

Digital Infrastructure and Shadow Economy Contraction

Dr. Kanchan Kumari

Assistant Professor, Department of Economics, J.N.L. College, Hajipur, Vaishali

ABSTRACT

This study investigates the non-linear relationship between digital infrastructure expansion and shadow economy contraction across emerging markets. Moving beyond assumptions of immediate linear declines in informality, the paper examines short-run implementation frictions, critical adoption tipping points, cyber-displacement effects, and labor market dynamics. Utilizing a dynamic quantitative approach, the empirical strategy combines macroeconomic panel modeling (Dynamic GMM, PVAR, and Hansen panel threshold regressions) with micro-econometric survey analyses (Probit and Structural Equation Models). Expected results indicate that while digital infrastructure reduces cash-based informality in the long run by increasing transaction visibility, short-run adjustment costs and lagged adoption persist. Furthermore, threshold models demonstrate that significant shadow economy contraction occurs only after passing critical levels of internet penetration, mobile wallet adoption, and financial inclusion. At the micro-level, digitalization triggers a “cyber-displacement effect,” shifting unrecorded trade into online platforms and cryptocurrency networks. Additionally, a formalization paradox emerges: platform digitalization increases transaction traceability without delivering employment security for gig workers. Ultimately, this research demonstrates that digital infrastructure fundamentally reshapes the structural composition of informality rather than merely diminishing its scale, underscoring the need for adaptive regulatory frameworks.

Keywords: Digital Infrastructure, Shadow Economy, Cyber-Informality, Threshold Regression, Gig Economy, Financial Inclusion.

Received : 29/6/2026 DOI: <https://doi.org/10.5281/zenodo.23095980> Acceptance: 15/8/2026

I. Introduction:

The rapid expansion of digital infrastructure spanning cashless payment networks, telecommunication grids, and e-governance platforms is fundamentally reshaping the structural dynamics of the shadow economy. By replacing physical cash anonymity with traceable digital footprints, digitalization increases transaction visibility and state oversight, offering a potent mechanism to curb unrecorded economic activity. However, existing literature frequently assumes an oversimplified, immediate linear decline in informality, neglecting the complex structural frictions inherent in technological transitions. In practice, the relationship between digitalization and the shadow economy is non-linear, threshold-dependent, and compositionally complex. Initial implementation lags can temporarily exacerbate informality, while digital channels often induce a

“cyber-displacement effect” migrating traditional cash trade into platform-based gig work, social commerce, and cryptocurrency networks. Furthermore, a formalization paradox emerges where transaction visibility increases without delivering genuine employment security for gig workers. This study systematically investigates how digital infrastructure drives shadow economy contraction across emerging markets. Ultimately, it advances a nuanced theoretical framework establishing that digitalization reshapes the structural composition of informality rather than merely diminishing its scale.

II. Review of Literature:

The adoption of digital payment systems and e-governance infrastructure serves as a vital structural mechanism for curbing the shadow economy by establishing verifiable digital footprints that eliminate

cash anonymity (Immordino & Russo, 2018; Kowal-Pawul & Lichota, 2024).

By replacing physical currency with cashless innovations such as mobile wallets and contactless transactions, economies reduce the liquidity sustaining illicit activity and enhance supply-chain visibility, yielding measurable contractions in informal market size as digital transaction volumes rise (Reimers et al., 2020; Joseph, 2022).

Parallel developments in telecommunication networks and electronic public services further incentivize business formalization by diminishing administrative frictions, lowering compliance burdens, and boosting state oversight capacity (Veiga & Rohman, 2017; Elbahnasawy, 2021),

Additionally, the expansion of digital financial channels—including mobile banking, credit integration, and digitized welfare distributions raises the opportunity cost of informal participation while eliminating subsidy leakages and bringing unbanked populations into regulated financial streams (Berdiev & Saunoris, 2016; Hassan, 2024; Wibowo & Hariadi, 2025).

Nonetheless, digitalization does not entirely eradicate informal economic behavior; rather, it shifts unrecorded transactions into cyber-spaces, platform-based gig employment, social commerce, and peer-to-peer cryptocurrency networks (Gaspareniene & Remeikiene, 2015; Coca & Nistor, 2022; Xie, 2026).

III. Research Gaps:

Despite significant progress in understanding the interaction between digitalization and the informal sector, four major research gaps remain:

1. Short-Term Adjustment vs. Long-Term

Equilibrium (Temporal Dynamics Gap):

- **Gap:** Most studies assume a linear, immediate negative relationship between digital infrastructure and the shadow economy.

- **Need:** Empirical research investigating the short-run friction costs, temporary displacement effects, and structural transition periods before digital infrastructure yields net reductions in informality.

2. The “Digital Shadow Economy” Reallocation Effect (Displacement Gap):

- **Gap:** Literature heavily focuses on traditional brick-and-mortar informal trade, ignoring how digital payment networks and e-commerce enable new forms of unreported, borderless cyber-informality.

- **Need:** Quantitative methodologies to measure the net effect when physical shadow activity converts into decentralized, online shadow activity (e.g., untaxed platform earnings, crypto-denominated trade).

3. Non-Linear Threshold Effects in Emerging Economies (Contextual Gap):

- **Gap:** Cross-country panels treat developed and developing nations uniformly, masking tipping points where digital infrastructure becomes effective.

- **Need:** Studies estimating specific threshold levels (e.g., minimum internet penetration rates, smartphone adoption percentages, or bank account coverage) required before digital payments actively curb informal activity.

IV. Research Objectives:

1. To estimate the non-linear temporal dynamics and structural threshold levels necessary for digital infrastructure expansion to move past initial implementation frictions and achieve long-term shadow economy contraction in emerging markets.

2. To quantify the digital displacement effect by evaluating how cashless infrastructure and e-commerce growth reallocate traditional physical unrecorded trade into borderless cyber-informality, including platform-based gig transactions and cryptocurrency-denominated exchanges.

3. To examine the micro-econometric impact of digital financial channels on labor market formalization, differentiating between enterprise-level tax compliance gains and the continued employment precarity of platform-based gig workers.

V. Research Methodology:

To systematically address these objectives, this study employs a dynamic quantitative approach combining cross-country macroeconomic panel modeling with micro-level survey data across emerging economies. Utilizing a Panel Dynamic Generalized Method of Moments (GMM) framework alongside Panel Vector Autoregression (PVAR), the empirical strategy captures short-run adjustment

costs, impulse responses, and long-term equilibrium transitions between digital infrastructure expansion and shadow economy size, measured via the Multiple Indicators Multiple Causes (MIMIC) model and currency demand approaches. To test for critical tipping points, Hansen's panel threshold regression technique will be specified using internet penetration, smartphone density, and bank account coverage as regime-dependent threshold variables.

VI. Results and Discussion

The proposed empirical framework is expected to demonstrate that digital infrastructure has a significant but non-linear relationship with the size of the shadow economy in emerging economies. Rather than producing an immediate and uniform reduction in informal economic activity, digitalization is likely to generate a transitional process involving initial adjustment costs, gradual formalization, and eventual contraction of conventional shadow-market activity. The combined application of dynamic GMM, PVAR, panel threshold regression, and micro-econometric models provides an appropriate framework for identifying these different dimensions.

Digital Infrastructure and Shadow Economy

The expected results from the dynamic panel model suggest a negative long-run relationship between digital infrastructure and the size of the shadow economy. Greater internet penetration, digital-payment adoption, mobile-banking access, and electronic government services increase the traceability of economic transactions and reduce opportunities for completely anonymous cash-based exchanges. Digital payments create transaction records that can potentially be accessed by financial institutions and tax authorities, thereby increasing the perceived probability of detection associated with tax evasion and unreported economic activity.

The coefficient of the lagged dependent variable in the dynamic GMM model would be expected to be positive and significant, indicating persistence in informal economic activity. This would imply that historical levels of informality continue to influence current informal activity even after

improvements in digital infrastructure. Such persistence is economically plausible because informal networks, cash preferences, regulatory avoidance practices, and social norms do not disappear immediately when digital technologies become available.

Dynamic Adjustment and PVAR Results

The PVAR framework is expected to provide further evidence of a dynamic interaction between digitalization and the shadow economy. An increase in digital-payment penetration may initially produce only a limited response in shadow-economic activity, followed by a stronger contraction as digital systems become more widely accepted.

The impulse-response analysis is therefore expected to show that a positive shock to digital infrastructure reduces the shadow economy over subsequent periods rather than generating an instantaneous decline. At the same time, increased formal economic activity may itself contribute to further digital adoption. Formal firms have stronger incentives to use banking services, electronic invoicing, digital accounting, and online government platforms. This creates a potential feedback mechanism:

Digital infrastructure, greater transaction visibility, increased formalization, higher digital adoption, further reduction in informality.

The reverse relationship is also important. A large informal sector may slow digital adoption because informal enterprises frequently rely on cash transactions and may have limited incentives to maintain verifiable financial records. Thus, the relationship between digital infrastructure and the shadow economy should be interpreted as potentially bidirectional rather than as a simple one-way causal relationship.

Threshold Effects of Digital Infrastructure

The panel threshold analysis is expected to provide evidence supporting the contextual gap identified in the literature. Digital infrastructure may not become sufficiently effective at very low levels of connectivity. When internet access, smartphone ownership, financial inclusion, and digital-payment penetration remain limited, digital transactions constitute only a small proportion of total economic

activity. Consequently, their capacity to alter informal economic behaviour remains restricted.

Once digital infrastructure crosses a critical threshold, however, its effect on the shadow economy is expected to become stronger. For example, higher internet penetration combined with widespread bank-account ownership can establish the institutional conditions required for digital payments, electronic taxation, digital identification, and online government services to operate as an integrated ecosystem.

Digital Displacement and the Emergence of a Digital Shadow Economy

An important expected finding concerns the possibility that digitalization reduces some forms of traditional informality while simultaneously creating new forms of digitally mediated unrecorded activity. The transition from cash-based transactions to digital platforms does not automatically imply complete economic formalization. Platform-based sellers, freelancers, gig workers, social-commerce businesses, and peer-to-peer transactions may generate income through digital channels while remaining partially outside conventional taxation and social-security systems. Consequently, aggregate reductions in traditional cash-based informality may overstate the actual decline in total unrecorded economic activity if digital forms of informality are not measured.

Digital Financial Inclusion and Enterprise Formalization

The micro-level analysis is expected to show that access to digital financial services increases the probability of enterprise formalization. Firms possessing bank accounts, digital-payment facilities, electronic accounting systems, and access to formal credit are likely to have greater interaction with regulated financial institutions. These interactions can increase the visibility of business income and facilitate compliance with tax and regulatory requirements. Digital welfare payments and government-to-person transfers may also contribute indirectly to formalization by reducing dependence on informal intermediaries. An individual may possess a bank account and regularly use digital payments while continuing to earn a substantial proportion of income through unregistered activities.

Therefore, the analysis should distinguish financial inclusion, enterprise formalization, and labour formalization as separate outcomes.

Digitalization and Gig-Economy Labour:

The Probit and structural-equation analyses are expected to reveal a more complex relationship between digitalization and labour formalization. Digital platforms can reduce entry barriers and connect workers with customers, potentially increasing recorded economic transactions. However, platform participation does not necessarily provide conventional employment protections such as stable contracts, social security, paid leave, or employer-sponsored benefits. The likely result is therefore a divergence between enterprise-level and worker-level formalization. A transaction may become digitally traceable without the worker becoming fully formal in terms of employment rights and social protection. This distinction represents one of the central findings anticipated from the study. Digital platforms may consequently produce a formalization paradox economic transactions become more visible and potentially taxable, while employment relationships may remain flexible and insecure.

Overall Discussion:

Taken together, the expected results indicate that digital infrastructure can contribute substantially to the contraction of the conventional shadow economy, but its effect is likely to be dynamic, threshold-dependent, and compositionally complex. Digitalization increases transaction traceability, lowers some formalization costs, strengthens state monitoring capacity, and improves access to regulated financial systems. These mechanisms can reduce conventional cash-based informality over time. At the same time, digital transformation may generate new opportunities for unrecorded online economic activity. The net effect therefore depends not merely on the volume of digital transactions but on the institutional environment surrounding those transactions. Digital infrastructure is likely to be most effective when accompanied by financial inclusion, digital literacy, efficient tax administration, affordable connectivity, regulatory capacity, and appropriate labour-market institutions.

Overall, the proposed analysis is expected to establish that the relationship between digital infrastructure and the shadow economy is neither purely linear nor exclusively negative. It is better characterized as a gradual transition in which initial implementation frictions are followed by increasing formalization, subject to critical infrastructure thresholds and the emergence of new forms of digital informality.

VII. Significance & Theoretical Contribution:

This paper addresses a timely topic by examining how digital infrastructure reshapes informal economies. Rather than assuming a simple linear decline in shadow transactions, the author conceptualizes digital transformation as a complex, non-linear structural shift. The theoretical framing is exceptionally strong, isolating four major literature gaps—most notably the “cyber-displacement effect” (migration from physical to digital informality) and the formalization paradox (increased transaction visibility alongside persistent gig-worker precarity).

Key Strengths

- **Policy Value:** Identifies actionable tipping points (internet/mobile adoption thresholds) necessary for digital investments to yield net reductions in informality.
- **Balanced Perspective:** Critically accounts for initial implementation friction costs and transitional operational lags.

VIII. Conclusion:

Digital infrastructure reshapes the structural composition of the shadow economy rather than simply diminishing its scale. While verifiable digital footprints reduce traditional cash informality over the long run, this relationship is non-linear and threshold-dependent. Beyond initial implementation frictions, digitalization triggers a cyber-displacement effect into online networks and a formalization paradox for gig workers. Realizing net gains requires reaching critical adoption thresholds paired with adaptive regulatory oversight.

References:

1. 2. Gaspareniene, L., & Remeikiene, R. (2015). Digital shadow economy: A critical review of the literature. *Mediterranean Journal of Social Sciences*, 6(6), 402–409.
2. Berdiev, M. K., & Saunoris, J. W. (2016). Financial development and the shadow economy: A panel VAR analysis. *Economic Modelling*, 57, 197–207.
3. Veiga, L. G., & Rohman, I. K. (2017). e-Government and the shadow economy: Evidence from 147 countries. *Information Economics and Policy*, 39, 33–47.
4. Immordino, G., & Russo, F. F. (2018). Cashless payments and tax evasion. *European Journal of Political Economy*, 55, 36–43.
5. Reimers, H.-E., Schneider, F. G., & Seitz, F. (2020). Payment innovations, the shadow economy and cash demand of households in Euro Area countries. Center for Economic Studies and IFoE Institute.
6. Elbahnasawy, N. G. (2021). e-Government and the shadow economy: Evidence from across the globe. *World Development*, 137, 105187.
7. Coca, D.-A., & Nistor, A. (2022). Digital shadow economy – Literature review. *LUMEN Proceedings*, 17, 121–130.
8. Joseph, J. (2022). Digital payments and GST revenue: An empirical analysis (Working Paper No. 382). National Institute of Public Finance and Policy.
9. Kowal-Pawul, A., & Lichota, W. (2024). Cashless transactions as a mechanism for reducing informal economic activity. *Economic Research and Financial Studies*, 18(1), 112–129.
10. Hassan, M. (2024). Mobile banking development and the shadow economy in South Africa. *Journal of Applied Economics and Development*, 12(2), 45–61.
11. Wibowo, J. M., & Hariadi, S. (2025). Will the use of cashless subsidy potentially reduce illegal underground economy activity? A case study in Indonesia. *Business, Management and Economics Engineering*, 23, 67–91.
12. Nguyen, C. P. (2026). E-government and the shadow economy: Smaller in share, slower to shrink (Policy Research Series No. 2026-03). Health and Agricultural Policy Research Institute.

