Digitalisation, Governance and the Informal Sector

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Dibyendu Maiti* and Bhavna Khari*

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This paper shows the effect of dgitalisation, which improves the governance, on size of informality. We build a simple model with heterogeneous labour markets where the productive firms meet the tax burden to produce in the formal sector and the rest manages to survive in the informal sector by incurring extra-legal cost to avoid tax burden. The difficulty to avoid the tax budget depends on the level of digitalisation, which requires public investment. The government faces a trade-off to spend between digitalisation and other public goods and services. The digitalisation that increases the chances of being caught the informal transactions encourages the formal activities directly. On the other hand, it demands higher taxation that works on the opposite direction. The relative strength of these two forces determines the size of informality. The positive relation between taxation and digitalization leads to result in an U-shape of informal size against the level of digitalization. The negative impact gets stronger under the improved governance with better rule of laws and judiciary system. If minimum wage or productivity are targeted to a higher level exogeneosly, it may result in higher informality. The econometric results from a cross-country panel data for around 148 countries for the period 1990-2017 confirm such conjectures.

Keywords: Digitalisation, governance, informal sector, judiciary system
JEL classification: C53, O40

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Abstract

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1 Introduction

A significant portion of economic activities is operated outside the formal sector to avoid tax compliance. This activity not only precludes the state from earnings for the use of potential social welfare but also represents a disgraceful and non-pellucid image of the economy. The literature highlighted that the segmented labour markets (Amaral and Quintin, 2006), lack of entrepreneur ability (De Paula and Scheinkman, 2007), higher tax burden (Ordonez, 2014) and rigid industrial and labour regulations (Bulow and Summers, 1986; Cuff et al., 2020) in a typical developing economy are some of responsible factors for the presence of the informal sector. In a pioneering work, De Soto et al. (1989) argued that the informal sector thrives to avoid the cost of higher tax burden and tight rules and regulations on formal sector activities. Several researchers (Rauch, 1991; Choi and Thum, 2005; Jonasson, 2011) have investigated various costs related issues in regard to the existence of informal sector and supported this conjecture to a large extent. Similarly, Antunes and Cavalcanti (2007) argued that stricter rules and regulations raise the start-up costs that bind the size of the formal sector. In parallel, many studies suggested that poor institutions with weak rules and regulations limit the incentive to invest in formal settings (Besley, 2016). It may also be the case that a state is often incapable of arresting such informal activities and may not enforce rules and regulations strongly in a typical unequal society (Maiti and Bhattacharyya, 2020). Innovation of digital technologies seems to have been improving the state capacity of governance and making it easier. The growing innovations of information and technology (i.e., digitalization) may curb the ability to avoid tax or rules and regulation, and thereby limit the economic activities outside the formal sector by improving the level of governance.There is a growing interest to investigate the impact of digitalisation or e-governance on development issues and modernisation of tax administration on fiscal performance (Besfamille and Siritto, 2009; Maiti et al., 2020). Whether the digitalisation reduces the size of informality successfully is still ambiguous in the literature. The access to various means of digital technologies (e.g., smartphone, digital gadgets, fast internet and high-speed computers) is growing fast across countries. And, most governments have been investing in digital infrastructure to improve the level of e-governance [2]. The immediate question is whether the rising

[2]Although the two terms - e-government and e-governance - are often used interchangeably, there is a difference between them. E-government refers to the use of the ICTs in public administration which, when combined with organizational change and new skills, are intended to improve public services and democratic processes and to strengthen support to the public. On the other hand, the governance of ICTs typically requires a substantial increase in regulation and policy-making capabilities, as well as additional expertise and opinion-shaping processes among various social stakeholders. The perspective

digitalisation or e-government has reduced the level of informality. The paper attempts to theoretically and empirically investigate this issue using cross-country data.

Since the early 1990s, the use of information technology has been growing fast for delivering government goods and services, news and information as well as for integrating various stand-alone systems between government to citizen (G2C), government-to-business (G2B), government-to-government (G2G), government-to-employees (G2E) for the improvement of governance and transparency. Besfamille and Siritto (2009) revealed that public sector have become more efficient from such modernisation and the fraction of tax collection used to provide public goods have increased. It is also evident that approximately 4.9 billion people (i.e., 63% of the world's population) are using the internet in 2021. This registers an increase of 47% from 2005 and 19% in two years time since 2019. This single figure demonstrates how the digitalisation is growing fast in the world economy. Through e-governance, the public services are made available to citizens economically and transparently within finger trips. However, the application of e-governance significantly varies across the globe. Everyone may not have internet access and digital skills. Access to digital services could also be costly to meet the expenses for small establishments and poor citizen. According to the UN-PAN, the level of the e-government development index (known as EGDI) substantially varies across the countries in terms of their development, income and geographical location. As per the information available for 2020, the index seems to have risen along with the level of development and income (see table 1). The online services and telecom infrastructure indices, a sub-component of EGDI, also revealed the same pattern. Note that Europe, Asia and America scored higher than the world average. In contrast, Oceania and Africa fall below the average. It should also be noted that the figures for Asia registered higher than America in all categories. All these evidences reveal a wide variation of digital infrastructure and governance across the countries.

The contemporary evidence further shows that the informal sector persists and the size of the sector does not seem to have reduced in number of developed and developing countries (Bonnet et al., 2019). According to the recent information, the informal sector produces about 35% of the gross domestic product (GDP) and employs 70% of the labour force in a typical developing economy on an average (Loayza, 2016). As per the report produced by ILO (2018), Africa employed about 85% workers in the informal sector. Among other countries, the estimates record 25.1% in Europe and Central Asia, 68.2%

of e-governance is "the use of the technologies that both help to govern and have to be governed (Rossel and Finger, 2007).

Table 1: E-Government Development Index (EGDI), 2020

Region / Grouping	EGDI	Online Service Index	Telecomm. Infrastructure Index
Africa	0.3914	0.3704	0.3165
Americas	0.6341	0.5808	0.5763
Asia	0.6373	0.6249	0.5893
Europe	0.817	0.7655	0.8162
Oceania	0.5106	0.4172	0.3851
World	0.5988	0.562	0.5464
Levels of Development			
Least Developed Countries	0.3387	0.3289	0.2523
Land Locked Developing Countries	0.4682	0.4693	0.3748
Small Island Developing States	0.5255	0.4161	0.4607
Levels of Income			
High income	0.8195	0.7663	0.8301
Upper middle income	0.6204	0.5515	0.5618
Lower middle income	0.4932	0.4864	0.4036
Low income	0.3021	0.3112	0.1984

Source : United Nations E-Governance Survey 2020
(https://publicadministration.un.org/en/ publicadministration.un.org/egovkb/en-us/)

in Asia and the Pacific, 40% in America and 68.6% in the Arab states. The report documented that the emerging and developing countries possessed about 93% workers of the world's informal sector. Recently, Elgin et al. (2021) introduced a comprehensive database over more than 160 economies for the period 1990-2018. It showed that the informal sector contributed 42% of world GDP in 2017. In the developed economies, they recorded a significant presence of the informal sector too. The size of this sector, measured as a percentage of official GDP, varies from 8.1% in the USA, 12% in UK and 17% in Norway to 26.2% in Greece in 2018. Although the contribution of informal sector to GDP registered a general declining trend, it rose in some developing countries. Informal employment in both advanced and emerging developing economies appeared to be largely stable. The presence of informal sector motivates us to investigate the impact of digitalisation or e-government on it.

Goldfarb and Tucker (2019) believed that the application of e-government exposed transactions outside the formal sector and sought for legal actions. That fear may discourage such transactions. In a study using panel data for a sample of 82 countries (14 developed and 68 developing) for 2006–2014, Montes et al. (2019) compared the scores of fiscal transparency and found that approximately 80% of the countries have improved efforts made to fiscal transparency through e-government. The application of ICTs plays a primal role in this regard, and, therefore, the most developing countries are pursuing digitalisation to improve fiscal performance. In an experimental study, Okunogbe and Pouliquen (2022) claimed that the firms pay fewer bribes, as e-filing reduces extortion opportunities in Tajikistan. However, the contemporary research does not support the favourable effect of digitalisation on governance unequivocally (Agarwal and Maiti, 2020). According to them, it depends on the effectiveness of judiciary system and rule of laws. At the same time, ICT innovations have also brought new challenges to employment opportunities, semi-skilled workers, individual rights as well as raised the concerns of privacy, security, and cyber-crime. It is also evident that the rate of absorption and access to ICTs substantially vary across individuals, income and age groups, rural-urban divisions, sectors, and regions, which seem to have created a 'digital divide' in the modern society (Connolly et al., 2017). They may encourage the persistence of informal activities. So, the immediate question is whether digitalisation has reduced informality significantly or not. The present paper attempts to investigate the impact of digitisation on the level of informality, both theoretically and empirically using across countries.

While investigating the effect of digitalisation on the size of informality, one would recognise that effective governance (or effective use of the rule of laws and judiciary sys-

tem) or the ability to apply them effectively must play a detrimental role. Despite the growing ICT innovations for e-government and social media proliferation, the existing evidence does not infer its role on corruption drop unambiguously. For example, Rontos et al. (2015) undertook a global study to determine the governance quality and found that the cross-country variation in governance level can be attributed to differences in the range of political freedom and the level of social development in addition to the difference in countries' level of economic development. Pina et al. (2007) assessed how ICTs enable better accountability in public bureaucracies through e-governance initiatives in the USA, Canada, Australia, New Zealand, and 15 EU countries. The analysis argued for the developments and changes in financial accountability levels, not on the government-citizen relationship. A study conducted by Holeman et al. (2016) revealed that problems of petty corruption and poor services in relatively less developed countries like the Dominican Republic, Nigeria, and Pakistan had dropped with the help of citizen feedback systems with digitalisation. Some evidences from Bangladesh indicated that digitalisation effectively addressed petty corruption of street-level bureaucrats, but less so for dealing with grand corruption of higher-level officials Muhammad (2015). Scholars also highlight that the relationship has not been monotonic and unambiguous. It depends on government infrastructure, trust, and motive. For example, Lee et al. (2019) focused on the importance of public confidence in the government.

The establishment is a typical developing economy with heterogeneous skills and assets that cannot meet compliance costs for producing in the formal sector. As a result, the production sector cannot offer gainful employment to all individuals looking for formal employment. Those who cannot find employment in the formal sector try to find something in the informal sector. Therefore, in the informal sector, a firm may try to manipulate the regulatory system to avoid taxation by paying extra-legal costs to access the low-cost sector. Such an explanation exists in the literature (De Soto et al., 1989; Maiti and Bhattacharyya, 2020). However, with the ability to store and share information with continuous digital innovations, a state can improve the policing system and raise the level of transparency. If this is effectively executed, digitalisation must bind the size of informality. The effective execution would depend on how the state's rules and regulations and judiciary system function. The state may document the non-compliance digitally but be unable to punish effectively, then the size of informality may not decline. Moreover, the greater degree of digitalisation needs public investment generated from taxation which contribute to the force of rising informalisation.

To demonstrate a relationship, we developed a model with two types of firms pro-

ducing similar goods at different productivity levels in formal and informal sectors respectively. Government imposes a tax on formal production. The less efficient firms may try to save tax if the governance system allows bypassing at a lower cost. The level of governance depends on the digitalisation and effective judiciary system. Hence, the state has a trade-off of spending money between digitalisation and other public services. The optimal allocation would determine the level of informality. We compile the information from various sources (mainly from the World Bank and ILO) to empirically validate the relationships. The panel data for more than 148 countries and the econometric results for a period of 1990-2017 support the theoretical prediction. We found that the digitalisation reduces the size of informality upto a certain level. The size of informality is U-shaped against the level of digitalisation. If the judiciary system is effective, the negative relationship may sustain. And, the positive relation between digitalisation and taxation when they are chosen endogenously contributed to the rise of informality. The rest of the paper is organised as follows. Section 2 presents a simple model. Section 3 discuss an outline of methodology applied in the present study to find empirical relationship. And, the section 4 ends with concluding remarks.

2 The Model

Let us build a simple framework for an economy with three types of agents - households, firms and government, similar to Ogura et al. (2018). Households consume goods produced in both formal and informal sectors and derive utility from public goods and services (except ICT goods). Better infrastructure, subsidies and social welfare transfers delivered by the state offer satisfaction to the consumers. Both quality and quantity of such goods and services would matter for consumers' satisfaction. On the other hand, the firms are differentiated in terms of their productivity and efficiencies. A firm chooses to produce in either formal or informal sectors, depending upon its level of productivity and ability to meet the cost for being in the formal sector. Essentially, the firm producing in the formal sector tends to be more productive to meet tax burden. The less productive firms that could not survive in the formal sector go to the informal sector by evading the tax burden. The extent they could escape depends on the efficiency of rule of laws and judiciary system (i.e., effective governance) and the extra-legal costs for informal transactions. Such a firm must meet the penalty charge once caught by the policing system. However, if the governance is relatively weak, the firm can easily bypass the penalty by paying a token amount of bribe (i.e., extra-legal costs) to the relevant

bureaucrats. Note that the quality of governance would depend on the efficiency of being caught and effective implementation of rules and regulations and judiciary acts against informal transactions and tax avoidance.

This apart, the government levies a tax on formal sector production, which will be spent to cater the goods and services to the individuals. There are two options to spend - digitalisation for e-government and other public services. If it spends on general public goods and services, the consumer derives satisfaction directly. In comparison, the increased spending on digitalisation may improve the level of governance and raise the probability of being caught in informal production. This pushes the production into the formal sector, leasing to a rise in tax revenue further. So, there is a clear trade-off between the two types of government spending. We shall try to find an equilibrium allocation that establishes a balance between them to maximise welfare and investigate its impact on the sectoral distribution.

2.1 Households

Each household of the economy owns one unit of labour, indexed as $z \in (0, 1)$, distributed uniformly. The household derives utility from consumption, C, and public goods and services, G. The total consumption is a composite of the goods produced in both the sectors, from informal to formal. They are strictly substitute. The utility function can be described as follows:

$$U = C + \phi v(G) \tag{1}$$

where, $v(G)$ presents the utility from public services with $v' > 0, v'' < 0$, and ϕ is the scalar parameter representing the quality of public goods and services. Assume that the consumer has a clear preference for the consumption of the public goods. Similarly, the transparent and efficient delivery of a particular service also raises satisfaction. So, ϕ rises with the quality and efficiency of public goods and services.

2.2 Firms

The production takes place in two sectors - formal and informal sectors. Further, assume that an individual worker possesses one unit of labour and a fraction, z will be offered to the formal sector. If A denotes the productivity parameter of the formal sector, the production in the formal sector from z amount of labour can be represented as follows:

$$y^F = Az \tag{2}$$

It shows that the production in the formal goods rises with the improvement of technology or productivity, Az. However, the formal output will be taxed, and if t denotes the tax rate per unit of formal output, the net income of the labour working in the formal sector would be as follows:

$$w^F = (1-t)Az \tag{3}$$

On the other hand, the informal sector firm has access to the same technology but would be relatively inefficient to use it due to a lack of talent or skill. The worker would devote the remaining hours in the informal sector. If α denotes the level of technical inefficiency, the output in the informal sector can be written as follows:

$$y^I = (1-\alpha)Az \tag{4}$$

The firm can evade the tax payment if the production takes place in the informal sector. But, the production in the informal sector incurs a cost to hide the transactions therein. If the governance level is relatively weak, the producer finds a way to bend the rules and regulations to hide the production by paying an extra-legal cost. The consealation cost can be presented as $s(z); s' > 0, s'' > 0, s''' = 0$. The extra-legal cost of hiding the production in the informal sector is assumed to be the usual concave function with respect to the working hour. The higher the time devoted to the informal sector production, the higher the output. The higher labour used in the informal sector would raise the chance of getting caught by the tax administration. The greater chance forces to pay a higher amount of penalty. The extra-legal cost must rise even if the governance level is strong. Assume that the chance of getting caught rises with a greater use of digital innovation for e-government or a greater application of digital transactions. The level of digitalisation or e-government is denoted by γ. The state provides the digital platform and offers digital infrastructure to the citizen, and a producer does not directly incur any cost for using digital technological innovation and infrastructure (excepts gadgets). We assume that the concealation cost is $s(z) = \frac{\mu}{2}z^2$, where μ represents the punishment intensity for informal activities. Note that the punishment rate would depend on how effective the policing and the judiciary system are. If the informal activities are caught by the system using digital technologies but not punished by the administration, the value of μ would be relatively lower. In this case, the net income of labour working in the informal sector can be represented as follows:

$$w^I = (1-\alpha)Az - \gamma s(z) \tag{5}$$

This expression represents that the informal firm produces output to bypass cost of operating in the the formal sector. Note that the formal and informal incomes depend on how the share of labour, z, is distributed between sectors that lies on the level of inefficiency, taxation and digitalisation. Workers would prefer to devote time on the formal sector, if $w^F \geq w^I$ or $(\alpha - t)Az + \gamma s(z) \geq 0$. This expression gives the workers an advantage in the formal sector. The worker prefers to work in the formal sector if the net tax burden over the efficiency loss does not exceed the extra-legal cost. So, if the level of technical inefficiency in the informal sector firm is greater than the tax rate levied on formal firm or $(t - \alpha)$ does not exceed $\gamma s(z)$, the formal workers would be better off. Thus, there is a threshold $z = \bar{z}$ such that workers are indifferent to be working between formal and informal sectors. At $z = \bar{z}$, we find that $w^F(\bar{z}) = w^I(\bar{z})$, where

$$(\alpha - t)A\bar{z} + \gamma s(\bar{z}) = 0 \tag{6}$$

From this expression, one can solve $\bar{z}$. Both wage incomes from formal and informal sectors have been plotted against z in figure 1. w_F starts at origin and rises along a straight line with a slope of $(1-t)A$. On the other hand, w_I also starts at origin but follows a concave path against z. Note that when z is low, the $\gamma s(z)$ tends to be very low, and the w^I would exceed w^F. As z rises, $\gamma s(z)$ would be stronger, and the w^I would rise at a decreasing rate and gradually fall below the w^F after a certain level of z, say $\bar{z}$.

Lemma 1 *In equilibrium when $w^F(\bar{z}) = w^I(\bar{z})$, we find $z = \bar{z}$ such that $[(\alpha - t)A\bar{z} + \gamma s(\bar{z}) = 0$ for $\alpha < t$. Workers prefer to work in the informal sector for $0 < z \leq \bar{z}$ and in the formal sector for $\bar{z} < z \leq 1$.*

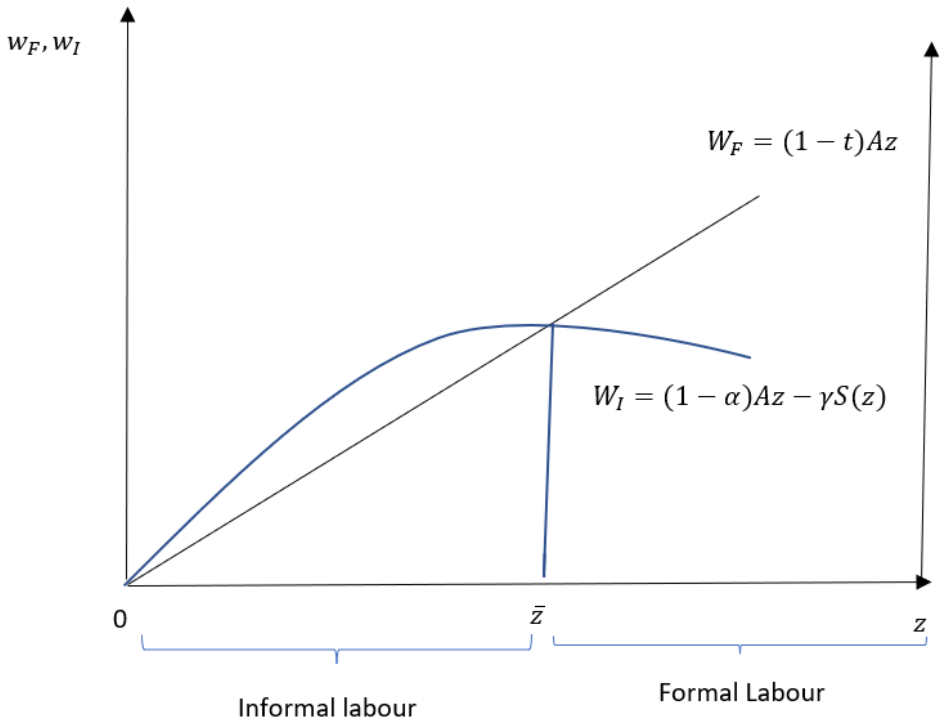
As a result, workers would spend labour on the informal sector upto $\bar{z}$, i.e., $(0 < z \leq \bar{z})$ and the rest will be spent on the formal sector. So, the labour spent on the informal sector is as follows:

$$L^I = \int_0^{\bar{z}} z dz = \frac{\bar{z}^2}{2} \tag{7}$$

On the other hand, the labour spent on the formal production can be expressed as follows:

$$L^F = \int_{\bar{z}}^1 (1-z) dz = \frac{1}{2} - \bar{z}(1 - \frac{\bar{z}}{2}) \tag{8}$$

Figure 1: Division of formal-informal labour



Since the workers prefer to work in the informal sector for $0 < z \leq \bar{z}$, the aggregate informal sector production can be solved as follows:

$$Y^I = \int_0^{\bar{z}} [(1-\alpha)Az - \gamma s(z)]dz = \frac{1}{2}(1-\alpha)A\bar{z}^2 - \gamma S(\bar{z}) \tag{9}$$

where, $S(\bar{z}) = \int_0^{\bar{z}} s(z)dz$ [3]. Note that the informal sector expands if $\bar{z}$ rises. This would be faster for higher $S(\bar{z})$.

Similarly, the workers working in the formal sector for $\bar{z} < z < 1$, the aggregate formal sector production can be solved as follows:

$$Y^F = \int_{\bar{z}}^1 y^F dz = \int_{\bar{z}}^1 Azdz = \frac{1}{2}A(1-\bar{z}^2) \tag{10}$$

Again, note that the formal sector production falls along with the rise of $\bar{z}$.

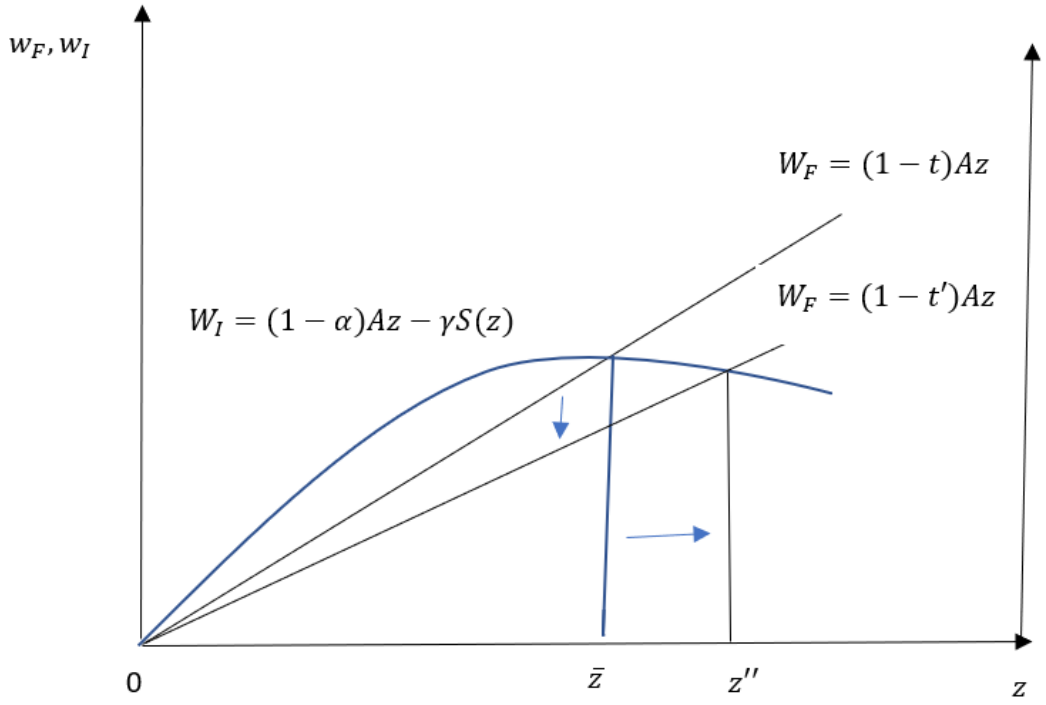
Let us now investigate the partial effect of taxation and digitalisation on the size of informality separately. If we totally differentiate $\bar{z}$ with respect to t, this can be written as:

[3] If $s(z) = \frac{\mu}{2}z^2$, then $S(\bar{z}) = \frac{\mu}{6}\bar{z}^3$

$$\frac{d\bar{z}}{dt} = \frac{A\bar{z}}{(\alpha - t) + \gamma s'(\bar{z})} > 0 \tag{11}$$

Where, $\frac{d^2\bar{z}}{dt^2} = \frac{A\bar{z}}{[(\alpha-t)+\gamma s'(\bar{z})]^2} > 0$. The above expression represents that a higher tax expands informality. If the tax rate is raised, the return from the works in the formal firms will fall, given the same level of concealation costs. They would prefer to shift some part of activities to the informal sector. Hence, the new cut-off point would shift to the right side of $\bar{z}$ to z'', leading to a rise in informality (see Figure 2). Moreover, the informalisation will accelerate with higher rate of taxation.

Figure 2: Tax rise and division of formal-informal labour



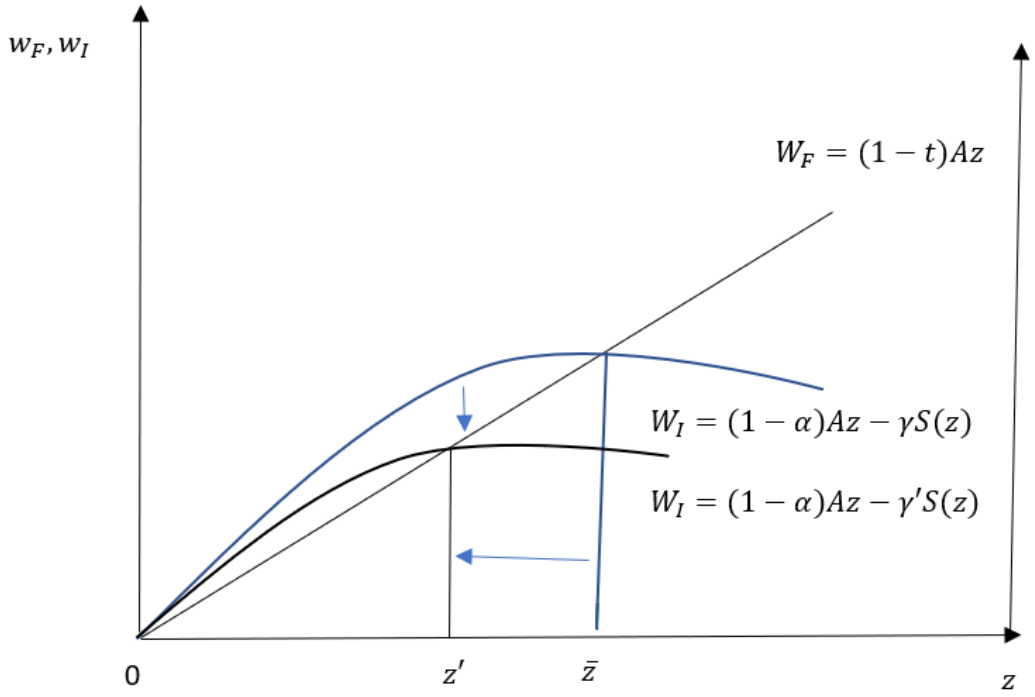
Similarly, taking total derivative of the expression with respect to γ, we represent

$$\frac{d\bar{z}}{d\gamma} = -\frac{s'(\bar{z})}{(\alpha - t) + \gamma s'(\bar{z})} < 0 \tag{12}$$

Where, $\frac{d^2\bar{z}}{d\gamma^2} = \left[\frac{s(\bar{z})}{[(\alpha-t)+\gamma s'(\bar{z})]}\right]^2 > 0$. The above expression further suggests that higher digitalisation hinders informality. If the state offers a better infrastructure of digital services, the cost of hiding transactions in the informal sector would be increased. As

a result, labour at the margin would prefer to shift to some extent to the formal sector from $\bar{z}$ to z', and the informality would shrink (see Figure 3).

Figure 3: Digitalisation and division of formal-informal labour



Proposition 2 *While the taxation raises the size of informality, the digitalisation reduces it under the partial equilibrium.*

3 Government

Now, the government should optimally choose taxation and digitalisation to maximize welfare when the digitalisation is financed by the taxation. Suppose that the state is aiming to reduce informality by offering better digital services that could record the informal transaction easily. In that case, it requires investment, which would essentially come from taxation, and this may work in the opposite direction. On the other hand, the taxation may raise public services that improves welfare. Therefore, the government needs to find the best combination of taxation and digitalisation levels that offers maximum welfare to the society. Welfare arises from two sources - consumption and public services. The consumption should be equivalent to the disposable output available at the hand

of consumers. While the formal output is taxed, the informal output is not. So, in equilibrium, the consumption is:

$$C = Y^I + (1-t)Y^F \tag{13}$$

Therefore, the government spends the tax revenue on two accounts: ICT innovations for the improved e-governance and other general public goods and services (like infrastructure, social welfare schemes etc.). The state essentially faces a trade-off of the optimal distribution to spend on the two counts. So, the residue of tax revenue after meeting expenditure on ICT innovations goes to the hand of consumers. The objective function of government can be written as follows:

$$\max_{t,\gamma} U = Y^I + (1-t)Y^F + \phi v(G); v'(G) > 0, v''(G) < 0, \phi > 0 \tag{14}$$

If the digitalisation involves a variable cost ($x(\gamma)$), the budget constraint can be presented as follows:

$$G = R - x(\gamma); x' > 0, x" > 0 \tag{15}$$

This expression represents that if the state wants to improve e-government (γ), the expenses for digitalisation (i.e., $x(\gamma)$) must rise, and the revenue left for the general public utilities will fall. So, we find the government revenue from the taxation imposed on the formal sector as follows:

$$R = tY^F = \frac{1}{2}tA(1-\bar{z}^2) \tag{16}$$

Substituting (15) and (16) into (14), we get an unconstrained maximisation problem of welfare to solve the optimum t and γ. The solution depends on whether the choice of wage and productivity is determined endogenously or not.

3.1 Endogenous e-governance

Let us assume that the wages and $\bar{z}$ are determined by the endogenous choice of t and γ. Given the level of digitalisation, the partial derivative of welfare function with respect to taxation gives the following expression.

$$\frac{\partial W}{\partial t} = -[(\alpha - t)A\bar{z} + \gamma s(\bar{z})]\frac{d\bar{z}}{dt} - \frac{1}{2}A(1-\bar{z}^2) + \phi v'(G)[\frac{1}{2}A(1-\bar{z}^2) - tA\bar{z}\frac{d\bar{z}}{dt}] \tag{17}$$

Since $[(\alpha - t)A\bar{z} + \gamma s(\bar{z})] = 0$ in equilibrium, the first part of the right-hand side vanishes. There would be such t (say, $\bar{t}$), for which $\frac{\partial W}{\partial t} = 0$. Rewriting this expression, at $t = \bar{t}$, we

find that:

$$\phi v'(G) = \frac{\frac{1}{2}A(1-\bar{z}^2)}{\frac{1}{2}A(1-\bar{z}^2) - tA\bar{z}\frac{d\bar{z}}{dt}} > 1 \tag{18}$$

This expression balances the trade-off between G (assuming z rises with t) and the private consumption in response to a change in taxation to keep the same utility level without changing the level of digitalisation. Give γ, a rise in tax rate raises G, leading to a gain in the utility. The rise in taxation would crowd out a part of the formal production and this leads to a drop in utility. On the other hand, the tax rise may increase informal production by $tA\bar{z}\frac{d\bar{z}}{dt}$, which would compensate the loss to some extent. At $t = \bar{t}$, the tax rate must be chosen in such a that this loss in utility must be compensated by the consumption rise of the informal goods. Therefore, in response to tax rise, the government revenue (R) increases, allowing the consumer to derive higher utility from G at the cost of consumption utility from formal goods. The left-hand side of this expression represents that the marginal rate of substitution of G for C (i.e., $MRS_{G,C}$) is $\phi v'(G)$. Because of the informality threat (i.e., due to $d\bar{z}/dt > 0$), some resources need a diversion to the e-government and G is under-provided. However, the effect of tax rise on the welfare still may be favourable if $t < \bar{t}$. The gain from public investment is higher than the loss from formal goods consumption in exchange of informal goods. In other words, whether welfare would rise or not depends on the relative strength of these changes.

Lemma 3 *For $t \leq \bar{t}$, we find that $\frac{\partial W}{\partial t} \geq 0$ when $\phi v'(G) - \frac{\frac{1}{2}A(1-\bar{z}^2)}{\frac{1}{2}A(1-\bar{z}^2) - tA\bar{z}\frac{d\bar{z}}{dt}} \geq 0$*

On the other hand, given a level of taxation, the partial derivative of welfare with respect to digitisation gives the following expression:

$$\frac{\partial W}{\partial \gamma} = -[(\alpha - t)A\bar{z} + \gamma s(\bar{z})]\frac{d\bar{z}}{d\gamma} - S(\bar{z}) - \phi v'(G)[tA\bar{z}\frac{d\bar{z}}{d\gamma} + x'(\gamma)] \tag{19}$$

Again, the first part of right-hand side should be zero in equilibrium. There would be such γ (say, $\bar{\gamma}$), for which $\frac{\partial W}{\partial \gamma} = 0$. Rewriting this expression, at $\gamma = \bar{\gamma}$, we find that:

$$\phi v'(G) = -\frac{S(\bar{z})}{tA\bar{z}\frac{d\bar{z}}{d\gamma} + x'(\gamma)} \tag{20}$$

For a rise in digitalisation (given t), G declines, leading to a drop in utility. A rise in formal goods consumption in exchange of informal goos must compensate for the utility drop. The loss of utility is compensated by the increased formal production and consumption. In order to satisfy this relation, it must be $tA\bar{z}|\frac{d\bar{z}}{d\gamma}| \geq x'(\gamma)$. It means the marginal gain in the tax revenue from formal sector expansion must be at least equivalent to the marginal loss of expenditure for e-government. Thus, γ should stop to raise when

either the marginal gain in G becomes too small or the aggregate concealment cost $S(\bar{z})$ and/or the enforcement cost $s(\gamma)$ become(s) too large. But, for a lower level of γ, the consumption may drop for a decline in total production (due to a large loss in the informal sector and a small gain of formal output) even when government spending (G) rises may result in a drop of welfare. In other words, once the γ crosses a critical limit, the welfare gain from the digitalisation would be positive if the gain from public investment along with formal goods consumption after meeting up the expenses for digital technology, enforcement cost and the resultant lost of informal goods consumption.

Lemma 4 *For $\gamma \leq \bar{\gamma}$, we find that $\frac{\partial W}{\partial \gamma} \leq 0$ when $\phi v'(G) + \frac{S(\bar{z})}{tA\bar{z}\frac{d\bar{z}}{d\gamma} + x'(\gamma)} \geq 0$*

Therefore, the state should choose t and γ in such a way the welfare is maximised. The above two expressions of first-order conditions would help us to simultaneously derive the optimal taxation and digitalisation (denoted by t^* and γ^*, respectively). We can solve them explicitly unless the expressions are specified explicitly. We can express them as functions of model parameters, i.e., $t^* = t(A, \phi, \alpha, \mu, x)$ and $\gamma^* = \gamma(A, \phi, \alpha, \mu, x)$. However, we are not interested to find such explicit functions here. Rather, we want to investigate the impact on tax burden if the state wants to increase the level of digitalisation or e-governance.

Then, the equilibrium taxation and digitalisation would be found when the net welfare change is cancelled out from each other, i.e., $dW = \frac{\partial W}{\partial t}dt + \frac{\partial W}{\partial \gamma}d\gamma = 0$. If we allow to change t for financing γ to maintain the same welfare, the relation between them can be traced out, i.e., $dt/d\gamma = -\frac{\partial W}{\partial \gamma}/\frac{\partial W}{\partial t}$. Substituting (17) and (18), we find it as follows:

$$\frac{dt}{d\gamma} = \frac{S(\bar{z}) + \phi v'(G)[tA\bar{z}\frac{d\bar{z}}{d\gamma} + x'(\gamma)]}{\phi v'(G)[\frac{1}{2}A(1-\bar{z}^2) - tA\bar{z}\frac{d\bar{z}}{dt}] - \frac{1}{2}A(1-\bar{z}^2)} \tag{21}$$

We can find that $\frac{dt}{d\gamma} > 0$ when (i) $\phi v'(G) - \frac{\frac{1}{2}A(1-\bar{z}^2)}{\frac{1}{2}A(1-\bar{z}^2) - tA\bar{z}\frac{d\bar{z}}{dt}} > 0$ and $\phi v'(G) + \frac{S(\bar{z})}{tA\bar{z}\frac{d\bar{z}}{d\gamma} + x'(\gamma)} > 0$, or (ii) $\phi v'(G) - \frac{\frac{1}{2}A(1-\bar{z}^2)}{\frac{1}{2}A(1-\bar{z}^2) - tA\bar{z}\frac{d\bar{z}}{dt}} < 0$ and $\phi v'(G) + \frac{S(\bar{z})}{tA\bar{z}\frac{d\bar{z}}{d\gamma} + x'(\gamma)} < 0$. If $t^* < \bar{t}$, we find that the taxation raises welfare, i.e., $dW/dt > 0$. To netralise this welfare gain, it must be $\gamma^* < \bar{\gamma}$ so that $dW/d\gamma < 0$. On the other hand, if $t^* > \bar{t}$, the higher taxation reduces the welfare. Then, the level of digitalisation must be sufficiently higher (i.e., $\gamma^* > \bar{\gamma}$) so that it can derive welfare gain to compensate the loss from higher taxation. This seems to suggest that the relation between taxation and digitalisation is positive. At lower level of digitalisation, a smaller amount of public investment is diverted. Since the cost of digitalisation is also low, it would effectively raise the formal production. The increased formal production would further raise the revenue to compensate the loss of public investment diversion. Hence, the need to tax the formal income would be lower.

On the other hand, for a higher level of digitalisation, the cost rises at an increasing rate. This demands a greater amount of public investment diversion for policing informal transactions. This would raise formal transactions and the gain in the formal production would slow down due to the increased cost of enforcement. The small increase in formal production forces to raise tax rate to compensate the losses. The higher taxation may raise G as well, which compensate the utility losses. In that case, if $\gamma^* > \bar{\gamma}$, this will increase the welfare, $dW/d\gamma > 0$. To finance the increased cost of digitalisation, the taxation must be higher, $t^* > \bar{t}$ and this may compensate the welfare gain by loss from higher taxation at the margin, i.e., $dW/dt < 0$.

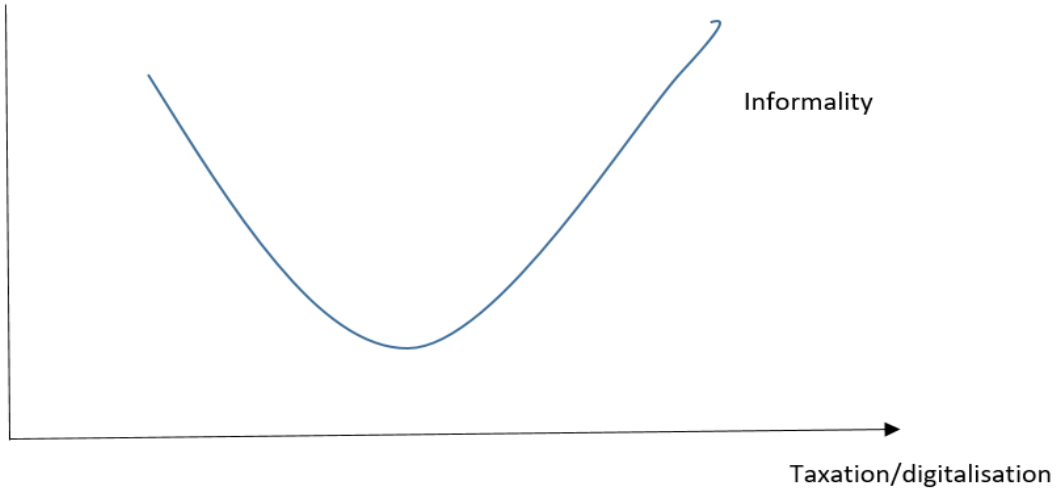
Proposition 5 *When the taxation and digitalisation are endogenously chosen, they are positively related. (i) $dt/d\gamma > 0$ when (a) $t^* < \bar{t}$ and $\gamma^* < \bar{\gamma}$, or (b) $t^* > \bar{t}$ and $\gamma^* > \bar{\gamma}$. (ii) Any combination from either $t^* < \bar{t}$ and $\gamma^* > \bar{\gamma}$ or $t^* > \bar{t}$ and $\gamma^* < \bar{\gamma}$ cannot be optimum.*

Substituting the optimum values of taxation and digitalisation on Y^I and $\bar{z}$, we get informal production. Let us see the effect of digitalisation on informality. We have found that t and γ are positively related. From (11) and (12), we find that $\frac{d^2\bar{z}}{dt^2} > 0$ and $\frac{d^2\bar{z}}{d\gamma^2} > 0$. This suggests that greater degree of digitalisation and taxation both adds to the force of informality. In response to an increase in digitalisation, the informal sector shirk as a direct effect. On the other hand, digitalisation needs increased taxation that may adversely affect the formal sector. If the direct effect dominates, the informal sector will shrink. But, the adverse effect rises increasingly with higher taxation, and it would dominate after a certain level of digitalisation. Hence, they tend to show a U-shaped relationship.

On the other hand, if the judiciary system is effective to undertake legal consequences for informal transactions, the cost of punishment or penalty ($S(\bar{z})$) rises. The expression (9) shows that the effect of γ on the fall of Y^I is stronger for higher value of $S(\bar{z})$. This is similar to Agarwal and Maiti (2020).

Proposition 6 *(i) The effect of digitalisation on informality shows a U-shaped relation, and (ii) the better rule of laws would raise the effectiveness of digitalisation.*

Figure 4: Digitalisation and Informality



3.2 Exogenous e-governance

Suppose that the state can target to raise the size of formality by fixing either wage or productivity at a minimum and desirable level. The target would be to reduce the size of informality, z, say $\hat{z}$. As long as $y^F(\bar{z} > \hat{z})$, the formal production is not affected by the binding condition. If the formal production is binding at $\bar{z} = \hat{z}$, the tax rate can no longer influence $\bar{z}$. The optimal condition (equation 17) for taxation turns into the following condition: $\phi v'(G)[\frac{1}{2}A(1-\hat{z}^2)] = [\frac{1}{2}A(1-\hat{z}^2)]$. This implies that

$$\phi v'(G) = 1 \tag{22}$$

This condition suggests that the state would spend the entire amount of additional taxation on public utilities (G). Because, $MRS_{G,C} = 1$. G would not be under-provided and also be higher than the previous case. As a result, taxation would be higher to provide higher G required here than the previous case.

Similarly, γ cannot influence $\bar{z}$. As a result, the second optimality condition (equation 19) of welfare function with respect to γ becomes $\frac{\partial W}{\partial \gamma} = -S(\hat{z}) - \phi v'(G)x'(\gamma) < 0$. γ should be enough to equalise the wage rate, i.e., $w^F(\hat{z}) = w^I(\bar{z})$. This means that higher γ would be wasteful. So, the strategy to reduce the informality by raising minimum wage or productivity does not positively correlate with the digitalisation. As a result, t would raise G, but not γ.

Proposition 7 *When the minimum wage and productivity are chosen exogenously, (i) taxation and digitalisation cannot guarantee positive relation, and (ii) the size of informality may be higher due to higher taxation or lower digitalisation in comparison to the endogenous case.*

3.3 Simulation

To investigate the effect of effective governance, we simulated the model with the help of parameters. For the sake of getting unique solutions, the utility function has been simplified as $U = log(W) + \phi log(G)$, where $W = W^I + (1-t)W^F$. Here, ϕ reports the preference for government services and takes a value of 0.5. The extra-legal cost function for informality represents as $s(z) = \frac{\mu}{2}z^2$. The inefficiency level of the informal sector is 0.2. The technology level, represented by A, takes the value of 2. Here, μ accounts for the effectiveness of rules and regulations or the degree of punishment. The cost of digitalisation is presented as $x(\gamma) = b\gamma$ (for simplicity). Here, b denotes the expenditure intensity for digitalisation. The simulated figures with the changes in b and μ show the impact of digitalisation without and with effective governance on taxation, e-governance and the size of informality (see Figures 4 and 5, respectively). When the state increases the level of digitalisation (by raising b), the expenditure for digitalisation rises (Figure 5(d)). The additional expense needs to be financed from the increased taxation (Figure 5(a). The increased taxation raises the cost of production in the formal sector, and hence the size of informality rises (Figure 5(c)). To accommodate the informal activities, the state should weaken the governance level (Figure 5(b)). So, taxation and e-governance are inversely related.

On the other hand, if the state raises the quality of e-governance and effective implementation of rules and regulations (by raising μ keeping at the same intensity of digitalisation (b)), the result may look different. The improved regulation reduces the requirement for spending on digitalisation (Figure 6(d)). Reduced spending relaxes the tax burden (see Figure 6(a)); thus, the activities move from informal to formal sectors (figure 6(c). As a result, e-governance may fall (Figure 6(b)). In this case, taxation and e-governance are directly related. We can also infer that taxation must rise to improve e-governance.

Figure 5: Effect of Digitalisation without effective governance

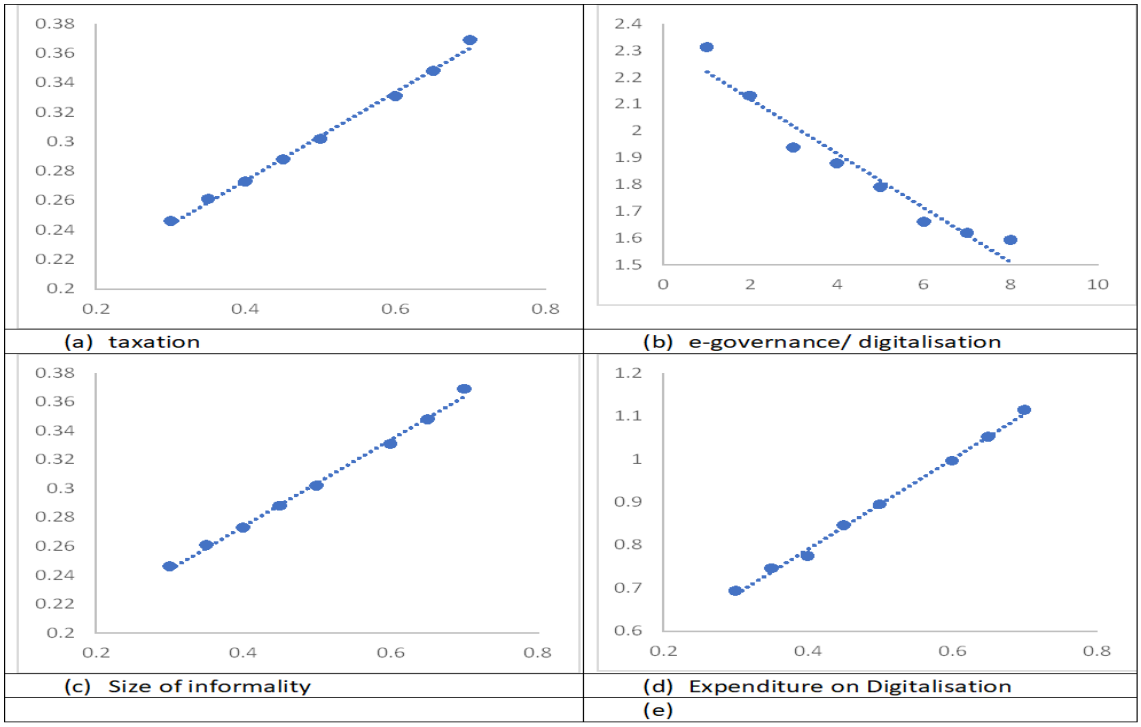
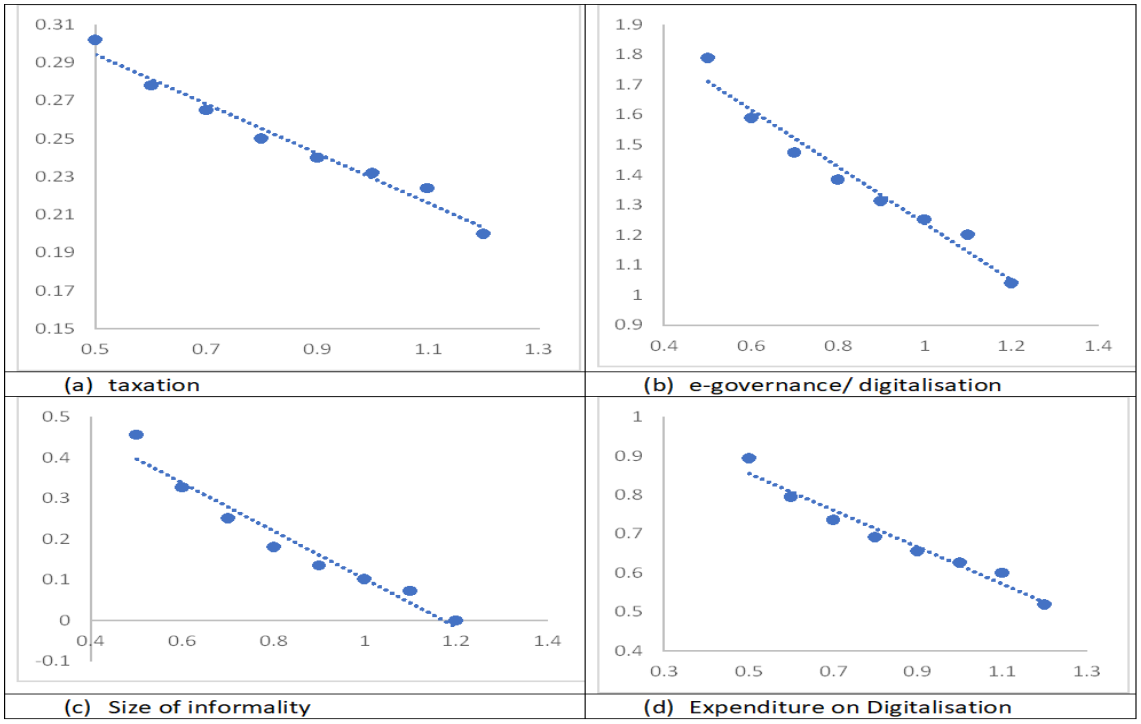


Figure 6: Effect of Digitalisation with effective governance



4 Empirical Analysis

4.1 Data

The empirical part is based on cross-country analysis. It aims to find the effect of digitalisation on the degree of informality in the presence of various degrees of governance. The relevant data has been drawn from various sources. The governance related indicators have been taken from Governance Indicators (WGI) dataset for the analysis to measure governance and institutional quality. The World Development Indicators (WDI) dataset has been used for the other variables. Freedom house arranged information on civil liberties (CL) and political rights (PR) and they are used as proxies for political freedom and rights. The human development index is procured from the United Nations Development Program (UNDP) database. The size of informal sector in terms of production share is not available at a panel format. So, we had to rely on the share of vulnerable employment, offered by the World Bank in the WDI database, and this has been considered as a proxy of informal share. Let us define the main variables constructed for the regression analysis.

- DIGITALIZATION: Digitalization or the ICT variable of a country has been created by using four ICT access indicators namely, fixed broadband subscriptions per 100, fixed telephone subscriptions per 100, mobile cellular subscriptions per 100 and secure internet serves per million from the WDI dataset. All the variables are normalized by using global maximum and minimum values, and then a weighted average is taken by giving equal weights to each of the four variables. We get the final variable representing the level of ICT or digitalisation.

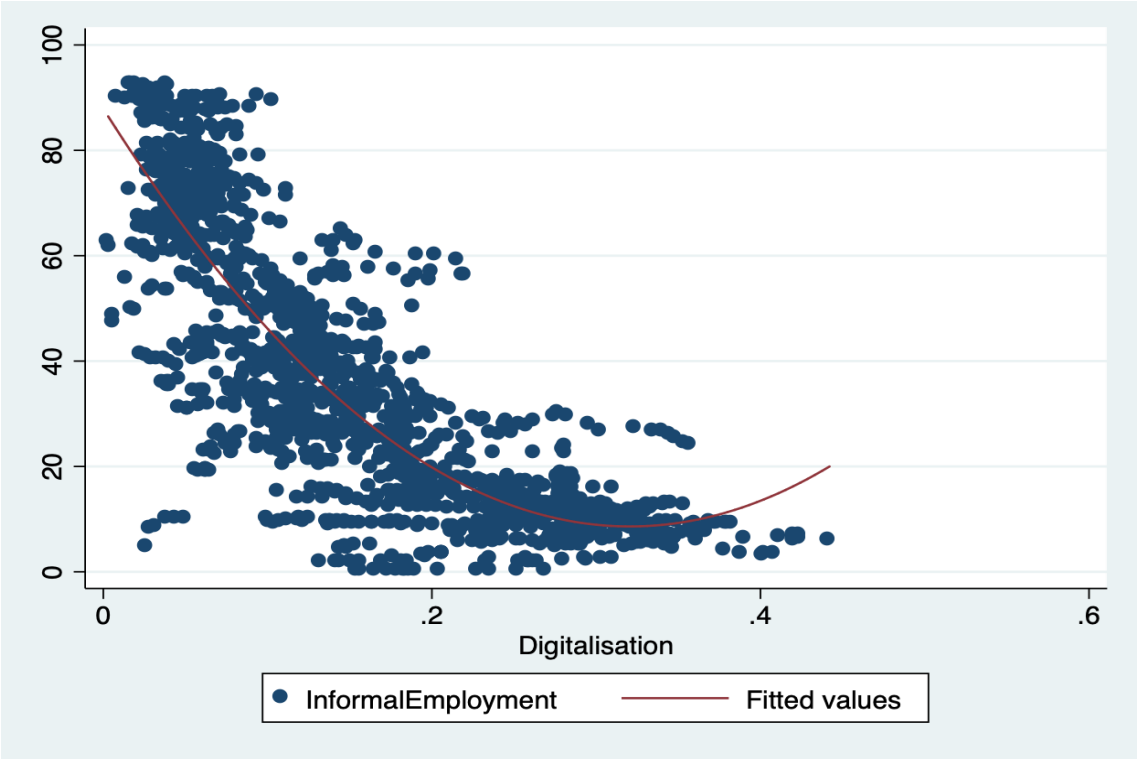
- INFORMALITY: We have used yearly vulnerable employment as a percentage of total employment as an indicator of informality in each nation. For simplicity, we assume that the country producing more informal output must hire more number of informal workers. Vulnerable employment refers to contributing family workers and own-account workers as a percentage of total employment (according to the World Bank). The estimates for the variable are derived from the International Labour Organization, ILOSTAT database.

- GOVERNANCE: The six measures for governance and institutional quality are taken from the WGI data set from 1990 (mentioned above). These measures were created by using the various underlying variables in the existing data sources and governance surveys, Kaufmann et al. (2010). The data set obtained from WGI includes more than 148 countries and territories, and considers six dimensions of governance and institutional quality starting from 1990. The six dimensions of governance indicators are - government effectiveness, control of corruption, political stability and absence of violence, voice and accountability, regulatory quality and the rule of law, Kaufmann et al. (2010). The WDI data set contains development indicators procured from various recognized international sources and provides a country-wise estimate of the variables that are treated here as control variables. For the analysis, we have combined the relevant indicators of ICTs and other variables drawn from WDI and governance indicators from WGI. And, CL and PR variables are taken from freedom house organization.

To visualize the tentative relationship, the size of informality has been plotted against the ICT variable or digitalisation across all the countries (see Figure 3). Note that the ICT variable for a country is created using four ICT variables (discussed above) from the WDI dataset (fixed broadband subscriptions per 100, fixed telephone subscriptions per 100, mobile cellular subscriptions per 100 and secure internet servers per million). All these variables were normalized by using the respective global maximum and minimum

H

Figure 7: Digitalisation and Informality : tentative relationship



values. Then, a weighted average (giving equal weights to the four variables) was taken to find the ICT variable. We could not make out a clear relation from the plot. It seems to suggest that the informality declines with digitalisation but starts rising after a critical level. However, one needs to undertake a regression analysis to find a robust relation.

4.2 Digitalisation and Informality

To investigate the effect of digitalization on informality, the baseline regressions are run using simple country fixed effects and time fixed effects model. Table 2 shows the results of regressing informality on ICT variable using country fixed effects and time fixed effects panel regression. As expected, ICT variable is negatively related to informality and ICT variable squared is positively related to informality in the columns 1 and 2. Both the ICT variable and its squared term are statistically significant in both the country fixed effects and time fixed effects models, indicating that digitalisation affects informality negatively. But, it seems to rise with the degree of digitalisation. As can be observed from columns 2A and 2B, ICT along with rule of law (ICT*Rule of Law) registers negative figure. The

interaction term of ICT with rule of law is significant in both the country fixed effects and time fixed effects model, indicating that ICT along with better rules and judiciary system (in place rule of laws) tends to reduce informality. Column 2C includes the result for both country and time fixed effects, here also we observe that the interaction term of ICT with rule of law is significant.

However, we need to control for the other factors affecting informality. The columns 3 and 4 of Table 2 show the results of regressing informality on the ICT variable and ICT squared along with other control variables. The control variable for GDP per capita (in logarithmic term) has been proxied by development indicators (like education and life expectancy). Civil liberties is used as political development indicators. Education index and life expectancy are used as social development indicators. As expected, ICT variable is negatively and significantly related to informal employment. ICT variable squared has the expected sign and is positively and significantly related to informal employment. Education index and life expectancy have the expected negative sign and are statistically significant. In column 3 we add the interaction term of ICT with rule of law, although the term has expected negative sign and significant. In column 4 we take the interaction term of ICT with government effectiveness and the term has also expected negative sign and it is significant too. In columns 3 and 4 we have included only country fixed effects because the control variables are turning out to be highly correlated with the time fixed effects. Because, some of them are constructed with ordinal values. In order to avoid this problem, we have further run dynamic panel model.

Lets run dynamic panel regression. Table 3 shows the effect of ICT on informality in the presence of various control variables using dynamic panel data estimation. Here, as expected, log of GDP per capita and education index are negatively and significantly related to informal employment. Life expectancy also has the expected positive sign and is statistically significant. ICT variable and its squared term also have the negative and positive signs respectively (in column 1), and are statistically significantly related to informality, indicating that digitalisation has a significant positive impact in reducing informal employment up to a certain level before it moves to the opposite direction.

Then in column 2, rule of law is considered as an interaction term with ICT variables, this variable becomes negative and significant. More importantly, both ICT and ICT squared have turned out to be significant. This is also true in column 4 where we have taken the interaction of governance effectiveness and ICT (as replacement of rule of law). The interaction term of ICT with governance effectiveness is negative and significant. Therefore, these results seem to suggest that the effect of ICT would be favourable to

Table 2: Digitalisation and Informality : Baseline Results

Variables	Informality 1A	Informality 1B	Informality 2A	Informality 2B	Informality 2C	Informality 3	Informality 4
ICT	-32.31****	-218.77****	-60.07****	-69.54****	-32.55****	-47.22**	-46.09**
	(2.57)	(4.26)	(7.07)	(8.37)	(7.80)	(23.93)	(23.77)
ICT^2			97.35****	125.40****	79.46****	106.53**	104.98**
			(18.97)	(20.65)	(18.73)	(51.11)	(51.22)
Education Index						-14.62**	-15.38**
						(7.34)	(7.33)
Life Expectancy						-0.50***	-0.50***
						(0.17)	(0.17)
GINI						0.20***	0.21***
						(0.07)	(0.07)
Civil Liberties						-0.60a	-0.58a
						(0.52)	(0.52)
ICT*Government Effectiveness							-1.70
							(3.32)
ICT*Rule of Law			-6.64****	-13.68****	-5.32***	-2.78	
			(2.16)	(2.24)	(2.13)	(4.28)	
Constant	42.193****	67.67****	42.68****	44.50****	39.56****	75.31****	75.86****
	(0.39)	(1.20)	(0.64)	(1.44)	(0.74)	(11.27)	(11.26)
Observations	1543	1543	1193	1193	1193	382	382
No. of countries	228		177	177	177	106	106
Model							
Country Effects	YES	NO	YES	NO	YES	YES	YES
Time Effects	NO	YES	NO	YES	YES	NO	NO

Standard errors in parentheses

****p=0.000, ***p<0.01, **p<0.05, *p<0.10

[a] – significant at 20%

reduce the size of informality, if the rule of laws and governance are strong and effective. Since the rule of laws represents the effectiveness of judiciary system, it may be correlated to the governance effectiveness.

It is evident from the results of table 3 that ICT plays an important role in terms of reducing the size of the informal sector in the presence of stronger rule of laws and effective judiciary system. But, we have also established theoretically that digitalisation requires public investment from tax revenue, suggesting a possible endogeneity issue in the regression analysis. So, the tax burden will also rise which will further put a pressure on the informal sector because of the endogenous relationship between tax exposure and ICT.

Hence, we considered taxation as an instrument for ICT and reworking the regression results in the presence of taxation. We have taken tax rate (as percentage of GDP) variable from the world bank data to capture the rate of taxation. Column 1 shows the dynamic panel regression results same as column 2 of table 3. In column 2 we take tax rate in place of ICT along with other control variables and they all come out to be significant as before. In column 3, we take the ICT variable along with the interaction term of ICT and Tax-Rate to capture the combined effect of both ICT and tax rate on the informality. Both the variables turn out to be significant along with other control variables.Column 4 shows the results with the interaction term of ICT and tax-rate. Column 5 shows results with both ICT and its squared term along with the interaction term. In all these regressions tax rate (with a lag) has been taken as an instrument for the ICT variable. The coefficient of tax-rate and its interaction term come out to be significant and positive. The interaction term of ICT and tax-rate has been taken to see the combined effect of both the variables on informality. It suggests that that the impact of digitalisation on the informal sector reduction slims down by the taxation. Because, the state requires to increase tax revenue to fund the expenditure on digitalisation. The combined effect of increased digitalisation and tax-rate is expected to increase the informal sector. Therefore, the negative impact of digitalisation on the informality starts fed out as the higher level of digitalisation requires larger fund from taxation that contributes to the rise in informality. This justifies the U-shaped informality against digitalisation.

5 Concluding Observations

This paper attempts to investigate the impact of digitalisation on the informality. It builds a theoretical model with three agents in the economy. While the household derives

Table 3: Digitalisation and Informality : Dynamic Panel Regression

	1	2	3	4
Variables	Informality	Informality	Informality	Informality
LN GDP per capita	-13.60****	-13.14****	-13.839****	-13.06****
	(0.223)	(0.293)	(0.228)	(0.23)
Education Index	-16.59****	-8.32*	-55.544****	1.52
	(3.617)	(4.738)	(2.920)	(4.07)
Life Expectancy	1.25****	1.23****	0.525****	1.13****
	(0.099)	(0.103)	(0.073)	(0.10)
Civil Liberties	0.448**	-0.090	-1.373****	-1.11****
	(0.235)	(0.313)	(0.238)	(0.28)
ICT	-327.98****	-355.244****	1.778	-336.55****
	(21.99)	(23.204)	(5.178)	(21.87)
ICT^2	692.60****	756.36****		744.03*****
	(43.57)	(47.137)		(43.43)
ICT*rule of law		-9.074***	8.831****	
		(3.308)	(2.449)	
ICT*Government Effectiveness				-22.72****
				(2.43)
Constant	101.02****	98.255****	159.324****	90.57****
	(6.49)	(6.654)	(4.292)	(8.35)
Observations	996	989	989	989
No. of countries	148	147	147	147

Standard errors in parentheses

****p=0.000, ***p<0.01, **p<0.05, *p<0.10

[a] – significant at 20%

Table 4: Digitalisation and Informality in the presence of taxation : Dynamic Panel Regression

Variables	Informality 1	Informality 2	Informality 3	Informality 4	Informality 5
ICT	-355.24****		-142.09****		-169.17****
	(23.20)		(8.71)		(17.94)
ICT^2	756.36****	-95.10****			81.89****
	(47.13)	(16.91)			(47.46)
ICT*Tax-Rate			3.28****	-0.62****	3.18****
			(0.15)	(0.19)	(0.16)
Tax rate		0.21****		0.24****	
		(0.00)		(0.01)	
Education Index	-8.32****	-31.34****	-26.37****	-36.36****	-25.68****
	(4.73)	(4.88)	(6.29)	(4.72)	(6.30)
Life Expectancy	1.23****	1.20****	1.46****	1.13****	1.46****
	(0.10)	(0.06)	(0.08)	(0.06)	(0.08)
Civil Liberties	-0.09****	-1.91****	-1.16****	-2.17****	-1.31****
	(0.31)	(0.22)	(0.29)	(0.24)	(0.31)
LN GDP per capita	-13.14****	-16.78****	-14.05****	-17.19****	-13.95****
	(0.29)	(0.53)	(0.65)	(0.52)	(0.65)
ICT*Rule of Law	-9.07****	-16.34****	-25.69****	-20.03****	-28.26****
	(3.30)	(2.67)	(3.09)	(2.51)	(3.43)
Constant	98.25****	124.83****	90.54****	136.54****	91.70****
	(6.65)	(5.16)	(6.54)	(4.61)	(6.57)
Observations	989	744	744	744	744
Countries	147	115	115	115	115

Standard errors in parentheses

****p=0.000, ***p<0.01, **p<0.05, *p<0.10

[a] – significant at 20%

utility from the private consumption of the goods produced in formal and informal sector and from public services. Firms with higher productivity can meet the tax burden and operate in the formal sector. But, the relative lower productive firm manage to evade tax to survive in the informal sector by paying extra-legal costs. The government spends the tax revenue for digitalisation or public services. We find that the digitalisation raises cost of informal production and reduces the informality. On the other hand, it requires higher taxation that essentially encourage the production to take place in the informal sector. The combined effect of these two sources determine the resultant impact on the size of informality. We find that the former dominates at the lower level of productivity and thus size of informality declines. As the level of digitalisation rises, it demands more tax revenue. As a result, the later become stronger and the size of informality start rising. So, we find a U-shared relation between them. To the best of our knowledge, such a model to establish the relation between taxation and digitalisation as well as digitalisation and informality do not exists in the literature. If the wage and productivity are exgeneously targeted at higher level to reduce the informality. the negative relationship may not sustain and the size of informality may rise.

Cross country evidences have been gathered from various secondary sources to empirically investigate the relationship for the period 1996-2017 over more than 152 countries. The dynamic panel regression results support the u-shared relationship. Moreover, the negative effect of digitalisation on the informal sector becomes significant in the presence of stronger rule of laws and judiciary system. This establishes that the digitalisation does not necessarily reduces the size of informality unless the governance is strong.

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Appendix

A: Derivation of $dt/d\gamma$

$\frac{dt}{d\gamma} = \frac{\phi v'(G)+\frac{S(\bar{z})}{tA\bar{z}\frac{d\bar{z}}{d\gamma}+x'(\gamma)}}{\phi v'(G)-\frac{\frac{1}{2}A(1-\bar{z}^2)}{\frac{1}{2}A(1-\bar{z}^2)-tA\bar{z}\frac{d\bar{z}}{dt}}} \frac{tA\bar{z}\frac{d\bar{z}}{d\gamma}+x'(\gamma)}{\frac{1}{2}A(1-\bar{z}^2)-tA\bar{z}\frac{d\bar{z}}{dt}} \geq 0$. Because, for $t \leq \bar{t}$ and $\gamma \leq \bar{\gamma}$ we know that $\phi v'(G) + \frac{S(\bar{z})}{tA\bar{z}\frac{d\bar{z}}{d\gamma}+x'(\gamma)} \geq 0$ and $\phi v'(G) - \frac{\frac{1}{2}A(1-\bar{z}^2)}{\frac{1}{2}A(1-\bar{z}^2)-tA\bar{z}\frac{d\bar{z}}{dt}} \geq 0$