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Impact of Financial Development on Productive Capacity: The Role of Digital Economy

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A B S T R A C T

In an era of slowing productivity growth and rising global competition, enhancing productive capacity has emerged as a central challenge for advanced economies. Financial development and the rapid diffusion of digital technologies are increasingly viewed as powerful mechanisms for improving investment efficiency, innovation, and resource allocation. Although, the growing role of financial development and the digital economy in enhancing productive capacity, limited evidence exists on their combined effects on productive capacity in OECD economies. This study examines the impact of financial development on productive capacity and the moderating role of the digital economy in OECD countries over the period 2005–2022. Employing the Driscoll–Kraay standard error approach, dynamic GMM, and method-of-moments quantile regression, the analysis reveals that financial development-through both financial markets and institutions-significantly enhances productive capacity. The positive effect is strongest at lower quantiles and gradually weakens, becoming insignificant at higher quantiles. Moreover, the digital economy amplifies the productivity-enhancing role of financial development, particularly in countries with lower productive capacity, while its influence diminishes at higher levels of productive capacity. These findings underscore the importance of strengthening financial systems and accelerating digital transformation as complementary policy tools for boosting productive capacity. Well-designed financial and digital policies can help narrow capacity gaps, improve economic resilience, and foster more inclusive and sustainable growth across OECD economies.

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Introduction

In the era of modern civilization, Significant transformations in the global economic structure have led to the concept of “productivity capacity” being increasingly recognized as a critical engine of economic growth, facilitating access to capital and promoting technological advancement, which continues to draw heightened attention from scholars and policymaker (Zhang & Jia, 2025). In response to these issues, the United Nations instituted 17 Sustainable Development Goals (SDGs), including Decent Work and Economic Growth, Industry,

Innovation and Infrastructure, and Responsible Consumption and Production, among others (UNDP, 2021). This underscores the need for financial growth mechanisms and measures to enhance productive capacity and improve investment efficiency, resource allocation, and competitive advantage (Oluc et al., 2023). Productive capacity comprises global productive inputs, entrepreneurial capacity, and output generation linkages that collectively define a nation's capacity to generate products and services, thereby facilitating its growth and development (UNCAPT). Moreover, the economic growth driven by total factor productivity (TFP) results from the optimal allocation of resources in light of reduced variation in knowledge about the utilization of financial technology innovations (Rehman & Islam, 2023). Promoting sustainable development depends on strengthening productive growth through efficiency gains and technological upgrading (Zheng & Chen, 2023). In this context, green total factor productivity (GTFP) provides a comprehensive metric for evaluating a country's capacity to mitigate environmental stresses while supporting economic growth (Jiakui et al., 2023).

Financial institutions promote companies by contributing the funds they require for technological improvements to machinery, thereby enhancing capital allocation efficiency, decreasing operating costs, productive investment, and strengthening competitiveness, which ultimately leads to reduced energy utilization and, consequently, lower carbon emissions (Cheng et al.2025). In recent times, Beck et al.(2013) differentiated between two aspects of financial development: Financial intermediation is quantified as the ratio of domestic private credit to GDP, while the magnitude of the financial sector is indicated by its value-added share of total economic output (Yao et al., 2019). Moreover, higher financial growth derives from the enforcement of policies that foster productive capability (Jiakui et al., 2023). A digital financial system focused on mobile payments, internet wealth management, online crowdfunding, and online lending has emerged, propelled by advancements in financial and mobile internet technologies (Guo & Wang, 2025). Financial development enhances the digital economy, which in turn affects productive development. Digital economic development has increasingly emerged as a vital infrastructural foundation supporting the transformation toward higher-quality growth and enhanced productivity (M. Zheng et al., 2025). Its transformative effects are transmitted through multiple pathways, whereby digital technologies improve factor-use efficiency, refine resource allocation, and fundamentally reshape production relationships (Yue & Shi, 2026). However, studies on the moderating role of the digital economy in the relationship between financial development and productive capacity are few.

Many previous scholars have addressed the impact of financial development on foreign direct investment (An et al., 2025), agricultural productivity (Zakaria et al., 2019), macroeconomic growth volatility (Struthmann, 2025), and economic growth (Maniraguha & Ndemezo, 2025). Nonetheless, there is a lack of studies examining the impact of financial development on productive capacity. Therefore, exploring the relationship between financial development and productive capacity addresses a key research gap, highlighting how financial development enhances capital efficiency, technological innovation, productive capital allocation, reduces energy consumption, and drives sustainable economic growth. Furthermore, limited empirical evidence exists on whether the digital economy strengthens or weakens the effect of financial development on productive capacity, particularly in OECD countries. This gap is important because OECD economies are characterized by advanced financial systems and varying levels of digital transformation, making them an appropriate setting to examine how digitalization enhances the effectiveness of financial development in improving productive capacity. To address this gap, this study investigates the moderating role of the digital economy in the relationship between financial development and productive capacity across OECD countries. Digital finance serves a crucial role in enhancing firms' total factor productivity by supporting R&D, innovation, and efficient resource

allocation (Guo & Wang, 2025). Financial institutions significantly contribute to increasing total factor productivity by deploying advanced technology, eliminating transaction costs, controlling reward systems, and supporting the implementation of market-based polices and environmental practices (Ma & Zhu, 2025). This study mitigates the existing research gap by ensuring novel empirical evidence on the linkage between financial development and productive capacity.

This research makes several contributions as follows: Firstly, we investigate the impact of financial development on the productive capacity. Although previous research has examined the effects of financial development on green development (Yang & Ni, 2022), green growth (Özkan et al., 2024) and agricultural productivity and crop production (Zakaria et al., 2019), its influence on productive capacity remains insufficiently explored. Secondly, our study investigates the mechanisms by which financial development influences productive capacity, highlighting the way it expands this ability through channels of the digital economy. Thirdly, it undertakes a comprehensive analysis of how the combination of financial development, financial market, financial institutions, and digital economy affects productive efficiency. Finally, the research further enhances the methodology by using advanced econometric models, such as DKSE, GMM, and Quantile regression, to address issues of heteroscedasticity and autocorrelation. Therefore, Quantile regression is a flexible nonparametric approach that overcomes the limitations of conventional econometric methods by effectively handling nonlinearity and irregular data distributions. This study provides substantial new insight into the process by which financial development enhances productive capacity within the OECD countries.

The structure of this research is as follows: Section 2 reviews the literature, Section 3 describes the data and methodology; Section 4 presents results and discussions; Section 5 reports the conclusions and policy implications.

Literature review

Theoretical Framework

The relationship between financial development and productive capacity is primarily grounded in Schumpeter's Theory of Financial Development, which posits that financial intermediaries foster economic development by mobilizing savings, allocating capital to productive investments, and financing innovation (Schumpeter, J. A. 1911). Efficient financial systems reduce financing constraints and facilitate technological advancement, thereby enhancing productive capacity. This theoretical perspective is further supported by the Financial Liberalization Theory Cole & Shaw (1974) Tobin (1965), which argues that liberalized financial markets improve the efficiency of savings mobilization and capital allocation. By expanding access to finance and directing resources toward high-productivity sectors, financial development encourages investment in productive activities and strengthens productive capacity. The Endogenous Growth Theory (Aghion & Howitt, 1992; King & Levine, 1993) extends this argument by emphasizing that financial development promotes long-run economic growth through innovation, technological progress, and capital accumulation. Well-functioning financial systems facilitate investment in research and development, accelerate technology diffusion, and support productivity-enhancing activities. Consistent with this view, King and Levine (1993) demonstrate that financial development reduces information asymmetries and transaction costs, leading to more efficient capital allocation and higher productivity. Drawing on these theoretical perspectives, this study posits that financial development enhances productive capacity by improving financial intermediation, facilitating investment,

and promoting technological innovation. This framework provides the theoretical foundation for examining the impact of financial development on productive capacity in OECD economies.

Research has increasingly concentrated on identifying the main contributors to productive capacity. Financial development is broadly recognized as a key driver of productive capacity. Zhang & Jia, (2025) suggested that the financial development of productive efficiency to access capital, its non-linear effects, and diminishing returns at high inclusion levels highlight the need for complementary policies. A well-developed financial system enables affordable access to credit and insurance, allowing farmers to adopt modern technologies and inputs that enhance yields and productivity (Yadav & Goyari, 2025). This study explores the multidimensional relationships between financial development, the digital economy, and productive capacity. From a global perspective, financial growth enhances nation's productive capacity (Yang & Ni, 2022). Dabla-Norris et al, (2010) indicated that productivity levels and the probability of innovation, whether through invention or adoption, are contingent upon the institutional context and the accessibility of financing. This field has experienced significant growth in recent years, driving various global financial advancements (Cevik et al., 2024). The advantages of financial development can be highlighted through advancements in digital payments, blockchain technology, lending technologies, and institutional tech solutions, considering the dimensions of access to financial services, cost efficiency, innovation, and competitiveness. Patel et al.(2022) conducted a systematic review of 260 papers published from 1981 to 2021 on financial market integration, investigating its principal features and their contributions to enhancing economic productivity. Despite the growing significance of green financing in promoting high-quality output, China's existing system faces significant limitations, including limited innovation and uneven green development across markets (Liu & Liu, 2025). Financial innovation encompasses a range of instruments and procedures to mitigate environmental risks and encourage green investment, thereby fostering an environmentally friendly society through carbon financing (Jiakui et al., 2023). However, research on the relationship between financial development and productivity growth is scarce.

Eventually, while previous research provides considerable evidence about the distinct contributions of financial growth and digital economy to enhancing productive capacity, synergistic benefits have not been adequately investigated. Primarily, the interaction between the digital economy and financial development in shaping productive capacity remains largely unexamined in the current literature. Moreover, most studies have concentrated on developed or major emerging economies, leaving the OECD region comparatively underexplored. Accordingly, the originality of this research is reflected in specific dimensions. Therefore, this research analyzes the impact of financial development on productive capacity across OECD countries. Finally, it investigates the interactive effects of financial development and the digital economy on productive capacity, encompassing human capital development, enhanced resource allocation, technological adoption, cost efficiency, innovation, and sustainable growth. By examining these underexplored areas, the study provides insights for OECD nations, supporting effective productive capacity strategies and policy implementation.

Financial development and productive capacity

Financial infrastructure promotes economic growth by deepening financial markets, stimulating investment, and shaping energy demand (ABIDIN et al., 2021; Paramati et al., 2022). In China's advancement, green finance promotes the development of green industries and underpins essential components of new-quality productivity, which include human capital, innovation, and effective resource allocation (Liu & Liu, 2025). Financial de-

velopment, along with strong institutional frameworks, plays a pivotal role in reducing environmental degradation by encouraging efficient resource use, enhancing productive capital investment and facilitating the adoption of sustainable technologies (Cheng et al. 2025). Therefore, these services offered by financial development enhance productive capacity by facilitating financial markets and institutions, improving the efficiency of resource allocation, developing human capital, and supporting technological advancement (Struthmann, 2025). Digital finance significantly improves total factor productivity, especially for non-state enterprises, improving resource allocation, promoting technical innovation, and expanding inclusive, efficient financial services beyond standard markets (Guo & Wang, 2025). It demonstrates that enhanced financial development fosters greater efficiency, thereby stimulating banking operations, mitigating the risk and cost of bank loans, and ultimately increasing the need for energy efficiency in both household and industrial sectors (Zheng & Chen, 2023). A sustainable financial system is essential for achieving these outcomes. Furthermore, the financial aspects of financial infrastructure facilitate productivity growth within the economy (Rehman & Islam, 2023). A more advanced level of financial development contributes to financial market expansion, drives economic growth, and expands the capital market(Jiakui et al. 2023). Nevertheless, empirical evidence supporting a robust relationship between financial development and productive capacity in OECD economies remains scarce. As a result, this research provides valuable insights into the potential role of financial development initiatives in fostering productive advancement. Based on the above, this paper proposes the following hypothesis

H1: Financial development is positively associated with an increase in productive capacity.

Digital economy, financial development and productive capacity

The digital economy plays a significant moderating role in the relationship between financial development and productive capacity. Digital economy enhances industrial production efficiency and organization, significantly promoting technological innovation, digital payment, ICT, e-commerce volume, digital service, and infrastructure development (Tian et al., 2023). The digital economy strengthens the relationship between financial development and productivity growth by improving the efficiency of fund allocation, though this moderating effect varies across regions, highlighting the need for targeted policies to promote inclusive development (Byrne, 2022). The digital economy enhances resource allocation efficiency, fosters financial innovation, and improves risk management capabilities by leveraging financial benefits for financial institutions (Zhang, 2025). The digital economy promotes fintech growth, ensuring agricultural loans and integrating credit portfolios (Chen et al., 2022). The digital economy can improve economic development through the use of big data, the internet, and artificial intelligence (Zhang et al., 2021). Digital finance plays a conducive role in improving the efficiency of the financial sector (Wang et al., 2020). The digital economy is essential for promoting financial advancement, accelerating its dissemination, and practical application (Zhou et al., 2024), which depends on financial development to improve productive capacity. Therefore, the advancement of financial development strengthens digital economy's role in enabling technological transformation, thereby strengthening support for the development and expansion of productive capacity. We propose the following as our third hypothesis.

H2: The development of the digital economy enhances the positive impact of financial development on productive capacity.

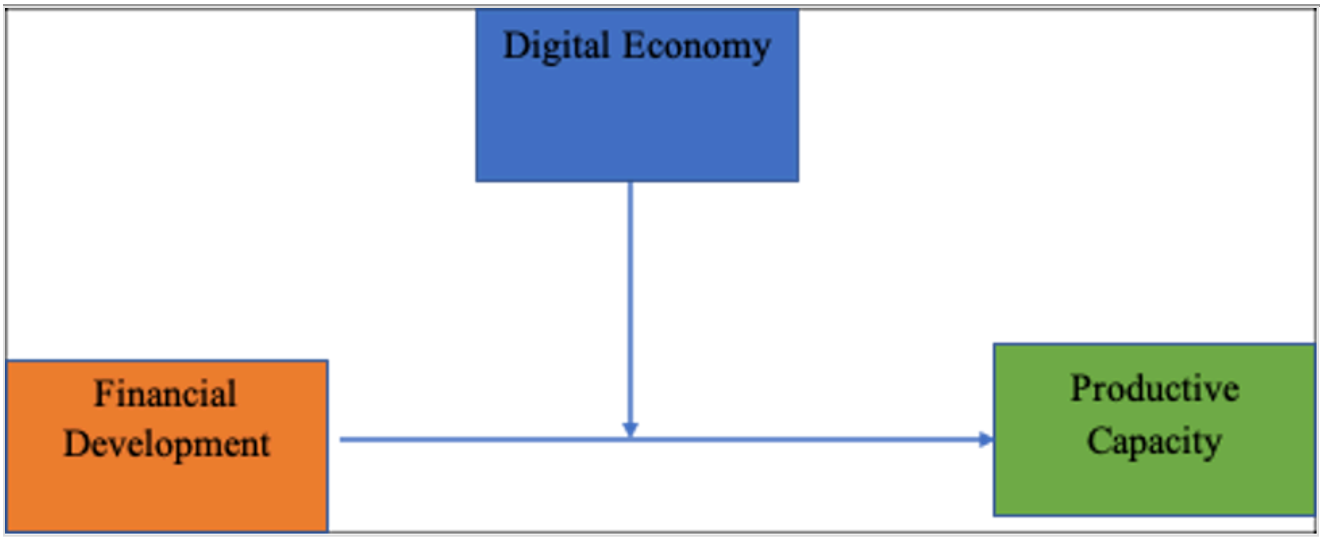

Figure 1.

Data and methodology

Data Sources and variable measurement

This research investigates the impact of financial development on productive capacity using a balanced panel of 36 OECD member countries, observed annually from 2005 to 2022. Productive capacity index data are sourced from UNCTAD financial development indices, which are derived from IMF Global Financial Stability Reports; digital economy indicators are built based on entropy calculated from series found within the OECD regions. Control variables are sourced from World Development Indicators (WDI), and the digital economy data are sourced from the Economic Policy Uncertainty database. All other control variables are obtained from the World Development Indicators (WDI). Table 1 provides detailed definitions and sources for each variable, all of which are used in logarithmic form in the regression model. Table 2 presents the descriptive statistics, and Table 3 reports the correlation analysis. Fig.1 shows the conceptual framework. The conceptual framework of this study illustrates the relationship between financial development and productive capacity, where digital economy acts as a moderating variable. It shows that financial development directly influences productive capacity.

Table 1. Variable's description

Variable type	Definition	Symbol	Measurement	Source
Dependent variables	Productive capacity	lPCI	Productive capacity index	UNCTAD
Independent variable	Financial development	lFnDI	Financial development index	IMF
Moderating variable	Digital economy	lDE	Index by the entropy method	Author calculated
Control variables	Trade uncertainty	TDU	Trade uncertainty index	EPU
	Economic growth	lGDPp	Per capita GDP	WDI
	Industrialization	lINDp	Industry value added (% of GDP)	WDI

	Trade	lTD	Sum of exports and imports of goods and services (% of GDP)	WDI
	Urbanization	lURB	Urban population	WDI

Fig.1: Conceptual Framework

Model specification

Baseline Regression Specification

Based on previous studies' theoretical frameworks, this study assumes that Trade uncertainty, economic growth, industrialization, trade, and urbanization. Moreover, financial development (FnDI) serves as the key explanatory variable, and the model is summarized below.

$$(PCI)_{it} = (FnDI)_{it}, (FnII)_{it} (FnMI)_{it} (GDPp)_{it} (INDSp)_{it}, (TD)_{it}, (nURB)_{it} \quad (1)$$

In this research, productive capacity is measured by the productive capacity index (*PCIit*), which captures potential output capabilities across eight core pillars: natural resources, human capital, energy, transport, information and communication technology (ICT), finance, private sector development, and institutional quality. Financial development is represented by indicators of financial development (*FnDIit)*, while financial institutions are measured by the financial institutions index (*FnIIit*), reflecting the depth and efficiency of the banking sector. Financial markets are captured by the financial markets index (*FnMIit*), which incorporates stock market capitalization and bond market development. The digital economy index (*DEit*) is constructed using broadband penetration, e-government development, digital payment adoption, and ICT investment, and synthesized through the entropy weighting method. Economic growth, measured by GDP per capita (*GDPpit)*, in constant 2015 U.S. dollars. Industrialization is measured by industry value-added share (*NDSpit*), trade openness (*TDit*) defined as exports-plus-imports-to-GDP, and urbanization (*nURBit*). The subscripts *i* and *t* denote the individual country and the corresponding time period, respectively.

To mitigate heteroscedasticity, the variables are transformed into logarithmic form in the following equation.

$$(lPCI)_{it} = \alpha + \beta_1 (lFnDI)_{it} + \beta_2 (lFnII)_{it} + \beta_3 (lFnMI)_{it} + \beta_4 (lGDPp)_{it} + \beta_5 (lINDSp)_{it} + \quad (2)$$

The seven coefficients, $\beta 1 - \beta 7$, in the equation capture the effects of the independent variables on the dependent variable. This study investigates the causal link between financial development and productive capacity, with $\beta 1$ serving as the primary indicator of a positive elasticity between financial development and productive capacity. The model also incorporates the error term ϵit.

After assessing the direct impact of the digital economy, we examine its moderating role in the relationship between financial development and productive capacity. To evaluate this influence, we develop a basic framework for analyzing the moderating effect, as shown in the equation.

$$(lPCI)_{it} = \alpha + \beta_1 (lFnDI)_{it} + \beta_2 (lModer)_{it} + \beta_3 (lFnDI)_{_} (lModer)_{it} + \sum \beta_n (lControl)_{it} + \quad (3)$$

In this model, it denotes the moderating variable, specifically the digital economy. α is the constant term, and $\beta_1 \ldots\ldots\ldots\ldots \beta_n$ are the coefficients to be estimated. The model is initially estimated without the interaction

term to assess the baseline effect, followed by a second estimation that indices the interaction term. The co-efficient β_3 corresponds to the interaction term $(lFnDI)_ (lModer)_{it}$. This captures the combined effects of financial development and the digital economy on productive capacity. A statistically significant result β_3 would indicate that the digital economy moderates the relationship between financial development and productive capacity.

Variable Measurement

This study clarifies and quantifies each variable using specific indicators to precisely determine their impact on the dependent, independent, and control variables, as well as the moderating variable. The dependent variable, productive capacity index (PCI), measures potential output capabilities through eight pillars: natural resources, human capital, energy, and transport, accompanied by ICT, finance, private sector development, and institutions. Financial development then breaks down into three constructs: the composite index (FnDI), which covers the depth and efficiency of the banking sector; the institutions index (FnII), which measures the depth and efficiency of the banking sector; and the markets index (FnMI), which measures stock market capitalization and bond market development. Broadband penetration, e-government development, digital payments adoption, and ICT investment comprise the digital economy index (DE), synthesized using an entropy weighting methodology. Control variables are economic growth (GDPp), industrialization measured as the industry value-added share (NDSp), trade openness (TD) defined as exports-plus-imports-to-GDP ratio and urbanization (nURB).

Moderating variable

To assess the development of the digital economy across national and provincial contexts, researchers increasingly utilize comprehensive evaluation frameworks that encompass multiple dimensions of digital transformation and development (Lee et al., 2024; & Pan et al., 2022) .This study proposes a Digital Economy Evaluation Index (DEI) that captures globalization, societal engagement in the digital economy, and national digital infrastructure. Indicator weights are calculated using the entropy weight method, which objectively determines the relative importance of each indicator based on its information entropy. The overall Digital Economy Evaluation Index (DEI) is computed using Equation (4), while the indicator weights are estimated based on Equations (3) and (4). The resulting weights for the digital economy evaluation system are presented in Table 1.

$$\frac{Y_{ij} - min\left(y_i\right)}{(max)_{ij} - min\left(y_i\right)} \tag{4}$$

$$(Y')_{ij}$$

$$d_{ij} \tag{5}$$

$$\frac{(Y')_{\ddot{i}j}}{\sum_{i=1}^{n} Y_{ij}} \tag{6}$$

$$w_j \tag{7}$$

$$\frac{1 + R\sum_{i=1}^{u} \lfloor d_{ij} \times In\left(d_{ij}\right) \rfloor}{-R\sum_{i=1}^{n}\sum_{j=1}^{m} \lfloor d_{ij} \times In\left(d_{ij}\right) \rfloor} \tag{8}$$

DKSE and GMM models

This study also employs the Driscoll & Kraay (1998), robust standard error model, which is suitable for panel regressions with cross-sectional dependence (CSD), to evaluate the influence of financial development on productive capacity in the OECD region. The estimated model is

$$Y_{it} = \alpha + \beta_1 \left(lFnDI\right)_{it} + \sum \beta_n \left(lControl\right)_{it} + \epsilon_{it} \tag{9}$$

$$Y_{it} = \alpha + \beta_1 \left(lFnDI\right)_{it} + \sum \beta_n \left(lControl\right)_{it} + \epsilon_{it} \tag{10}$$

Where; Y_{it} presents productive capacity, α denotes the constant; β_1 is the vector of coefficients to be estimated. $\left(lFnDI\right)_{it}$ is the matrix of the independent variable and $\left(Control\right)_{it}$ depicts all control variables; ϵ_{it} represents the residual term.

The study applies the Dynamic GMM estimator to address potential endogeneity, incorporating lagged dependent variables and using appropriate internal instruments to obtain consistent estimates. The control model for GMM is specified as follows:

$$X_{it} = \alpha + \tau X_{i,Y-1} + \sum \beta_n \left(lControl\right)_{it} + \epsilon_{it} \tag{11}$$

$$X_{it} = \alpha + \tau X_{i,Y-1} + \sum \beta_n \left(lControl\right)_{it} + \epsilon_{it} \tag{12}$$

Where: X_{it} dependent variable (IPCI), $X_{i,Y-1}$ presents the one-period lag of productive capacity (lPCI) and τ depicts the persistence coefficient. $\beta_1 X_{it}$ is an explanatory variable and $\left(Control\right)_{it}$, depicts all control variables, ϵ_{it} shows error terms.

To examine the heterogeneous effects of financial development and the digital economy on productive capacity across different points of its conditional distribution, this study employs the Method of Moments Quantile Regression (MMQR) proposed by (Machado & Santos Silva, 2019).The baseline MMQR model is specified as follows:

$$\left(lPCI\right)_{it} = \alpha_0 + \beta_1 \left(lFnDI\right)_{it} + \beta_2 \left(IDE\right)_{it} + \sum \beta_n \left(lControl\right)_{it} + \epsilon_{it} \tag{13}$$

$$\left(lPCI\right)_{it} = \alpha_0 + \beta_1 \left(lFnDI\right)_{it} + \beta_2 \left(IDE\right)_{it} + \sum \beta_n \left(lControl\right)_{it} + \epsilon_{it} \tag{14}$$

Where:

$\left(lPCI\right)_{it}$= The conditional quantile of productive capacity.

$\left(lFnDI\right)_{it}$= Financial Development Index.

$\left(IDE\right)_{it}$= Digital Economy Index.

$\left(lControl\right)_{it}$= control variables (e.g., GDP growth, inflation, FDI, trade openness).

ϵ_{it}= quantile-specific error term.

Results and discussions

Descriptive statistics and correlation matrix

The descriptive statistics table.1 gives the distributional properties of all variables used in the analysis over 648 observations from OECD countries for the 2005-2022 period. The results indicate that the productive capacity scores ranged from 3.732 to 4.264, with a mean of 4.097 (SD = 0.102). These values characterize the overall distribution of the data. In contrast, financial development exhibited greater variance and negative positioning, with a minimum value of -1.682, a maximum of 0.392, and a mean of -0.540 (SD = 0.003). The data indicate that, though production capacity was generally stable and positive, financial development experienced significant downward fluctuations during the investigated period. A pairwise correlation analysis is performed to investigate the correlations among variables, as shown in Table 2. The findings reveal that the majority of independent variables exhibit significant correlations with the dependent variable at the 10%, 5%, and 1% significance levels, indicating that the chosen control variables are appropriate for the model specification.

Table 2. Variable's description

Variable	Obs	Mean	Std. Dev.	Min	Max
lPCI	648	4.097	.102	3.732	4.264
lFnDI	648	-.54	.392	-1.682	-.003
lFnII	648	-.418	.28	-1.252	0
lFnMI	648	-.879	.933	-4.227	-.011
lDE	648	-.709	.222	-1.472	-.384
lGDPp	648	10.245	.658	8.4	11.486
lINDSp	648	3.196	.217	2.592	3.895
lTD	648	4.411	.491	3.14	5.531
lnURB	648	16.906	1.486	13.222	20.135

Table 3. Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) lPCI	1.000								
(2) lFnDI	0.685***	1.000							
(3) lFnII	0.739***	0.850***	1.000						
(4) lFnMI	0.517***	0.914***	0.598***	1.000					
(5) lDE	0.585***	0.408***	0.499***	0.246***	1.000				
(6) lGDPp	0.855***	0.717***	0.766***	0.520***	0.658***	1.000			
(7) lINDSp	-0.299***	-0.246***	-0.349***	-0.142***	-0.253***	-0.253***	1.000		
(8) lTD	-0.032	-0.405***	-0.237***	-0.456***	0.073**	-0.023	0.160***	1.000	
(9) lnURB	-0.007	0.470***	0.194***	0.554***	0.051	-0.051	0.006	-0.643***	1.000

Notes: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Results of the regression analysis

The baseline regression uses Driscoll–Kraay standard errors (DKSE) to correct for cross-sectional dependence and heteroskedasticity, as reported in Table 4. Results in column (1) show that financial development (FnDI) increases productive capacity with a coefficient of 0.060 while achieving statistical significance. Column (2) presents that the financial institutions (FnII) are positively and significantly correlated with productive capacity, with a coefficient of 0.071, implying that digital finance fosters productive capacity growth. Financial markets (FnMII) significantly enhance productive potential, with a coefficient of 0.015, highlighting their critical role in promoting capital accumulation, technological sophistication, and the expansion of industrial capacity. Column (1)-(3) Economic growth (GDPp) has a positive effect on productive capacity. On the other hand, industrialization (INDPp) appears to negatively affect productive performance, indicating that it reduces the economy's output potential, while factors such as global economic policy uncertainty and natural resource endowment also exert significant adverse effects (Emeka et al., 2025). Trade openness positively affects productive capacity, indicating that higher exports and imports are associated with greater production efficiency.

Moreover, Urbanization(nURb) has mixed effects on productive capacity, confirming that it can both promote and decline productive efficiency. Mendez et al. (2023) implied that urbanization increases productivity in developed countries, but reduces it in developing countries. Financial development enhances output potential, mitigating information asymmetry and financing limitations, and expands access to credit and financial services, thereby fostering a more equitable financial system (Magazzino & Santeramo, 2023). This advancement enables enterprises to obtain financing more efficiently, thereby enhancing their productive capacity.

Table 4. Results of baseline regression

	(1)	(2)	(3)
	lPCI	lPCI	lPCI
lFnDI	0.060***		
	(0.008)		
lFnII		0.071***	
		(0.013)	
lFnMI			0.015***
			(0.005)
lGDPp	0.103***	0.107***	0.117***
	(0.003)	(0.004)	(0.005)
lINDSp	-0.039***	-0.031***	-0.045***
	(0.005)	(0.006)	(0.005)
lTD	0.013**	0.012**	0.012**
	(0.006)	(0.006)	(0.006)
lnURB	-0.003*	0.002*	-0.000
	(0.001)	(0.001)	(0.001)
_cons	3.183***	3.040***	3.005***
	(0.069)	(0.049)	(0.094)
No. Obs.	648	648	648
R^2	0.752	0.753	0.748

Notes: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Results of robustness analysis

Table 5 reports the robustness analysis using the dynamic Generalized Method of Moments (GMM) estimator. Dynamic GMM is employed to address dynamic panel bias arising from the inclusion of the lagged dependent variable and to mitigate potential endogeneity caused by reverse causality, omitted variables, and unobserved heterogeneity through the use of internal instruments.The diagnostic tests confirm the validity of the estimation. The Arellano–Bond AR(1) test is significant at the 1% level, as expected in first-differenced GMM, while the AR(2) test is insignificant, indicating no second-order serial correlation. Moreover, the insignificant Sargan test confirms the validity of the instruments and the consistency of the GMM estimates.

Table 5. Results of robustness regression by dynamic GMM

	(1)	(2)	(3)
	lPCI	lPCI	lPCI
L.lPCI	0.513***	0.501***	0.515***
	(0.013)	(0.013)	(0.025)
lFnDI	0.049***		
	(0.003)		
lFnII		0.051***	
		(0.006)	
lFnMI			0.023***
			(0.001)
lGDPp	0.026***	0.029***	0.027***
	(0.005)	(0.004)	(0.004)
lINDSp	-0.008	-0.008	-0.000
	(0.005)	(0.005)	(0.004)
lTD	0.014***	0.004	0.018***
	(0.002)	(0.003)	(0.002)
lnURB	0.003*	0.006***	-0.001
	(0.001)	(0.001)	(0.001)
_cons	1.678***	1.694***	1.660***
	(0.066)	(0.063)	(0.073)
No. Obs.	612	612	612
AR1	-3.492***	-3.389***	-3.6435***
	(0.000)	(0.000)	(0.000)
AR2	0.696	0.468	0.793
	(0.486)	(0.639)	(0.427)
Sargan	35.632	35.509	35.639

Notes: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The lagged dependent variable remains positive and highly significant ($\beta = 0.501–0.515$, $p < 0.01$), indicating strong persistence in productive capacity over time. To assess robustness, the aggregate financial development index is replaced by its two components: financial institutions and financial markets. The coefficients of the

overall financial development index (β = 0.049), financial institutions (β = 0.051), and financial markets (β = 0.023) are all positive and statistically significant. The larger coefficient of financial institutions suggests a stronger contribution to productive capacity than financial markets.

Table 6. Results of the moderating effect of the digital economy

	(1)	(2)	(3)
	lPCI	lPCI	lPCI
lFnDI	0.137***		
	(0.016)		
lDE	0.087***	0.026	0.079***
	(0.010)	(0.025)	(0.009)
c.lFnDI#c.lDE	**0.089*** **		
	(0.023)		
lFnII		0.095***	
		(0.032)	
c.lFnII#c.lDE		**0.029**	
		(0.027)	
lFnMI			0.062***
			(0.013)
c.lFnMI#c.lDE			**0.056*** **
			(0.016)
lGDPp	0.091***	0.104***	0.106***
	(0.006)	(0.007)	(0.003)
lINDSp	-0.035***	-0.028***	-0.042***
	(0.005)	(0.008)	(0.005)
lTD	0.012**	0.012**	0.010*
	(0.004)	(0.005)	(0.005)
lnURB	-0.006***	0.001	-0.004**
	(0.002)	(0.002)	(0.001)
_cons	3.426***	3.102***	3.240***
	(0.083)	(0.095)	(0.071)
No. Obs.	648	648	648
R^2	0.757	0.753	0.758

Notes: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Results of moderating effect analysis

Table 6 illustrates the results of the moderating effect of the digital economy on the relationship between financial development and productive capacity. The digital economy (DE) exerts a positive direct effect on productive efficiency, as indicated by a coefficient of 0.087. Moreover, Column (1) indicates a positive interaction effect (c.FnDI#c.DE) on productive capacity, with a coefficient of 0.089 at 1% level of significance, suggesting

that higher levels of digitalization amplify the contribution of financial development and productive capacity in OECD countries. The coefficient for the interaction term (c.FnII#c.DE) is statistically insignificant, indicating that the digital economy has a notable moderating effect on the relationship between financial institutions and productive capacity. Specifically, provinces with higher levels of digital development are more likely to experience improved resource allocation efficiency and promote more efficient production systems (Zhao et al., 2024). This result indicates that financial institutions do not significantly affect productive potential. Column (3), The combination of financial development with the digital yields significant positive effects on productive capacity, particularly by efficiently allocating capital, facilitating credit access, supporting technological adoption, and is statistically significant at the 1% level with a coefficient of 0.56. This confirms that the development of the digital economy can promote the productivity of the financial market. These outcomes confirm theoretical propositions that digital infrastructure strengthens financial intermediation and expands access to productive investment opportunities (Xu et al., 2025). Therefore, enhancing the digital economy may be crucial for improving productive capacity.

Table 7. Results of MMQ for baseline regression

location			scale		
lFnDI	0.060***		lFnDI	-0.033***	
	(0.012)			(0.007)	
Control	Yes		Control	Yes	
_cons	3.183***		_cons	-0.201***	
	(0.097)			(0.055)	
qtile	10th	25th	50th	75th	90th
lFnDI	0.117***	0.083***	0.062***	0.029**	0.010
	(0.018)	(0.013)	(0.012)	(0.013)	(0.014)
lGDPp	0.080***	0.094***	0.102***	0.116***	0.123***
	(0.009)	(0.006)	(0.006)	(0.006)	(0.007)
lINDSp	-0.029**	-0.035***	-0.039***	-0.044***	-0.047***
	(0.015)	(0.011)	(0.010)	(0.010)	(0.012)
lTD	0.009	0.012*	0.013**	0.016***	0.017***
	(0.008)	(0.006)	(0.005)	(0.006)	(0.007)
lnURB	-0.013***	-0.007***	-0.003	0.003	0.006**
	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)
_cons	3.531***	3.322***	3.195***	2.989***	2.876***
	(0.146)	(0.109)	(0.098)	(0.104)	(0.118)
N	648	648	648	648	648

Notes: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Results of MMQ regression analysis

The “Location” column in Table 7 presents the average effects of the independent variables on the dependent variable, thereby capturing central tendencies. Conversely, the “Scale” column illustrates how these effects dif-

fer across the distribution, highlighting heterogeneity across quantiles. This distinction facilitates a more refined evaluation of whether the relationships vary across different segments of the distribution.

Table 8. Results of MMQ for moderating effect analysis

location			scale		
lFnDI	0.137***		lFnDI	-0.057***	
	(0.027)			(0.015)	
lDE	0.087***		lDE	-0.024*	
	(0.023)			(0.013)	
c.lFnDI#c.lDE	0.089***		c.lFnDI#c.lDE	-0.027	
	(0.029)			(0.017)	
Control	Yes		Control	Yes	
_cons	3.426***		_cons	-0.270***	
	(0.123)			(0.071)	
qtile	10th	25th	50th	75th	90th
lFnDI	0.229***	0.178***	0.138***	0.081***	0.048
	(0.040)	(0.031)	(0.027)	(0.028)	(0.032)
lDE	0.126***	0.105***	0.087***	0.063***	0.049*
	(0.034)	(0.027)	(0.023)	(0.024)	(0.028)
c.lFnDI#c.lDE	0.133***	0.109***	0.089***	0.062**	0.046
	(0.044)	(0.034)	(0.029)	(0.031)	(0.035)
lGDPp	0.065***	0.079***	0.091***	0.107***	0.117***
	(0.011)	(0.008)	(0.007)	(0.007)	(0.009)
lINDSp	-0.039***	-0.037***	-0.035***	-0.032***	-0.031**
	(0.015)	(0.012)	(0.010)	(0.010)	(0.012)
lTD	0.014	0.013*	0.012**	0.010*	0.010
	(0.008)	(0.006)	(0.006)	(0.006)	(0.007)
lnURB	-0.016***	-0.011***	-0.006**	-0.000	0.003
	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
_cons	3.865***	3.624***	3.431***	3.159***	3.003***
	(0.187)	(0.144)	(0.125)	(0.130)	(0.149)
N	648	648	648	648	648

Notes: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

We apply the Method of Moments Quantile Regression (MMQR) method, as illustrated in Table 6, to analyze the diverse impacts of financial development on productive capacity. The findings suggest that financial development affects productive capacity differently across quantiles, demonstrating stage-specific variations in its influence. Financial development positively affects productive potential across all quantiles. However, the magnitude of this effect decreases systematically from lower to higher quantiles, with the strongest impact observed at the 10th quantile with a coefficient of 0.117. The effect gradually diminishes at the 25th, 50th, and 75th quantiles with coefficients of 0.083, 0.062, and 0.029, respectively, indicating that utilizing financial resources, enhancing capital allocation, and fintech efficiency can improve the productive capacity. Although at

the 90th quantile, exhibiting a coefficient of 0.010 and statistically insignificant, it may not have a robust impact on productive capacity.

MMQ for moderating effect analysis

Table 8 employs a MMQR model with a moderating variable. The “Location” column in the table reports that the digital economy has a positive impact on productive capacity. In contrast, the “Scale” column indicates that the digital economy exerts a negative effect across the distribution of productive capacity. Column (1) shows that the combination of financial development (FnDI) with the digital economy (DE) positively affects productive capacity, indicating that the digital economy moderates the effect of financial development on productive capacity. Column (2) shows the interaction term FnDI and DE capturing the impact of financial development and productive capacity, which is negative and insignificant.

Secondly, the (MMQR) results show that the aggregation of (FnDI) and DE declines across quantiles. Financial development has a stronger positive impact on productive capacity at the lower quantiles (10th, 25th, 50th, 75th) with coefficients of 0.229,0.178 0.138, and 0.081,respectively. The influence turns positive at the highest quantile (90th), with a coefficient of 0.048, but is insignificant. Moreover, the quantile regression results show that the interaction term (c.FnDI#c.lDEc) is positive across all quantiles but declines from 0.133 at the 10th percentile to 0.046 at the 90th percentile, indicating that moderating remains at the same level of outcomes. These outcomes indicate that the digital economy's moderating effect on financial development is strongest at lower levels of productive capacity and weakens at higher levels. At the 90th percentile, the effect becomes statistically insignificant, suggesting minimal impact at high capacity levels.

Discussion

The findings indicate that financial development significantly enhances productive capacity by improving capital allocation, reducing financing constraints, and facilitating investment in productive sectors. This result is consistent with Schumpeterian financial development theory, which argues that well-functioning financial systems promote innovation by mobilizing savings and directing capital toward productive investments. Similarly, financial liberalization theory suggests that efficient financial markets increase investment efficiency and stimulate technological progress, thereby strengthening productive capacity. These findings are consistent with previous empirical evidence reported by (Yao et al., 2019) who found that financial sector development promotes productivity through improved resource allocation. Méndez-Morales & Yanes-Guerra (2021) showed that efficient financial intermediation channels investment toward high-productivity firms while reducing financing constraints. The present study extends this evidence by demonstrating that these relationships remain robust across OECD economies using advanced panel estimation techniques. On the other hand, financial markets and the digital economy do not independently exert a statistically significant influence on productive capacity. One possible explanation is that financial market expansion alone may not generate productivity gains unless supported by efficient institutions and complementary digital infrastructure. Moreover, digitalization without sufficient financial inclusion or investment may fail to translate into higher productive efficiency. This finding partially differs from Byrne (2022) and Hung (2023), suggesting that the effectiveness of digital transformation (Byrne, 2022) depends on country-specific institutional conditions and the maturity of financial systems. The significant moderating effect of the digital economy suggests that digital technologies strengthen the productivity-enhancing role of financial development by lowering transaction costs, improving

information transparency, expanding access to financial services, and accelerating technology diffusion. This finding supports innovation diffusion theory, which argues that digital technologies facilitate the dissemination and adoption of innovation across firms. It also complements signaling theory, whereby digital financial platforms reduce information asymmetry between borrowers and lenders, allowing financial resources to be allocated more efficiently. Therefore, financial development becomes more effective in promoting productive capacity under higher levels of digitalization. This study contributes to the literature by extending the finance–productivity framework through the integration of financial development theory with innovation diffusion and digital economy perspectives. The findings support Schumpeterian theory, showing that financial development enhances productive capacity through efficient resource allocation and technological innovation. Moreover, the significant moderating role of the digital economy demonstrates that digitalization strengthens the productivity gains from financial development by improving financial access, reducing information asymmetry, and facilitating technology adoption. These findings provide a more comprehensive explanation of how financial development and digitalization jointly promote productive capacity.

Conclusion and policy implications

This study examined the impact of financial development on productive capacity and the moderating role of the digital economy, using panel data from OECD countries between 2005 and 2022. The main conclusions are as follows: (1) Financial development significantly enhances productive capacity, with stronger effects observed at lower quantiles and diminishing effects at higher quantiles. (2) Financial markets and financial institutions contribute to productive capacity by improving capital allocation efficiency and supporting productive investment. (3) The digital economy strengthens the positive effect of financial development on productive capacity, particularly in countries operating at lower levels of productive capacity, while its influence weakens at higher quantiles. (4) The productivity-enhancing effects of financial development and digitalization are more pronounced in countries with relatively lower productive capacity, indicating the presence of diminishing returns in more advanced economies.

The findings of this study offer several important policy implications for enhancing productive capacity through financial development and the digital economy. First, since financial development significantly promotes productive capacity, particularly at lower levels of capacity, governments should prioritize strengthening financial markets and institutions. Policies aimed at improving financial inclusion, deepening capital markets, and enhancing the efficiency of financial intermediation can help channel resources toward productive investments, especially in countries operating below their potential capacity. Second, given that the digital economy amplifies the positive effect of financial development on productive capacity, policymakers should actively promote digital transformation. Investments in digital infrastructure, such as broadband networks, data platforms, and digital payment systems, can improve the allocation and utilization of financial resources. Encouraging firms, especially small and medium-sized enterprises, to adopt digital technologies will further enhance productivity gains derived from financial development. Third, the heterogeneous effects across quantiles suggest that a one-size-fits-all policy approach may be ineffective. Countries with lower productive capacity should adopt integrated financial and digital policies to maximize marginal gains, while countries at higher capacity levels may need complementary structural reforms, such as innovation policies and skill development, to sustain productivity growth beyond financial and digital expansion alone. Fourth, policymakers

should focus on coordination between financial and digital strategies. Strengthening regulatory frameworks that support fintech development, digital finance, and secure data usage can enhance the synergy between finance and digitalization, thereby improving productive outcomes. Finally, addressing cross-country disparities within the OECD requires tailored policy designs that consider each country's financial maturity, digital readiness, and productive capacity level to ensure inclusive and sustainable economic growth.

This study contributes to the existing literature by investigating the effect of financial development on productive capacity, while accounting for the digital economy as a moderating variable. However, several limitations of this study should be acknowledged, which provide directions for future research. Firstly, despite using a comprehensive OECD panel, data availability on productive capacity and the digital economy was limited for some countries, which may have the consistency of the variables. Future studies could incorporate data from South Asian regions or sector-specific data to provide greater granularity. Future research could explore quasi-experimental or longitudinal approaches to strengthen causal inferences. Thirdly, the study focused primarily on financial development and productive capacity, while other non-financial factors, such as technological innovation, regulatory environment, demographic shifts, or institutional quality, were not fully integrated. Including these dimensions could offer a more holistic view of employment dynamics.

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Author contributions

Touhidul Islam: Conceptualization, Investigation, Software, Writing – original draft, Writing – review & editing, Supervision, Validation, Visualization, Formal analysis, Data curation, Methodology.
Shahed Mahmud: Conceptualization, Validation, Visualization, Writing – original draft, Writing – review & editing.
Md. Fatin Ilham Tanzim: Validation, Project administration, Resources, Software, Writing – review & editing.

Declaration of competing interest

The authors declare no conflicts of interest.

Ethics statement

Not applicable.

Data availability

Data available on request from the corresponding author.

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