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Digital infrastructure and inclusive monetary transmission in Asia-Pacific developing economies

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Abstract

Digital infrastructure is changing how developing economies circulate information, credit, payments and liquidity. However, existing evidence has not sufficiently explained whether digital infrastructure strengthens the capacity of monetary liquidity to reach the real economy. This study examines this question using country-year panel data for 32 Asia-Pacific developing economies from 2000 to 2024. Drawing on World Development Indicators, the analysis applies dynamic panel Generalized Method of Moments estimation to test whether digital infrastructure, proxied by internet use, moderates the relationship between monetary liquidity and economic growth. The results show that digital infrastructure strengthens the positive association between monetary liquidity and growth. This finding suggests that digitally connected economies may be better able to convert liquidity into real economic activity through wider financial access, faster payment circulation, improved information flows and more responsive credit channels. The study contributes to social-science debates on digital transformation, financial inclusion and macroeconomic governance by showing that digital infrastructure is not only a technological resource but also a transmission condition that shapes how macro-financial resources circulate. For developing economies, the findings highlight the need to align monetary-liquidity management with digital inclusion, fintech regulation, cybersecurity, consumer protection and public trust so that digital transformation supports more resilient and socially accessible economic growth.

1. Introduction

Digital transformation is reshaping the economic and social infrastructure of developing economies. Internet connectivity, mobile banking, digital payments, fintech platforms and public digital infrastructure increasingly influence how households, firms, governments and financial institutions exchange information, access credit, settle transactions and respond to policy signals (Demirgüç-Kunt et al., 2022; Chen et al., 2023; Basnayake et al., 2024; Mohd Daud et al., 2024). These changes matter beyond technological modernisation because digital infrastructure affects financial inclusion, market participation, policy responsiveness and the distribution of economic opportunities across social groups and territories (Anakpo et al., 2023; Siddiki and Bala-Keffi, 2024). Recent evidence suggests that digital financial inclusion and digital technology can support growth by expanding formal financial access, reducing transaction frictions and strengthening the connection between financial systems and real economic activity (Chen et al., 2023; Basnayake et al., 2024; Mohd Daud et al., 2024). Yet the macroeconomic transmission role of digital infrastructure remains insufficiently understood, especially in developing economies where digital access, financial depth and institutional capacity remain uneven (Jiang et al., 2022; Siddiki and Bala-Keffi, 2024).

This issue is particularly relevant for Asia-Pacific developing economies. The region includes large economies with rapidly expanding digital ecosystems, lower-middle-income economies where financial exclusion remains a persistent development constraint and small island states exposed to external shocks (Basnayake et al., 2024; World Bank, 2025). Across these diverse contexts, digital infrastructure may influence whether monetary liquidity reaches households, small firms, informal workers and peripheral communities, or whether it remains concentrated in already connected financial and urban sectors (Anakpo et al., 2023; Mohd Daud et al., 2024). Digital access should therefore not be treated only as a technological indicator. It is part of the institutional and social infrastructure through which financial services, market opportunities and policy signals are transmitted. Evidence from Asia-Pacific economies shows that digital financial inclusion can promote growth, but its effects depend on adoption depth, financial-system readiness and the capacity to convert access into productive activity (Basnayake et al., 2024; Siddiki and Bala-Keffi, 2024).

Monetary liquidity can support economic growth through investment, consumption, credit creation and confidence, but liquidity does not automatically reach the real economy (Jiang et al., 2022). Its transmission depends on financial-system depth, payment-network reach, borrower information, institutional trust and the ability of households and firms to access formal financial channels (Glocker and Piribauer, 2021). In many developing economies, these channels are constrained by shallow banking systems, large informal sectors, limited credit access and uneven financial inclusion (Demirgüç-Kunt et al., 2022; Anakpo et al., 2023). As a result, liquidity expansion may generate uneven outcomes, with formal-sector firms and urban consumers responding faster than financially excluded groups. Recent studies on fintech, bank risk and digitalisation further suggest that digital financial systems now interact with financial intermediation, policy responsiveness and macro-financial stability (Zhao et al., 2023; Liu et al., 2025; He et al., 2025).

Digital infrastructure may reduce several of these transmission frictions. Internet access, mobile connectivity and digital financial services can lower transaction costs, broaden the reach of financial institutions, improve borrower information, accelerate payment settlement and make public and monetary signals more visible (Glocker and Piribauer, 2021; Jiang et al., 2022; Basnayake et al., 2024). Digital payment systems and fintech platforms may also connect underbanked households and small firms to savings, credit and transfer systems (Demirgüç-Kunt et al., 2022; Mohd Daud et al., 2024). These mechanisms suggest that digitalisation may contribute to growth not only as a direct driver of productivity or innovation, but also as a condition that shapes how liquidity circulates through the economy. In more digitally connected economies, monetary liquidity may be converted into consumption, investment and credit activity more effectively because the channels linking financial institutions to households and firms are broader, faster and more information-rich (Jiang et al., 2022; Basnayake et al., 2024; Mohd Daud et al., 2024).

Existing studies have examined digital finance, financial inclusion, monetary transmission and economic growth, but these strands are often treated separately. Digital finance studies typically focus on access, inclusion, payment efficiency or fintech adoption (Anakpo et al., 2023; Chen et al., 2023; Mohd Daud et al., 2024). Monetary transmission studies usually examine interest rates, credit channels and macroeconomic outcomes (Glocker and Piribauer, 2021; Jiang et al., 2022). Growth studies often treat digitalisation as a direct driver of productivity or financial development rather than as a condition that shapes the circulation of monetary liquidity (Basnayake et al., 2024; Siddiki and Bala-Keffi, 2024). What remains less clear is whether digital infrastructure changes the ability of developing economies to transform monetary liquidity into real economic growth. This gap is important because the central issue is not only whether liquidity expands, but whether the channels through which liquidity moves are technologically enabled, socially accessible and institutionally resilient.

This study addresses this gap by asking: Does digital infrastructure strengthen the relationship between monetary liquidity and economic growth in Asia-Pacific developing economies? The question is motivated by the expectation that digital access functions as a transmission condition. Where digital infrastructure is stronger, households and firms may obtain information faster, access financial services more easily and respond more effectively to liquidity conditions. Where digital infrastructure is weak, the same liquidity expansion may have a weaker or more uneven relationship with real economic activity because payment systems, credit access and financial-information channels remain limited (Jiang et al., 2022; Basnayake et al., 2024; Siddiki and Bala-Keffi, 2024).

Empirically, the analysis uses panel data for 32 Asia-Pacific developing economies over 2000–2024. Digital infrastructure is measured by the share of individuals using the internet, monetary liquidity is proxied by broad money as a share of GDP and economic growth is measured by annual growth in GDP per capita (World Bank,

2025). The study applies dynamic panel Generalized Method of Moments estimation to account for growth persistence, unobserved country-level heterogeneity and potential simultaneity among digitalisation, liquidity and growth (Arellano and Bond, 1991; Hansen, 1982; Roodman, 2009). The interaction between digital infrastructure and monetary liquidity is the key empirical focus because it captures whether the growth association of liquidity varies with the level of digitalisation.

The paper makes three contributions. First, it contributes to recent debates on digital transformation by conceptualising digital infrastructure as a transmission condition rather than only as an independent growth factor. Second, it links financial inclusion and macroeconomic governance by showing why digital access may influence the extent to which monetary liquidity reaches the real economy. Third, it provides comparative evidence from Asia-Pacific developing economies, where rapid digital adoption coexists with substantial variation in financial depth, institutional capacity and vulnerability to external shocks. Together, these contributions clarify how digital transformation may shape more resilient policy transmission in economies undergoing simultaneous technological, financial and institutional transition.

2. Digital infrastructure, financial inclusion and monetary transmission

2.1 Digital transformation and financial inclusion

Digitalization has become central to development research because it shapes access to information, markets, payments, credit and public services (Demirgüç-Kunt et al., 2022; Chen et al., 2023; Basnayake et al., 2024). In financial systems, digital technologies can reduce transaction costs, expand formal financial access and make financial services more reachable for low-income users, small firms and geographically remote communities (Anakpo et al., 2023; Mohd Daud et al., 2024). Recent evidence suggests that digital financial inclusion contributes to economic growth, but its effect depends on adoption depth, affordability, financial literacy, institutional readiness and regulatory safeguards (Basnayake et al., 2024; Siddiki and Bala-Keffi, 2024). Therefore, digital finance should not be viewed only as a technological upgrade; it is also a social and institutional mechanism that can either widen or limit participation in formal economic life (Demirgüç-Kunt et al., 2022; Anakpo et al., 2023).

2.2 Monetary liquidity and uneven policy transmission

Monetary liquidity influences economic activity through credit creation, investment, consumption, payment circulation and confidence (Jiang et al., 2022). However, in developing economies, the transmission of liquidity to the real economy is often weakened by shallow financial markets, segmented banking systems, high informality, limited credit access and uneven institutional credibility (Demirgüç-Kunt et al., 2022). These constraints can delay or dilute the effect of liquidity on growth, especially where households and small firms remain outside formal financial channels (Anakpo et al., 2023; Siddiki and Bala-Keffi, 2024). For this reason, this study uses the term monetary liquidity rather than treating broad money as a direct monetary-policy instrument. Broad money as a share of GDP captures the economy-wide liquidity environment and the extent to which money circulates through formal financial channels, although it is not equivalent to a policy-rate shock or an identified monetary-policy surprise (Jiang et al., 2022).

2.3 Digital infrastructure as a transmission amplifier

Digital infrastructure may strengthen monetary-liquidity transmission through several channels. Digital payment systems can accelerate settlement and circulation; mobile banking and fintech platforms can expand access to savings, credit and transfers; digital records can improve borrower information; and online communication can

make policy signals more visible to firms and households (Glocker and Piribauer, 2021; Jiang et al., 2022; Basnayake et al., 2024). Recent studies show that digital financial development can improve monetary transmission by expanding participation, reducing information frictions and connecting liquidity more effectively to real-sector activity (Jiang et al., 2022; Mohd Daud et al., 2024). However, the effect is not automatically positive. Fintech expansion, digital currencies and non-bank platforms may also reshape bank lending, risk-taking, money demand and regulatory control (Zhao et al., 2023; Wronka, 2023; Liu et al., 2025). These mixed findings suggest that digitalization should be examined as a conditional transmission factor, not as an inherently beneficial or harmful force.

2.4 Asia-Pacific developing economies as the study context

Asia-Pacific developing economies provide a suitable context for examining this relationship because the region combines rapid digital adoption with substantial variation in financial inclusion, institutional capacity and macroeconomic vulnerability (Basnayake et al., 2024; World Bank, 2025). Larger economies such as India, Indonesia, Malaysia, Thailand, Viet Nam and the Philippines have expanded digital payment and fintech ecosystems, while smaller and lower-income economies continue to face infrastructure, affordability and regulatory constraints (Demirgüç-Kunt et al., 2022; Basnayake et al., 2024). This heterogeneity makes the region useful for assessing whether digital infrastructure changes the relationship between liquidity and growth. The COVID-19 period further highlighted the importance of digital systems, as digital payments, online services and digital transfers became more important for maintaining transactions and delivering support during mobility restrictions (Demirgüç-Kunt et al., 2022; Mohd Daud et al., 2024). However, digitalization does not automatically ensure inclusive outcomes; its benefits depend on access, trust, regulation, literacy and institutional readiness (Anakpo et al., 2023; Siddiki and Bala-Keffi, 2024).

2.5 Hypotheses

The theoretical argument leads to three hypotheses:

H1

Digital infrastructure is positively associated with economic growth in Asia-Pacific developing economies.

H2

Monetary liquidity is positively associated with economic growth in Asia-Pacific developing economies.

H3

Digital infrastructure positively moderates the relationship between monetary liquidity and economic growth, such that liquidity has a stronger growth association in more digitally connected economies.

2.6 Regional context and conceptual framework

The study period covers a major expansion of digital access across the Asia-Pacific developing region. The original data show a steady increase in internet use over 2000 to 2024, alongside rising monetary liquidity and generally increasing real income levels. These patterns do not establish causality, but they motivate a closer analysis of whether digital infrastructure and liquidity move together in shaping growth outcomes.

The conceptual framework is built around the idea of inclusive monetary transmission. Digital infrastructure is treated as a country-level social and economic infrastructure. Its influence operates through financial inclusion, payment speed, information flows, credit access and policy reach. These channels can strengthen the capacity of monetary liquidity to support consumption, investment and broader economic activity. Country-specific conditions such as institutional quality, digital literacy, regulation, cybersecurity and inequality may strengthen or weaken this pathway.

Figure 1 summarises this logic. The figure is intended as a conceptual guide, not as a tested mediation model. The empirical model tests the moderating role of digital infrastructure in the relationship between monetary liquidity and growth.

3. Data and methods

3.1 Sample and data sources

The study uses annual country-level data from the World Development Indicators of the World Bank, which provides internationally comparable macroeconomic and development indicators across countries and years (World Bank, 2025). The sample includes 32 Asia-Pacific developing economies: Armenia, Azerbaijan, Bangladesh, Bhutan, Cambodia, China, Fiji, Georgia, India, Indonesia, Kazakhstan, Kiribati, Kyrgyzstan, Lao PDR, Malaysia, Maldives, Micronesia, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Samoa, Solomon Islands, Sri Lanka, Tajikistan, Thailand, Timor-Leste, Turkmenistan, Uzbekistan, Vanuatu and Viet Nam. These economies are selected from lower-middle-income and upper-middle-income country groups according to World Bank income classifications (World Bank, 2025). The descriptive panel covers 2000–2024 and contains 800 country-year observations. The dynamic models use 768 observations because the inclusion of lagged growth removes the first year for each country, which is standard in dynamic panel specifications (Arellano and Bond, 1991; Roodman, 2009). The timeframe (2000–2024) of the study is most relevant to the global macroeconomic context, particularly regarding digitalization in the current era of globalization in developing economies. In certain panels of Asia-Pacific developing nations, the usual statistical and econometric techniques (Deaton, 1985; Baltagi, 2021) are used to handle some limited missing data on a few variables, thereby balancing the panel data sets over the study period. Table 1 defines the variables and their conceptual roles.

Table 1
Variables, measures and conceptual roles

Variable	Measure	Conceptual role
Digital infrastructure (DIG)	Individuals using the internet (% of population)	Digital access and connectivity
Monetary liquidity (MSP)	Broad money (% of GDP)	Economy-wide liquidity environment
Economic growth (GRO)	Annual percentage growth rate of GDP per capita	Real economic outcome
Government expenditure (GEX)	Government final consumption expenditure (% of GDP)	Fiscal presence and public-sector demand
Domestic capital formation (DCF)	Gross domestic capital formation (% of GDP)	Investment capacity
FDI inflows (FDI)	Net inflows of foreign direct investment (% of GDP)	External investment exposure
Trade openness (TRO)	Exports plus imports (% of GDP)	External integration
Inflation (INF)	Annual percentage growth rate of GDP deflator	Macroeconomic instability

3.2 Variable measurement

Digital infrastructure is measured by individuals using the internet as a percentage of the population, following recent cross-country studies that use internet penetration as a broad proxy for national digital access and digital readiness (Basnayake et al., 2024; Mohd Daud et al., 2024; World Bank, 2025). This indicator should be interpreted as a conservative proxy because it does not fully capture digital financial intensity, mobile money use, fintech regulation, digital payment frequency or platform-based financial activity. However, because comparable annual digital-finance indicators are not consistently available for all countries and years in the sample, internet use provides the most consistent region-wide measure of digital infrastructure (Demirgüç-Kunt et al., 2022; World Bank, 2025).

Monetary liquidity is measured by broad money as a percentage of GDP. Broad money captures the scale of liquidity circulating through formal monetary and financial channels and is widely used as an indicator of financial depth and economy-wide liquidity conditions (World Bank, 2025; Jiang et al., 2022). The variable is not interpreted as a pure monetary-policy shock or as a direct policy-rate instrument. Rather, it represents the liquidity environment through which financial depth, credit circulation and monetary conditions may influence real economic activity (Jiang et al., 2022). The outcome variable is annual percentage growth in GDP per capita, which captures real economic growth at the country level (World Bank, 2025). The control variables include government final consumption expenditure, gross domestic capital formation, foreign direct investment inflows, trade openness and inflation, all of which are commonly used in cross-country growth and macro-financial models to account for fiscal conditions, investment capacity, external integration and price instability (Basnayake et al., 2024; World Bank, 2025).

3.3 Model specification

The empirical model estimates whether digital infrastructure moderates the relationship between monetary liquidity and economic growth. The baseline dynamic panel specification is:

$$\Delta GRO_{it} = \beta_1 \Delta GRO_{it-1} + \beta_2 \Delta DIG_{it} + \beta_3 \Delta MSP_{it} + \beta_4 \Delta MSP_{it} \times DIG_{it} + \beta_5 \Delta X'_{it} + \Delta \epsilon_{it}$$

where X'_{it} is a component matrix of all control variables GEX, DCF, FDI, TRO, and INF, and ϵ_{it} is the error term. In connection with the central objective of the study, equation has to be estimated first by excluding X'_{it}, and thereafter, each control variable has to be added to confirm the robustness of outcomes. $MSP_{it} \times DIG_{it}$ is the core regressor denoting the interaction term between MSP (monetary policy) and DIG (digitalization).

The models are expressed in first differences to remove time-invariant country-specific effects, following the logic of dynamic panel GMM estimation (Arellano and Bond, 1991; Roodman, 2009). The lagged dependent variable accounts for persistence in economic growth, while the interaction term tests the central hypothesis that digital infrastructure conditions the liquidity-growth relationship. The coefficient on the interaction term is interpreted cautiously as evidence of conditional association rather than definitive causality, because digitalization, liquidity and growth may influence one another over time in country-level macroeconomic systems (Jiang et al., 2022).

3.4 Estimation strategy and diagnostics

Dynamic panel Generalized Method of Moments estimation is used because economic growth is persistent and because digital infrastructure, monetary liquidity and growth may be jointly determined (Arellano and Bond, 1991; Hansen, 1982; Roodman, 2009). This approach helps reduce bias arising from the lagged dependent variable, unobserved country-level heterogeneity and potential reverse causality between macroeconomic variables. Instrument validity is assessed using Sargan and Hansen tests, while second-order serial correlation is assessed using the Arellano-Bond AR(2) test (Sargan, 1958; Hansen, 1982; Arellano and Bond, 1991).

Before estimation, panel unit-root tests are used to assess the time-series properties of the variables. The Levin-Lin-Chu and Im-Pesaran-Shin tests are reported because they are widely used in heterogeneous panel settings (Levin et al., 2002; Im et al., 2003). A structural-break panel unit-root test is also included following Karavias and Tzavalis because the study period includes major global disruptions, including the global financial crisis and the COVID-19 period (Karavias and Tzavalis, 2014). Time effects are included to reduce confounding from common shocks that may affect all countries in the panel.

A diagnostic caution is necessary because Asia-Pacific developing economies are connected through trade, commodity cycles, global financial conditions, tourism flows, remittances and crisis exposure. Cross-sectional dependence is therefore plausible in the panel, and Pesaran CD tests are used to assess this issue (Pesaran, 2007). If cross-sectional dependence is detected, the findings should be interpreted as baseline dynamic-panel evidence rather than final causal estimates. For submission-stage robustness, common-shock corrections such as Driscoll-Kraay standard errors, common correlated effects estimators or additional global-shock controls should be considered if the raw dataset is available for re-estimation (Driscoll and Kraay, 1998; Pesaran, 2006; Pesaran, 2007).

4. Results

4.1 Descriptive evidence

Table 2 reports the descriptive statistics for the study variables. The average internet-use rate is 39.76%, indicating that the sample includes economies at different stages of digital access. Broad money averages 95.35% of GDP, suggesting substantial economy-wide monetary liquidity relative to output. Average per capita GDP growth is 5.23%, although the sample period includes major global shocks and heterogeneous national growth trajectories. Government expenditure averages 13.87% of GDP, while domestic capital formation averages 29.48% of GDP. The

mean values for FDI inflows, trade openness and inflation are 2.74%, 50.12% and 4.78%, respectively. These values show that Asia-Pacific developing economies differ substantially in digital access, financial depth, external integration and macroeconomic conditions.

These descriptive patterns support the use of a comparative regional panel. They also indicate why Asia-Pacific developing economies should not be treated as a homogeneous group. Differences in digital access, financial depth, investment conditions, external openness and inflation are likely to shape how monetary liquidity is transmitted into real economic activity.

Table 2
Descriptive statistics

Variable	Mean	Median	Std. Dev.	Min	Max	Obs.
DIG	39.76	40.20	16.30	12.11	67.89	800
MSP	95.35	101.44	24.67	67.23	134.78	800
GRO	5.23	5.10	1.65	2.45	8.12	800
GEX	13.87	14.01	0.75	12.90	15.02	800
DCF	29.48	30.74	3.56	23.90	33.81	800
FDI	2.74	2.79	0.46	1.90	3.65	800
TRO	50.12	50.05	5.11	43.02	59.83	800
INF	4.78	3.95	2.28	2.10	9.80	800

Notes: DIG = individuals using the internet (% of population); MSP = broad money (% of GDP); GRO = annual growth in GDP per capita; GEX = government final consumption expenditure (% of GDP); DCF = gross domestic capital formation (% of GDP); FDI = foreign direct investment inflows (% of GDP); TRO = trade openness; INF = inflation. Source: World Bank (2025).

4.2 Correlation and diagnostic evidence

Table 3 reports the correlation matrix. Digital infrastructure is positively correlated with monetary liquidity and growth. Monetary liquidity is also strongly correlated with growth. These initial associations are consistent with the study's theoretical expectation that digital access and liquidity conditions are linked to real economic performance. However, several pairwise correlations are high. For example, the correlation between MSP and GRO is 0.95, between MSP and TRO is -0.94, between GEX and TRO is -0.92, and between FDI and TRO is 0.91. These high correlations indicate that multicollinearity should be treated as a diagnostic concern.

Table 3
Correlation matrix

Variable	DIG	MSP	GRO	GEX	DCF	FDI	TRO	INF
DIG	1.00							
MSP	0.75	1.00						
GRO	0.66	0.95	1.00					
GEX	0.61	0.93	0.91	1.00				
DCF	0.58	0.72	0.78	0.83	1.00			
FDI	0.65	-0.88	-0.87	-0.88	-0.58	1.00		
TRO	0.72	-0.94	-0.88	-0.92	-0.71	0.91	1.00	
INF	-0.71	-0.80	-0.70	-0.81	-0.54	0.82	0.85	1.00
Notes: Variable definitions are given in Table 2.								

The high correlations do not invalidate the study, but they require careful interpretation. For submission, a variance inflation factor test should be added to assess whether multicollinearity materially affects coefficient stability. If VIF values are high, reduced-control models, centred interaction terms or alternative specifications should be reported as robustness checks. This is especially important because the interaction between digital infrastructure and monetary liquidity is the core empirical term of the study.

4.3 Panel stationarity tests

Table 4 reports panel unit-root tests. The Levin-Lin-Chu, Im-Pesaran-Shin and structural-break panel unit-root tests indicate that the variables are generally non-stationary in levels but become stationary after first differencing. This supports the use of first-differenced dynamic panel models. The structural-break results are important because the study period includes major global shocks, including the global financial crisis and the COVID-19 period.

Table 4
Panel unit-root tests

Variable	Levin-Lin-Chu Level	Levin-Lin-Chu 1st Diff.	Im-Pesaran-Shin Level	Im-Pesaran-Shin 1st Diff.	Karavias-Tzavalis Level	Karavias-Tzavalis 1st Diff.
DIG	1.45	-4.92***	-1.05	-5.30***	-3.11	-8.72**
MSP	1.32	-4.71**	-1.18	-5.13***	-1.66	-7.67***
GRO	-0.75	-4.61***	-1.27	-5.20**	-1.85	-9.39***
GEX	-1.58	-5.10***	-1.16	-5.50***	2.07	-9.01***
DCF	-1.68	-4.96**	-1.44	-5.78***	-0.09	-6.07**
FDI	-2.33	-5.22**	-1.67	-5.81***	-2.01	-8.89**
TRO	-2.98	-6.00**	-1.98	-6.15***	2.16	-11.05***
INF	1.65	-4.60***	-1.82	-5.32***	-1.74	-9.03**

Notes: ***, ** denote significance at the 1% and 5% levels, respectively.

4.4 Dynamic panel estimates

Table 5 presents the dynamic GMM estimates. The coefficient on lagged growth is positive and statistically significant across all models, indicating persistence in economic growth. Digital infrastructure is positively associated with growth across the specifications, supporting H1. Monetary liquidity is also positively associated with growth, supporting H2. Most importantly, the interaction between digital infrastructure and monetary liquidity is positive and statistically significant across all models, supporting H3.

Table 5
Dynamic panel GMM estimates

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
ΔGRO(t-1)	0.14***	0.13***	0.18***	0.16***	0.17***	0.15***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ΔDIG	0.02**	0.02***	0.01***	0.01**	0.03**	0.02**
	(0.01)	(0.00)	(0.02)	(0.01)	(0.01)	(0.02)
ΔMSP	0.04***	0.05***	0.03**	0.04***	0.05**	0.04***
	(0.00)	(0.00)	(0.02)	(0.00)	(0.02)	(0.00)
ΔMSP × DIG	0.09***	0.07**	0.08***	0.10**	0.08**	0.09**
	(0.00)	(0.01)	(0.00)	(0.02)	(0.01)	(0.01)
ΔGEX		0.03***			0.04**	0.03**
		(0.00)			(0.01)	(0.01)
ΔDCF			0.04***		0.03**	0.02**
			(0.00)		(0.01)	(0.01)
ΔFDI			0.02**	0.04***		0.03***
			(0.01)	(0.00)		(0.00)
ΔTRO		0.03***		0.03**		0.05**
		(0.00)		(0.03)		(0.01)
ΔINF			-0.03***		-0.02**	-0.03**
			(0.00)		(0.01)	(0.02)
Observations	768	768	768	768	768	768
Number of instruments	9	10	8	9	10	9
AR(2) p-value	0.22	0.19	0.20	0.22	0.24	0.25
Sargan p-value	0.18	0.21	0.19	0.17	0.19	0.20
Hansen p-value	0.28	0.30	0.15	0.23	0.24	0.18
Wald p-value	0.00	0.00	0.00	0.00	0.00	0.00
Pesaran CD p-value	0.00	0.00	0.00	0.00	0.00	0.00

Notes: The dependent variable is ΔGRO. Parentheses report p-values as provided in the original estimation output. ***, ** denote significance at the 1% and 5% levels, respectively. DIG = digital infrastructure; MSP = monetary liquidity; GRO = economic growth; GEX = government expenditure; DCF = domestic capital formation; FDI = foreign direct investment; TRO = trade openness; INF = inflation.

The interaction result is the substantive centre of the paper. It suggests that monetary liquidity has a stronger growth association in more digitally connected economies. This finding supports the argument that digital

infrastructure can strengthen liquidity transmission by widening financial access, accelerating payment circulation, improving information flows and making credit channels more responsive. In practical terms, liquidity appears more likely to translate into real economic activity when financial systems are supported by broader digital access.

The control variables generally show expected associations. Government expenditure, domestic capital formation, foreign direct investment and trade openness are positively associated with growth in the adjusted models, while inflation is negatively associated with growth. These patterns are consistent with the view that investment capacity, fiscal activity and external integration can support growth, whereas price instability can weaken real economic performance.

5. Discussion

5.1 Digital infrastructure as social and economic infrastructure

The findings support the view that digital infrastructure is not merely a technology indicator, but a social and economic infrastructure that shapes how households, firms, governments and financial institutions interact with the financial system. The positive interaction between digital infrastructure and monetary liquidity suggests that liquidity is more strongly associated with growth where digital access is broader. This aligns with recent evidence that digital financial inclusion can strengthen the connection between financial systems and real economic activity by reducing transaction frictions, expanding access to formal finance and improving the circulation of information (Chen et al., 2023; Basnayake et al., 2024; Mohd Daud et al., 2024).

This interpretation extends prior work on monetary transmission in developing economies. Earlier research shows that liquidity and monetary impulses often transmit weakly in low-income and developing economies because of shallow banking systems, limited credit access, informal economic activity and uneven institutional credibility. The present findings suggest that digital infrastructure may partly reduce these frictions by broadening the channels through which liquidity reaches the real economy. Digital payments, mobile banking, online credit platforms, digital public services and faster information exchange can make liquidity circulation quicker and more inclusive, particularly where traditional financial networks are limited (Jiang et al., 2022; Demirgüç-Kunt et al., 2022; Anakpo et al., 2023).

The results also help connect macroeconomic governance with social inclusion. In economies where digital and financial access remain restricted, monetary liquidity may remain concentrated in formal, urban or already connected sectors. In more digitally connected economies, the channels through which liquidity can reach households and firms are broader and more responsive. This does not mean that digitalization automatically produces inclusive outcomes. Rather, the findings suggest that the inclusiveness and effectiveness of liquidity transmission depend partly on digital access, financial readiness and governance capacity (Siddiki and Bala-Keffi, 2024; Basnayake et al., 2024).

5.2 Implications for financial inclusion and resilience

The study suggests that digital inclusion should be treated as part of the macroeconomic policy environment, not only as a technology or development agenda. Internet access, affordable mobile connectivity, interoperable payment systems and trustworthy digital finance can support faster liquidity circulation by connecting households and firms to formal financial channels (Demirgüç-Kunt et al., 2022; Mohd Daud et al., 2024). These mechanisms may be especially important for small firms, informal workers and households outside traditional banking networks,

because they often face higher transaction costs and weaker access to credit, savings and transfer systems (Anakpo et al., 2023; Siddiki and Bala-Keffı, 2024).

The findings are also relevant for economic resilience. During crises, digital infrastructure can help maintain transactions, support remote services, enable digital transfers and preserve financial connectivity when physical mobility and branch-based banking are disrupted. The COVID-19 period showed that digital payments and digital financial access became more important for households, firms and governments seeking to maintain economic activity under restrictions (Demirgüç-Kunt et al., 2022; Mohd Daud et al., 2024). In this sense, digital infrastructure can operate as a resilience mechanism, helping economies maintain liquidity circulation during periods of uncertainty.

However, resilience requires more than technology adoption. Digital financial systems need consumer protection, cybersecurity, data governance, competition policy and public trust. Recent research on fintech, bank risk and digitalization shows that digital financial expansion can reshape financial intermediation and policy responsiveness, but it may also introduce new risks related to platform concentration, regulatory gaps and financial instability (Zhao et al., 2023; Wronka, 2023; Liu et al., 2025; He et al., 2025). Therefore, policymakers should treat digital infrastructure as a macro-financial governance issue rather than as a purely technological upgrade.

5.3 Cautions, risks and future research

The positive interaction result should not be read as a blanket endorsement of digitalization. Digital transformation can create new exclusions when access is unequal, digital literacy is low, connectivity is costly or vulnerable groups lack trust in formal digital systems (Anakpo et al., 2023; Demirgüç-Kunt et al., 2022). It can also increase exposure to cybersecurity risks, data misuse, algorithmic bias and platform concentration, especially where regulation and institutional oversight lag behind technological adoption (Zhao et al., 2023; Wronka, 2023; He et al., 2025). A digital monetary-transmission agenda therefore needs to be paired with social safeguards, regulatory capacity and inclusion-oriented public policy.

The country-level design also limits the distributional interpretation of the findings. The study shows that digital infrastructure is associated with stronger liquidity-growth transmission at the national level, but it cannot identify which social groups benefit most. The results therefore should be interpreted as evidence of macro-level conditional association rather than proof of inclusive distributional effects. Future research should examine household, firm, gender, rural-urban and informal-sector channels to determine whether digital monetary transmission is genuinely inclusive. Further work should also test alternative digitalization indicators, such as mobile money use, digital payment intensity, broadband access and fintech regulation, to clarify which forms of digital infrastructure matter most for liquidity transmission and economic resilience.

6. Policy implications

The findings suggest that digital infrastructure should be treated as part of economic governance, not only as a technology agenda. Expanding affordable internet access, mobile connectivity and digital literacy can improve the reach of financial systems and strengthen the channels through which liquidity circulates in the real economy. For developing economies, investment in digital infrastructure should therefore be connected to broader goals of financial inclusion, small-firm participation, rural access and economic resilience (Demirgüç-Kunt et al., 2022; Anakpo et al., 2023; Basnayake et al., 2024).

Central banks and financial regulators should also connect monetary governance with digital financial inclusion. The results indicate that monetary liquidity is more strongly associated with growth when digital infrastructure is higher. This implies that payment interoperability, consumer protection, fintech oversight and safe competition in digital finance may help liquidity reach a wider set of users. Digital payment systems, mobile banking and fintech platforms can support liquidity transmission, but only when supported by regulatory capacity, institutional trust and safeguards against exclusion or abuse (Jiang et al., 2022; Zhao et al., 2023; Mohd Daud et al., 2024).

Policy coordination is also essential. Digital identity, social protection, fiscal transfers, payment systems and monetary governance should not be designed in isolation. Coordinated digital public infrastructure can improve the speed and reach of policy delivery, especially during periods of crisis or economic stress. The COVID-19 period showed that digital financial systems can help maintain transactions and distribute support when physical mobility and branch-based services are disrupted (Demirgüç-Kunt et al., 2022; Mohd Daud et al., 2024). However, digital systems can strengthen resilience only when they are inclusive, trusted and institutionally embedded.

Finally, digital transformation should be governed carefully. Cybersecurity, data privacy, algorithmic accountability, financial literacy and competition policy are necessary if digital infrastructure is to support inclusive growth rather than reproduce existing inequalities. Without these safeguards, digital finance may concentrate benefits among already connected groups, increase exposure to fraud or cyber risks and deepen exclusion for households and firms with weak digital access (Anakpo et al., 2023; Wronka, 2023; He et al., 2025). A digital monetary-transmission agenda therefore requires both infrastructure investment and social protection-oriented governance.

7. Conclusion

This study examined whether digital infrastructure strengthens the relationship between monetary liquidity and economic growth in 32 Asia-Pacific developing economies over 2000–2024. The findings show that digital infrastructure is positively associated with growth and that monetary liquidity has a stronger growth association where digital infrastructure is higher. This supports the central argument that digitalization can function as a transmission condition in developing economies.

The study contributes to social-science debates on digital transformation by showing that digital infrastructure is not only a direct growth-related resource, but also a channel through which macro-financial resources may circulate more effectively. Wider digital access can support liquidity transmission by improving financial access, accelerating payments, strengthening information flows and supporting credit circulation. This is relevant for Asia-Pacific developing economies, where rapid digital adoption coexists with uneven financial depth, institutional capacity and vulnerability to external shocks.

The study has limitations. Internet use is a broad proxy and does not fully capture digital payment intensity, mobile money, fintech regulation or digital public infrastructure. Broad money reflects liquidity conditions but not a clean monetary-policy shock. The country-level design also cannot identify which households, firms or social groups benefit most. Future research should combine macro-panel evidence with micro-level data on digital payments, account ownership, firm credit, household welfare and informal-sector participation to assess whether digital monetary-liquidity transmission is genuinely inclusive.

Declarations

Ethics statement

This study uses publicly available country-level secondary data and does not involve human participants, personal data or animal subjects. Ethical approval was therefore not required.

Competing interests

The authors declare no competing interests.

Author contributions

Author contribution details are provided separately in the title page file and are omitted from this manuscript for double-blind peer review.

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Author Contribution

ZC: conceptualization, data curation, formal analysis, methodology, writing-original draft. BKD: writing-original draft, writing-review and editing, project administration and supervision.MS: formal analysis, methodology, writing-original draft, writing-review and editing.

Data Availability

The data set [panel of 32 Asia-Pacific developing countries over 2000-2024] as used in this study is available / collected from the World Development Indicators (World Bank, 2026) using the following link (publicly accessible repository): https://databank.worldbank.org/source/world-development-indicators, and the particular panel data set used in empirical exercises of this study is available for the journal's peer review purposes as uploaded in separate sheet with the manuscript.

References

1. Anakpo G, Xhate Z, Mishi S (2023) The policies, practices, and challenges of digital financial inclusion for sustainable development: The case of a developing economy. FinTech 2(2):327–343. https://doi.org/10.3390/fintech2020019
2. Arellano M, Bond S (1991) Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. Rev Econ Stud 58(2):277–297. https://doi.org/10.2307/2297968
3. Baltagi BH (2021) Econometric analysis of panel data. *Sixth Edition*, Springer Cham: Switzerland https://doi.org/10.1007/978-3-030-53953-5

4. Basnayake D, Naranpanawa A, Selvanathan S, Bandara JS (2024) Financial inclusion through digitalization and economic growth in Asia-Pacific countries. Int Rev Financial Anal 96:103596. https://doi.org/10.1016/j.irfa.2024.103596
5. Chen S, Ozili PK, Wang J (2023) Digital financial inclusion and economic growth in emerging markets. Emerg Markets Rev 57:100962. https://doi.org/10.1016/j.ememar.2023.100962
6. Deaton A (1985) Panel data from time series of cross-sections. J Econ 30(1–2):109–126. https://doi.org/10.1016/0304-4076(85)90134-4
7. Demirgüç-Kunt A, Klapper L, Singer D, Ansar S (2022) The Global Findex Database 2021: Financial Inclusion, Digital Payments, and Resilience in the Age of COVID-19. World Bank, Washington, DC. https://www.worldbank.org/en/publication/globalfindex
8. Driscoll JC, Kraay AC (1998) Consistent covariance matrix estimation with spatially dependent panel data. Rev Econ Stat 80(4):549–560. https://doi.org/10.1162/003465398557825
9. Glocker C, Piribauer P (2021) Digitalization, retail trade and monetary policy. J Int Money Finance 112:102340. https://doi.org/10.1016/j.jimonfin.2020.102340
10. Hansen LP (1982) Large sample properties of generalized method of moments estimators. Econometrica 50(4):1029–1054. https://doi.org/10.2307/1912775
11. He Y, Feng G, Zeng S, Chang CP (2025) Economic policy uncertainty, digital transformation, and bank systemic risk. Int Rev Financial Anal 98:103882. https://doi.org/10.1016/j.irfa.2024.103882
12. Im KS, Pesaran MH, Shin Y (2003) Testing for unit roots in heterogeneous panels. J Econ 115(1):53–74. https://doi.org/10.1016/S0304-4076(03)00092-7
13. Jiang S, Qiu S, Zhou H (2022) Will digital financial development affect the effectiveness of monetary policy in emerging market countries? Economic Research-EkonomskaIstraživanja 35(1):3437–3472. https://doi.org/10.1080/1331677X.2021.1997621
14. Karavias Y, Tzavalis E (2014) Testing for unit roots in short panels allowing for a structural break. Comput Stat Data Anal 76:391–407. https://doi.org/10.1016/j.csda.2012.10.014
15. Levin A, Lin CF, Chu CSJ (2002) Unit root tests in panel data: Asymptotic and finite-sample properties. J Econ 108(1):1–24. https://doi.org/10.1016/S0304-4076(01)00098-7
16. Liu Q, Fu Y, Zhu C (2025) Economic policy uncertainty and bank stability: The role of digitalization level. J Chin Economic Bus Stud 23(2):165–190
17. Mohd Daud SN, Ahmad AH, Trinugroho I (2024) Financial inclusion, digital technology, and economic growth: Further evidence. Res Int Bus Finance 70:102361. https://doi.org/10.1016/j.ribaf.2024.102361
18. Pesaran MH (2006) Estimation and inference in large heterogeneous panels with a multifactor error structure. Econometrica 74(4):967–1012. https://doi.org/10.1111/j.1468-0262.2006.00692.x
19. Pesaran MH (2007) A simple panel unit root test in the presence of cross-section dependence. J Appl Econom 22(2):265–312. https://doi.org/10.1002/jae.951
20. Roodman D (2009) How to do xtabond2: An introduction to difference and system GMM in Stata. Stata J 9(1):86–136. https://doi.org/10.1177/1536867X0900900106
21. Sargan JD (1958) The estimation of economic relationships using instrumental variables. Econometrica 26(3):393–415. https://doi.org/10.2307/1907619
22. Siddiki J, Bala-Keffi LR (2024) Revisiting the relation between financial inclusion and economic growth: A global analysis using panel threshold regression. Econ Model 135:106707.

https://doi.org/10.1016/j.econmod.2024.106707

23. World Bank (2025) World Development Indicators. World Bank, Washington, DC. https://databank.worldbank.org/source/world-development-indicators
24. Wronka C (2023) Central bank digital currencies and their potential impact on traditional banking and monetary policy: An initial analysis. Digit Finance 5(3):613–641. https://doi.org/10.1007/s42521-023-00076-4
25. Zhao Y, Goodell JW, Wang Y, Abedin MZ (2023) Fintech, macroprudential policies, and bank risk: Evidence from China. Int Rev Financial Anal 87:102648. https://doi.org/10.1016/j.irfa.2023.102648

Figures

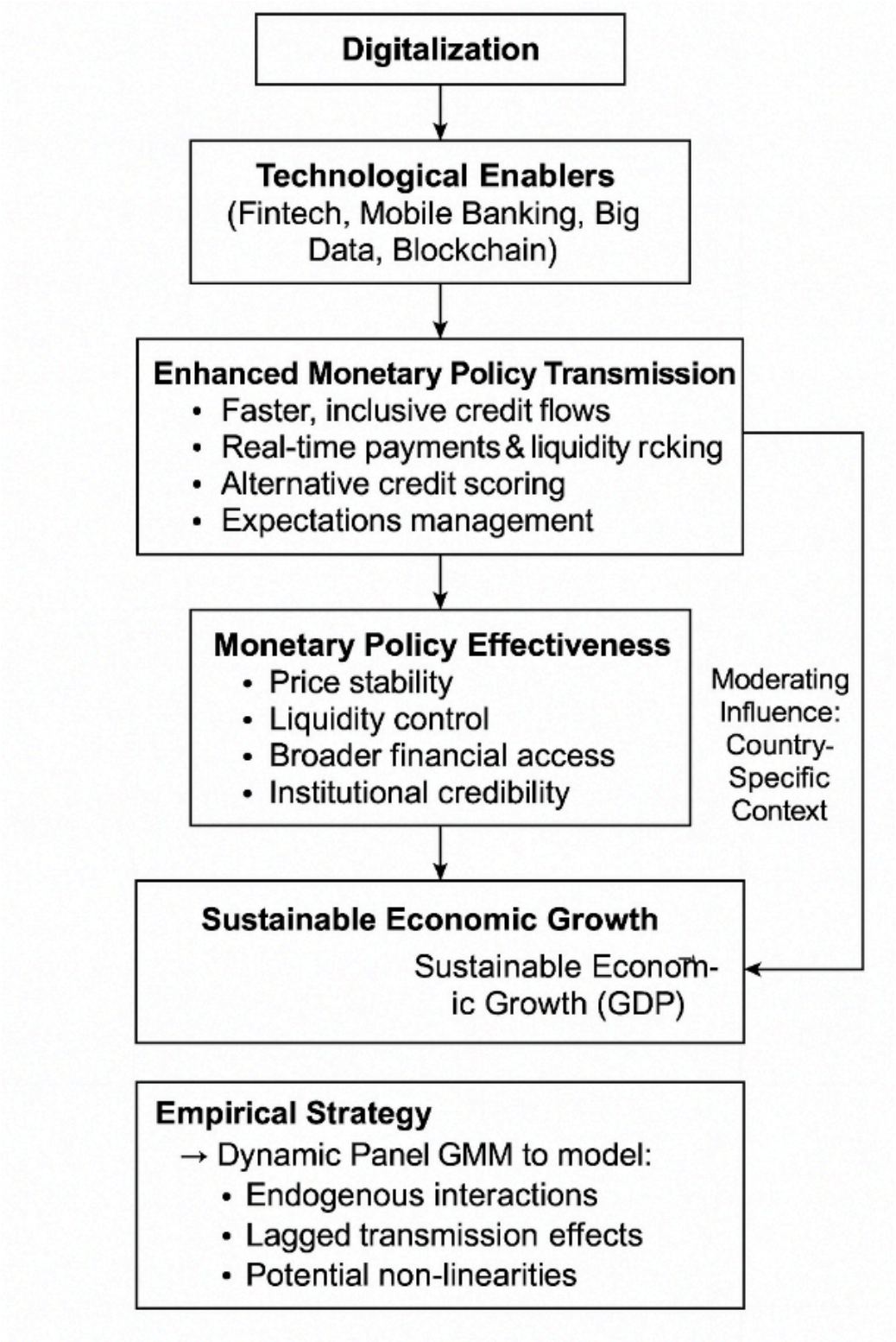


Figure 1

Conceptual Framework