* 3** Share of Formal Employment in Indonesia (2021)

***Source*:** BPS (2022c), computed and mapped by the authors.

Data on digital device ownership, disaggregated by occupation (see: *Additional Figures* B.1-B.4), also demonstrates that individuals who work in the formal economy have the highest percentage of ownership of more advanced digital devices such as smartphone, computer, and laptop. Among the non-salary-based employees, those working in commerce have a higher percentage of advanced digital device ownership compared to those in the agriculture sector. Provinces with low IDC, as measured by digital device ownership and use have a higher share of informal employment and a lower share of formal employment.

Figures 4 and 5 highlight that a gendered pattern of IDC is present – whereby improvement in digital connectivity over time among men is more significant than for women.

***Figure* 4** Recent Internet Access by Men in Indonesia (%)

2016 **2021**

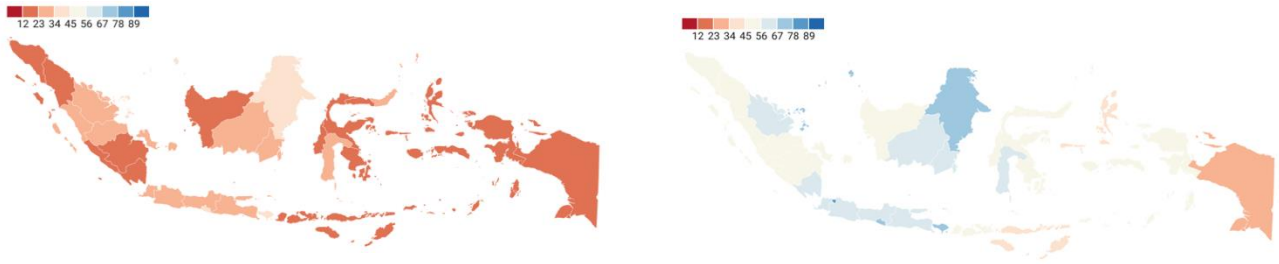
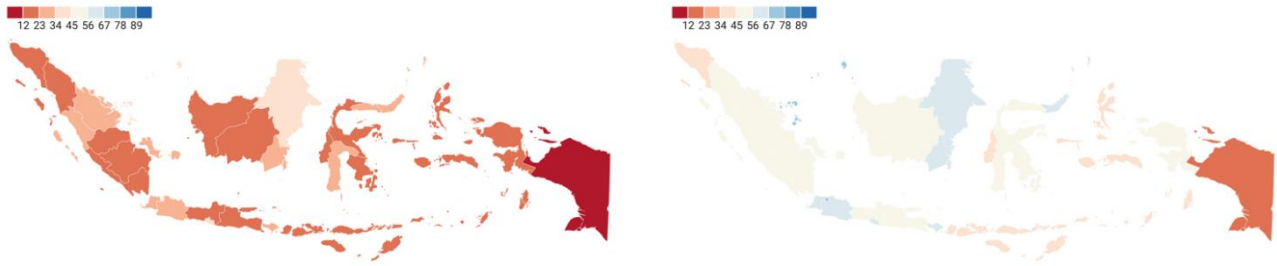


***Figure* 5** Recent Internet Access by Women in Indonesia (%)

2016 **2021**

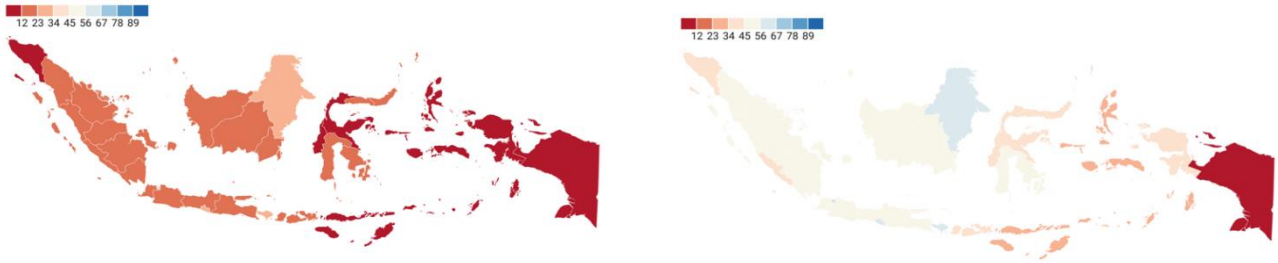


***Sources for Figures 4-5**:* BPS (2020; 2021c), computed and mapped by the authors.

The IDC gender divide appears to have geographical patterns. As shown by *Figures* 6 and 7, the positive change over time in the percentage of men who had accessed internet in the last three months in rural areas is higher than that of women. In *Figures* 8 and 9, conversely, the gender divide in IDC in urban Indonesia drastically declines from 2016 to 2021.

***Figure* 6** Recent Internet Access by Men in Rural Indonesia (%)

2016 **2021**



Sources for Figure 6: BPS (2020; 2021c), computed and mapped by the authors.

***Figure* 7** Recent Internet Access by Women in Rural Indonesia (%)

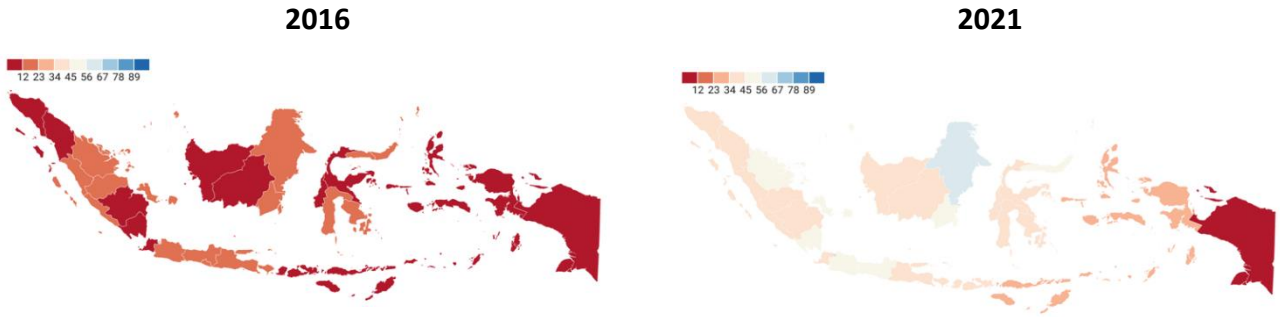


***Figure* 8** Recent Internet Access by Men in Urban Indonesia (%)

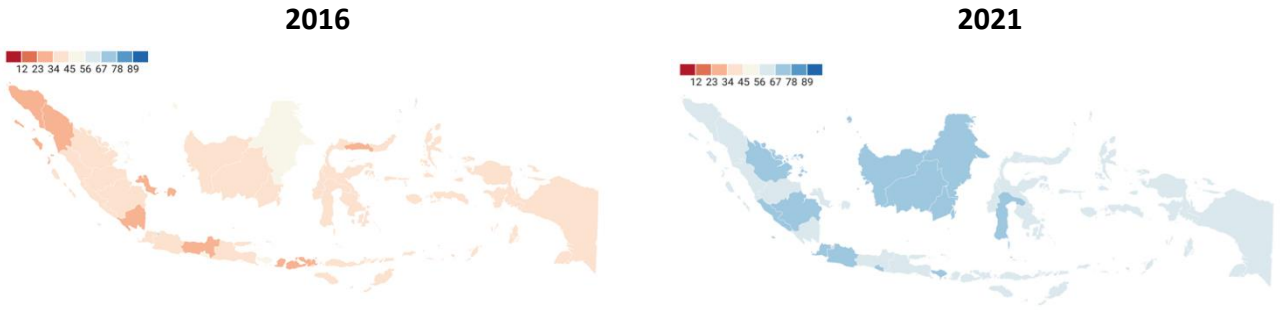
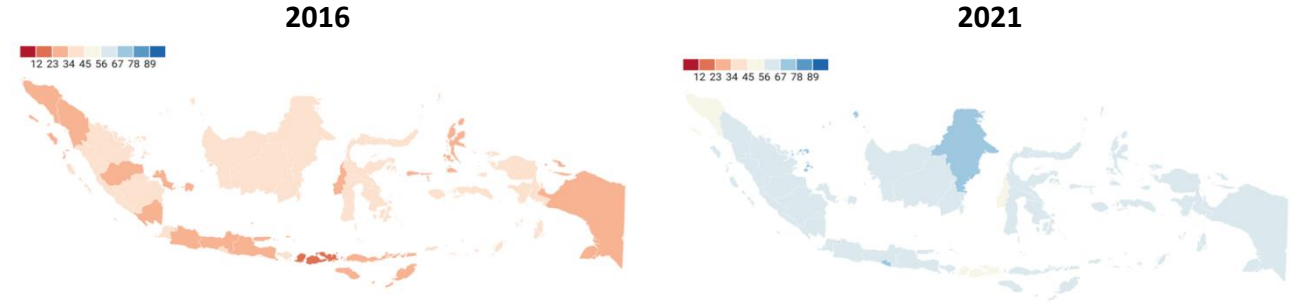


***Figure* 9** Recent Internet Access by Women in Urban Indonesia (%)



Sources for Figures 7-9: BPS (2020; 2021c), computed and mapped by the authors.

Descriptive statistics from the SOFIA data indicate that the level of digital capabilities (*Additional Table* A.1) is dominated by individuals without IDC (69 per cent), followed by medium IDC (smartphone or computer with access to internet) (19 per cent), high IDC (smartphone + computer with access to internet) (7 per cent), and low IDC (simple mobile phone with access to internet) (5 per cent).

The percentage of individuals who engage in ISE in commerce across the low (9 per cent), medium (11 per cent), and high (9 per cent) levels of IDC appear not to dramatically fluctuate. This contrasts with those who engage in ISE in agriculture and service-based sectors, with their share of the population showing a decline from low to medium to high levels of IDC. Thus, it is not merely income that governs the association between employment and IDC but rather what these different sectors of employment represent.

We can see from the descriptive statistics that there appears to be a positive association between financial resources such as savings and financial support from household members and the level of IDC. A similar pattern is also observed with ownership of movable assets, particularly of both a car and a motorcycle based on the level of IDC. Among those with a high level of IDC, most of the sample holds a bachelor's degree (34 per cent), completed K-12 education (33 per cent), or vocational degree (23 per cent), whilst those without digital capability are dominated by those without an elementary school certificate.

The qualitative fieldwork complements the quantitative data by investigating the lived experiences of women who are members of credit and savings institutions, investigating the factors in their economic sector that drive them to have IDC. The fieldwork was held at KOMIDA branches in rural East Java (Barada and Garda) in 2022, a six-year gap with the SOFIA dataset. We consider this an advantage in seeing how much connectivity and digital capabilities have changed. We can also investigate the timeline of someone's digital device ownership and use and the ways the market influences that decision.[3]

In terms of digitalisation, 56 per cent of the rural population in East Java have IDC. This is relatively lower than other rural areas in other Indonesian provinces (BPS, 2021). The decision to conduct the fieldwork at KOMIDA, a credit and savings institution, instead of capturing a general sample of women workers is because of the following reasons. Firstly, our main interest is to investigate the drivers in informal economic activities that might contribute to a person's IDC. Members of these institutions mainly partake in economic activities in the informal economy, which ensures that we can be connected to the hub of the informal labour market. Secondly, we have the advantage of also evaluating the roles of resources such as credit and savings and related financial affairs in digital capabilities.

The interview questions focussed on the respondents' phone ownership, internet access and usage, and the utilisation of digital platforms to execute their economic activities. The latter information is crucial in terms of drawing a conclusion, given that such information is not available in the SOFIA dataset. We also investigated the digital capabilities of the non-respondent household members to gauge the effects of household affairs, by collecting data on management of household finance, household chores, and other domestic activities, on the respondent's digital capabilities. The descriptive statistics can be reviewed in *Additional Table* A.6.

D2. Empirical Strategy

We follow the approach of prior literature (Balgobin and Dubus, 2022; Rice and Katz, 2003) by adopting a three-step regression strategy to disentangle the association between related employment and digital capabilities. Notably, we seek to understand the association between mobile phones and employment, beginning with i) mobile phone (ownership and use) and employment status (1 = employed, 0 = unemployed), ii) mobile phone (ownership and use) and job regularity (1 = regular job, 0 = irregular job), and iii) mobile phone (ownership and use) and self-employment (1 = self-employed, 0 = other forms of employment).

[3] To protect the respondents' identities, the names of the respondents and the locations have been replaced with pseudonyms.

$$IDC = \alpha + \beta_1 employment + \beta_2 Xi + \varepsilon i \quad \text{[equation 1]}$$

IDC is the independent digital connectivity constructed variable with the main explanatory variable, $employment$, taking different forms depending on the sequence of the analysis. We first evaluate the notion of employment as an income-generating activity, followed by employment based on income security, and lastly, employment based on sectoral activities. Xi accounts for all the variables that might contribute to the individual's IDC.

In this first stage of the econometric analysis we test the effects of employment based on the different conceptual meanings of independent digital connectivity, beginning with i) Employment as Income-Generating Activity, followed by ii) Employment based on Legal Status, and iii) Employment based on Sectoral Activities, extending the contribution of prior existing literature (Balgobin and Dubus, 2022; Forenbacher *et al.*, 2019; Galperin and Arcidiacono, 2021) and controlling for various financial and non-financial variables that might influence IDC. Employment is a categorical variable reflecting three employment statuses (not working, informal employment, and formal employment - Chen and Hamori, (2013)). We extend the disaggregation to consider iii) Employment Based on Sectoral Activities, consisting of 1) Not Working, 2) ISE in Agriculture, 4) ISE in Commerce, 4) ISE in Services and 5) Formal Employment. Our approach differs from Balgobin and Dubus (2022), who individually tested the association between employment and mobile phone ownership using three probit models: being employed, regular job, and self-employed. Our approach is advantageous in understanding the marginal effects of each ISE activity relative to formal employment.

The second stage of the econometric work provides a focus on the gender divide in digital device ownership and use and access to internet (Galperin and Arcidiacono, 2021) to assess the gendered employment effects on IDC. The third stage of the econometric work provides a rural-urban-gender interaction thus permitting the analysis to go beyond a simple biological sex disaggregation (Manlove and Whitacre. 2019). We provide a focus on the vector of tangible resources (credit, savings, government cash assistance, financial support from household members, ownership of fixed assets and movable assets), intangible resources (education and financial education), essential capabilities (energy, floor material, toilet), and socio-demographic information (gender, age, province of residence).

D2.1 Independent Digital Connectivity

Our dependent variable is *independent digital connectivity*. The independent aspect of this variable is based on Sen (1999)'s conceptualisation of individual capabilities that concerns *freedom of being and doing.* It means an individual does not have to rely on anyone else's support to be someone or perform an activity that she or he wants to be or do.

The *digital connectivity* component captures the various ways of connecting to the digital world. As such, the focal point of interest is not merely the ability to have digital connectivity but also the *means* through which to connect to the internet via a digital device. The *means* can be divided into personal and non-personal digital device. Personal device can be, for instance, simple mobile phone, smartphone, computer, laptop, tablet, and other types of digital devices owned by an individual (Moreno-Llamas *et al.,* 2020). Non-personal digital device that individuals can access tend to be publicly owned, such as computers in a public library (Anderson and Whalley, 2015). Such *means* can also be

facilitated via loans, such as a company's provision of digital device to its employees, which they need to return when they leave their positions (Sipilä, 2010). The validity of *digital connectivity* requires the fulfilment of the *independence* criteria. In this instance, only 'personal' device with access to internet can be considered a form of IDC.

We construct IDC as a variable that captures the combination of an individual's digital device ownership and access to internet by considering its scale of utility (see*: Figure* 1). Using SOFIA datasets, we can capture the four levels of IDC, namely: 1) Zero IDC; 2) Low IDC (Simple Mobile Phone with Internet Access); 3) Medium IDC (Smartphone or Computer with Internet Access); 4) High IDC (Smartphone + Computer with Internet Access). *Simple mobile phone* is a portable digital device that only fulfils a communication device's function; hence it is considered a low IDC. *Smartphone* is a portable digital device with communication and computing functions, putting it in a medium level of IDC. Lastly, a *desktop computer* is a non-portable digital device with both communication and computing functions.

The combination of smartphone and desktop computer with access to internet puts the variable as the highest level of IDC within our construct. The construction of this variable adds to Rice and Katz (2003) that differentiated mobile phone and internet with respect to whether they are users or non-users, veteran or recent, and continuing or dropout (former users). It also builds on empirical work such as by Balgobin and Dubus (2022) that uses ownership of different types of mobile phone as a categorical variable.

D2.2 Employment Based on Sectoral Activities

The main explanatory variable, *employment based on sectoral activities,* is developed by disaggregating employment/self-employment status to its sectoral level. The construction of the employment variable by Galperin and Arcidiacono (2021) based on factors influencing the gender digital divide in four Latin American countries merely assessed the effect of a binary variable of employment status (1 = employed, 0 = otherwise). We contribute to this discussion by extending the employment variable constructed by Balgobin and Dubus (2022) who differentiated three employment statuses: employed, regular jobs, and self-employment in relation to mobile phone use in Uganda. For our study, we are able to divide employment into five categories: i) not working, ii) formal employment, iii) ISE in agriculture, iv) ISE in commerce, and v) ISE in services.

Formal employment is defined as work with salary or wages received from a registered business or organization. Meanwhile, informal self-employment refers to individuals who acquire money from trading/selling in the informal economy, which is characterised by businesses without legal status (Dimova *et al.,* 2010). Our constructed variable seeks to understand the marginal effect of different informal self-employment activities relative to formal employment.[4] We posit that engagement in different informal self-employment activities might result in different likelihoods of having a digital device with internet access, as measured by our conceptualisation of IDC.

Varying employment categories have different determinants of digital adoption/usage. For example, regarding informal self-employment in agriculture, Paudel *et al.* (2020) and Smidt and Jokonya (2022) identified profitability as the factor guiding cotton farmers' adoption of digital technology. In commerce-based and service-based informal self-employment, the

[4] We perform a Likelihood Ratio test to assess whether sectoral disaggregation improves the model's fit (*see: Additional Table* A.5).

ways customers want to be served are strongly linked to the business owners' intention to be digital. Townsend *et al.* (2017), through the analysis of creative industries in rural Scotland, identified the heightening dependency of rural creative enterprises on broadband connectivity to promote and market their products. They argued that it is not just a way to develop new markets but also maintain the existing ones. As a result, enterprises in areas with poor connectivity relocated to areas with better connectivity. This demonstrates instances where people seek adaptive strategies to remain in their respective markets (Philip and Williams, 2019).

Another distinguishing element between different informal self-employment activities is the customers and consumers. In commercial agriculture, customers and consumers tend to be detached from each other; customers that directly interact with farmers tend to be intermediaries, usually distributors who then sell the farmers' products to the final consumers. In other cases, farmers sell directly to nearby markets. Meanwhile, in commerce and services, items or services are sold to individual customers who are meant to consume the end products. We argue that this could be a factor that differentiates the cost of being disconnected between different informal self-employment activities and their willingness to adapt to retain income (*see:* Tanle and Abane, 2018).

Our mixed-methods approach permits us to both investigate the marginal effects of different employment/self-employment activities in relation to IDC and, qualitatively, assist the identification of IDC drivers that exist in informal self-employment activities.

D2.3 A Sequential Approach to Assess Gendered Digital Capabilities Divide

We utilise the multinomial logit model to examine the association between employment and *independent digital connectivity*. This multinomial logit model enables us to analyse the different employment choices that people make (Crawford *et al.,* 1998). To ensure robustness of approach we test the parallel regression assumptions required by the alternative regression model, Ordered Logit (Gim, 2022), whereby the effect of or odd ratios of independent variables on a category of dependent variable must be the same on the other categories. As shown by the ordered logit results (*Additional Table* A.5), the violation of the parallel regression assumptions confirms that the natural ordering of the dependent variables is not present, which confirms the validity of the use of multinomial logistic regression.

Key assumptions of multinomial logit estimation include the *independence of irrelevant alternatives (*IIA) – which concerns the change in relative probabilities of the outcome variables.[5] The IIA assumption requires that the relative probabilities of existing outcome variables should not change even when some of the outcome variables are removed, or a new outcome is added. Thus, if, for instance, laptop ownership and access to internet is added as IDC or Medium IDC is removed, there would be no alteration of the current relative probabilities. This assumption was tested using the Small Hsiao test (Small and Hsiao, 1985), and the results confirmed the fulfilment of the IIA assumption (see: *Additional Table* A.3).

We treat the first category, namely 'Zero IDC', as the base outcome to which we compare the remainder of the categories. The default category follows prior work such as Balgobin

[5] We also run the Goodness of Fit test to establish the model's reliability. The results can be found in *Additional Table* A.3.

and Dubus (2022) who treated '*no mobile phone ownership*' as the base category. We utilise 'Zero IDC' as the base outcome to capture the choice between the two extremes of opting for a certain form of IDC and living without IDC – both of which can illuminate why some people remain digitally disconnected. Our main independent variable, "employment", takes three forms, beginning with i) a dummy variable of employment (equal to 1 if the individual is working, 0 otherwise), followed by ii) a categorical variable of employment (not working, formal/salary-based employment, and informal self-employment), and lastly iii) a categorical variable of employment based on sectoral activities, which extends the second form by disaggregating informal self-employment based on its sectors (agriculture, commerce, and services). A three-stage econometric analysis is undertaken to examine the gendered digital divide.

D2.4 Threats to Internal Validity

Prior literature has highlighted potential concerns relating to reverse causality between employment and IDC. However, we argue, and agree with prior literature, that there are instances in which the approach such as that used in this study is justified.

Firstly, this study does not simply measure 'use' or 'ownership' of a digital device. Rather, it creates a proxy variable as undertaken by Ochoa *et al.* (2022). The proxy of digital capabilities in this research is a merger of two observations, namely: ownership of a digital device and access to internet. The merged variable represents an individual's independent digital connectivity (IDC). The use of proxy or constructed variables has been documented in the literature as a sound strategy to counteract endogeneity or related threats to internal validity (Levinsohn and Petrin, 2003; Malikov and Lien, 2021; Miao *et al.,* 2018).

The existing literature (Balgobin and Dubus, 2022; Forenbacher *et al.*, 2019; Galperin and Arcidiacono, 2021; Hasbi and Dubus, 2020) does not capture digital capabilities and only considers a single category of observation – either digital device ownership or digital device usage. We argue that this reduces the likelihood of a reverse causality between employment and IDC. Given that IDC is a constructed variable, its combined, theoretical value, is less likely to correlate collectively. Ochoa *et al.* (2022) constructed a proxy of price measure of mobile services merging individual-level positive expenditures on prepaid mobile phone cards and data transfers, arguing that the creation of such a proxy eliminated potential endogeneity.

Prior literature such as Forenbacher *et al.* (2019) and Grzybowski (2015) also formulated the same pathway, namely that employment determines mobile phone ownership. They consider it as one of the socio-economic determinants of mobile phone ownership to address the digital divide. Grzybowski (2015) found that economically inactive individuals are less likely to own a mobile phone. In line with both Forenbacher *et al.* (2019) and Grzybowski (2015), we do not empirically correct for endogeneity bias, but argue that the inclusion of relevant control variables should improve the model.

Secondly, our mixed-methods research design adopts qual-quant-qual sequencing as with Davis and Baulch (2010). Our qualitative work on the drivers of IDC informed the quantitative functional form within the econometric modelling, which ensured that the presence of association between IDC and employment in the informal economy is not bi-directional. This approach is also advocated by Shaffer (2018) and Lawson *et al.* (2007) to improve the modelling. Thirdly, our model contains 422 observations per variable. This ratio surpasses the minimum ratio required to ensure empirical validity (Hosmer *et al.,* 2013).

However, we must note that we could not test or address the endogeneity concerns econometrically because of data limitation. Within the observations themselves, we are unable to find a variable to be used as an instrumental variable. Therefore, our findings should be taken with a caveat that it strictly establishes association and not causality.

E. Results and Discussion

This section reports the results from econometric analysis and fieldwork. Firstly we outline the regression results for the employment effects on IDC, and then provide the gender-rural-urban disaggregated results.

E1. Employment Effects

Employment effects on IDC are tested in three separate regressions: 1) Employment as Income-Generating Activity, 2) Employment Based on Legal Status, 3) Employment Based on Sectoral Activities.

E1.1 Employment as Income-Generating Activity

Table 1 shows the relationship between employment and IDC, which is found to be insignificant. In a related study, Galperin and Alciridiacono (2021) found an insignificant association between *being employed* and internet usage in Latin America. They used income as a control variable, permitting individuals to separate *being employed* as being able to work from *being employed* as being able to generate income. There are several potential reasons for the insignificance. Firstly, the financial ability to purchase a digital device and internet access might come from the individual's capital reserves instead of the ability to generate income. Secondly, the ability to generate income might only matter if tested as a categorical variable based on income earned.

***Table* 1** Employment as income-generating activity and IDC (N=13,085)

	INDEPENDENT DIGITAL CONNECTIVITY		
	Low	**Medium**	**High**
Employment As Income-Generating Activity			
Working	0.2873	0.0416	-0.2883
	(0.2036)	(0.1408)	(0.2291)
Control Variables	YES	YES	YES
Cons	1.0387	0.3653	-3.6268***
	(0.6895)	(0.6247)	(0.9556)
R-squared/Pseudo R-squared			0.3659

Notes: Standard errors are in parentheses. ***, **, * denote statistical significance at 1, 5, and 10 per cent, respectively.

E1.2 Employment Based on Legal Status

By differentiating employment based on legal status, we examine the marginal effects of *not working* and ISE relative to *formal employment. Table* 2 demonstrates that an individual who is *not working* is significantly less likely to own a digital device and access the internet – measured by low IDC and medium IDC. However, *not working* is not significantly associated with high IDC. Informal self-employment has a significant and negative association with medium and high IDC.

***Table* 2** Employment Based on Legal Status and IDC (N=13,085)

	INDEPENDENT DIGITAL CONNECTIVITY		
	Low	**Medium**	**High**
Employment Based on Legal Status (ref: formal employment)			
Not Working	-0.4327*	-0.3060*	0.0209
	(0.2280)	(0.1610)	(0.2415)
Informal Self-Employment	-0.2457	-0.5573***	-0.5703***
	(0.2034)	(0.1454)	(0.2183)
Control Variables	YES	YES	YES
Cons	1.4451*	-0.2258	-3.6440***
	(0.7648)	(0.6226)	(0.9438)
R-squared/Pseudo R-squared			0.3681
Prob.Chi2			0.0000

Notes: Standard errors are in parentheses. ***, **, * denote statistical significance at 1, 5, and 10 per cent, respectively.

E1.3 Employment Based on Sectoral Activities

Prior studies have shown that a segmented analysis of the labour market can help explain how livelihoods are affected by different work undertaken (Dubey *et al.,* 2017; Rajkarnikar and Ramnarain, 2020). Results in *Table* 3 highlight that, relative to formal employment, informal self-employment in agriculture is only significantly and negatively associated with medium IDC. Meanwhile, ISE in commerce shows significant negative coefficients in low and medium IDC. ISE in services shows significant associations with medium and high IDC, with the coefficient increasing as the level of IDC rises. Generally, ISE in commerce has a higher negative association with low and medium IDC compared with ISE in agriculture or services. The results suggest that medium IDC is the form of IDC most sensitive to *employment based on sectoral activities,* which aligns with previous findings on the positive association between smartphone ownership and employment (Balgobin and Dubus, 2022).

The Effects of Control Variables

The association between credit and IDC is insignificant, except when credit is acquired from formal sources, which is shown to be positively associated with medium IDC. Meanwhile, savings demonstrate positive and significant association with IDC. *Financial support from household members* and *government cash assistance* are insignificant across all IDC levels. Ownership of fixed assets has insignificant effects on medium and high IDC compared to ownership of movable assets such as (i) a motorcycle and ii) a motorcycle and a car have significantly positive coefficients. Apart from being factors of wealth, individuals might use movable assets as collateral to purchase digital devices (Love *et al.,* 2015).

There appears to be a positive marginal effect of *years of education* on IDC. A one-year increase in years of education improves the likelihood to have IDC by 0.1661 (low IDC), 0.2254 (medium IDC), and 0.5305 (high IDC). Similarly, financial education, a variable that captures the respondent's attendance at a financial education seminar, is shown to contribute to IDC, except under medium IDC. The negative effect of gender is lower on higher IDC, indicating that the procedural aspect of purchasing a simple mobile phone is

much more gendered than when purchasing a higher-level digital device. It is likely that those with a simple cellular phone with internet live within or closer to the poverty line, supporting the well-established gender and poverty hypotheses (Bridges *et al.*, 2011; Chant, 2003; 2014; Lawson *et al.,* 2020), thus women are restricted to own and use a simple mobile phone with internet.

***Table* 3** Employment Based on Sectoral Activities and IDC (N=13,085)

		INDEPENDENT DIGITAL CONNECTIVITY		
		Low	**Medium**	**High**
Employment Based on Sectoral Activities (ref: formally employed)	Not Working	-0.4373*	-0.2978*	0.0312
		[0.2279]	[0.1611]	[0.2417]
	ISE in Agriculture	0.0078	-0.7987***	-0.5219
		[0.2625]	[0.2292]	[0.4599]
	ISE in Commerce	-0.5173**	-0.4142**	-0.4238
		[0.2600]	[0.1790]	[0.2728]
	ISE in Services	-0.1534	-0.6370***	-0.8273**
		[0.3147]	[0.2282]	[0.3369]
Gender	Female	-0.6716***	-0.5386***	-0.2810
		[0.2273]	[0.1562]	[0.2429]
Age	Age	-0.1934***	-0.1794***	-0.3380***
		[0.0351]	[0.0321]	[0.0427]
	Age-Squared	0.0013***	0.0006	0.0026***
		[0.0004]	[0.0004]	[0.0005]
Education	Years of Education	0.1661***	0.2254***	0.5305***
		[0.0217]	[0.0200]	[0.0370]
Financial Education	Attended a course or were taught or informed about financial services	0.9103**	0.4143	1.2983***
		[0.4156]	[0.3039]	[0.3066]
Province X Urban/Rural (ref: Rural NTT)	Rural East Java	-0.3500	0.5079**	-0.0128
		[0.2908]	[0.2129]	[0.4137]
	Rural NTB	-0.5060	-0.8490***	-1.6430***
		[0.3201]	[0.2507]	[0.4419]
	Rural South Sulawesi	-0.8639***	0.0719	-0.2456
		[0.3078]	[0.2159]	[0.3999]
	Urban East Java	-0.3007	0.6437***	0.0985
		[0.3409]	[0.2332]	[0.4107]
	Urban NTB	-0.6075	-0.4822*	-0.8052*
		[0.3985]	[0.2922]	[0.4107]
	Urban NTT	0.6100**	0.6932***	-0.9683**
		[0.3042]	[0.2532]	[0.3908]
	Urban South Sulawesi	-0.2329	0.5481**	0.6169
		[0.3685]	[0.2541]	[0.4023]
Energy (ref: Traditional Fuel)	Modern Fuel but No LPG	0.7603***	0.9033***	1.2299***
		[0.2256]	[0.1632]	[0.3407]
	Modern Fuel and LPG	1.2231***	1.7715***	2.5590
		[0.3374]	[0.2531]	[0.3997]
Floor Material	Not Dirt Floor Material	-0.0310	0.1067	0.6931
		[0.3095]	[0.2436]	[0.5494]
Toilet (Ref: No Toilet)	Basic Toilet	0.7835*	0.2699	0.5307
		[0.4488]	[0.2807]	[0.5441]
	Proper Toilet	0.7963***	0.3439**	0.8932**
		[0.2239]	[0.1526]	[0.4138]
Borrowing (ref: Does Not Borrow)	Borrows from Informal Sources	-0.1896	0.0979	-0.0892
		[0.1777]	[0.1297]	[0.1951]
	Borrows from Semi-Formal Sources	0.0911	0.2168	-0.0656
		[0.3724]	[0.2786]	[0.3585]
	Borrows from Formal Sources	-0.1026	0.4356**	0.3761
		[0.2544]	[0.2087]	[0.2556]
Savings	Has Savings	0.3428*	0.4566***	0.6784***
		[0.1796]	[0.1325]	[0.2331]
Fin. Support from Gov't	Receiving Government Cash Assistance	-0.0053	-0.4265	0.3468
		[0.3274]	[0.2624]	[0.3502]

Fin. Support from HH Members	Receiving Money from HH Members	-0.3348	-0.2273	-0.2640
		[0.2232]	[0.1391]	[0.2327]
Fixed Asset (Home Ownership) (Ref: Not Owned)	House is owned by the respondent	-0.4722**	-0.1982	0.0135
		[0.1983]	[0.1462]	[0.1925]
	House is owned by another HH member	0.4157**	0.2003	0.1673
		[0.1852]	[0.1440]	[0.2130]
Movable Assets (Ref: No Vehicle Owned)	Owned a Motorcycle Only	-0.2541	0.6148***	1.2492***
		[0.2057]	[0.1384]	[0.2414]
	Owned a Car Only	0.2003	0.3006	1.9714***
		[0.6713]	[0.4836]	[0.5203]
	Owned both a Motorcycle and a Car	0.0059	1.3739***	3.1428***
		[0.4310]	[0.3044]	[0.3560]
	Cons	1.2906*	0.7006	-3.6212***
		[0.7652]	[0.6432]	[0.9549]
	R-squared/Pseudo R-squared			**0.3689**

Notes: Standard errors are in parentheses. ***, **, * denote statistical significance at 1, 5, and 10 per cent, respectively.

E2. Gender-Disaggregated Results

Gendered disaggregation of informal self-employment analysis suggests that, relative to formal employment, men and not women who are not working are significantly less likely to have medium instead of zero IDC. According to the results, women's lack of participation in the labour market (*not* working) is not associated with their likelihood to have a digital device and access the internet as captured by IDC. However, their participation in informal self-employment activities indicates a significant association in relation to IDC.

Table 4 shows that informal self-employment in agriculture has a higher negative association with the likelihood to have medium IDC among men than women in Indonesia. This might be linked to the division of labour, where men are accustomed to handling outside work and physically demanding tasks involving tools and machinery (Contzen and Forney, 2017). This is supported by our qualitative findings, whereby women in a family farm business tend to be relegated to non-physical tasks, including the utilisation of smartphones to access markets. These agricultural masculinities and femininities lead to men's lack of inclination to own a smartphone with internet. Our findings provide clarity to the work of Krell *et al.* (2021) on the use of mobile phone services among smallholder farmers in Kenya. They concluded that the minimal involvement of women in agricultural decision-making, when they live in a male-headed household, explains why women have lower smartphone ownership than men. However, their study only focused on respondents owning a mobile phone (basic feature phone and smartphone), whereas we include those without any digital device. Moreover, their analysis does not cover how engagement in agriculture relative to other sectors is associated with ownership and use of a digital device among men versus women.

The extent to which digital connectivity is utilised and demanded in agriculture appears to be limited to smartphones; we do not find evidence of women in the qualitative sample utilising computers to market agricultural produce. This also links to the statistical analysis, which indicates that women who partake in informal self-employment in agriculture are significantly less likely to have high IDC (smartphone + computer + access to internet). Such findings are consistent with Briggeman and Whitacre (2010), who denoted that farmers would only adopt the internet or computer if the perceived benefits exceed the perceived costs.

In services-type informal self-employment, men are significantly less likely to have medium IDC*,* while women are significantly less likely to have high IDC, which could be attributed to the highly gendered economic activities in the service sector, including those included in our quantitative sample. Men are more likely to engage in traditionally masculine economic activities such as informal transport or repairs, where the use of a smartphone might not be demanded by customers as these services can be executed with the help of a simple mobile phone or even without any digital device. These activities tend to be geographically bounded (Peters, 2020), limiting the need to expand the market with the help of a smartphone. Meanwhile, women are more likely to participate in traditionally feminine economic activities such as tailoring, hairdressing, or dressmaking. These services might have higher perceived benefits from the use of smartphones with internet, such as keeping up with modern development and expanding the market beyond the local area.

We find that men who are informally self-employed in commerce are significantly less likely to have high IDC*,* while such an association is absent among women. Apart from the overall lack of utilisation of a computing device in informal micro, small, and medium-sized enterprises (Bhattacharya, 2019), through the qualitative data we find that an individual who partakes in the formal economy, either because they are already a part of the formal labour economy or are eligible to seek formal employment opportunities, must conform to innovations that are demanded of them, including digitalisation (ILO, 2021). Otherwise, their ability to work in the formal economy will be revoked. Meanwhile, people in the informal economy possess more freedom in terms of opting out of or into the digital sphere, which negatively impacts the incentive to have IDC.

The findings extend Maloney (2004)'s argument about the voluntary nature of ISE by connecting it into more contemporary aspects of work, namely digitalisation. Fiess *et al.* (2010) asserted that a decision to undertake self-employment involves logical decision-making, such as whether capital is available prior to entering this line of activity. However, they did not further investigate the logical decisions aspect (Bosch and Maloney, 2010; Maloney, 2004). Thus, instead of simply positing the empowering nature of ISE, this study investigates what drives the informally self-employed individuals to invest in digital capabilities; their choices can have positive or negative implications for their place in the increasingly digitalised market – whether they can still be market players in the informal economy or they are pressed to quit being informal self-employment actors and work in a sector with less freedom.

***Table* 4** Gender-Disaggregated Results of Employment Based on Sectoral Activities

	INDEPENDENT DIGITAL CONNECTIVITY					
	MALE (N=5,661)			**FEMALE (N=7,424)**		
	Low	**Medium**	**High**	**Low**	**Medium**	**High**
Employment Based on Sectoral Activities (ref: formally employed)						
Not Working	-0.6243	-0.4990*	0.4064	-0.3525	-0.1619	-0.1925
	[0.3853]	[0.3010]	[0.5188]	[0.3169]	[0.2150]	[0.2615]
ISE in Agriculture	-0.1660	-0.8296***	-0.4708	0.1275	-0.5901*	-1.3003*
	[0.3503]	[0.2924]	[0.5010]	[0.4406]	[0.3322]	[0.6959]
ISE in Commerce	-0.6216	-0.3410	-1.0465**	-0.3943	-0.4209	-0.0983
	[0.4177]	[0.2449]	[0.4203]	[0.3529]	[0.2650]	[0.3655]
ISE Services	-0.0787	-0.6628**	-0.4325	-0.4938	-0.4550	-1.7959***
	[0.3766]	[0.2792]	[0.3915]	[0.6056]	[0.3968]	[0.5205]
Age						
Age	-0.1205*	-0.1501***	-0.1435**	-0.2449***	-0.2178***	-0.4830***

	[0.0658]	[0.0495]	[0.0707]	[0.0399]	[0.0469]	[0.0569]
Age-Squared	0.0004	0.0003	0.0004	0.0020***	0.0011*	0.0043***
	[0.0007]	[0.0006]	[0.0008]	[0.0004]	[0.0006]	[0.0006]
Education						
Years of Education	0.1318***	0.1931***	0.4196***	0.2062***	0.2666***	0.6351***
	[0.0272]	[0.0264]	[0.0494]	[0.0363]	[0.0295]	[0.0539]
Financial Education						
Attended a course or were taught or	0.5298	0.1299	0.9403*	0.8398*	0.5882	1.6872***
informed about financial services	[0.5094]	[0.4147]	[0.5188]	[0.4529]	[0.4302]	[0.3857]
Province X Urban/Rural (ref: Rural NTT)						
Rural East Java	0.0600	0.8356**	0.5467	-0.6708	0.4118	-0.1217
	[0.4310]	[0.3498]	[0.5451]	[0.4077]	[0.2758]	[0.6001]
Rural NTB	-0.2238	-0.4818	-1.1920*	-0.6186	-1.0937***	-1.7316***
	[0.4415]	[0.4002]	[0.6125]	[0.4526]	[0.3354]	[0.6316]
Rural South Sulawesi	-1.1701***	0.1813	-0.0715	-0.4789	0.0134	-0.1796
	[0.4281]	[0.3443]	[0.5728]	[0.4382]	[0.2803]	[0.5775]
Urban East Java	-0.8093*	0.7855**	0.1668	0.3231	0.6453**	0.4366
	[0.4377]	[0.3763]	[0.5838]	[0.4785]	[0.2986]	[0.5823]
Urban NTB	-0.7493	-0.1995	-0.8563	-0.4097	-0.6438*	-0.5396
	[0.5806]	[0.4678]	[0.6284]	[0.5493]	[0.3754]	[0.6525]
Urban NTT	0.5801	0.6851*	0.8964	0.6251	0.7761**	1.2580**
	[0.4413]	[0.3981]	[0.5639]	[0.4329]	[0.3349]	[0.5603]
Urban South Sulawesi	-0.5609	0.5472	0.4138	0.1319	0.6103*	1.1533**
	[0.5182]	[0.4229]	[0.5702]	[0.5126]	[0.3190]	[0.587]
Energy (ref: Traditional Fuel)						
Modern Fuel but No LPG	0.8791***	0.8709***	1.6605***	0.6911**	0.9862***	0.7597*
	[0.3064]	[0.2561]	[0.4834]	[0.3192]	[0.2096]	[0.4403]
Modern Fuel and LPG	1.8667***	2.1952***	3.3420***	0.7384	1.6044***	1.9870***
	[0.4489]	[0.3989]	[0.5997]	[0.5225]	[0.3276]	[0.5154]
Floor Material						
Not Dirt Floor Material	0.5461	0.1246	0.3093	-0.4479	0.1589	0.9766
	[0.4411]	[0.3593]	[1.0654]	[0.3815]	[0.3046]	[0.6132]
Toilet (Ref: No Toilet)						
Basic Toilet	0.2548	0.0987	-0.9052	1.2656**	0.3498	0.9105
	[0.5404]	[0.4396]	[0.6909]	[0.6438]	[0.3667]	[0.6122]
Proper Toilet	0.6522*	0.0568	0.6810	0.9215***	0.6091***	0.7985*
	[0.3534]	[0.2256]	[0.6259]	[0.2752]	[0.2129]	[0.4460]
Borrowing (ref: Does Not Borrow)						
Borrows from Informal Sources	-0.0897	-0.0484	0.0414	-0.3512	0.2541	-0.3534
	[0.2771]	[0.2037]	[0.3263]	[0.2200]	[0.1675]	[0.2342]
Borrows from Semi-Formal Sources	0.2717	0.0797	0.4775	-0.0987	0.3358	-0.9010*
	[0.4951]	[0.3640]	[0.5067]	[0.5857]	[0.3926]	[0.4759]
Borrows from Formal Sources	-0.0706	-0.0373	0.3510	-0.3844	0.9062***	0.3247
	[0.3529]	[0.3035]	[0.3744]	[0.3543]	[0.2658]	[0.3656]
Savings						
Has Savings	0.4065	0.5040***	1.0114***	0.4035	0.4437**	0.5287*
	[0.2478]	[0.1886]	[0.3212]	[0.2506]	[0.1821]	[0.2823]
Fin. Support from Government						
Receiving Government Cash	-0.3245	-0.3341	0.1638	0.1664	-0.3844	0.4549
Assistance	[0.5067]	[0.4451]	[0.6521]	[0.3445]	[0.3077]	[0.4225]
Fin. Support from HH Members						
Receiving Money from HH Members	0.2734	-00561	0.3750	-0.6563***	-0.2342	-0.5758**
	[0.3376]	[0.2763]	[0.4219]	[0.2355]	[0.1625]	[0.2726]
Fixed Asset (Ownership of a house) (ref: Not Owned						
House is owned by the respondent	-0.4547*	-0.2601	-0.2581	-0.5557*	-0.1297	0.2742
	[0.2615]	[0.2151]	[0.2768]	[0.3097]	[0.2009]	[0.2685]
House is owned by a non-respondent	0.4028	-0.1227	-0.1373	0.2909	0.4200**	0.3513
household member	[0.2885]	[0.2377]	[0.3503]	[0.2400]	[0.1792]	[0.2566]
Movable Assets (Ownership of a car and/or a Motorcycle) (ref: Not Owned)						
Owned a Motorcycle Only	-0.5038*	0.2722	0.9594**	-0.1236	0.8124***	1.4998***
	[0.2919]	[0.2191]	[0.4634]	[0.2782]	[0.1740]	[0.2673]

Owned a Car Only	0.8039	0.3231	2.1470***	-21.5464***	0.0550	1.3856*
	[0.7519]	[0.6726]	[0.6553]	[0.5539]	[0.6882]	[0.8086]
Owned both a Motorcycle and a Car	0.0431	1.2382***	2.8298***	-0.3814	1.3939***	3.5405***
	[0.5270]	[0.4012]	[0.5714]	[0.8193]	[0.4754]	[0.4836]
Cons	-0.8212	0.3558	-6.2552***	0.8346	-0.7211	-2.5286*
	[1.3782]	[1.0292]	[1.7070]	[0.9488]	[0.8884]	[1.2943]
R-squared/Pseudo R-squared			0.3721			0.3906

Notes: Standard errors are in parentheses. ***, **, * denote statistical significance at 1, 5, and 10 per cent, respectively.

E3. Rural-Urban-Disaggregated Results

We interact gender with province by using *South Sulawesi females* as a reference category. In *Figure* 10, among the rural sample, relative to zero IDC, men are more likely to have low IDC, with a higher marginal effect among those in East Java. The association between men who live in East Java and medium IDC is also significant in both rural and urban areas. In *Figure* 11, among the urban sample, females in East Java are less likely to have high IDC.

***Figure* 10** The Likelihood to Have IDC in Rural Areas Based on Gender & Province

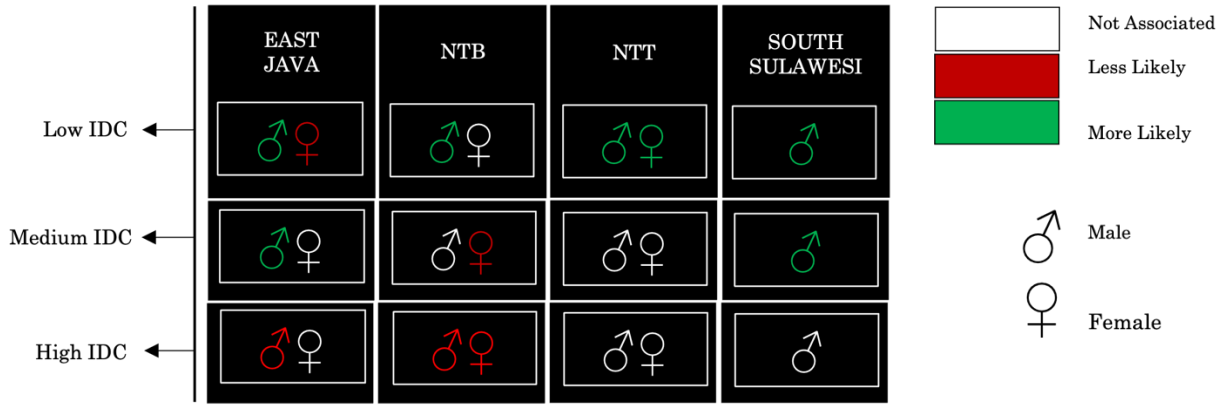
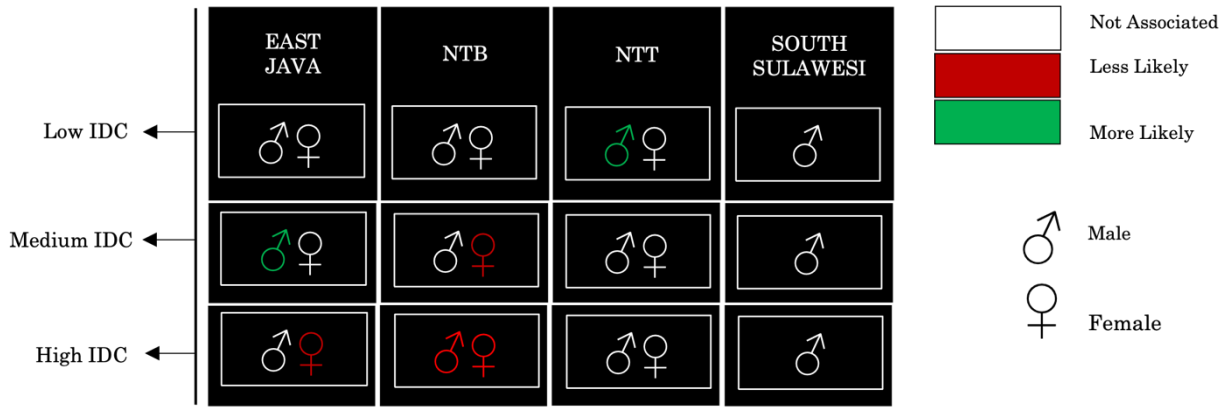


***Figure* 11** The Likelihood to Have IDC in Urban Areas Based on Gender & Province



Sources for Figures 10 & 11: authors' visualisation of research findings

As depicted in *Figure* 10, women who live in rural East Java are less likely to have low IDC compared to zero IDC, whereas no association is found with medium IDC and high IDC.

Additional main IDC drivers that we unpack from our fieldwork in rural East Java are profitability, connecting buyers and the presence of local online platforms – highlighted by interviewees as being key for gendered and employment-based issues.

Trend and profitability influence the usage of digital devices for informal enterprises through word of mouth among the communities. Yatini, who previously ran an offline microenterprise, decided to transition to open an online clothing store in her village due to her friend's testimony. Having run an online shop for six years, she claims that the decision to trade online significantly increases her profitability and expands her business coverage beyond her village. About 43 per cent of the respondents who trade online use WhatsApp as a medium of economic activity, 10 per cent use Facebook, 33 per cent use both WhatsApp and Facebook and 14 per cent trade in a local online marketplace.

This unique nature of rural entrepreneurship as shown by the case of Yatini above, also appeared in Geng and Xue's (2023) study in rural Jiangxi, China. Their research differentiated rural entrepreneurship by industry, although it is strictly limited to the agricultural industry (e.g., traditional agriculture, agribusiness, *et cetera*). The findings showed that the neighbourhood effects, which include information exchange and social learning mechanisms among an entrepreneur's circle, play a more dominant role in ICT adoption than institutional drivers.

Connecting with prospective buyers was identified as a driver that helps informal enterprise owners such as Lasmi who sells perishable products. For instance, without digital platforms, Lasmi will need a longer time frame to finish selling the products, and prices will eventually reduce as the level of freshness declines. She uses WhatsApp and Facebook status to advertise her products. Despite the seemingly simplistic nature of the strategy, this practice requires persistence and continuity. Respondents stated that maintaining customer relations is essential for business continuity. Sulis, a home enterprise owner, asserted how she utilised WhatsApp to keep in contact with her loyal customers and inform them about newly arrived products.

The presence of local online platforms, including local trading and selling groups on Facebook, was also identified as helping those in ISE to connect with buyers from all parts of the village. With Facebook marketplace groups, all they must do is post the products, and the prospective buyers will instantly make contact or secure orders. The results provide much-needed clarity to the analysis by Justman and Van Der Beek (2015), which pictured market forces as a one-element factor stemming from the market that would automatically transform labour.

We find that women in ISE in commerce are more likely to utilise digital platforms if they can facilitate sales without difficulties in operation. Usually, if dealing with an advanced food delivery app, a seller must register their business through the app for customers to be able to purchase from them. One respondent spoke of a joint local online ride-hailing and food delivery services that does not require the seller to register any business information.

> *"Many people now know my address. All they have to do is order via JODO, the online ride-hailing service. And the driver will come to order the food, and I will then prepare them as per the order."*
>
> *Source: Sulastri, food shop and small convenience store owner*

None of the respondents in our qualitative sample market their products in a sophisticated online marketplace. We find that the simplicity of digital platforms or tools might encourage the sellers to have IDC (*also see:* Kang, 2022). Our findings are in line with Davis's (1989) technology acceptance model theory which posits that among two key drivers of digital adoption are perceived ease of use and perceived usefulness. Moreover, they relate to the functionality of platform-based markets discussed by Cennamo (2021) which highlights that such platforms can better attract users when they accurately identify the market segments and tailor their platform architecture to the targeted customers. It also links to our conceptualisation of IDC, whereby the portability and function aspects of a digital device determine not just the scale of utility but also the level of IDC.

Loss prevention is another tool that the digital device facilitates for informal enterprise owners. Fatia is someone whom we could consider as a quasi-intermediary. As a business owner, she sells products by posting pictures of clothes from her distributors with the price that she will assign to the products on her WhatsApp and Facebook statuses, and once order requests are received, she will then purchase the products. However, she refuses to have an inventory because she does not want to lose even a cent from unsold or out-of-fashion clothing. Our observation shows that the informally self-employed perceive loss prevention strategies differently. For instance, when it comes to pre-order mechanisms, Yatini believes it is just a matter of expression of interest without any down payment. The contrary is observed with Rahayu, a caterer who always asks for a 50 per cent down payment.

Finally, of the additional qualitatively identified drivers, *market saturation* was found to be used by the respondents to determine whether using a digital device to run their businesses is needed. An example is Putri – a coffee house owner who also sells fritters, which she advertises and sells online. It seems like a straightforward process that if you advertise your fritters, then you might as well market your other products online. But she does not advertise or sell her coffees online because, as she noted, *"there are many coffee houses already, so I do not see the benefit of marketing it online".* This finding extends Brigeman and Whitacre's (2010) conceptualisation of internet adoption among farmers based on perceived benefits exceeding the perceived costs.

F. Conclusion

This study investigates the association between employment based on sectoral activities and *independent digital connectivity* (IDC) as a form of digital capabilities and provides a gendered lens to examine the drivers of independent digital connectivity adoption in rural East Java, Indonesia.

The main contributions of the findings are as follows. Firstly, the paper provides evidence as to how different economic sectors in the informal economy, relative to formal employment, are associated with the level of IDC. None of the previous studies account for the interaction between the variation of informal self-employment activities and digitalisation variables. We find that the commerce sector in the informal economy is much less resistant than the agriculture or services sectors in the acquisition of IDC. The qualitative analysis allows us to uncover different market forces in commerce that support digital capabilities. We argue

that the logic of the informal market that depends on the relative incentive that the workers might acquire from investing in IDC governs the IDC in the informal economy.

Through our quantitative analysis, we find that the difference between employment and IDC, for men and women, could be attributed to the informal sector activities. Men have higher negative marginal effects on medium IDC than women when they work in ISE in agriculture and services. Such results suggest that there may be a higher negative marginal effect, for women, on high IDC than for men when they work in ISE in agriculture and services. Extended by the qualitative research, such associations might be attributed to the "masculine" or "feminine" nature of the economic activities, which serve as the drivers of IDC. Furthermore, the negative association between employment in the informal economy and high IDC can be attributed to the generally low usage of computers in ISE.

This study rejects the much-discussed claim of access to finance as the antidote to any form of social or economic exclusion (Beck *et al.,* 2007; Beck *et al.,* 2009; Hermes, 2014). We find that it is neither credit nor income but rather savings which has a positive association with IDC. This could mean that individuals still treat digitalisation as a non-basic need. A short-term strategy to enhance digitalisation could be to promote savings behaviour and to encourage financial institutions, both formal and semi-formal, to offer savings programmes that can accommodate the needs and abilities of people from different economic capabilities.

Secondly, whilst there have been a number of studies on digital device ownership or digital use and employment, they do not properly define what these variables represent in the context of human development. As such, it is nearly impossible for the debate on the importance of digital devices for human development to continue going forward when there is no established ground. Our contribution in the conceptualisation of IDC could therefore be seen as a starting point through which we can model and discuss digital variables using the capability lens.

This study's conceptualisation of IDC delivers the narrative that, while we should be going forward with an enhancement of the quality of internet connection through public and private investments, it is important that we consider the independence of digital connectivity. Our results further suggest the need for accessible innovation. Before the informal workers are introduced to complex digital tools, it is imperative to help the transition to IDC by ensuring that markets can facilitate the incentive for IDC adoption and that governments invest in digital training and upskilling (*see:* UNECA, 2021).

Lastly, this study identifies the drivers of IDC in the informal economy. The informal economy is by and large treated as if it has no positive attributes to be learned from when it comes to digitalisation. We address this limitation by identifying the drivers of IDC through connecting IDC with the concept of 'economic incentives', making it relevant to policy-making needs. It demonstrates how incentives can engineer interests to take the matter of investing in IDC seriously among informal self-employed actors. It further demonstrates the variation in consequences of not adopting IDC in different economic sectors. Based on the findings, the solution generated is therefore not to equalise incentives. Rather, it is about creating sector-specific incentives to the adoption of the digital device that does not jeopardise the economic actors' livelihoods.

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Additional Tables

Table A.1 Descriptive Statistics of the Working Sample [SOFIA] [N=13,085]

	Variables	ALL		INDEPENDENT DIGITAL CONNECTIVITY (IDC)				GENDER	
		Mean	SD	No IDC (N=9,047)	Low IDC (N=649)	Med IDC (N=2,464)	High IDC (N=925)	Male (N=5,661)	Female (N=7,424)
	DEPENDENT VARIABLES								
IDC	No IDC	69.14%	0.4619					64.89%	72.37%
	Low IDC (Simple Mobile Phone + Internet)	4.96%	0.2170					5.81%	4.30%
	Medium IDC (Smartphone or Computer + Internet)	18.83%	0.3910					21.55%	16.77%
	High IDC (Smartphone + Computer + Internet)	7.07%	0.2563					7.75%	6.56%
	MAIN INDEPENDENT VARIABLES								
Employment	Not Working	36.53%	0.4815	34.78%	39.21%	41.28%	39.13%	18.33%	50.41%
	Informal Self-Employment in Agriculture	13.09%	0.3373	16.92%	8.93%	3.57%	3.89%	17.77%	9.53%
	Informal Self-Employment in Commerce	13.51%	0.3417	14.99%	8.94%	10.74%	9.48%	10.64%	15.68%
	Informal Self-Employment in Services	7.61%	0.2652	8.13%	8.73%	6.11%	5.79%	11.41%	4.72%
	Formal Employment	29.26%	0.4549	25.17%	34.19%	38.30%	41.71%	41.85%	19.67%
	CONTROL VARIABLES								
Gender	Male	43.26%	0.4954	40.60%	50.74%	49.48%	47.41%		
	Female	56.74%		59.40%	49.26%	50.52%	52.59%		
Age	Age	39.0968	0.16820	44.4737	27.4399	26.3805	28.5695	40.7733	37.8186
	Age-Squared	1811.5980	1527.3380	2255.201	865.2911	765.3273	924.7471	1968.119	1692.276
Education	Years of Education			5.8986	10.4095	11.1556	13.6973	7.8647	7.5109
Financial Education	Did Not Attend a Course or Receive Information about money or finances or were taught or informed about financial services	97.76%	0.1480	98.54%	95.12%	97.50%	92.63%	98.02%	97.56%
	Attended a course or receive information about money or finances or were taught or informed about financial services	2.24%		1.46%	4.88%	2.50%	7.37%	1.98%	2.44%
Province of Residence	East Java	68.70%	0.4637	68.98%	60.29%	73.37%	59.37%	68.87%	68.56%
	NTB	8.32%	0.2762	9.42%	10.58%	5.07%	4.69%	8.00%	8.57%
	NTT	7.41%	0.2619	7.61%	14.51%	5.12%	6.56%	7.35%	7.46%
	South Sulawesi	15.57%	0.3625	13.99%	14.62%	16.44%	29.38%	15.77%	15.41%
Geography	Rural East Java	33.07%	0.4704	36.68%	25.01%	27.53%	18.19%	31.85%	34.01%
	Rural NTB	4.33%	0.2034	5.24%	5.17%	1.94%	1.19%	4.12%	4.48%
	Rural NTT	5.60%	0.2300	6.47%	9.30%	2.70%	2.26%	5.50%	5.69%
	Rural South Sulawesi	9.06%	0.2870	9.83%	6.76%	7.18%	8.08%	9.19%	8.96%
	Urban East Java	35.63%	0.4789	32.31%	35.27%	45.84%	41.19%	37.04%	34.55%
	Urban NTB	4.00%	0.1958	4.18%	5.41%	3.13%	3.50%	3.88%	4.08%
	Urban NTT	1.80%	0.1331	1.14%	5.21%	2.41%	4.30%	1.84%	1.77%
	Urban South Sulawesi	6.51%	0.2467	4.15%	7.87%	9.27%	21.29%	6.59%	6.46%
Energy	Lives in a House that Uses Traditional Source of Fuel	35.29%	0.4778	43.31%	26.47%	18.25%	8.37%	35.60%	35.05%
	Lives in a House that Uses a Modern Source of Fuel with no LPG	59.54%	0.4908	53.53%	69.03%	74.79%	71.10%	59.37%	59.67%

	Variables	ALL		INDEPENDENT DIGITAL CONNECTIVITY (IDC)				GENDER	
		Mean	SD	No IDC (N=9,047)	Low IDC (N=649)	Med IDC (N=2,464)	High IDC (N=925)	Male (N=5,661)	Female (N=7,424)
	Lives in a House that Uses a Modern Source of Fuel and LPG	5.17%	0.2214	3.16%	4.50%	6.96%	20.53%	5.03%	5.28%
Floor Material	Lives in a House that Uses Dirt Floor Material	9.40%	0.2918	11.42%	8.19%	5.34%	1.33%	8.40%	10.16%
	Lives in a House that Does Not Use Dirt Floor Material	90.60%		88.58%	91.81%	94.66%	98.67%	91.60%	89.84%
Toilet	Lives in a House without a Toilet	26.11%	0.4329	30.12%	16.27%	20.73%	8.15%	25.66%	26.46%
	Lives in a House that Has a Basic Toilet	4.13%	0.1989	4.55%	5.59%	3.11%	1.71%	4.51%	3.84%
	Lives in a House that Has a Proper Toilet	69.76%	0.4593	65.33%	78.14%	76.16%	90.14%	69.83%	69.70%
Credit	Does Not Acquire Credit	43.30%	0.4955	44.19%	45.00%	38.12%	47.28%	44.68%	42.25%
	Receive Informal Credit	47.68%	0.4994	47.47%	46.35%	51.81%	39.68%	44.65%	49.99%
	Receive Semiformal Credit	3.76%	0.1901	3.71%	4.44%	3.99%	3.10%	3.94%	3.62%
	Receive Formal Credit	5.26%	0.2232	4.63%	4.21%	6.08%	9.94%	6.73%	4.14%
Savings	Does Not Have Savings	43.06%	0.4951	49.54%	35.72%	30.23%	19.01%	54.69%	34.20%
	Has Savings	56.94%		50.46%	64.28%	69.77%	80.99%	45.31%	65.80%
Gov't Fin. Support	No Government Assistance	94.12%	0.2353	93.03%	93.88%	97.24%	96.59%	95.49%	93.07%
	Receive Government Assistance	5.88%		6.97%	6.12%	2.76%	3.41%	4.51%	6.93%
Household Fin. Support	No Money from Household Members	49.55%	0.4999	51.10%	47.46%	45.92%	45.47%	79.35%	26.83%
	Receiving Money from Household Members	50.45%		48.90%	52.54%	54.08%	54.53%	20.65%	73.17%
Fixed Asset	Does Not Own a House	44.12%	0.4965	36.67%	12.71%	16.38%	23.18%	34.09%	28.13%
	House is owned by the respondent	30.71%	0.4613	19.76%	42.49%	37.43%	33.23%	21.55%	27.92%
	House is owned by a non-respondent household member	25.17%	0.4339	43.57%	44.80%	46.19%	43.60%	44.36%	43.94%
Movable Asset	Does Not Own Both a Motorcycle and a Car	55.54%	0.4969	61.91%	61.40%	41.60%	26.31%	37.47%	69.31%
	Own a motorcycle only	40.93%	0.4917	35.89%	36.42%	54.68%	56.67%	57.49%	28.31%
	Own a car only	0.44%	0.0663	0.38%	0.46%	0.28%	1.54%	0.53%	0.38%
	Own both a motorcycle and a car	3.09%	0.1730	1.82%	1.72%	3.44%	15.48%	4.51%	2.00%

Table A.2 Small Hsiao Tests of Independence of Irrelevant Alternatives Assumption (IDC)

Ho: Odds (Outcome-J vs Outcome-K) are independent of other alternatives

Omitted Category	**lnL (full)**	**lnL (omit)**	**P>chi2**	**evidence**
No IDC	-1115.782	-1102.891	0.843	For Ho
Low IDC	-2013.258	-1999.012	0.734	For Ho
Medium IDC	-1329.751	-1318.519	0.935	For Ho
High IDC	-2171.475	-2161.675	0.977	For Ho

Table A.3 Goodness-of-Fit Statistics of Multinomial Logistic Regression

		mlogit
Log-likelihood		
	Model	-1.665e+07
	Intercept-only	-2.638e+07
Chi-square		

	Deviance (df=12986)	3.331e+07
	Wald (df=96)	1229.706
	p-value	0.000
R2		
	McFadden	0.369
	McFadden (adjusted)	0.369
IC		
	AIC	3.330e+07
	BIC (df=99)	3.330e+07

Table A.4 Ordered Logistic Regression (OLR) – Parallel Regression Assumption

Approximate tests of proportionality of odds	**Chi2**	**df**	**P>Chi2**
Wolfe Gould	337.9	64	0.000
Brant	378	64	0.000
Score	347.5	64	0.000
Likelihood Ratio	339.9	64	0.000
Wald	395.7	64	0.000

We tested the parallel regression assumption by ordering the dependent variable based on the logical hierarchy of IDC: 1) Zero IDC, 2) Low IDC (Simple Mobile Phone + Access to Internet, 3) Medium IDC (Smartphone or Computer + Access to Internet), 4) High IDC (Smartphone + Computer + Access to Internet).

Conclusion: *The assumption is violated. The relationship between each pair of outcome group is different.*

Table A.5 Likelihood Ratio Test

Assumption **=** *the Restricted Model is nested in the Full Model*

LR chi2(30) **=** 268.40

Prob > chi2 **=** 0.0000

Model	**Obs**	**df**	**AIC**	**BIC**
Restricted Model	13,085	66	11889.49	12383.12
Full Model	13,085	99	11687.09	12427.53

Note: *In the restricted model, two categorical variables in the Full Model of Employment Based on Sectoral Activities are treated as dummy variables: Employment (1 if working, 0 otherwise) & Borrowing (1 if borrow from any sources, 0 otherwise). Moreover, we restrict Province of Residence into simply Urban/Rural.*

Conclusion: *Based on the Likelihood Ratio (LR) Test, we can reject* H_0 *and conclude that the full model, which disaggregates employment status based on sectors, borrowing based on sources, and province of residence substantially improves the model fit.*

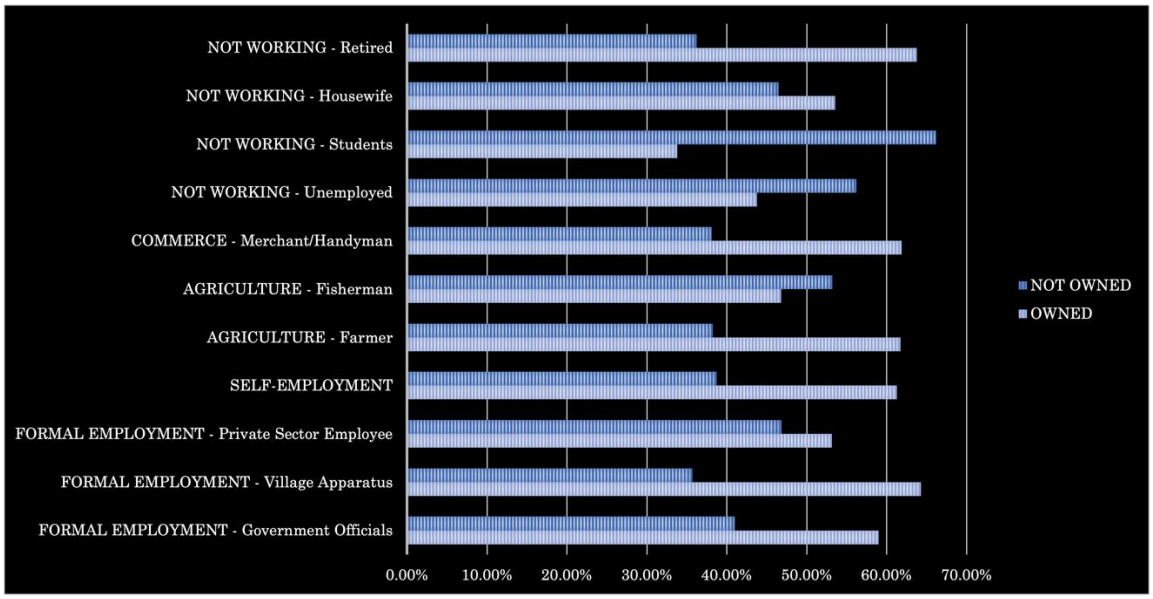
Table A.6 Descriptive Statistics of KOMIDA dataset [N=100]

No	**Variables**	**N**
1	***Age***	
	Average Age	42.92
2	***Household Size***	
	<4	22
	4	36
	5-6	33
	>6	9
3	***Education Level***	

No	Variables	N
	Never Been to School or Dropped Out of Elementary School	4
	Elementary School	44
	Junior High School	31
	Senior High School/Vocational School	20
	Bachelor's Degree	1
4	***Marital Status***	
	Married	88
	Widowed	10
	Divorced	1
	Separated	1
5	***Household Head***	
	Male-Headed Households	79
	Female-Headed Households *(De Facto)*	10
	Female-Headed Households *(De Jure)*	11
6	***Household Finance***	
	In Male-Headed Households	
	Alone	62
	Husband	5
	Co-Managed by the Husband and Wife (Jointly)	7
	Co-Managed by the Woman and Someone Else	5
	in Female-Headed Households (De Facto)	
	Alone	8
	Co-Managed by the Husband and Wife (Jointly)	1
	Co-Managed by the Woman and Someone Else	1
	In Female-Headed Households (De Jure)	
	Alone	6
	Co-Managed by the Woman and Someone Else	2
	Managed by one of the children	3
7	***Household Chores***	
	In Male-Headed Households	
	Alone	69
	Co-Managed by the Woman and Someone Else	10
	in Female-Headed Households (De Facto)	
	Alone	8
	Co-Managed by the Woman and Someone Else	2
	In Female-Headed Households (De Jure)	
	Alone	6
	Co-Managed by the Woman and Someone Else	4
	Managed by one of the children	1
8	***Credit User***	
	Husband as the Credit User	16
	Woman as the Credit User	84
9	***Employment***	
	Not Working	11
	Informal Employment in Agriculture	1
	Informal Employment in Commerce	5
	Informal Self-Employment in Agriculture	22
	Informal Self-Employment in Commerce	61
10	***Business Income***	
	Rp. 0 *(Not Working)*	11
	<Rp. 500,000	2
	Rp. 500,000 – 999,999	4
	Rp. 1,000,000 – 2,499,999	36
	Rp. 2,500,000 – 4,999,999	33
	Rp. 5,000,000 - 7,499,999	8
	>Rp. 7,500,000	6

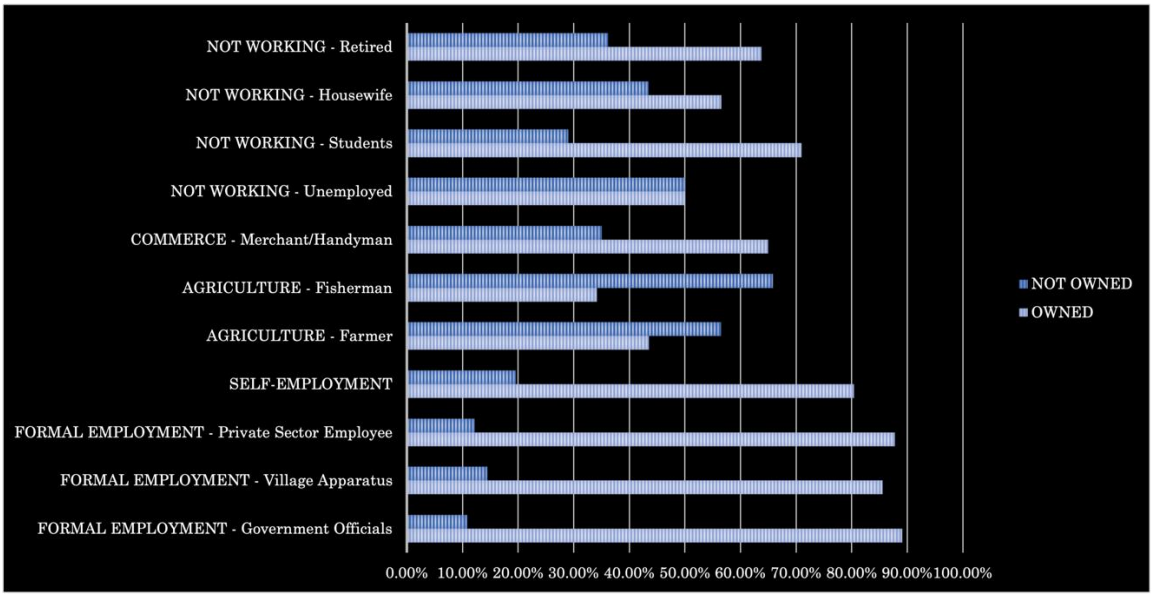
Additional Figures

Figure B.1 Simple Mobile Phone Ownership in Indonesia by Occupation (2017) *(N=5,072)*



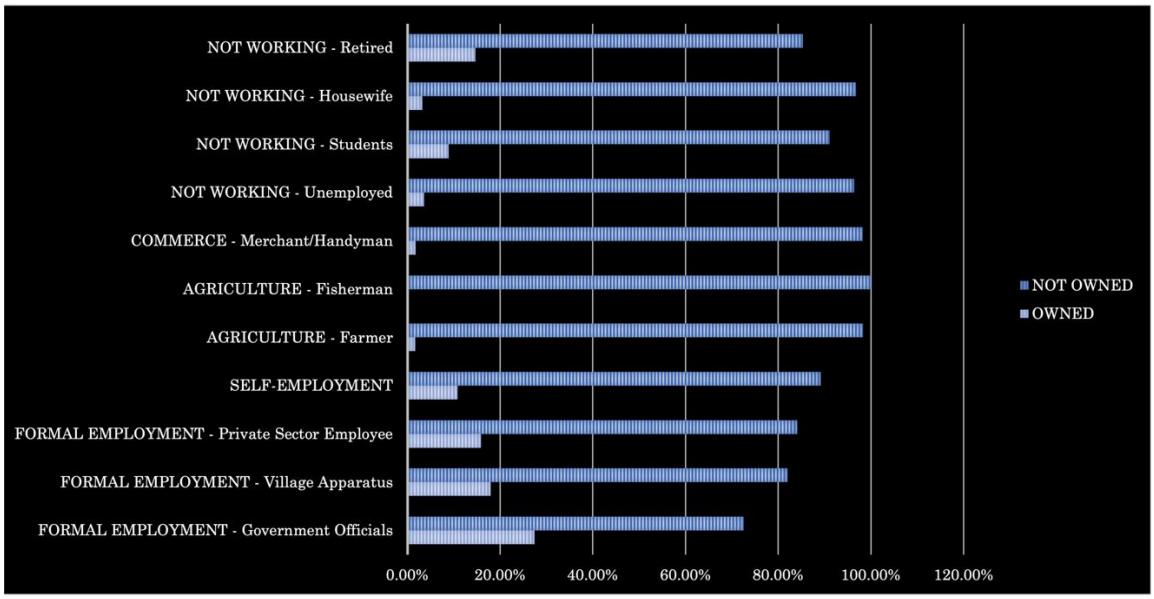
Source: KOMINFO (2017) – Indonesia's Ministry of Communication and Information Technology (2017), *Technology, Information, and Communication Survey*.

Figure B.2 Smartphone Ownership in Indonesia by Occupation (2017) *(N=6,246)*



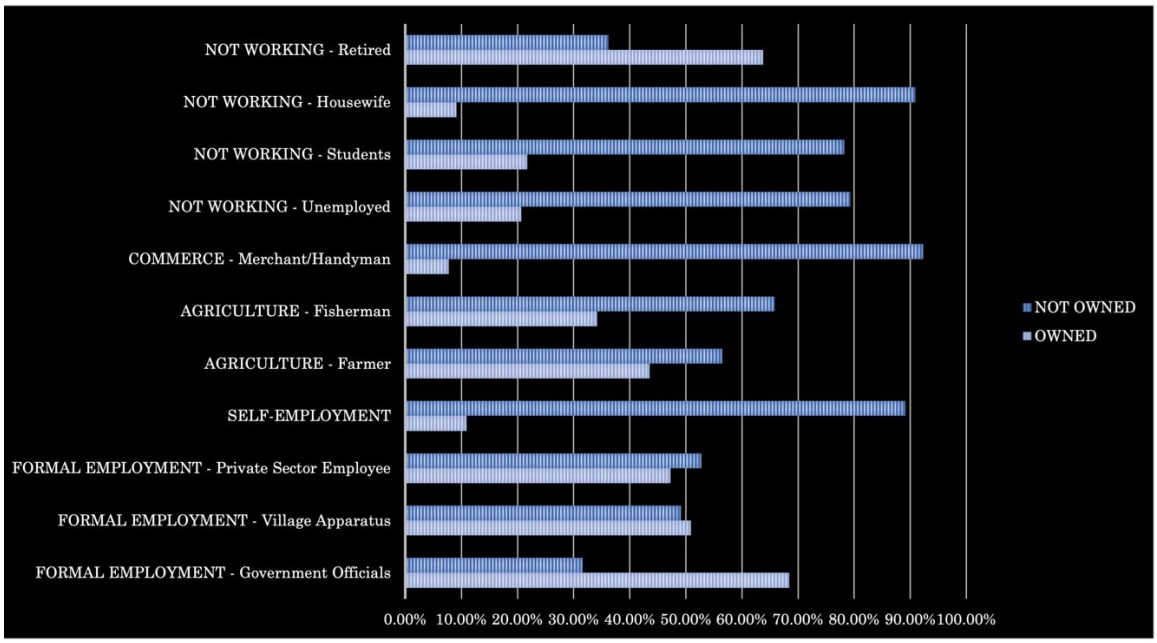
Source: KOMINFO (2017) – Indonesia's Ministry of Communication and Information Technology (2017), *Technology, Information, and Communication Survey*.

Figure B.3 Computer Ownership in Indonesia by Occupation (2017) *(N=751)*



Source: KOMINFO (2017) – Indonesia's Ministry of Communication and Information Technology (2017), *Technology, Information, and Communication Survey.*

Figure B.4 Laptop Ownership in Indonesia by Occupation (2017) (*N=2,012)*



Source: KOMINFO (2017) – Indonesia's Ministry of Communication and Information Technology (2017), *Technology, Information, and Communication Survey.*