DIGITAL FINANCE, HUMAN CAPITAL, AND URBAN INNOVATION IN INDONESIA

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ABSTRACT

Objective: The objective of this study is to investigate digital finance and urban innovation in 98 cities in Indonesia. This study uses panel data with a time period from 2000 to 2021.

Theoretical Framework: This research is based on theories that discuss digital finance to understand the development of digital financial technology, and human capital theory to explain actors who utilize digital technology and also innovation theory to explain the innovation of actors in digital technology, especially those who live in urban areas with a high level of digital dependence

Method: This study uses heterogeneity analysis with a panel data structure. This study also use two-step system generalized method of moments estimation model.

Results and Discussion: This research finds that digital finance has a significant impact on urban innovation. However, the heterogeneous impact of digital finance on urban innovation for each city in Indonesia has a different level of commercial attractiveness.

Research Implications: In Indonesia, traditional finance also plays an important role in urban innovation where the supply of traditional finance plays a role in moderating the effect of digital finance promotion on urban innovation. Human capital is a vital factor driving innovation.

Originality/Value: This research builds on previous research regarding the impact of digital finance on innovation where most of the research related to digital finance and innovation focuses on enterprise technology innovation, while this research focuses on urban innovation as an originality this study.

FINANÇAS DIGITAIS, CAPITAL HUMANO E INOVAÇÃO URBANA NA INDONÉSIA

RESUMO

Objetivo: O objetivo deste estudo é investigar as finanças digitais e a inovação urbana em 98 cidades da Indonésia. Este estudo utiliza dados em painel com período de 2000 a 2021.

Estrutura Teórica: Esta pesquisa se baseia em teorias que analisam as finanças digitais para compreender o desenvolvimento da tecnologia financeira digital e na teoria do capital humano para explicar os atores que utilizam a tecnologia digital e também na teoria da inovação para explicar a inovação dos atores da tecnologia digital, especialmente aqueles que vivem em áreas urbanas. áreas. áreas áreas com alto nível de dependência digital.

Método: Este estudo utiliza análise de heterogeneidade com estrutura de dados em painel. Este estudo também utiliza o modelo de estimativa de momento do método generalizado de sistema de duas etapas.

Resultados e Discussão: Esta pesquisa conclui que o financiamento digital tem um impacto significativo na inovação urbana. No entanto, o impacto heterogéneo do financiamento digital na inovação urbana para cada cidade da Indonésia tem um nível diferente de atratividade comercial.

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Implicações da Pesquisa: Na Indonésia, o financiamento tradicional também desempenha um papel importante na inovação urbana, onde a oferta de financiamento tradicional desempenha um papel na moderação do efeito da promoção do financiamento digital na inovação urbana. O capital humano é um fator vital que impulsiona a inovação.

Originalidade/Valor: Esta investigação baseia-se em pesquisas anteriores sobre o impacto das finanças digitais na inovação, onde a maior parte da investigação relacionada com finanças e inovação digitais centra-se na inovação tecnológica empresarial, enquanto esta investigação centra-se na inovação urbana como uma originalidade deste estudo.

Palavras-chave: Finanças Digitais, Tecnologia, Inovação Urbana, Indonésia.

FINANZAS DIGITALES, CAPITAL HUMANO E INNOVACIÓN URBANA EN INDONESIA

RESUMEN

Objetivo: El objetivo de este estudio es investigar las finanzas digitales y la innovación urbana en 98 ciudades de Indonesia. Este estudio utiliza datos de panel con un período de tiempo de 2000 a 2021

Marco teórico: Esta investigación se basa en teorías que analizan las finanzas digitales para comprender el desarrollo de la tecnología financiera digital y la teoría del capital humano para explicar a los actores que utilizan la tecnología digital y también la teoría de la innovación para explicar la innovación de los actores en la tecnología digital, especialmente aquellos que viven en zonas urbanas. zonas zonas con un alto nivel de dependencia digital

Método: Este estudio utiliza análisis de heterogeneidad con una estructura de datos de panel. Este estudio también utiliza el modelo de estimación de momentos del método generalizado del sistema de dos pasos.

Resultados y Debate: Esta investigación encuentra que las finanzas digitales tienen un impacto significativo en la innovación urbana. Sin embargo, el impacto heterogéneo de las finanzas digitales en la innovación urbana para cada ciudad de Indonesia tiene un nivel diferente de atractivo comercial.

Implicaciones de la Investigación: En Indonesia, las finanzas tradicionales también juegan un papel importante en la innovación urbana, donde la oferta de finanzas tradicionales juega un papel en la moderación del efecto de la promoción de las finanzas digitales en la innovación urbana. El capital humano es un factor vital que impulsa la innovación.

Originalidad/Valor: Esta investigación se basa en investigaciones anteriores sobre el impacto de las finanzas digitales en la innovación, donde la mayor parte de la investigación relacionada con las finanzas digitales y la innovación se centra en la innovación tecnológica empresarial, mientras que esta investigación se centra en la innovación urbana como una originalidad de este estudio.

Palabras clave: Finanzas Digitales, Tecnología, Innovación Urbana, Indonesia.

1 BACKGROUND

Economic growth and innovation are significantly influenced by financial support. Innovation and economic growth have a causal relationship that influences one another (Adebayo & Kirikkaleli, 2021). Innovation has a long-term effect on the real sector which is influenced by human resources, technology, and financial support (Jelonek et al., 2022). However, traditional financial support has various limitations. Innovation itself certainly requires separate financing and investment (Lerner & Nanda, 2020).

The traditional financial model that currently exists requires the development of technology-based innovations so that digital financial studies and urban innovation are born (Liu et al., 2022). Digital technology is developing rapidly and is increasingly supporting the

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development of digital finance (Hasan et al., 2022). Big data technology provides results that are proven to be able to help the effectiveness of digital finance supported by artificial intelligence (Bag et al., 2021). However, blockchain technology is still a mystery in itself in supporting artificial finance, especially in the banking sector (Bawono & Topçu, 2022).

The advantage of digital finance is being able to streamline the distance factor which is a limitation of the traditional financial system (Feng et al., 2022). The digital financial system can operate effectively in supporting the needs of financial services across regions and even across continents (Mavilia & Pisani, 2020). Digitalization of finance in Indonesia is important in minimizing the uneven distribution of financial support in remote areas. Digitalization of finance and internet technology supports financial inclusion in Indonesia (Priyanto et al., 2022). Digital technology adapted to the financial system provides various benefits and supports urban innovation. Human capital drives organizational performance (Triatmanto, Wahyuni, & Respati, 2019). Organizational performance depends on the human resources working in the organization (Cahyono et al., 2022). Human capital is a vital factor driving innovation (Fonseca et al., 2019).

The development of digital finance has a significant impact on urban innovation so the development of digital finance becomes necessary for support (Mhlanga, 2020). To increase understanding of the causal relationship between digital finance and urban innovation, this research investigates the causal relationship between the development of digital finance and urban innovation that contributes to theoretical and practical developments related to digital finance and the digital economy. This research builds on previous research regarding the impact of digital finance on innovation where most of the research related to digital finance and innovation focuses on enterprise technology innovation, while this paper focuses on urban innovation. In addition, this research also considers traditional finance and its role in urban innovation. This research also takes into account the large differences in regional development in Indonesia. We use an urban sample with an urban commercial attractiveness index and use a wealth of resources to study the impact of digital finance on urban innovation. This research only focuses on 98 cities in Indonesia.

2 LITERATURE REVIEW

Previous research on digital finance on urban innovation has only focused on the effects of digital finance and the factors that influence innovation (Li et al., 2020). Digital finance and

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digital technology developments expand financial inclusion through crowdfunding and peer to peer landing (Priyanto et al., 2022). However, block chain technology still cannot be adapted to the financial sector, especially banking (Bawono & Topçu, 2022). Digital technology adapted to the financial sector gave birth to digital finance (Machkour & Abriane, 2020). Digital finance is a complement to the traditional financial system due to constraints or limitations on distance (Chen & Zhang, 2021). Digital technology has a significant impact on increasing financial inclusion (Ozili, 2018). Increasing digital technology also has an impact on increasing economic growth (Haftu, 2019), increasing domestic consumption (Bawono, 2021), and reducing unemployment (Zemtsov, 2020).

Digital financial inclusion increases domestic consumption and increases online transactions (Li et al., 2020). Digital finance has an impact on increasing sustainable employment. Digital technology plays an important role in driving economic growth (Hasan, Yajuan, & Khan, 2022). Digital finance improves the performance of MSME companies and encourages the real sector nationally (Sinaga & Tambunan, 2022). Innovation is the cornerstone of today's modern economy where innovation is a driver of economic growth (Ahmadov, 2020). Innovation can develop through the development of human capital and technological development (Darsana & Sudjana, 2022).

The accelerating development of digital technology which is increasingly massive has an impact on national economic growth (Bilan et al., 2019). Measurement of financial development in the traditional financial system generally uses venture capital, the stock market, and the credit market (Ji & Zhang, 2019). Financial performance is generally measured by financial structure, financial scale, and financial efficiency (Xie et al., 2019). Financial system development has an impact on innovation. In studying the relationship between innovation and financial development, it is necessary to carry out in-depth studies (Baloch et al., 2021).

Innovation activities certainly require financial support so that it becomes a rational thing where innovation has a causal relationship with financial developments (Mekinjić, Grujić, & Vujičić-Stefanović, 2020). But the support of innovation to productivity in business creates a monopoly economy where the companies that win in innovation have the potential to monopolize the market (Rikap, 2022). The impact of innovation on the economy is heterogeneous. Methods of financing in the industry have an impact on innovation (Morris, 2018). Increasing digital technology has an impact on improving the financial system and innovation (Hasan et al., 2020). However, developments in the financial system also have the potential to stifle innovation (Truby et al., 2020).

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Research literature related to urban innovation is still scarce that discusses financial innovation and urban innovation (Domanski et al., 2020). To add to the research literature and theoretical developments related to digital finance, this research examines 98 cities in Indonesia regarding digital finance and its impact on urban innovation.

Digital finance increases the pace of urban innovation by increasing financial inclusion through information and communication technology so that financial services are more accessible to people across regions (Chen & Zhang, 2021). Increasing financial inclusion has an impact on financing innovation and increasing urban innovation (Hasan et al., 2022). Increasing digital finance provides increased access to financial services which encourages investment and the creation of new businesses in the real sector thereby increasing competition which has an impact on increasing innovation (Li et al., 2020). Digital finance also supports the capital chain so that the real sector and innovation also develop in urban innovation (Ba & Bai, 2020). Based on this analysis, this paper proposes Hypothesis 1.

Hypothesis 1. Digital finance has a significant positive relationship to urban innovation.

Every city in Indonesia has different commercial power. Urban commercial attractiveness has a significant positive relationship with urban innovation and business competition in the city (Mahendra, Paturusi, Dwijendra, & Putra, 2020). The commercial attractiveness of cities has an impact on improving investment and financial systems (Sabirov, Berdiyarov, Yusupov, Absalamov, & Berdibekov, 2021). Commercial attractiveness has an impact on differences and disparities in technology adoption which have an impact on differences in the impact of digital finance on urban innovation (Nanda, Xu, & Zhang, 2021). Based on this analysis, this paper proposes Hypothesis 2.

Hypothesis 2. The impact of digital finance on urban innovation is different for each city with different commercial attractiveness.

Digital finance minimizes corporate financing constraints thereby encouraging urban innovation (Lu, Wu, Li, & Nguyen, 2022). Digital finance itself also requires traditional financial supplies which are the main money supply in today's modern financial system (Popescu, 2020). Digital finance plays a role in minimizing financing constraints which have an impact on increasing innovation (Hasan, Yajuan, & Khan, 2022). Based on this analysis, this paper proposes Hypothesis 3.

Hypothesis 3. Traditional finance still has a role in urban innovation and digital finance plays a role as a driving force for minimizing financing constraints in innovation.

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3 RESEARCH METHOD

This paper uses a sample of 98 cities in Indonesia from 2000 to 2021, with a panel data structure. We use two-step system generalized method of moments estimation model with following equation:

$$\text{Inv}_t = \alpha_0 + \alpha_1 \text{Df}_{t1} + \sum\nolimits_{j=1}^{5} \delta_j \text{Cv}_{it} + \mu_t + \sigma_i + \varepsilon_{it} \qquad (1)$$

Where:

i is the city;

t is the year;

$\text{Inv}_{,t}$ is the innovation level of city i in year t;

$\text{Df}_{,t}$ is the digital finance level of city i in year t;

$\text{Cv}_{,i,t}$ is the control variable;

$\varepsilon_{i,t}$ is the random interference term;

μ_t is time-fixed effects; and

σ_i is individualfixed effects.

In describing digital finance, this study uses 4 explanatory indicators of digital finance variables, namely the level of urban digital finance (Udf), the breadth of urban digital finance coverage (Br), the depth of urban digital finance use (Dh), and the level of digitalization (Lv). The 4 indicators are measured based on reports on Indonesia's level of financial inclusion taken from secondary data sourced from Bank Indonesia.

This study uses macroeconomic variables as control variables including the level of economic development (Ed) as measured by GDP growth in Indonesia which is measured per city using data from the Central Bureau of Statistics of the Republic of Indonesia (BPS) after logarithmic processing. The second control variable is the supply of traditional finance (TF) using secondary data from Bank Indonesia. The third control variable is human capital (Hc) which is measured using the Human Development Index, which is sourced from the Central Bureau of Statistics of the Republic of Indonesia after logarithmic processing. The selection of human capital (Hc) as the control variable is significant because innovation originates from human capital. The fourth control variable is the industrial increase index as measured using the Manufacturing Industry Production Index (Mi) which originates from the central statistics agency of the Republic of Indonesia. The fifth control variable is urban government

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spending(Gx) sourced from the Central Bureau of Statistics of the Republic of Indonesia. And the sixth control variable is urban commercial attractiveness (Uca) which is measured using Realization of Domestic Investment in urban areas sourced from the Central Bureau of Statistics of the Republic of Indonesia. The descriptive statistics are listed in Table 1.

Table 1

Descriptive of the main variables

Variable	Description	Source	Unit Analysis
Inv	The innovation level of city	Bank Indonesia	Index
Udf	The level of urban digital finance	Bank Indonesia	Index
Br	The breadth of urban digital finance coverage	Bank Indonesia	Index
Dh	The depth of urban digital finance use	Bank Indonesia	Index
Lv	The level of digitalization	Bank Indonesia	Index
Mi	The Manufacturing Industry Production Index	BPS	Index
Tf	the supply of traditional finance	Bank Indonesia	Percent
Gx	Urban government spending	BPS	Percent
Hc	human capital which is measured using the Human Development Index	BPS	Index
Ed	the level of economic development as measured by GDP growth in Indonesia which is measured per city	BPS	Percent
Uca	Urban commercial attractiveness (Uca) which is measured using Realization of Domestic Investment in urban areas	BPS	Percent

The data from this study comes from Bank Indonesia as the central bank in the republic of Indonesia and BPS as the central statistical agency for the republic of Indonesia. The statistical results are shown in Table 2.

Table 2

Descriptive statistics of the main variables

Variable	Obs	Mean	Std. Dev	Min	Max
Inv	98	51.021	1.212	29.013	71.112
Udf	98	21.009	2.113	15.011	39.013
Br	98	33.145	1.081	21.112	59.321
Dh	98	29.331	1.071	16.421	41.065
Lv	98	18.002	0.982	2.971	21.331
Mi	98	19.131	0.779	4.321	24.221
Tf	98	9.121	2.109	4.115	12.123
Gx	98	7.221	1.197	2.214	11.221
Hc	98	56.213	2.331	33.221	71.223
Ed	98	8.234	1.031	3.211	12.412
Uca	98	7.112	1.091	4.145	9.112

On average, innovation approaches human capital in descriptive statistics indicating that human capital is a driving force for urban innovation

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4 RESULT AND DISCUSSION

We perform parameter estimation to investigate the causal relationship between digital finance including human capital and urban innovation. The results of estimating specific parameters are shown in Table 3.

Table 3

Parameter estimations of the impact of digital finance on urban innovation.

Variable	Coefisient	P value
Inv_{t-1}	0.4912*	0.3371*
Udf	0.1991*	0.1021*
Br	0.3124*	0.2032*
Dh	-0.0481	-0.1272
Lv	0.7091	0.6582
Mi	0.8123*	0.7214*
Tf	0.4651	0.5412
Gx	0.5112	0.6221
Hc	0.4821*	0.3112*
Ed	0.2831*	0.1922*
Uca	0.2911*	0.1822*
Constant	0.5481	0.4332

Urban innovation in the past has had a significant positive relationship with today's urban innovation. Where The level of urban digital finance and The breadth of urban digital finance coverage has a significant positive influence on urban innovation. However, the depth of urban digital finance use has no significant effect. The level of digitalization, the supply of traditional finance, and urban government spending also have no significant effect on innovation. However, human capital which is measured using the Human Development Index, the level of economic development as measured by GDP growth in Indonesia which is measured per city, and urban commercial attractiveness have a significant positive effect. Based on the results in table 3, it shows that hypothesis 1 is accepted where digital finance has a significant positive relationship to urban innovation. Human capital plays a role as a driver of urban innovation.

Next we use the method used to test the robustness. We add the lagged term of the variable for the degree of urban innovation into the two-step system generalized method of moments estimation model as a dynamic model estimation. The results of our estimates are presented in Table 4.

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Table 4

Robustness test results

Variable / Lag	Lag 1	Lag 2	Lag 3
Inv_{t-1}	0.5121* (10.12)	0.4212* (9.21)	0.3131* (8.11)
Udf	0.1891* (4.80)	0.1662* (3.79)	0.1216* (2.51)
Br	0.9071* (2.81)	0.8122* (2.67)	0.6311* (1.59)
Dh	0.0711* (1.95)	0.0622* (1.71)	0.0311* (1.22)
Lv	0.0123 (0.73)	0.0112 (0.69)	0.0091 (0.21)
Mi	-12.3121 (-1.48)	-11.2232 (-1.29)	-7.1141 (-0.89)
Tf	0.0671 (0.46)	0.0442 (0.39)	0.0213 (0.28)
Gx	1.7887 (1.44)	1.4321 (1.21)	1.1142 (0.91)
Hc	0.8121* (1.92)	0.5232* (1.51)	0.2114* (1.13)
Ed	1.3121* (2.11)	1.0212* (2.01)	0.8123* (1.71)
Uca	1.213* (2.72)	1.1023* (2.01)	0.7112* (1.32)
Constant	1.251 (1.34)	1.112 (1.11)	0.8341(0.62)

The results in Table 4 show that our results are strong. The estimation results up to lag 3 provide consistent results where digital finance still has a significant positive impact on urban innovation. Next, we divide 98 cities in Indonesia into two groups where the first group is cities that are commercially attractive and cities that are less commercially attractive to measure the heterogeneity of the impact of the influence of digital finance on innovation. The results of the test are presented in table 5.

Table 5

Heterogeneity test results.

Variable / Commercially attractive	Attractive cities	Unattractive cities
Inv_{t-1}	0.3212 (0.21)	0.3921* (8.32)
Udf	0.1722 (0.71)	0.1521* (1.68)
Br	0.8172 (0.79)	0.6213* (1.56)
Dh	0.1622 (0.15)	0.0511* (0.69)
Lv	0.1211 (0.11)	0.0221 (0.54)
Mi	-1.2314 (-1.17)	-1.3312 (-1.78)
Tf	0.1522 (0.12)	0.0339 (0.26)
Gx	1.2112* (1.71)	1.3112 (1.17)
Hc	0.7232 (0.62)	0.4111* (1.29)
Ed	1.2312 (1.11)	1.0133* (1.71)
Uca	1.121 (1.02)	1.0079* (1.21)
Constant	1.112 (1.04)	1.003 (1.21)

The results in Table 5 show the heterogeneity of the impact of digital finance on urban innovation with different levels of commercial attractiveness. Cities with low commercial attractiveness have a different impact on the impact of digital finance. This is influenced by different supports so that cities with a less attractive commercial level have a large space for innovation to respond to any changes in the innovation-driving variables. However, in the

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attractive city group, only the depth of use of digital finance, human capital, and government expenditure has a significant impact on urban innovation. This shows that human capital plays an important role in innovation in both cities with low and high commercial attractiveness. These results confirm H2. Based on these results, we find that this heterogeneity is due to the different marginal effects of digital finance. Cities with high commercial attractiveness have high innovation and innovation development space that is heading to saturation so encouragement from government spending and financial depth strengthened by human capital is needed to continue to increase urban innovation. However, cities that are less commercially attractive still have ample space for innovation so almost all of the driving factors for innovation have a significant impact on urban innovation.

To confirm H3, we created a moderating effect model to explore the mechanisms by which digital finance influences urban innovation. We present the results of hypothesis testing 3 in table 6. The model is constructed as follows, with the empirical results in Table 6.

Table 6

Empirical results of the moderating effect

Variable / Lag	Lag 1	Lag 2	Lag 3
Inv_{t-1}	0.3212* (9.21)	0.2921* (3.12)	0.1831* (2.24)
Udf	0.2112* (2.17)	0.1922* (1.06)	0.1311* (0.96)
Br	0.8162* (1.79)	0.2051* (0.99)	0.1923* (0.87)
Dh	0.0622* (0.98)	0.1511* (0.77)	0.1032* (0.68)
Lv	0.0141 (0.69)	0.0232 (0.58)	0.0121 (0.27)
Mi	-1.2232 (-1.19)	-1.1114 (-1.09)	-1.0321 (-1.01)
Tf	0.7121* (1.39)	0.6213* (1.28)	0.5121* (1.19)
Gx	1.1121 (1.04)	1.0032 (0.84)	1.0011 (0.72)
Hc	0.7212* (1.05)	0.6121* (1.01)	0.3212* (0.81)
Ed	1.2419* (1.71)	1.1242* (1.42)	1.0131* (1.31)
Uca	1.1019* (1.76)	1.0829* (1.25)	1.0134* (1.05)
Constant	1.112 (1.23)	1.009 (1.13)	0.819 (1.01)

The results in Table 6 show that the supply of traditional finance has a moderate role in promoting digital finance in urban innovation. These results confirm H3. Traditional finance still has a role in urban innovation and digital finance plays a role as a driving force for minimizing financing constraints in innovation. In cities with an inadequate supply of traditional finance, digital finance at the same level of development has a more significant role to play in driving the development of urban innovation.

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5 CONCLUSION

Digital finance is driving urban innovation levels. But the impact of digital finance on urban innovation is heterogeneous across cities with different levels of commercial attractiveness. In cities with low levels of urban commercial attractiveness, digital finance can play a greater role in increasing urban innovation rates. Traditional financial supplies play a moderating role in promoting digital finance in urban innovation. Human capital has an important role in increasing urban innovation. Digital finance has a significant impact on urban innovation. However, the heterogeneous impact of digital finance on urban innovation for each city in Indonesia has a different level of commercial attractiveness. In Indonesia, traditional finance also plays an important role in urban innovation where the supply of traditional finance plays a role in moderating the effect of digital finance promotion on urban innovation. Human capital is a vital factor driving innovation.

LIMITATION

This research is limited by the research period and data availability.

CONTRIBUTION

City governments must increase the development of digital financial infrastructure to provide strong financial support for the development of urban innovation. To increase innovation, cities with high commercial attractiveness should focus on increasing human capital to keep innovating and maintain urban competitiveness. Cities with low commercial attractiveness can leverage digital finance through developing human capital to drive urban innovation.

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