Impact of ICT, Financial Development and Trade on Economic Growth: A Panel Data Analysis of Asian Countries

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Impact of ICT, Financial Development and Trade on Economic Growth: A Panel Data Analysis of Asian Countries

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Certificate

This is to certify that this dissertation entitled **"Impact of ICT, Financial Development and Trade on Economic Growth: A Panel Data Analysis of Asian Countries"**, written by **Mr. Sherzad Ahmed**, is accepted in its current form by School of Economics, Quid-i-Azam University, Islamabad, Pakistan, as satisfying the dissertation requirements for the degree of ***"Master of Philosophy in Economics".***

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Declaration

I, **Sherzad Ahmed**, hereby declare that this thesis, entitled **"Impact of ICT, Financial Development and Trade on Economic Growth: A Panel Data Analysis of Asian Countries"**, is my original work and has been completed under the supervision of **Dr. Muhammad Tariq Majeed**, at **Quaid-i-Azam University, Islamabad**. All sources of information and material used in this thesis have been duly acknowledged and referenced. This thesis has not been submitted, either in part or in full, for any other degree or qualification at any other institution.


بسم الله الرحمن الرحيم

Dedicated to the Reader

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Abstract

This study presents a comprehensive panel data analysis investigating the effect of Information and Communication Technology (ICT), financial development, and trade on economic growth in Asian countries from 2000 to 2019. From a regional perspective, the study explores the individual and interactive effects of these variables across various subregions by utilizing static as well as dynamic panel data approaches. The study findings reveal that ICT and financial development individually show a statistically significant and positive impact on economic growth across the full sample of Asian countries. However, this impact exhibits variations when examined at the subregional level, indicating the effect of region-specific factors. In contrast, trade's impact on economic growth is found to be non-significant for the full sample, but variations exist across subregions, highlighting the diverse trade dynamics within Asia. To explore the impact of trade in more depth, exports and imports are used as proxy variables. The findings demonstrate that exports display a statistically significant positive effect on economic growth, confirming the concept of export-led growth in the region. On the other hand, imports exhibit a negative and significant effect across the full sample and subregions, underscoring the importance of a balanced trade strategy. Moreover, the study shows a positive interactive effect of ICT, financial development, and trade across full sample and subregions. The significance of this interaction, however, varies across subregions. This research study enhances our knowledge of the diverse impacts of ICT, financial development, and trade on economic growth in Asia. The highlighted potential for growth in the region emphasizes the need for targeted policies like investing in digital infrastructure, fostering financial development, and facilitating trade.

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List of Abbreviations

Information and communication technology	ICT
Fixed effect	FE
Random effect	RE
Ordinary least squares	OLS
Generalized Method of Moments	GMM
Cross-sectional Dependence	CD
Lagrangian multiplier	LM
Cross-sectionally Augmented IPS	CIPS
Least squares dummy variable	LSDV
World development indicators	WDI

Chapter 1 Introduction

1.1. Background

The relationship between economic growth and various determinants has been the subject of scholarly research, with researchers seeking to identify the key drivers behind sustainable and robust economic growth. Rapid advancements in technology, increasing financial development, and the deep integration of markets through international trade have significantly transformed the global economic landscape. The key determinants—information and communication technology (ICT) (Niebel, 2018), financial development (Djalilov & Piesse, 2011), and trade (Ji *et al*., 2022) — have evolved into the cornerstones of economic growth strategies for countries all over the world.

Advancements in ICT have transformed the way economies operate, impacting productivity, innovation, and efficiency across various sectors. Rising Internet usage and mobile phone subscriptions from ICT can have three positive effects on economic growth (Sassi & Goaied, 2013; Shahiduzzaman & Alam, 2014). First, it may support innovation and technological diffusion across every sector of the economy. Second, it may improve the decision-making ability of economic actors. Additionally, technology can increase productivity by reducing manufacturing costs and increasing demand for goods and services (Vu, 2011). A surge in the count of mobile and internet users has become evident across numerous developing countries in the Asian region. Six out of the top twenty-five performances on the ICT Development Index are from the Asia-Pacific area, indicating that this region has had the fastest technological growth overall. South Asia and Southeast Asia have experienced exceptional growth in tandem with these changes. The developing economies in South Asia and Southeast Asia are expected to grow at rates of 6.5% and 5.0%, respectively, in 2023 (Asian Development Bank, 2023).

The depth, efficiency, and stability of financial markets and institutions are just a few of the many dimensions of financial development (Levine, 2021). These factors have significant implications for capital allocation, investment, technological innovation, and economic growth. By channeling savings to productive investments and facilitating

capital flows, a well-developed financial system can spur economic growth and promote inclusive development (Estrada et al., 2010). However, it is important to note that the impact of financial development on economic growth is not uniform across all Asian countries. Various factors, including the initial level of financial development, the quality of institutions, and the policy environment, can mediate this relationship (Sahay et al., 2015). Some economies might experience diminishing returns from further financial deepening, while others may face challenges such as financial instability and systemic risks.

Furthermore, trade liberalization and globalization have brought about increased cross-border exchange, facilitating access to larger markets, fostering specialization, and creating avenues for technological diffusion (Salcedo, 2023; Staff, 2001; World Bank, 2018; Xu *et al*., 2020). As Asian countries continue to integrate into the global economy, understanding the magnitude and direction of this integration for their economic growth becomes crucial. However, the potential of trade to act as a driver of economic growth is multidimensional. The degree to which trade positively affects economic growth depends on several factors, such as the level of trade openness, the variety of trading partners, the extent of economic diversification, and the institutional framework that underpins trade policies (Fatima *et al*., 2020; Romer & Frankel, 1999).

Although some studies have individually analyzed the effects of ICT, financial development, and trade on economic growth, there is still a lack of comprehensive analyses investigating the interactions of these factors in a panel data setting for Asian economies (Ahmed & Ridzuan, 2013; Amna Intisar *et al*., 2020; Das *et al*., 2016; Estrada *et al*., 2010; Ximei *et al*., 2022). Thus, against the backdrop of rapid technological advancements, evolving financial landscapes, and dynamic trade dynamics, this research emerges with the purpose of bridging these gaps. By conducting an in-depth panel data analysis, this research study seeks to explore the interactive effects of ICT, financial development, and trade on economic growth. By addressing these gaps within the regional context, the research endeavors to provide valuable insights that can inform policy decisions, guide strategic investments, and catalyze sustainable economic growth.

The significance of analyzing these individual and interactive impacts becomes even more pronounced in the context of the rapid transformations taking place in the region. As Asia continues to rise as a global economic powerhouse, its growth trajectory is increasingly shaped by technological advancements, financial reforms, and global trade dynamics. The findings of this study could offer valuable insights for policymakers and economists to formulate targeted strategies that harness the interactions between ICT, financial development, and trade for sustained and inclusive economic growth.

1.2. Research objectives

The research objectives of the study can be outlined as follows:

- Investigate the degree to which ICT contributes to the economic growth of Asian nations. This will encompass a thorough examination of ICT variables such as internet penetration, mobile phone usage, and telephone subscriptions, aiming to uncover their direct impacts on the growth of GDP.
- Analyze the relationships between economic growth and financial development across Asia. To evaluate how a robust financial sector can act as a catalyst, fostering innovation, stimulating investment, and ultimately enhancing the overall economic performance of the region.
- Analyze the interactions between trade dynamics, including imports and exports, and their contributions to the economic growth of the Asian countries under consideration. This analysis will provide insights into how trade activities influence the region's economic trajectory.
- Examine the interactive relationships among ICT, financial development, and trade. This investigation will reveal how these variables complement each other.
- The study will account for the regional differences within Asia. This will enable the research to capture the interplay between ICT, financial development, trade, and economic growth within unique institutional, economic, and social contexts present across different subregions.

To achieve the research objectives, this study will employ a comprehensive panel data approach, utilizing reliable and robust econometric methodologies. A diverse set of Asian economies will be considered to capture the heterogeneity present within the region.

1.3. Purpose

The primary purpose of this study is to conduct a comprehensive examination of both the individual and interactive impacts of ICT, financial development, and trade on the economic growth of Asian countries. With increasing economic integration, global trade dynamics, and technological advancements, understanding the relationships among these variables has become crucial for sustainable growth and policy formulation in the Asian region. The primary objective is to add to the existing body of knowledge by analyzing the specific contributions made to economic growth in Asian countries by ICT, financial development, and trade. The goal of this study is to provide empirical insights that will help stakeholders, policymakers, and researchers understand how these factors may affect economic growth. This thesis aims at capturing both the cross-sectional and time-series dimensions of the relationships under investigation by performing a panel data regional analysis. A thorough investigation of various economic, social, and institutional factors that may have an impact on the observed relationships can be carried out owing to the inclusion of a wide range of Asian countries.

1.4. Significance of the research

The significance of this study lies in its potential to contribute to both theoretical understanding and policy formulation in the context of economic growth, particularly within the dynamic landscape of Asian economies. The findings of this study can provide policymakers with evidence-based insights into the effective strategies for promoting growth in Asia. By identifying the contributions of these individual and interactive effects to economic growth, policymakers can design targeted policies that leverage the strengths of each variable while mitigating potential risks and challenges. Asia is characterized by a wide range of economic growth levels across its subregions. The focus of the study on different subregions can shed light on the factors driving growth disparities and inform policies that promote more balanced and inclusive growth. Tailoring policies to each

subregion's unique strengths and challenges can help reduce inequalities and foster more equitable growth. Given Asia's increasing influence on the global economy, the study's findings have implications beyond the region. As other economies seek to formulate successful growth strategies, the insights derived from this research can offer valuable lessons and benchmarks for both developing and developed nations.

1.5. Outline

The outline of this study is as follows: Chapter 2 provides the existing literature that highlights the significant advancements made in the field. Chapter 3 presents the empirical framework adopted for the study. This chapter also comprises an explanation of the pre-estimation, estimation, and post-estimation techniques employed. Chapter 4 introduces the data sources and variables that form the basis of the empirical analysis. Drawing insights from both prior research and theoretical foundations, the results derived from the estimated regression methods are carefully examined in Chapter 5. The next section concludes the outcomes of the study. Additionally, policy recommendations are put forward for future research.

Chapter 2 Literature review

This section aims to bridge the gap between the existing body of knowledge and the innovative insights the study seeks to offer. By synthesizing the existing knowledge, this section not only sheds light on the current state of understanding but also identifies the gaps within the chosen research domain. This review of the literature will set the stage for the subsequent chapters, which will address the research objectives of the study. By analyzing the existing literature, this section reveals the dimensions of the effect of ICT, financial development, and trade on economic growth within the Asian context. It reveals the dynamics, patterns, and varying impacts that have been documented across different subregions of Asia. By synthesizing diverse perspectives, methodologies, and findings, this review not only provides an overview of the current landscape but also reveals the pathways through which these variables might interact to shape economic outcomes.

2.1. Economic growth and ICT

Asia is at the forefront of this digital revolution, and the rise of ICT has sparked transformative changes in economies all over the world. Within a regional context, the convergence of ICT and economic growth reveals a dynamic landscape characterized by rapid adoption, innovation, and specific challenges.

The study conducted by Ahmed and Ridzuan (2013) delved into the effect of ICT on the economic growth of the ASEAN 5+3 countries, utilizing panel data spanning the years 1975 to 2006. Through static panel data approaches, their research revealed a positive association between GDP and several factors, including labor, capital, and investments in telecommunications. These findings emphasize the substantial role played by ICT in contributing to economic growth within the specific context of these countries. Similarly, the empirical research conducted by Das et al. (2016) aimed to explore the impact of ICT on the economic growth of developing Asian nations. Their findings provided evidence of a positive association between ICT diffusion and the growth of the regional economy. This research underscores the significant potential of ICT as a driving force behind economic growth in these developing Asian countries.

The study conducted by Aghaei and Rezagholizadeh (2017) provided an in-depth examination of the economies of the Organization of Islamic Cooperation (OIC) countries, covering the years from 1990 to 2014. By employing both static and dynamic panel data approaches within a growth theory framework, their research highlighted the significant impact of investments in ICT on the economic performance of these OIC countries. This study underscores the pivotal role of ICT in driving economic growth within the context of these countries.

Similarly, Hussain et al. (2021) conducted a comprehensive study to explore the effects of ICT adoption on the economic growth of four South Asian countries. Their analysis, spanning the years from 1995 to 2016, unveiled a positive relationship between ICT adoption and the long-run economic growth of these South Asian economies. These findings emphasize the significant contribution of ICT to the sustained economic growth of these countries, providing valuable insights into the role of technology in shaping economic development in the South Asian region

The study conducted by Sharma et al. (2021) examined the relationships between economic growth, energy use, and ICT in a panel comprising ten developing Asian nations, spanning the years from 2000 to 2017. Employing robust econometric methods, their findings revealed not only bidirectional causality between ICT and economic growth but also underscored the positive effects of both internet usage and mobile cellular subscriptions on overall economic growth. This research emphasizes the intricate dynamics between ICT and economic development in the context of these Asian countries.

Similarly, Usman et al. (2021) undertook an empirical investigation aimed at understanding the impact of ICT on energy usage and economic growth within South Asian economies, utilizing a bounds testing approach. Their results highlighted a significant and positive effect of ICT on economic growth, particularly in the long run, with India emerging as a notable performer in this regard. These findings provide valuable insights into the potential of ICT as a driver of economic growth and energy efficiency within the South Asian region.

The empirical investigation conducted by Aziz et al. (2023) aimed to shed light on the relationship between financial development, ICT, and economic growth within a

sample of 10 developing Asian economies during the period spanning from 2001 to 2017. To explore this relationship, the researchers employed several econometric methods, including the autoregressive distributed lag (ARDL), the pooled mean group (PMG), dynamic ordinary least squares (DOLS), and fully modified ordinary least squares (FMOLS). Their findings revealed an intriguing pattern in the relationship between these variables. When examining ICT in isolation, it exhibited a negative association with economic growth. However, this relationship underwent a transformation when ICT was considered in conjunction with financial development. The interaction between ICT and financial development yielded a positive and statistically significant effect on economic growth.

Kurniawati (2022) contributed to the topic by analyzed the causal relationship between ICT and economic growth within both high- and middle-income Asian countries. Analyzing data spanning 25 Asian countries over the years 2000 -2018, the study showed that high-income Asian nations significantly and positively benefited from increased internet penetration. Furthermore, middle-income countries exhibited promising signs of reaping benefits from the adoption of ICT-driven internet technologies.

These studies collectively provide insights into the complex dynamics between ICT, financial development, and economic growth across diverse Asian economies.

2.2. Economic growth and financial development

The relationship between financial systems and economic growth assumes an intriguing dimension within the dynamic context of Asia, a region distinguished by its diversity of economies, regulatory frameworks, and development trajectories. The topic of how financial development catalyzes, and shapes economic growth remains a matter of profound significance as economies in Asia continue to rise on the global stage.

The study conducted by Djalilov and Piesse (2011) investigated the consequences of policies aimed at enhancing economic and financial development in a panel of 27 Central Asian countries, covering the years from 1992 to 2008. The researchers employed ordinary least squares (OLS) and two-stage least squares (2SLS) approaches for their analysis. Surprisingly, their results indicated that, particularly when considering the credit

to the private sector indicator, financial development had an insignificant effect on economic growth within these Central Asian countries. This suggests that the impact of financial development on economic growth may vary and is not always straightforward.

In contrast, the study conducted by Al-Malkawi et al. (2012) focused on exploring the association between economic growth and financial development in the United Arab Emirates, utilizing time series data spanning from 1974 to 2008. The research findings in this case showed a significant and negative relationship between economic growth and financial development within the context of the UAE. This underscores the complexity of these relationships and the need for careful consideration of various factors influencing economic growth.

The study conducted by Malarvizhi et al. (2019) focused on a specific subset of ASEAN-5 countries and analyzed data spanning from 1980 to 2011. Their research aimed to explore the relationship between financial development and economic growth. Their findings indicated a significant and positive effect of financial development on economic growth, highlighting the pivotal role of a robust financial sector in fostering economic growth within these countries.

Sharma and Kautish (2020) analyzed the impact of financial sector development on the economic growth of four South Asian countries during the period from 1990 to 2016 using PMG estimation. Their results suggested that there was a limited impact of the financial sector on economic growth. However, in the long run, financial development contributed positively to economic growth, emphasizing the importance of considering the time horizon when assessing the relationship between financial development and economic growth. Ahmed et al. (2022) explored the role of both financial development and institutional quality in promoting sustainable economic growth across South Asian countries from 2000 to 2018. The findings highlighted the contributions of both financial development and institutional quality as catalysts for sustainable long-run economic growth within the South Asian region.

Together, these studies provide valuable insights into the complex relationship between financial development, institutional quality, and economic growth within

different regions and time periods, offering guidance for policymakers and researchers in their efforts to promote sustainable economic growth.

2.3. Economic growth and trade

As global markets become more integrated and regional dynamics redefine trade patterns, empirical research on how trade affects economic growth in Asia takes on heightened significance.

Shahbaz (2012) conducted a comprehensive study with the aim of examining the impact of trade on long-run economic growth, utilizing the ARDL method. The study's findings revealed a significant role for trade in catalyzing economic growth, emphasizing its potential as a driver of economic growth. Hye and Lau (2015) approached the subject by employing the trade openness index to examine the relationship between economic growth and trade in India. The results of the study revealed that while trade exhibited a short-run positive relationship with growth, it displayed a long-run negative relationship with growth.

Mahmoodi and Mahmoodi (2016) conducted an empirical analysis to explore the causal relationship between exports, FDI, and economic growth across two distinct panels of developing nations. The first panel comprised eight developing European countries, while the second panel encompassed eight Asian developing countries. Their findings indicated bidirectional causality between exports and economic growth in the short run within the panel of developing Asian countries. This implies that exports and economic growth may mutually influence each other in the short term within the Asian context.

Rahman et al. (2020) conducted an extensive analysis using panel data from five South Asian countries, covering the years from 1990 to 2017. Their findings suggested a negative impact of trade on the growth of the South Asian economy. This highlights the complex dynamics surrounding the relationship between trade and economic growth in this specific context.

Islam (2022) focused on the trade-led growth theory within South Asia. Utilizing PMG estimation, the study revealed a positive relationship between economic growth and

trade. This suggests that trade can indeed be a driving force behind economic growth within the South Asian region. These findings provide valuable insights into the potential for trade to stimulate economic growth in South Asia, offering a different perspective on the relationship between trade and economic development in the region.

These studies contribute to our understanding of the complex interactions between trade and economic growth, emphasizing the need to consider the specific context and factors at play in different regions when assessing the impact of trade on economic expansion. Such insights can inform policy decisions and strategies aimed at leveraging trade for sustainable economic development.

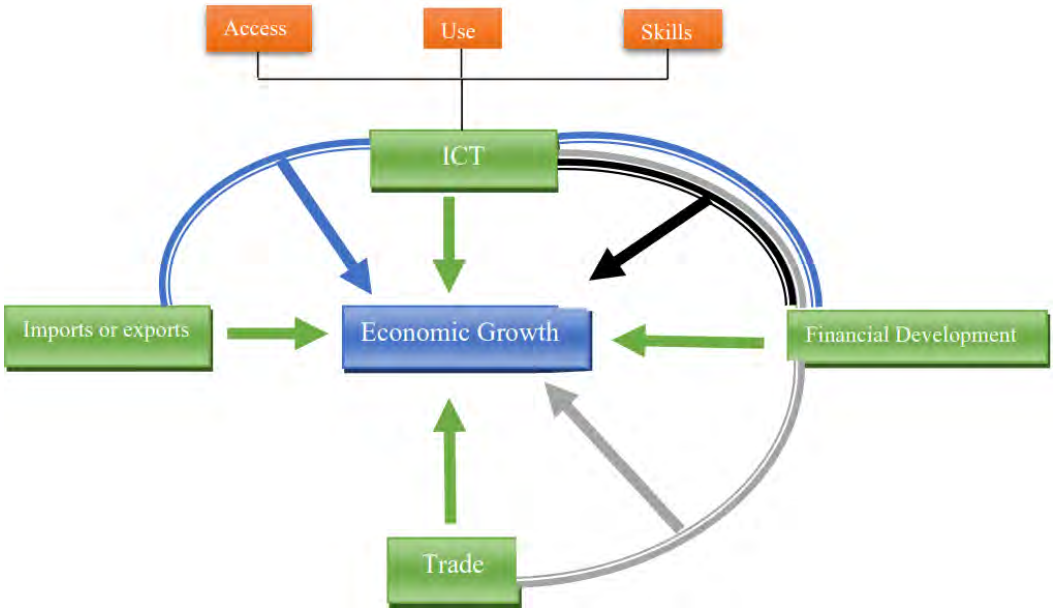

Figure 1. Visual representation of individual and interactive impacts of ICT, financial development, trade, imports, and exports on economic growth.

2.4. Research gap

The individual and interactive effects of ICT, financial development, and trade on economic growth in Asia represent a huge research gap that needs to be addressed. The individual effects of ICT, financial development, and trade on economic growth have been extensively studied in the literature; however, no empirical studies have looked at the potential interactions between these variables in the Asian setting. Also, despite the importance of regional dynamics, there has not yet been any comparative regional research conducted in Asia, creating a significant research gap. This gap highlights the exceptional opportunity to advance the field by carrying out a thorough comparative analysis across five regions. In contrast to earlier studies, this study uses three aspects of the digital economy—access, usage, and skills—to provide a more comprehensive ICT index. This study seeks to address these gaps in the literature in order to provide insights that go beyond specific regional analyses and create a more thorough understanding of the interactions between these variables and their effects on economic growth in the Asian region.

Chapter 3 Methodology

This chapter establishes a solid framework for investigating the individual and interactive effects of ICT, financial development, and trade on growth. Beginning with a theoretical foundation, the chapter elaborates on the relationship between these variables and explores interactions. The empirical framework is then introduced, highlighting the datasets and preliminary analyses, including cross-section dependence, unit roots, cointegration, and causality tests. The panel estimation methods are divided into two segments: static and dynamic methods. Overall, this chapter bridges theory and practice, outlining a systematic pathway for uncovering the dynamics shaping economic growth.

3.1. Theoretical framework

The New Growth Theory, which is an extension of the Endogenous Growth Theory, provides an economic framework that can relate ICT, financial development, and trade to economic growth. The New Growth Theory, developed by (Romer, 1986) and (Lucas Jr, 1988), posits that economic growth is not solely driven by exogenous factors (such as capital and labor), but it can also be affected by endogenous factors, such as technological progress, knowledge accumulation, and innovation.

In the context of New Growth Theory, the incorporation of ICT, financial development, and trade can be understood as follows:

3.1.1. ICT and economic growth

ICT is essential for fostering innovation, increasing productivity, and creating new knowledge. Investment in ICT infrastructure and adoption can result in increased R&D efforts, better business operations, and higher efficiency. Higher productivity as a result of this technological advancement fuel economic growth, which ultimately helps to increase GDP and income (Nair *et al*., 2020).

The Cobb-Douglas production function displays the relationship between inputs (capital and labor) and output (growth) in an economy. Incorporating ICT as an additional factor in this framework allows us to analyze how ICT affects economic growth. The standard Cobb-Douglas production function is given by:

$$Y = AL^{\alpha}K^{\beta} \ldots\ldots\ldots\ldots\ldots\ldots \textbf{(1)}$$

Where:

Y = Output (economic growth)

A = Technological factor

L = Labor Stocks

K= Capital Stocks

α = elasticities of stocks labor

β = elasticities of stocks capital

To incorporate ICT, we modify the production function as follows:

$$Y = AL^{\alpha}K^{\beta}I^{\gamma} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{(2)}$$

Where:

I = ICT

γ = ICT's contribution to growth

The incorporation of ICT into the Cobb-Douglas production function provides a way to understand how the adoption of emerging technologies affects economic growth. It stresses the importance of ICT in raising the productivity and efficacy of traditional inputs and the role played by technological advancement in fostering economic growth.

3.1.2. Financial development and economic growth

Economic growth can be fueled by a well-developed financial system that is characterized by effective capital allocation and intermediation (Taddese Bekele & Abebaw Degu, 2023). Financial sector aids in the mobilization of savings and allocate funds towards profitable investments. Access to credit encourages innovation, R&D, and entrepreneurship, fostering the economic activities that drive growth.

Expanding the production function to include financial development (F):

$$Y = AL^{\alpha}K^{\beta}I^{\gamma}F^{\Psi} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{(3)}$$

Where:

F = Financial development

Ψ = Financial development's contribution to growth

When financial development is taken into account within the context of the Cobb-Douglas production function, the larger system in which production takes place is recognized, and it is acknowledged that the effectiveness of resource allocation and the availability of finance can have a big impact on the production process. The ability to undertake a more extensive analysis that considers the relationship between financial development and economic outcomes is made feasible by this addition.

3.1.3. Trade and economic growth

Exposure to international markets through trade promotes technology transfer, knowledge spillovers, and absorbing best practices globally. Trade expansion results in competition, which pushes businesses to develop new products and raise productivity to stay ahead of the competition (Melitz & Redding, 2021). Trade-based market expansion can lead to economies of scale, which can further increase production and growth.

The production function can be further extended to incorporate trade (T):

$$Y = AL^{\alpha}K^{\beta}I^{\gamma}F^{\Psi}T^{\delta} \text{..... (4)}$$

Where:

T = Trade

δ = Trade's contribution to growth

To further breakdown the effect of trade, the variables of imports and exports are utilized.

$$Y = AL^{\alpha}K^{\beta}I^{\gamma}F^{\Psi}M^{\zeta}X^{\vartheta} \text{..... (5)}$$

Where:

M = Imports

X = Exports

ζ and ϑ = Imports and exports' contribution to growth

3.1.4. Interactive effect of ICT and financial development

ICT enhances productivity by fostering innovation, knowledge creation, and technological advancement. It can lead to improved information flows, which in turn enable financial institutions to better assess risks and allocate resources. Financial development supports and facilitates efficient resource allocation, enabling successful implementation of ICT projects and innovation-driven entrepreneurship.

The production function can be modified as:

$$Y = AL^{\alpha}K^{\beta}I^{\gamma}F^{\Psi}T^{\delta}(I * F)^{\rho} \ldots\ldots\ldots\ldots\ldots \textbf{(6)}$$

Where:

(I * F) = interactive impact of ICT and financial development.

ρ = Degree of interaction

Incorporating the interactive effect of ICT and financial development within the New Growth Theory framework sheds light on how these variables work together to drive economic growth. This approach underscores the dynamic interplay between innovation, finance, and sustained economic expansion, aligning with the principles of the New Growth Theory.

3.1.5. Interactive effect of ICT, financial development, and trade

In the New Growth Theory framework, the interplay of these variables - ICT, financial development, and trade - can be seen as mechanisms that generate endogenous growth. Technological progress driven by ICT investments, efficient capital allocation through financial development, and the exposure to global markets through trade all contribute to the accumulation of knowledge, innovation, and productivity gains. These factors reinforce each other, creating a virtuous cycle that propels economic growth over time.

The production function can be modified as:

$$Y = AL^{\alpha}K^{\beta}I^{\gamma}F^{\Psi}T^{\delta}(I * F * T)^{\eta} \ldots\ldots\ldots\ldots\ldots \textbf{(7)}$$

Where:

(I * F*T) = interactive impact of ICT, financial development, and trade.

η = Degree of interaction

This interaction can be modified to incorporate imports and exports instead of trade:

$$Y = AL^{\alpha}K^{\beta}I^{\gamma}F^{\Psi}T^{\delta}(I * F * X)^{\eta_1} \ldots\ldots\ldots\ldots\ldots \textbf{(8)}$$

$$Y = AL^{\alpha}K^{\beta}I^{\gamma}F^{\Psi}T^{\delta}(I * F * M)^{\eta_2} \ldots\ldots\ldots\ldots\ldots \textbf{(9)}$$

It provides a theoretical foundation to understand how the integration of ICT, financial development, and trade can interactively contribute to economic growth by fostering knowledge accumulation, innovation, and increased productivity within an economy.

3.2. Empirical framework

The log-transformed Cobb-Douglas production function with constant returns to scale offers a comprehensive framework to examine the individual and interactive effect of ICT, financial development, and trade on economic growth.

$$ln(Y)_{it} = \alpha_0 + \alpha \ln(L)_{it} + \beta \ln(K)_{it} + \gamma \ln(I)_{it} + \Psi \ln(F)_{it} + \delta \ln(T)_{it} + \ln(C)_{it} + \theta_i + \omega_i + \mathcal{E}_{it} \ldots\ldots\ldots\ldots\ldots\ldots \textbf{(10)}$$

Where:

ln(Y) = Log of Output (Gross Domestic Product)

ln(K) = Log of Capital input

ln(L) = Log of Labor input

ln (I) = vector of the log of indicators of ICT

ln (F) = Log of financial development

ln (T) = Log of trade

ln (C) = Vector of log of control variables

α_0 = The constant

θ_i = Year dummies.

ω_i = Regional Dummies

$\mathcal{E}_{it}$= Random error term

If we use variables of imports and exports instead of trade, the model is modified as:

$$ln(Y)_{it} = \alpha_0 + \alpha \ln(L)_{it} + \beta \ln(K)_{it} + \gamma \ln(I)_{it} + \Psi \ln(F)_{it} + \vartheta \ln(X)_{it} + \zeta \ln(M)_{it} + \ln(C)_{it} + \theta_i + \omega_i + \mathcal{E}_{it} \ldots\ldots\ldots\ldots \textbf{(11)}$$

In case of interaction between ICT and financial development:

$$ln(Y)_{it} = \alpha_0 + \alpha \ln(L)_{it} + \beta \ln(K)_{it} + \gamma \ln(I)_{it} + \Psi \ln(F)_{it} + \delta \ln(T)_{it} + \ln(C)_{it} + \rho \ln(I * F)_{it} + \theta_i + \omega_i + \mathcal{E}_{it} \ldots\ldots\ldots \textbf{(12)}$$

In case of interaction between ICT, financial development, and trade:

$$ln(Y)_{it} = \alpha_0 + \alpha \ln(L)_{it} + \beta \ln(K)_{it} + \gamma \ln(I)_{it} + \Psi \ln(F)_{it} + \delta \ln(T)_{it} + \ln(C)_{it} + \eta \ln(I * F * T)_{it} + \theta_i + \omega_i + \mathcal{E}_{it} \ldots\ldots\ldots\ldots \textbf{(13)}$$

ICT and financial development are further interacted with imports and exports:

$$ln(Y)_{it} = \alpha_0 + \alpha \ln(L)_{it} + \beta \ln(K)_{it} + \gamma \ln(I)_{it} + \Psi \ln(F)_{it} + \delta \ln(T)_{it} + \ln(C)_{it} + \eta_1 \ln(I * F * X)_{it} + \theta_i + \omega_i + \mathcal{E}_{it} \ldots\ldots\ldots \textbf{(14)}$$

$$ln(Y)_{it} = \alpha_0 + \alpha \ln(L)_{it} + \beta \ln(K)_{it} + \gamma \ln(I)_{it} + \Psi \ln(F)_{it} + \delta \ln(T)_{it} + \ln(C)_{it} + \eta_2 \ln(I * F * M)_{it} + \theta_i + \omega_i + \mathcal{E}_{it} \ldots\ldots\ldots\ldots \textbf{(15)}$$

3.3. Dataset

A comprehensive panel dataset encompassing 32 Asian countries from 2000 to 2019 was employed for this study. The chosen period enables the analysis of changes and trends in the variables of interest while considering how the economic environment has changed over the previous two decades. A panel dataset can be used to account for both cross-sectional and temporal variations, offering a solid framework for analysis.

This study does not employ traditional classifications like developing, developed, underdeveloped, or middle-high income. Instead, a regional classification approach is used, which divides the 32 Asian countries into five different regions. This approach acknowledges the various economic and developmental contexts in Asia and allows an examination of the interactions among ICT, financial development, and trade in each of these contexts.

To investigate these relationships, both static and dynamic estimation techniques are employed. Static estimation techniques offer insights into contemporaneous effects, while dynamic estimation techniques take into account lagged effects. By employing this comprehensive and regionally focused dataset, the study seeks to yield valuable insights into the dynamics of ICT, financial development, trade, and economic growth across diverse Asian subregions. The regional classification additionally enhances the significance of the findings by considering the distinct dynamics operating within each of these economic zones.

3.4. Preliminary analysis

3.4.1. Test for cross-section dependence (CD)

Overlooking common correlation effects in panel data might alter the estimate findings (Baltagi *et al*., 2007); hence, the cross-sectional dependence (CD) test is used to look for potential common correlation effects between the variables. These tests serve as crucial tools for detecting cross-sectional dependence in the data.

3.4.2. Panel unit root test

At this stage, a test is run to determine the order in which all the variables will be integrated. A first-generation unit root analysis may produce results that are biased if CD is present. Second-generation unit root analysis is utilized due to the CD of errors and the heterogeneity of slope (Pesaran, 2003; Pesaran, 2007). The analysis conducted using the cross-sectionally augmented IPS (CIPS) offers a higher level of reliability (Baltagi *et al*., 2007).

3.4.3. Panel cointegration test

The co-integration test is carried out once the order of integration of variables has been determined. The aim is to determine whether there is a linear combination between the stationary variables in levels and in first differences. By examining cointegration, it is possible to evaluate whether the variables have a long-run equilibrium relationship. The panel cointegration test proposed by Pedroni (2020) is used in this study to address the issues of CD and slope heterogeneity.

3.4.4. Dumitrescu and Hurlin causality test

To verify the reliability of econometric findings, a dynamic Granger non-causality analysis is utilized (Dumitrescu & Hurlin, 2012). While the Granger test implies that the coefficients are similar for every cross-section of the panel data, this test implies that the coefficients vary across cross-sections. Time series and cross-sectional data are combined in this test, granting it special power.

3.5. Panel estimation methods

Panel data estimation has gained prominence as an efficient analytical approach for econometric data analysis. Cross-sectional entities including households, countries, organizations, and individuals are heterogeneous in panel data. Studies using time series and cross-sections that fail to account for this variation face the challenge of producing unreliable results (Moulton, 1987). This method offers the advantage of utilizing data from cross-sections (N) over time periods (T). Consequently, panel data analysis has become increasingly popular among social scientists, enabling them to unravel complex relationships and trends within their research domains. Panel data offers more reliable information, decreased collinearity between variables, increased efficiency, and a greater degree of freedom (Baltagi, 2021).

Both the whole sample and the regional subsamples of countries are subjected to econometric analysis. Different estimators for estimating the Cobb-Douglas production function for the sample regressions are employed. The pooled ordinary least squares (OLS) effects model is one of the static estimating models used in this study. A pooled OLS regression is used as the baseline model. A panel data regression model with fixed

effects (FE) and a random effects (RE) estimator is also employed. While FE and RE estimators take into consideration the potential heterogeneities across the samples, the OLS estimation method overlooks these concerns. The dynamic estimation model, two-step system GMM, is also utilized to correct for potential endogeneity (Murtazashvili & Wooldridge, 2008).

Pooled OLS estimation is applied to both the entire sample and its subsamples. Due to practical constraints and a limited number of observations, FE, RE, and dynamic techniques are only used on the whole sample and are not applied to smaller sub-samples.

3.5.1. Static models

Pooled ordinary least square method

The pooled OLS technique, also known as the common constant method, offers results based on the fundamental assumption that there are no differences between the data matrix and the cross-sectional dimension (N). In other terms, a common constant is estimated by the model for all cross-sections (Wooldridge, 2015).

Fixed effect estimation method

The FE estimation method treats the constant as cross-section specific. This shows that for each cross-section, the model can use a different set of constants. The FE estimation, also called the least squares dummy variable (LSDV) estimation, includes a dummy variable that is assigned to each cross-section (Wooldridge, 2015).

Testing for fixed effects

To check the validity of the FE approach, F-test is employed that determines the joint significance of the dummy variables. The pooled regression supports of the null hypothesis. The alternative hypothesis supports the FE.

$$H_0: \mu_1 = \mu_2 = \cdots = \mu_N = 0$$

$$H_1: \mu_i \neq 0$$

The random effects method

Another method of estimation is the RE model. As opposed to the FE, it treats the constants for each cross-section as random parameters. A clear limitation of the RE

technique is the need to make presumptions regarding the distribution of the random component. Also, the estimates may be inconsistent and biased if the unobserved cross-sectional effects are correlated with the explanatory variables (Das, 2019).

Breusch and Pagan Lagrangian multiplier (LM) test for random effects

The choice between RE and OLS estimation can be made using the Breusch and Pagan LM test. The null hypothesis of the test is that the variance across cross-sections is zero. This indicates that there are no significant differences between the cross-sections. If the test statistics do not support the null hypothesis, then the heterogeneity of the panel data is random. This heterogeneity can be handled using the RE model (Baltagi & Baltagi, 2008).

$$H_0: \sigma^2_\mu = 0$$

$$H_1: \sigma^2_\mu > 0$$

Fixed or random effect: Hausman test

A formal testing of hypotheses is conducted to determine whether the RE or the FE is most appropriate for this model. The Hausman specification test, which contrasts models with fixed and random effects, is the most widely used test. Individual effects being uncorrelated with any of the model's regressors is the null hypothesis for this test (Hausman, 1978). In other words, the preferred model, RE, is the null hypothesis in the Hausman test, while FE is the alternative. The FE is appropriate if the null hypothesis is rejected (Greene, 2008).

$$H_0: E(u_{it}|X_{it}) = 0$$

$$H_1: E(u_{it}|X_{it}) \neq 0$$

If the null hypothesis is found to be rejected, it can be argued that individual effects have a significant correlation with at least one independent variable. FE model is an effective estimator in this case since the RE model is not appropriate.

3.5.2. Dynamic model

Two-step system generalized method of moments (GMM)

To address the issue of endogeneity, a dynamic approach, i.e., a two-step system GMM approach, is implemented. The two-step system GMM is a robust econometric technique that helps mitigate potential endogeneity issues. By employing this dynamic approach, the robustness and credibility of empirical findings can be enhanced (Das, 2019). This ensures that the estimated relationships between ICT, financial development, trade, and economic growth are less susceptible to biases caused by endogeneity, ultimately contributing to a more accurate analysis.

Chapter 4 Data Source and Variables

The following sections provide a brief overview of the variables under study. In Section 4.1, an introduction to the variable will be provided. In Section 4.2, the source of the data variables is described. Section 4.3 describes all the variables. In Section 4.4, descriptive statistics of variables of interest are presented, which include graphical and tabular representations of the data. Finally, in the Section 4.5, a correlation matrix is tabulated to examine the correlation between the variables.

4.1. Introduction of variables

Within the quantitative analysis conducted in the thesis, variables are classified as dependent, independent, and control variables. The main variable of our study is GDP per capita (GDP), which serves as the dependent measure. Independent variables in this study are ICT components such as mobile cellular subscription (MCSUB), individuals using the internet (IUIT), fixed telephone subscription (FTSUB), and secondary school enrollment (SSY). Furthermore, financial development is proxied by domestic credit to the private sector (DC2PS). Trade (TR), imports (IM), and exports (EX) are used as measures of trade. Capital input, as represented by gross fixed capital formation (GFC), and labor input, indicated by labor force participation (LFP), are also taken into account. Control variables within the analysis comprise inflation measured by the Consumer Price Index (CPI) and government final consumption expenditure (GFE).

4.2. Source of variables

All of the variables used in the analysis, which covers 36 Asian nations from 2000 to 2019, are taken from the World Development Indicators (WDI). The primary rationale for limiting the sample period is that, before 2000, the ICT variables in the majority of Asian nations had missing values. Therefore, the time period must be limited to include a greater number of countries in order to increase the representation of the continent.

4.3. Description of the variables

4.3.1. Gross domestic product per capita

The average economic output or income of a country per person is measured by GDP per capita. It is determined by dividing a country's total GDP by its population. As it approximates the average income or economic output that each individual contributes to within the nation, this metric offers insight into the economic well-being and standard of living of a country's citizens (Jin & Cho, 2015).

4.3.2. Trade

The number of goods exported and imported divided by the GDP in current US dollars is used to calculate the volume of trade. Economic growth is expected to benefit from trade between countries. The efficient use of capital and technological transfer is facilitated through trade with other countries (Martínez-Zarzoso & Chelala, 2021).

4.3.3. Imports

It is the percentage of imports relative to a country's GDP. A higher percentage of imports may suggest that the economy heavily depends on international trade for meeting domestic production and consumption needs. This relationship highlights the integration of economies and underscores the importance of global trade dynamics in shaping a country's economic structure and growth trajectory.

4.3.4. Exports

It represents the proportion of a country's GDP that is derived from the value of goods and services sold to other countries. A higher percentage of exports relative to GDP indicates that a considerable portion of a country's economic growth stems from its ability to compete and engage in global markets. This relationship highlights the role of exports in driving economic growth, facilitating job creation, and improving competitiveness of a nation on the global stage.

4.3.5. Gross fixed capital formation

Gross fixed capital formation is used to describe the net increase in physical assets over the course of the measurement period. It evaluates the absorptive capacity to produce, which affects the growth of the economy (Ugochukwu & Chinyere, 2013). A positive relationship is projected between gross fixed capital formation and economic growth.

4.3.6. Labor force participation

The proportion of the population that is economically active is known as the labor force participation rate. Due to the high cost of capital acquisition in developing nations, labor is a crucial production component. Therefore, in order to achieve a high degree of growth, it is crucial that the technical knowledge and education required be gained (Flaminiano *et al*., 2022). Consequently, its role in this model is to reflect how labor input influences economic growth, and a positive coefficient is expected.

4.3.7. Domestic credit to private sector

Domestic credit to the private sector represents the proportion of credit extended by financial institutions to the private sector in an economy, indicating the accessibility of funding for various economic activities. As credit availability to the private sector increases, it can stimulate consumption, investment, and business activities, ultimately fostering economic development and growth. A higher percentage of domestic credit to the private sector is indicative of a supportive financial environment that encourages capital formation, entrepreneurship, and innovation, all of which contribute positively to the overall GDP of the country.

4.3.8. ICT components

Individuals using the internet: The percentage of the population using the internet shows the extent of digital connectivity and information dissemination.

Mobile cellular subscription: It is the number of mobile cellular subscriptions per 100 people. It provides insights into mobile communication accessibility and utilization.

Fixed telephone subscription: The number of fixed telephone subscriptions per 100 people indicate the prevalence of landline communication infrastructure.

Secondary school enrollment: It is the total number of students enrolled in secondary education (typically grades 9 to 12), represented as a percentage of the total population of those officially in the secondary school age range.

4.3.9. Government final consumption expenditure

Government spending on goods and services for consumption contributes to overall economic activity. A higher level of government consumption expenditure often contributes positively to GDP, reflecting the government's role in fostering economic growth and development through its initiatives.

4.3.10. Consumer price index

It is an indicator of price changes in a basket of goods and services, which can influence economic stability. While moderate levels of inflation can stimulate spending and investment by maintaining consumer purchasing power, excessively high or volatile inflation can hinder economic growth.

Table 1. Key economic variables used in the study.

Variable	Unit	Abbreviation	Data Source
Gross Domestic Product Per Capita	Current US$	GDP	WDI
Gross Fixed Capital Formation	Current US$	GFC	WDI
Labor Force, total	Number of Individuals	LFP	WDI
Fixed Telephone Subscriptions	Per 100 people	FTSUB	WDI
Individuals Using the Internet	Per 100 people	IUIT	WDI
Mobile Cellular Subscriptions	Per 100 people	MCSUB	WDI
Secondary School Enrollment	% Gross	SSY	WDI
Domestic Credit to Private Sector	% of GDP	DC2PS	WDI
Trade	% Of GDP	TR	WDI
Imports	% of GDP	IM	WDI
Exports	% Of GDP	EX	WDI
Consumer Price Index	Annual %	CPI	WDI
Government Final Consumption Expenditure	% Of GDP	GFE	WDI

4.4. Descriptive statistics

The summary statistics of the variables are presented in **Table 2** for the full sample. The dataset provides valuable insights into the economic factors that influence GDP. **Figure 2** shows an upward trend in mean GDP from the year 2000 to 2019. During these two decades, Asia maintained an average GDP of approximately US$11,926.393. Within this diverse continent, Macau stood out as the economic leader, boasting the highest GDP at an impressive US$90,873.93. In stark contrast, Tajikistan emerged with the lowest GDP value, a mere US$137.1786. These figures underscore the remarkable disparity in economic performance across the region's countries, emphasizing the dynamic nature of Asia's financial landscape.

Table 2. Summary statistics of variables for entire sample (2000-2019).

Variables	Observations	Mean	Standard	Maximum	Minimum
GDP	640	11926.393	15690.988	90873.93	137.179
GFC	640	$1.816 * 10^{11}$	$6.247* 10^{11}$	$6.115* 10^{12}$	63863604
LFP	640	54583704	$1.519* 10^{8}$	$8.000* 10^{11}$	156443
FTSUB	640	19.202	17.056	63.095	.19
IUIT	640	33.946	29.278	99.701	.047
MCSUB	640	85.737	60.151	436.103	.019
SSY	640	82.636	19.594	120.651	17.285
DC2PS	640	66.911	51.28	254.668	3.829
TR	640	101.839	77.926	442.62	19.56
IM	640	51.639	37.292	221.01	9.099
EX	640	50.073	42.577	228.994	7.78
CPI	640	4.977	6.227	54.915	-18.109
GFE	640	13.493	4.817	29.399	3.46

Capital input, represented by the GFC, has a mean of US$181.6 billion. While LFP shows a mean value of US$54583704. High standard deviation values for GFC and LFP indicate that the observations for these variables are widely scattered around the mean value. Examining the ICT components, the average IUIT stands at 33.946 %, while MCSUB averages around 85.737 %, and FTSUB averages 19.202 %. The SSY, with an average of 82.636, underscores the educational context. In order to better understand the evolution of ICT components, **Figure 3** shows the trend of mean values throughout the analyzed period.

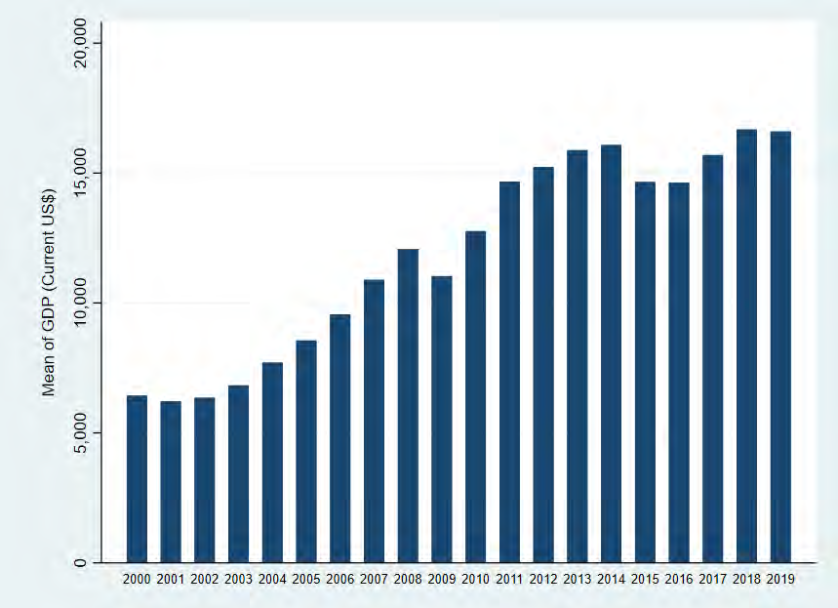

Figure 2. Trend of GDP for entire sample (2000-2019).

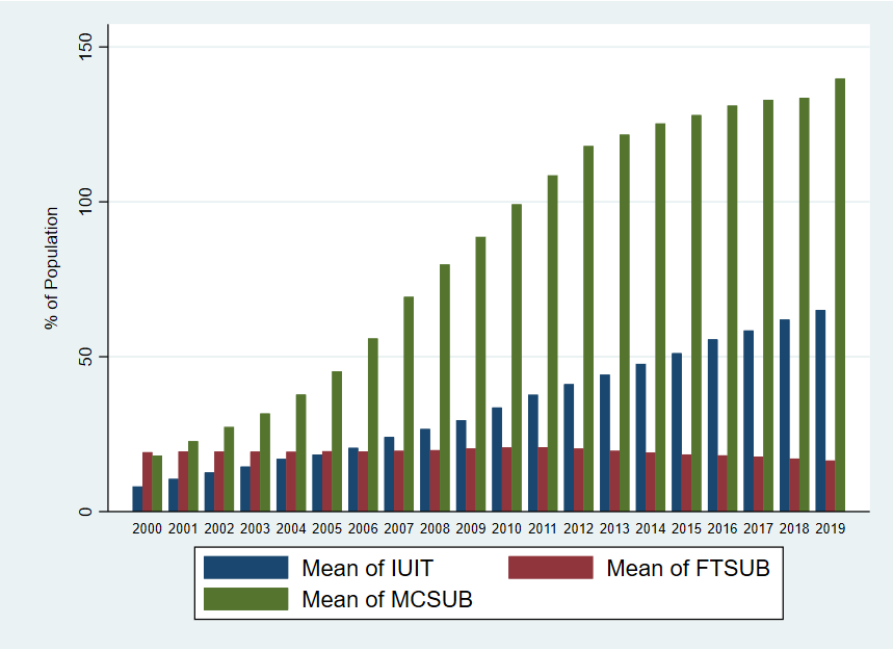

Figure 3. Trend of mean values of ICT components (2000-2019).

Regarding financial development, the mean DC2PS is 66.911%. There has been a consistent increase in financial development, as illustrated by the upward trajectory of mean values of DC2PS over the years in **Figure 4**. Additionally, TR shows an average value of 101.839%, highlighting the significance of trade in the economic landscape of Asia. The trade pattern is relatively consistent, as shown in **Figure 5.** Furthermore, IM and EX have mean values of 51.639% and 50.073%, respectively.

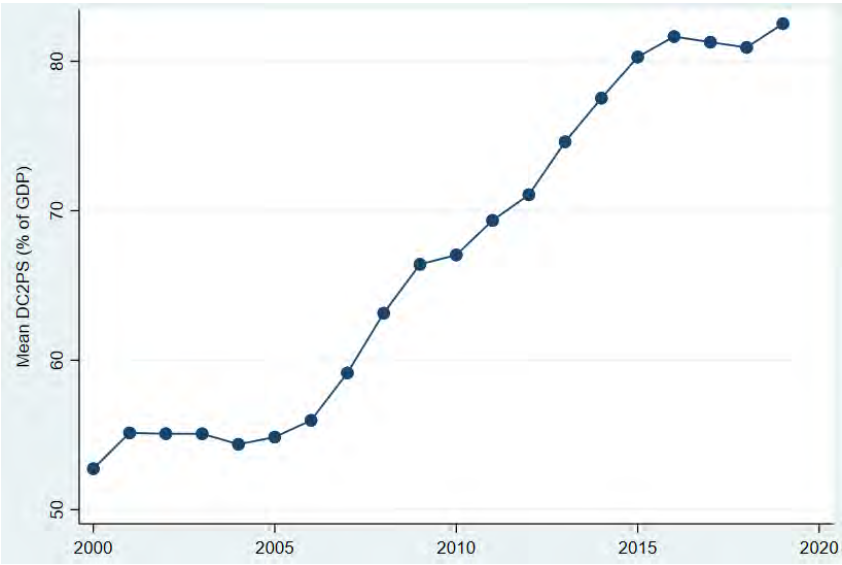

Figure 4. Trend of mean values of DC2PS (2000-2019).

Control variable, such as GFE, which has a mean value of 13.493%, represents the extent of government expenditure on final goods and services. On the other hand, CPI, averaging at 4.977%, serves as a vital measure of inflation and price movements. These findings highlight the diversity of the economic, technological, and social landscape across the entities, motivating a thorough analysis to uncover potential relationships and effects on GDP through further statistical exploration.

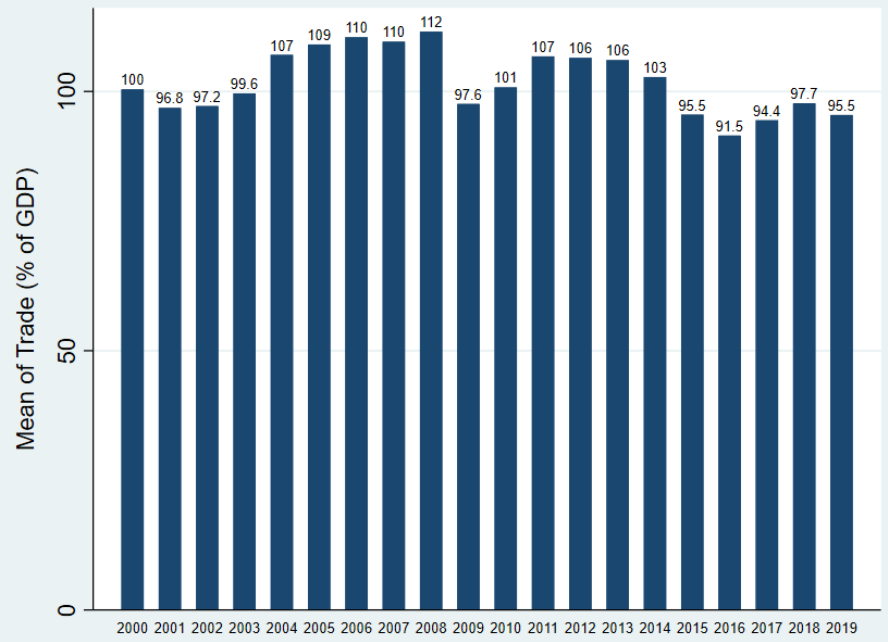

Figure 5. Trend of mean values of TR (2000-2019).

Table 3. Summary statistics of variables for South Asia (2000-2019).

Variables	Observations	Mean	Std. Dev.	Maximum	Minimum
GDP	140	1834.495	1646.689	8329.002	223.712
GFC	140	$9.284* 10^{10}$	$1.779* 10^{11}$	$8.093* 10^{11}$	$2.216* 10^{8}$
LFP	140	87033721	$1.503* 10^{8}$	$4.827* 10^{8}$	248668
FTSUB	140	7.906	10.89	38.818	.385
IUIT	140	12.517	14.611	77.771	.071
MCSUB	140	51.111	41.88	142.651	.043
SSY	140	63.929	21.954	100.435	19.011
DC2PS	140	38.029	14.796	78.845	9.161
TR	140	51.623	22.276	116.55	25.306
IM	140	30.077	14.071	72.444	13.244
EX	140	21.18	9.906	56.276	7.78
CPI	140	8.068	6.455	39.907	-18.109
GFE	140	11.16	4.509	22.704	4.846

Table 4. Summary statistics of variables for Southeast Asia (2000-2019).

Variables	Observations	Mean	Std. Dev.	Maximum	Minimum
GDP	140	13161.44	17203.897	66859.336	301.517
GFC	140	$6.135* 10^{10}$	$7.650* 10^{10}$	$3.620* 10^{11}$	$6.306* 10^{8}$
LFP	140	30453824	37594553	1.362* 108	156443
FTSUB	140	14.434	12.67	48.301	.19
IUIT	140	35.348	28.059	95	.047
MCSUB	140	91.078	49.896	186.159	1.074
SSY	140	79.656	19.954	120.651	17.285
DC2PS	140	69.322	42.686	149.373	5.988
TR	140	144.027	99.608	437.327	37.421
IM	140	67.033	46.76	208.333	18.332
EX	140	77	53.643	228.994	18.592
CPI	140	2.917	3.272	24.097	-2.315
GFE	140	12.092	5.449	29.399	3.46

Table 5. Summary statistics of variables for East Asia (2000-2019).

Variables	Observations	Mean	Std. Dev.	Maximum	Minimum
GDP	120	24926.264	21236.447	90873.93	463.854
GFC	120	$7.385* 10^{11}$	$1.288* 10^{12}$	$6.115* 10^{12}$	$2.731* 10^{8}$
LFP	120	$1.454* 10^{8}$	$2.836* 10^{8}$	$8.000* 10^{8}$	215323
FTSUB	120	36.305	19.357	62.611	4.901
IUIT	120	53.088	29.707	96.158	1.256
MCSUB	120	119.935	83.084	436.103	6.449
SSY	120	89.948	11.875	107.74	60.084
DC2PS	120	118.244	55.272	236.755	6.933
TR	120	126.153	112.505	442.62	19.56
IM	120	59.327	56.317	221.01	9.099
EX	120	66.826	57.511	221.61	10.077
CPI	120	3	4.056	27.956	-3.686
GFE	120	13.542	3.52	19.957	6.501

Table 6. Summary statistics of variables for West Asia (2000-2019).

Variables	Observations	Mean	Std. Dev.	Maximum	Minimum
GDP	180	13137.498	10932.282	44452.234	603.298
GFC	180	$2.996* 10^{10}$	$6.008* 10^{10}$	$2.715* 10^{11}$	$4.151* 10^{8}$
LFP	180	4353798.4	7887509.3	33420003	305968
FTSUB	180	23.084	14.247	63.095	3.52
IUIT	180	40.848	28.472	99.701	.485
MCSUB	180	88.94	46.545	210.049	.57
SSY	180	91.527	11.783	107.583	57.885
DC2PS	180	68.761	50.688	254.668	5.64
TR	180	93.606	31.94	191.873	42.354
IM	180	49.757	15.814	94.204	22.473
EX	180	43.689	19.921	104.805	14.178
CPI	180	4.174	7.197	54.915	-3.749
GFE	180	16.409	4.161	26.125	8.119

Table 7. Summary statistics of variables for Central Asia (2000-2019).

Variables	Observations	Mean	Std. Dev.	Maximum	Minimum
GDP	60	2959.32	3923.667	13890.631	137.179
GFC	60	$1.070* 10^{10}$	$1.604* 10^{10}$	$5.178* 10^{10}$	63863604
LFP	60	4305874.6	3020828.7	9227219	1588518
FTSUB	60	10.837	7.262	26.036	3.515
IUIT	60	21.685	23.431	81.878	.049
MCSUB	60	76.067	57.228	180.493	.019
SSY	60	91.936	9.46	114.244	72.884
DC2PS	60	20.458	12.56	58.94	3.829
TR	60	96.65	30.918	175.351	53.05
IM	60	56.304	21.678	99.669	24.428
EX	60	40.311	15.968	86.752	9.17
CPI	60	8.933	6.903	38.592	.389
GFE	60	13.357	3.525	20.106	8.264

Across the subregions, the lowest mean GDP is in Central Asia (US$2959.32), and the highest is in East Asia (US$24926.26). The highest mean GFC is shown by East Asia at US$738.5 billion, while the lowest is in Central Asia at US$10.70 billion. It shows the relative absorptive capacity of these regions. The largest mean LFP is in East Asia with 145.4 million, followed by East Africa with 4.305 million.

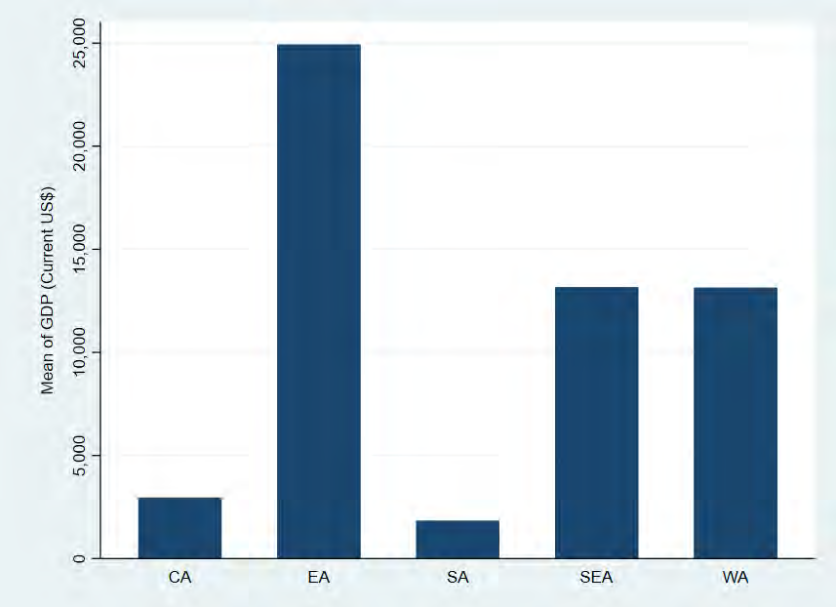

Figure 6. Mean GDP across regional classifications (2000-2019).

Regarding ICT variables, East Asia has the highest average number of IUIT, FTSUB, and MCSUB at 53.08, 36.305, and 119.935, respectively. Figure 6 reveals the mean values of IUIT, FTSUB, and MCSUB across various Asian regions. The highest percentage of secondary school enrollment is in Central Asia (91.936%), followed by West Asia (91.527%). A closer examination of the data reveals that Cyprus has the highest number of FTSUB, ranging between 63.095 million (2000) and 36.478 million (2019), while Macau has the highest MCSUB, ranging between 314.54 million (2014) and 436.10 million (2019).

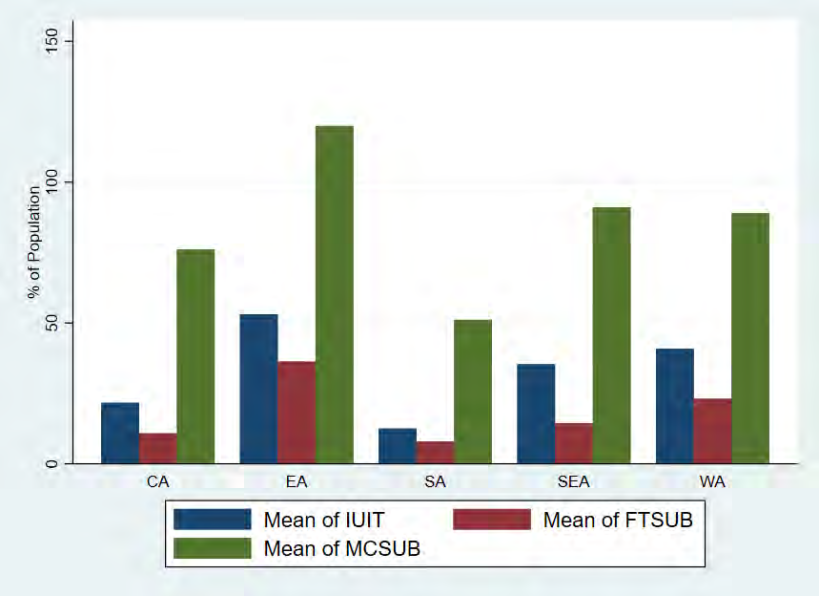

Figure 7. Mean values of IUIT, FTSUB, and MCSUB across regional classification (2000-2019).

The dataset reveals significant variations across regions, as shown in **Figure 8.** In East Asia, the DC2PS has the highest value at 118.244%. On the other hand, in Central Asia, the DC2PS stands at 20.458%. The mean TR (% of GDP) as shown in **Figure 9** has the highest value in Southeast Asia at 144.027%, and the lowest value is in Central Asia at 96.65%.

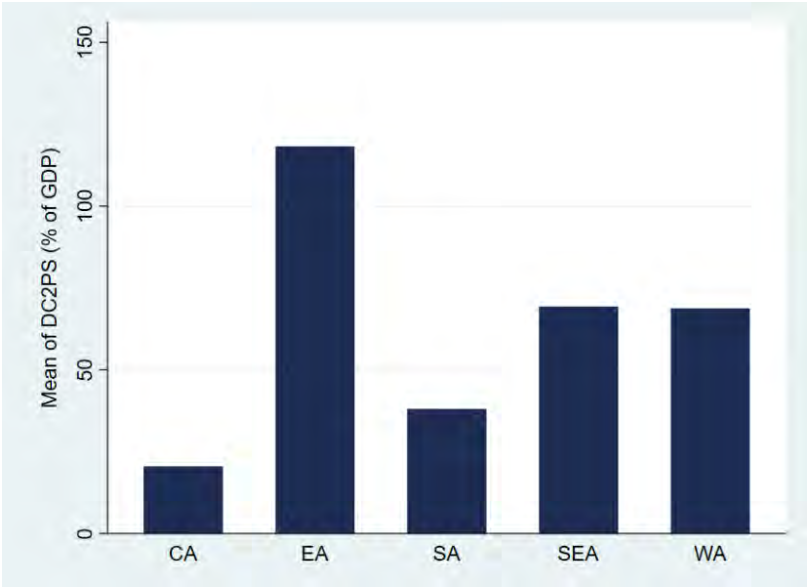

Figure 8. Mean values of DC2PS across regional classification (2000-2019).

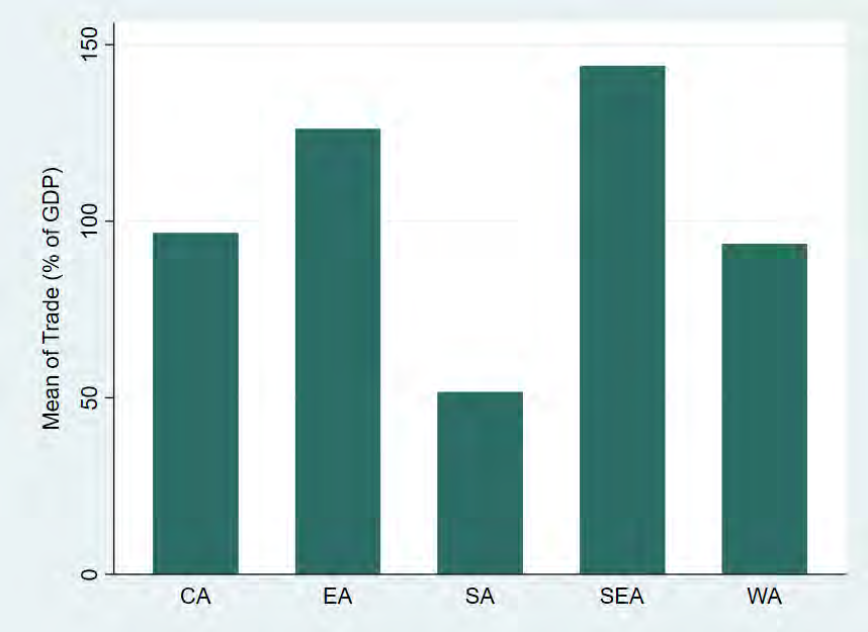

Figure 9. Mean values of TR across regional classification (2000-2019).

4.5. Pairwise correlational matrix

The correlation matrix of the variables in **Table 8** shows that GFC shows a very weak positive correlation with GDP, a relationship that is not statistically significant. LFP demonstrates a negative correlation (-0.157) with GDP with statistical significance. On the other hand, FTSUB, IUIT, and MCSUB all display strong positive correlations with GDP, showing coefficients of 0.650, 0.705, and 0.682, respectively. Each of these correlations holds statistical significance. Similarly, SSY, DC2PS, TR, IM, and EX exhibit statistically significant positive correlations with GDP. While GFE shows a statistically significant positive correlation with GDP, CPI shows a negative correlation. The correlation coefficients indicate that all ICT variables show a significant negative correlation with LFP. Except for SSY, all ICT variables, i.e., FTSUB, IUIT, and MCSUB, show a positive correlation with GFC.

The correlation analysis of DC2PS reveals interesting findings. The correlation coefficient between DC2PS and GDP is 0.525, indicating a positive relationship. It shows a statistically significant positive correlation with all the ICT variables. DC2PS shows a

positive and significant correlation with TR (0.391), IM (0.350), and EX (0.409). There exists a statistically significant negative correlation between DC2PS and CPI (-0.340). Lastly, DC2PS displays a positive and statistically significant correlation with factors of production and GFE.

Within the correlation matrix, TR shows a significant and positive correlation with IM and EX. It shows a positive and significant correlation with ICT variables. On the contrary, TR shows a negative correlation with both CPI and GFE. A statistically significant negative correlation is observed between TR and both factors of production.

Table 8. Pairwise correlation matrix of variables (2000-2019).

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
GDP	1.000												
GFC	0.046	1.000											
	(0.241)												
LFP	-0.157*	0.728*	1.000										
	(0.000)	(0.000)											
FTSUB	0.650*	0.109*	-0.105*	1.000									
	(0.000)	(0.006)	(0.008)										
IUIT	0.705*	0.156*	-0.112*	0.580*	1.000								
	(0.000)	(0.000)	(0.005)	(0.000)									
MCSUB	0.682*	0.025	-0.139*	0.378*	0.736*	1.000							
	(0.000)	(0.532)	(0.000)	(0.000)	(0.000)								
SSY	0.479*	-0.017	-0.230*	0.532*	0.532*	0.520*	1.000						
	(0.000)	(0.659)	(0.000)	(0.000)	(0.000)	(0.000)							
DC2PS	0.525*	0.337*	0.152*	0.661*	0.605*	0.449*	0.320*	1.000					
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)						
TR	0.448*	-0.183*	-0.236*	0.402*	0.333*	0.357*	0.226*	0.391*	1.000				
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)					
IM	0.319*	-0.204*	-0.255*	0.333*	0.265*	0.288*	0.177*	0.350*	0.973*	1.000			
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)				
EX	0.540*	-0.156*	-0.207*	0.444*	0.377*	0.400*	0.257*	0.409*	0.980*	0.908*	1.000		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)			
CPI	-0.282*	-0.094*	-0.037	-0.172*	-0.307*	-0.192*	-0.110*	-0.340*	-0.180*	-0.145*	-0.202*	1.000	
	(0.000)	(0.017)	(0.347)	(0.000)	(0.000)	(0.000)	(0.005)	(0.000)	(0.000)	(0.000)	(0.000)		
GFE	0.177*	0.114*	-0.028	0.225*	0.263*	0.047	0.394*	0.172*	-0.089*	-0.089*	-0.085*	-0.224*	1.000
	(0.000)	(0.004)	(0.481)	(0.000)	(0.000)	(0.237)	(0.000)	(0.000)	(0.024)	(0.025)	(0.032)	(0.000)	
**** p<0.01, ** p<0.05, * p<0.1*													

Chapter 5 Results and Discussion

This chapter presents the results of the empirical analysis, shedding light on the relationships between the variables under investigation: ICT, financial development, trade, and economic growth. The discussion of findings starts with an analysis of cross-sectional dependence (CD), both at the individual series level and for the overall model, providing insight into potential interdependencies among the variables. Subsequently, the chapter delves into the results of second-generation panel unit root tests, exploring the stationarity properties of the variables. A crucial step follows with the presentation of the results of the panel co-integration test, which offers insights into the long-term relationships among the variables. The panel causality test's results are then discussed, shedding light on the directional relationships and potential causalities among the variables. In the end, the chapter presents and discusses the regression results, offering comprehensive insights into the individual and interactive impacts of the study variables.

5.1. Cross-sectional dependence (CD) tests for individual series

The results of the CD test indicate that all the variables exhibit cross-sectional dependence. Results of the CD test of individual series show that the null hypothesis of slope homogeneity is rejected. As a result, we must consider the panel's heterogeneity and infer that the coefficients are not homogeneous and that slopes differ from one country to the next. **Table 9** displays the results of CD tests for the study variables.

5.2. Cross-sectional dependence (CD) tests for overall model

The results of the CD tests in **Table 10** for the overall model are quite informative. The p-values for both the Breusch-Pagan LM and Pesaran scaled LM statistics are below the significance level, strongly indicating the presence of cross-sectional dependence in the overall model. Additionally, the p-value for the Pesaran CD statistic also falls below the significance level, providing further evidence of cross-sectional dependence among the variables.

These findings suggest that there are interdependencies among the variables in the model, which can have important implications for panel data analysis. To account for

these dependencies and obtain more robust results, it is advisable to proceed with second-generation unit root tests, which can help address the issue of cross-sectional dependence and improve the reliability of the analysis.

Table 9. Cross-sectional dependence (CD) test results for individual series (2000-2019).

Variables	Breusch-Pagan LM		Pesaran scaled LM		Bias-corrected scaled LM		Pesaran CD	
	CD-Statistics	***p*-value**	**CD-Statistics**	***p*-value**	**CD-Statistics**	***p*-value**	**CD-Statistics**	***p*-value**
lnGDP	8342.188	0.000	249.1167	0.000	248.2746	0.000	90.850	0.000
lnGFC	7211.842	0.000	213.228	0.000	212.386	0.000	82.407	0.000
lnLFP	7679.211	0.000	228.067	0.000	227.225	0.000	77.023	0.000
ICT	8825.203	0.000	264.452	0.000	263.610	0.000	93.736	0.000
lnDC2PS	4518.281	0.000	127.707	0.000	126.865	0.000	29.242	0.000
lnTR	2573.377	0.000	65.956	0.000	65.114	0.000	11.248	0.000
lnIM	2490.0475	0.000	63.311	0.000	62.468	0.000	7.5008	0.000
lnEX	2596.111	0.000	66.678	0.000	65.836	0.000	12.650	0.000
lnGFE	2094.441	0.000	50.750	0.000	49.908	0.000	5.1202	0.000
lnCPI	1482.189	0.000	31.311	0.000	30.469	0.000	22.877	0.000

Table 10. Cross-sectional dependence (CD) test results for overall model (2000-2019).

Test (H_o= No Cross-Sectional Dependence)	**CD-Statistics**	***p*-value**
Breusch-Pagan LM	2085.001	0.000
Pesaran scaled LM	50.450	0.00
Pesaran CD	2.3807	0.01727

5.3. Second-generation panel unit root tests

The unit root test results are presented in **Table 11** in terms of levels and first differences. Based on the Pesaran (2007) panel unit root test, the following variables—lnGDP, lnGFC, lnDC2PS, lnTR, lnIM, lnEX, and lnGFE—are found to be non-stationary at the level. In contrast, lnCPI, ICT, and lnLFP exhibit stationarity at the level. Notably, all variables exhibit stationarity when examined at the first difference.

Table 11. Results of the cross-sectionally augmented IPS (CIPS) test (Pesaran, 2007).

	Statistic	***p*-value**
Modified Phillips-Perron t	7.2686	0.0000
Phillips-Perron t	-2.0830	0.0186
Augmented Dickey-Fuller t	-2.0555	0.0199

5.4. Panel co-integration test

Table 12 provides the results of the Pedroni (2004) cointegration test, which is commonly employed in panel data regression analysis, particularly when there are concerns about cross-sectional dependence among the data points. All the tests conducted have rejected the null hypothesis, indicating that cointegration does not exist, in favor of the alternative hypothesis. This evidence supports the presence of cointegration among the variables under investigation. In other words, the results suggest that there are long-run relationships or common trends among these variables across the 32 countries, which is a significant finding for panel data analysis. These cointegrating relationships can provide valuable insights into the interplay among the variables and contribute to a deeper understanding of economic dynamics in this context.

Table 12. Results of Pedroni (2004) panel cointegration test.

Variable	**Level**		**1st Difference**	
	*Z*t-bar	*p*-value	*Z*t-bar	*p*-value
lnGDP	-1.251	0.106	-3.799	0.000
lnGFC	-1.044	0.148	-2.811	0.002
lnLFP	-3.837	0.000	-2.647	0.004
ICT	-2.562	0.005	-4.523	0.000
lnDC2PS	0.202	0.580	-3.761	0.000
lnTR	0.828	0.796	-4.434	0.000
lnIM	1.150	0.875	-5.873	0.000
lnEX	-0.728	0.233	-3.431	0.000
lnGFE	0.090	0.536	-6.185	0.000
lnCPI	-6.037	0.000	-9.868	0.000

5.5. Panel causality test

To determine the causal relationship between variables, the heterogeneous panel non-causality approach is utilized (Dumitrescu & Hurlin, 2012). This approach delivers more robust causality results in comparison to other causality approaches. The results of the Dumitrescu and Hurlin (2012) panel Granger causality test are presented in **Table 13.** The results reveal the significant ability of one variable to predict another based on past values. Notably, LNGDP was found to Granger-cause several variables, including lnGFC, lnLFP, ICT, lnDC2PS, lnTR, lnIM, lnEX, lnGFE, and lnCPI. Bidirectional causality was observed between lnGDP and lnLFP, lnGDP and ICT, lnGDP and lnDC2PS, lnGDP and lnTR, lnGDP and lnIM, lnGDP and lnEX, and lnGDP and lnGFE, indicating a mutual predictive effect. Unidirectional causality from lnGDP to lnGFC and from lnGDP to lnCPI was observed.

5.6. Regression results

Table 14 presents the results of a comprehensive model that analyzes the impact of ICT, financial development, and trade on economic growth across the entire sample of Asian countries in the region.

This analysis also examines the effect of two fundamental factors of production, capital and labor, shedding light on their respective effects on economic growth. The coefficient associated with lnGFC stands at 0.452, suggesting that a one percent increase in capital stock is associated with an approximate 0.452 percent increase in economic growth. This result is consistent with previous studies (Bahrini & Qaffas, 2019; Muhammad & Khan, 2019; Yousefi, 2011). This underscores the vital role of capital investments in driving growth within the Asian countries under study, highlighting the importance of strategic initiatives aimed at enhancing capital accumulation.

On the other hand, the coefficient for lnLFP is -0.598, indicating that a one percent increase in labor input corresponds to an approximate 0.598 percent decrease in economic growth. This result contradicts the findings of Kurniawati (2021). This negative relationship relates to the concept of diminishing returns in labor-intensive economies, where an excess influx of labor can potentially lead to decreased productivity. It suggests

the need for policies that focus not only on increasing labor force participation but also on improving labor productivity and skill development to achieve sustainable economic growth. The statistical significance of the coefficients is observed in all the estimation methods.

Table 13. Results of Dumitrescu and Hurlin (2012) panel Granger causality test.

Test	**w-statistics**	**z-statistics**	**p-value**	**Test**	**w-statistics**	**z-statistics**	**p-value**	**Direction**
lnGDP→lnGFC	2.0061	4.0243	0.0001	lnGFC →lnGDP	1.3804	1.5215	0.1281	Unidirectional
lnGDP→lnLFP	8.4296	29.7183	0.0000	lnLFP →lnGDP	3.333	9.3341	0.0000	Bidirectional
lnGDP→ICT	2.1307	4.5228	0.0000	ICT→lnGDP	6.9748	23.8991	0.0000	Bidirectional
lnGDP→lnDC2PS	9.7672	35.0686	0.0000	lnDC2PS→lnGDP	2.0912	4.3648	0.0000	Bidirectional
lnGDP→lnTR	2.3159	5.2634	0.0090	lnTR→lnGDP	2.5276	6.1102	0.0000	Bidirectional
lnGDP→lnIM	3.1046	8.9290	0.0000	lnIM →lnGDP	2.4133	5.6533	0.0000	Bidirectional
lnGDP→lnEX	2.8091	7.2366	0.0000	lnEX →lnGDP	2.8204	7.2818	0.0000	Bidirectional
lnGDP→lnGFE	3.2121	8.8483	0.0000	lnGFE →lnGDP	2.7325	6.9300	0.0000	Bidirectional
lnGDP→lnCPI	1.6892	2.7569	0.0058	lnCPI→lnGDP	1.2300	0.9200	0.3576	Unidirectional

The results of the analysis highlight a pivotal aspect of economic growth, namely, the profound impact of ICT. The coefficient of 0.0539 indicates a remarkably robust and significant positive relationship between ICT and economic growth. These results are consistent with previous findings (Das et al., 2016; Kurniawati, 2021; Nipo et al., 2022). This outcome underscores the vital role that technological advancements and digital infrastructure play in shaping economies and fostering growth.

Table 14. Individual effects of ICT, lnDC2PS, and lnTR on lnGDP for entire sample (2000-2019).

	OLS	OLS (Robust)	RE	RE (Robust)	FE	FE (Robust)
Variable						
lnGFC	0.452***	0.452***	0.501***	0.501***	0.375***	0.375***
	(0.0199)	(0.0677)	(0.0204)	(0.0609)	(0.0193)	(0.0659)
lnLFP	-0.598***	-0.598***	-0.631***	-0.631***	-0.680***	-0.680***
	(0.0288)	(0.0675)	(0.0280)	(0.0640)	(0.0527)	(0.123)
ICT	0.0539***	0.0539*	0.0589***	0.0589*	0.0469***	0.0469
	(0.0136)	(0.0283)	(0.0144)	(0.0303)	(0.0124)	(0.0296)
lnDC2PS	0.135***	0.135**	0.134***	0.134**	0.142***	0.142**
	(0.0214)	(0.0591)	(0.0226)	(0.0589)	(0.0196)	(0.0573)
lnTR	-0.111***	-0.111	-0.0264	-0.0264	-0.211***	-0.211**
	(0.0393)	(0.100)	(0.0401)	(0.107)	(0.0379)	(0.0884)
lnGFE	-0.120**	-0.120	-0.0990*	-0.0990	-0.177***	-0.177
	(0.0488)	(0.106)	(0.0516)	(0.114)	(0.0461)	(0.105)
lnCPI	-0.00602	-0.00602	-0.0137	-0.0137	0.000148	0.000148
	(0.00907)	(0.0120)	(0.00962)	(0.0112)	(0.00825)	(0.0130)
WA	0.759***	0.759				
	(0.188)	(0.484)				
EA	1.179***	1.179**				
	(0.205)	(0.579)				
SEA	0.831***	0.831*				
	(0.197)	(0.470)				
SA	0.0236	0.0236				
	(0.198)	(0.445)				
Constant	6.551***	6.551***	6.181***	6.181***	10.73***	10.73***
	(0.571)	(1.446)	(0.562)	(1.542)	(0.959)	(1.402)
*** $p<0.01$, ** $p<0.05$, * $p<0.1$						
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of countries	32	32	32	32	32	32
Observations	640	640	640	640	640	640
Hausman Test Results	χ^2 statistics = 7268.31***					
R-squared	0.94	0.94	0.94	0.94	0.94	0.94
Standard errors in parentheses.						

Additionally, the results offer valuable insights into the relationship between financial development and economic growth within the Asian context. The coefficient of 0.135 signifies a significant and positive effect of financial development on economic growth. This is in-line with the previous findings (Estrada et al., 2010); Kurniawati, 2021;

Malarvizhi et al., 2019). This finding underscores the importance of a well-developed financial sector in driving economic growth in Asia. It emphasizes that an efficient and robust financial sector is a critical component of economic growth strategies within Asian region. This underscores the relevance of factors such as efficient capital allocation, access to credit, and a conducive financial ecosystem in fostering economic growth.

The coefficient of trade, as represented by the lnTR, highlights a statistically significant and negative relationship between trade and economic growth, revealing that a percentage increase in the lnTR corresponds to a 0.111% decrease in lnGDP. This is in-line with the findings of Nguyen et al. (2023) and Rahman et al. (2020). The significance of this effect, however, varies across different model specifications. While not statistically significant in the RE model (both with and without robust standard errors) and OLS (robust), the significance observed in the FE model (with or without robust standard errors) and OLS (without robust) raises questions about the consistency of this relationship. To delve deeper into this effect and gain a more comprehensive understanding, **Table 16** replaces lnTR with lnIM and lnEX. This more detailed analysis aims to unravel the effects of imports and exports on economic growth, providing deeper insights into the trade dynamics within the diverse economic landscape of Asia.

The analysis also takes into account the effect of control variables. Government final consumption expenditure, represented by lnGFE, shows a coefficient of -0.120, which is significant only in the absence of robust standard errors. This suggests that a one percent increase in lnGFE corresponds to a 0.120 percent decrease in economic growth. Similar effect was observed in the study of Shodiev et al. (2021). Additionally, inflation, represented by lnCPI, has a coefficient of -0.00602. While the negative relationship indicates that a one percent increase in lnCPI is associated with a minor decrease in lnGDP, this effect does not show statistical significance. Policymakers should consider these results when formulating strategies that balance government spending and inflation dynamics to foster sustainable economic growth.

Moreover, the analysis of regional dummies reveals significant regional variations in economic performance within the Asian context, suggesting the importance of tailored

policies and strategies to address the unique challenges and opportunities present in each region.

East Asia has a GDP that is 225.1% higher than that of Central Asia. Similarly, South Asia shows a 2.38% higher GDP than Central Asia. Southeast Asia has a 129.51% higher GDP than Central Asia. Likewise, West Asia exhibits a 113.61% higher GDP than Central Asia, which shows significance in both the main model and its subsequent robustness check. Moreover, the model shows robust goodness-of-fit, i.e., 94% of the variance in the dependent variable is explained by the independent variables. Moreover, the result of the Haussman test highlights that the FE method presents a better fit for our model.

Table 15. Individual effects of ICT, lnDC2PS, and lnTR on lnGDP across subregions (2000-2019).

	(EA)	**(WA)**	**(SEA)**	**(SA)**	**(CA)**
Variable					
lnGFC	0.655***	0.348***	0.810***	0.521***	-0.108
	(0.222)	(0.0437)	(0.0962)	(0.0342)	(0.279)
lnLFP	-0.718***	-0.672***	-0.904***	-0.544***	1.605**
	(0.167)	(0.0991)	(0.0801)	(0.0429)	(0.656)
ICT	0.323**	0.185***	0.0423	0.252***	0.176
	(0.155)	(0.0377)	(0.0894)	(0.0278)	(0.157)
lnDC2PS	0.0138	0.119**	0.103	-0.288***	0.141
	(0.286)	(0.0567)	(0.134)	(0.0442)	(0.128)
lnTR	-0.209	-0.350***	0.0655	-0.267**	-0.138
	(0.192)	(0.130)	(0.167)	(0.129)	(0.210)
lnGFE	-1.129***	-0.0582	-0.0520	-0.0538	-0.129
	(0.428)	(0.216)	(0.227)	(0.103)	(0.127)
lnCPI	-0.247***	-0.00300	-0.0164	0.0342	-0.0830***
	(0.0763)	(0.00959)	(0.0313)	(0.0213)	(0.0308)
Constant	8.377**	11.66***	3.159	6.629***	-14.46**
	(3.740)	(1.788)	(2.259)	(0.405)	(6.189)
*** $p<0.01$, ** $p<0.05$, * $p<0.1$					
Observations	120	180	140	140	60
Year Dummies	Added	Added	Added	Added	Added
Robust standard errors in parentheses.					

Table 15 extends the analysis of individual effects of ICT, financial development, and trade to different regions: East Asia (EA), West Asia (WA), Southeast Asia (SEA),

South Asia (SA), and Central Asia (CA). The coefficients for various predictor variables shed light on the region-specific dynamics of economic growth.

Table 16. Individual effects of ICT, lnDC2PS, lnIM and lnEX on lnGDP for entire sample (2000-2019).

	OLS	**OLS (Robust)**	**RE**	**RE (Robust)**	**FE**	**FE (Robust)**
Variable						
lnGFC	0.509***	0.509***	0.545***	0.545***	0.447***	0.447***
	(0.0168)	(0.0560)	(0.0167)	(0.0492)	(0.0173)	(0.0563)
lnLFP	-0.623***	-0.623***	-0.651***	-0.651***	-0.645***	-0.645***
	(0.0234)	(0.0588)	(0.0226)	(0.0503)	(0.0446)	(0.106)
ICT	0.0772***	0.0772***	0.0831***	0.0831***	0.0684***	0.0684**
	(0.0113)	(0.0272)	(0.0117)	(0.0290)	(0.0106)	(0.0277)
lnDC2PS	0.0857***	0.0857	0.0810***	0.0810	0.0948***	0.0948*
	(0.0179)	(0.0534)	(0.0185)	(0.0546)	(0.0170)	(0.0504)
lnIM	-0.604***	-0.604***	-0.619***	-0.619***	-0.578***	-0.578***
	(0.0356)	(0.0889)	(0.0369)	(0.0891)	(0.0347)	(0.0932)
lnEX	0.423***	0.423***	0.488***	0.488***	0.323***	0.323***
	(0.0315)	(0.0618)	(0.0314)	(0.0573)	(0.0323)	(0.0596)
lnGFE	0.106**	0.106	0.135***	0.135*	0.0670	0.0670
	(0.0421)	(0.0771)	(0.0435)	(0.0777)	(0.0422)	(0.0810)
lnCPI	-0.00538	-0.00538	-0.0105	-0.0105	0.000272	0.000272
	(0.00746)	(0.0109)	(0.00775)	(0.0110)	(0.00697)	(0.0109)
WA	0.577***	0.577**				
	(0.152)	(0.283)				
EA	0.824***	0.824**				
	(0.166)	(0.415)				
SEA	0.593***	0.593**				
	(0.159)	(0.297)				
SA	0.0229	0.0229				
	(0.159)	(0.272)				
Constant	5.664***	5.664***	5.512***	5.512***	8.172***	8.172***
	(0.448)	(0.936)	(0.436)	(0.954)	(0.819)	(1.270)
*** $p<0.01$, ** $p<0.05$, * $p<0.1$						
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	640	640	640	640	640	640
R-squared	0.96	0.96	0.96	0.96	0.96	0.96
Number of countries	32	32	32	32	32	32
Standard errors in parentheses.						

The capital variable, lnGFC, exhibits a positive and significant coefficient for all the regions except Central Asia, indicating that an increase in capital stock is associated with a positive impact on economic growth in these regions. Conversely, lnLFP shows a negative and significant coefficient for all the regions except Central Asia, suggesting that an increase in labor input might lead to a decrease in economic growth within these regions.

The analysis across different regions reveals a consistent trend in the positive effect of ICT on economic growth. This positive effect is statistically significant in most regions, except for Southeast Asia and Central Asia. The varying levels of technological infrastructure, rates of adoption, or specific regional dynamics could contribute to the differing impact of ICT on economic growth.

In the context of financial development, the analysis reveals distinct patterns across various regions. For South Asia, the negative and highly significant coefficient associated with lnDC2PS suggests that fluctuations in domestic credit allocation might exert an adverse impact on economic growth within the region. This underscores the need for careful management and efficient distribution of credit to stimulate growth. In West Asia, the positive and significant coefficient indicates that domestic credit to the private sector plays a constructive role in promoting economic growth. The significance underscores the importance of well-structured credit mechanisms in driving growth and development. On the other hand, in Southeast Asia, East Asia, and Central Asia, the variable lnDC2PS demonstrates positive coefficients but lacks statistical significance. While the positive trends suggest a potential favorable effect of domestic credit, the absence of significance in these regions necessitates further exploration to determine the role of credit in their respective growth dynamics. These diverse findings highlight the region-specific nature of financial development's impact on economic growth.

In terms of trade, the analysis reveals consistent trends across various regions. The coefficients of lnTR exhibit negative values across all regions, indicating a potential negative relationship between trade and economic growth. For South Asia and West Asia, the negative coefficient is statistically significant, suggesting that higher trade, relative to GDP, might have an adverse impact on economic growth within these regions. This

finding underscores the need to carefully evaluate the potential challenges associated with trade integration in South Asia and West Asia's economic landscape. In contrast, for Southeast Asia, East Asia, and Central Asia, the coefficients of lnTR lack significance. These findings highlight the complexity of the relationship between trade and economic growth, which can vary across different regional contexts.

Table 17. Individual effects of ICT, lnDC2PS, lnIM and lnEX on lnGDP across subregions (2000-2019).

	(EA)	**(WA)**	**(SEA)**	**(SA)**	**(CA)**
Variable					
lnGFC	0.749***	0.591***	0.685***	0.413***	0.104
	(0.165)	(0.0526)	(0.0907)	(0.0412)	(0.127)
lnLFP	-0.797***	-0.780***	-0.695***	-0.470***	0.924***
	(0.156)	(0.0637)	(0.0801)	(0.0437)	(0.348)
ICT	0.277*	0.304***	0.105	0.260***	0.00559
	(0.155)	(0.0536)	(0.0813)	(0.0237)	(0.0421)
LnDC2PS	0.0651	0.278***	-0.123	-0.229***	0.191***
	(0.175)	(0.0540)	(0.125)	(0.0473)	(0.0167)
lnIM	-0.908***	-1.201***	-0.668***	-0.531***	-0.668***
	(0.115)	(0.227)	(0.151)	(0.0801)	(0.0763)
lnEX	1.122***	0.547***	1.087***	0.183***	0.350***
	(0.275)	(0.0958)	(0.229)	(0.0454)	(0.0632)
lnGFE	0.626	-0.154	0.0692	0.0149	0.171***
	(0.521)	(0.179)	(0.0884)	(0.112)	(0.0578)
lnCPI	-0.0799	-0.0200	-0.00157	0.0148	-0.0533
	(0.0581)	(0.0249)	(0.0253)	(0.0228)	(0.0595)
Constant	0.677	8.718***	1.791	7.701***	-9.303***
	(3.227)	(2.177)	(1.357)	(0.362)	(2.653)
*** $p<0.01$, ** $p<0.05$, * $p<0.1$					
Observations	120	180	140	140	60
Year Dummies	Added	Added	Added	Added	Added
Robust standard errors in parentheses.					

The coefficients of lnGFE and lnCPI exhibit diverse patterns across the different regions in terms of both their sign and significance. This implies that the impact of inflation and government spending on economic growth is not uniform throughout Asia.

In **Table 16,** we refined our analysis by replacing the trade variable, lnTR, with two measures that delve deeper into effect of trade: imports represented by lnIM and exports represented by lnEX. This allowed us to gain a more refined understanding of the impact of trade relationships on economic growth across various regions. Crucially, the

coefficients associated with lnIM consistently reveal a negative impact on growth in all estimation methods. This is consistent with the findings of Kumar et al. (2020). It implies that higher levels of imports may cause a potential dampening effect on economic growth, irrespective of the estimation technique employed.

Table 18. Interactive effects of ICT and lnDC2PS on lnGDP for entire sample (2000-2019).

	OLS	**OLS (Robust)**	**RE**	**RE (Robust)**	**FE**	**FE (Robust)**
Variable						
lnGFC	0.438***	0.438***	0.475***	0.475***	0.373***	0.373***
	(0.0192)	(0.0599)	(0.0196)	(0.0542)	(0.0189)	(0.0604)
lnLFP	-0.584***	-0.584***	-0.609***	-0.609***	-0.659***	-0.659***
	(0.0282)	(0.0613)	(0.0271)	(0.0601)	(0.0518)	(0.118)
ICT	-0.0666***	-0.0666	-0.0880***	-0.0880*	-0.0405*	-0.0405
	(0.0222)	(0.0492)	(0.0230)	(0.0512)	(0.0207)	(0.0504)
lnDC2PS	0.188***	0.188***	0.198***	0.198***	0.182***	0.182***
	(0.0220)	(0.0621)	(0.0229)	(0.0609)	(0.0206)	(0.0622)
lnTR	-0.151***	-0.151*	-0.0893**	-0.0893	-0.229***	-0.229***
	(0.0382)	(0.0858)	(0.0387)	(0.0888)	(0.0373)	(0.0804)
lnGFE	-0.154***	-0.154	-0.144***	-0.144	-0.197***	-0.197*
	(0.0472)	(0.110)	(0.0492)	(0.117)	(0.0453)	(0.110)
lnCPI	-0.00732	-0.00732	-0.0138	-0.0138	-0.00166	-0.00166
	(0.00871)	(0.0126)	(0.00909)	(0.0125)	(0.00808)	(0.0132)
ICT*lnDC2PS	0.0467***	0.0467***	0.0565***	0.0565***	0.0342***	0.0342*
	(0.00698)	(0.0173)	(0.00719)	(0.0179)	(0.00658)	(0.0173)
WA	0.688***	0.688				
	(0.187)	(0.450)				
EA	1.015***	1.015*				
	(0.204)	(0.532)				
SEA	0.777***	0.777*				
	(0.195)	(0.439)				
SA	0.0320	0.0320				
	(0.196)	(0.426)				
Constant	6.805***	6.805***	6.609***	6.609***	10.46***	10.46***
	(0.558)	(1.377)	(0.543)	(1.429)	(0.940)	(1.489)
*** $p<0.01$, ** $p<0.05$, * $p<0.1$						
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	640	640	640	640	640	640
R-squared	0.95	0.95	0.94	0.94	0.95	0.95
Number of countries	32	32	32	32	32	32
Standard errors in parentheses.						

Conversely, the coefficients related to lnEX, which signify exports as a percentage of GDP, consistently demonstrate a positive and highly significant impact on economic growth across all estimation methods. Similar effect was observed in the study of Sultanuzzaman et al. (2019). These findings offer valuable insights into the nature of trade-led growth in different regions. The positive and significant effect of exports, coupled with the negative effect of imports, suggests that strategies oriented toward promoting exports hold greater promise for fostering economic growth.

Table 19. Interactive effects of ICT and lnDC2PS on lnGDP across subregions (2000-2019).

	(EA)	**(WA)**	**(SEA)**	**(SA)**	**(CA)**
Variable					
LNGFC	0.556***	0.847***	0.785***	0.520***	0.0756
	(0.134)	(0.0908)	(0.0986)	(0.0253)	(0.100)
lnLFP	-0.634***	-0.945***	-0.919***	-0.542***	1.043***
	(0.119)	(0.144)	(0.0617)	(0.0280)	(0.236)
ICT	-0.0371	-0.181*	-0.125	0.238	-0.268***
	(0.305)	(0.0929)	(0.135)	(0.153)	(0.00655)
lnDC2PS	0.0757	-0.00751	0.250	-0.283***	0.304***
	(0.205)	(0.0703)	(0.250)	(0.0763)	(0.0795)
lnTR	-0.364***	-0.0958	-0.158	-0.263**	0.0441
	(0.135)	(0.243)	(0.346)	(0.118)	(0.0939)
lnGFE	-1.580***	0.118	-0.186	-0.0562	-0.0798
	(0.453)	(0.210)	(0.304)	(0.108)	(0.117)
lnCPI	-0.283***	-0.0331*	0.0148	0.0339	-0.0206**
	(0.0822)	(0.0180)	(0.0411)	(0.0224)	(0.00942)
ICT*lnDC2PS	0.0897	0.143***	0.0603	0.00410	0.174***
	(0.0601)	(0.0189)	(0.0608)	(0.0429)	(0.00881)
Constant	10.93***	3.478	4.804	6.598***	-11.40***
	(2.837)	(2.394)	(3.441)	(0.446)	(1.693)
*** $p<0.01$, ** $p<0.05$, * $p<0.1$					
Observations	120	180	140	140	60
Year Dummies	Added	Added	Added	Added	Added
Robust standard errors in parentheses					

This phenomenon holds true consistently across all analyzed regions in **Table 17.** Regardless of the regional context, the coefficients of lnIM consistently demonstrate a negative effect on economic growth. This indicates potential challenges associated with excessive reliance on imports. On the other hand, the positive and significant coefficients for lnEX consistently affirm the positive impact of exports on

economic growth in all regions. This finding underscores the universal significance of export-oriented strategies as potent drivers of economic development across diverse regional landscapes.

Table 20. Interactive effects of ICT, lnDC2PS, and lnTR on lnGDP for entire sample (2000-2019).

	OLS	**OLS (Robust)**	**RE**	**RE (Robust)**	**FE**	**FE (Robust)**
Variable						
lnGFC	0.449***	0.449***	0.486***	0.486***	0.375***	0.375***
	(0.0197)	(0.0649)	(0.0201)	(0.0589)	(0.0192)	(0.0648)
lnLFP	-0.586***	-0.586***	-0.611***	-0.611***	-0.672***	-0.672***
	(0.0280)	(0.0661)	(0.0275)	(0.0638)	(0.0527)	(0.123)
ICT	-0.00553	-0.00553	-0.0197	-0.0197	0.0207	0.0207
	(0.0188)	(0.0400)	(0.0195)	(0.0413)	(0.0173)	(0.0411)
lnDC2PS	0.152***	0.152**	0.158***	0.158***	0.150***	0.150**
	(0.0216)	(0.0598)	(0.0224)	(0.0592)	(0.0199)	(0.0596)
lnTR	-0.116***	-0.116	-0.0499	-0.0499	-0.209***	-0.209**
	(0.0389)	(0.0955)	(0.0392)	(0.0989)	(0.0378)	(0.0869)
lnGFE	-0.129***	-0.129	-0.116**	-0.116	-0.182***	-0.182
	(0.0483)	(0.109)	(0.0503)	(0.117)	(0.0460)	(0.109)
lnCPI	-0.00878	-0.00878	-0.0160*	-0.0160	-0.00133	-0.00133
	(0.00900)	(0.0130)	(0.00938)	(0.0130)	(0.00825)	(0.0130)
ICT*lnDC2PS*lnTR	0.00640***	0.00640*	0.00834***	0.00834**	0.00284**	0.00284
	(0.00140)	(0.00333)	(0.00144)	(0.00335)	(0.00132)	(0.00329)
WA	0.703***	0.703				
	(0.180)	(0.460)				
EA	1.047***	1.047*				
	(0.197)	(0.554)				
SEA	0.774***	0.774*				
	(0.188)	(0.441)				
SA	0.0268	0.0268				
	(0.189)	(0.424)				
Constant	6.486***	6.486***	6.306***	6.306***	10.60***	10.60***
	(0.555)	(1.407)	(0.548)	(1.464)	(0.958)	(1.410)
*** p<0.01, ** p<0.05, * p<0.1						
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	640	640	640	640	640	640
R-squared	0.94	0.94	0.94	0.94	0.95	0.95
Number of countries	32	32	32	32	32	32
Standard errors in parentheses.						

Furthermore, the interactive effect of ICT and financial development in Asian region is examined in **Table 18**. The coefficients associated with the interaction term consistently display positive and statistically significant values across all estimation methods. Aziz et al. (2023) found a similar effect. This suggests that the interaction between technological advancement and increased access to domestic credit has a positive impact on economic growth within the Asian region.

The positive coefficient for the interaction term underscores the importance of not only advancing technological skills but also ensuring a conducive financial environment. With a strategic alliance of technological innovation and improved financial development, economies in Asia can harness a synergistic effect that drives growth dynamics to a higher trajectory. Such insights are crucial for formulating targeted policies that can leverage the complementary strengths of technology and finance to drive inclusive and sustainable economic growth across Asian regions.

Table 21. Interactive effects of ICT, lnDC2PS, and lnTR on lnGDP across subregions (2000-2019).

	(EA)	**(WA)**	**(SEA)**	**(SA)**	**(CA)**
Variable					
lnGDP	0.571***	0.842***	0.738***	0.520***	-0.0368
	(0.147)	(0.0867)	(0.0955)	(0.0266)	(0.0984)
lnLFP	-0.651***	-0.935***	-0.911***	-0.542***	1.254***
	(0.123)	(0.139)	(0.0551)	(0.0287)	(0.247)
ICT	0.0322	-0.148*	-0.227*	0.243**	-0.274***
	(0.286)	(0.0821)	(0.123)	(0.123)	(0.0253)
lnDC2PS	-0.0395	-0.0134	0.371*	-0.286***	0.340***
	(0.222)	(0.0676)	(0.218)	(0.0519)	(0.0912)
lnTR	-0.494**	-0.195	-0.360	-0.258***	0.0467
	(0.206)	(0.239)	(0.317)	(0.0945)	(0.0863)
lnGFE	-1.413***	0.202	-0.204	-0.0557	-0.239*
	(0.411)	(0.190)	(0.228)	(0.105)	(0.138)
lnCPI	-0.298***	-0.0362**	0.0239	0.0340	-0.00521
	(0.0798)	(0.0174)	(0.0375)	(0.0221)	(0.0145)
ICT*lnDC2PS*lnTR	0.0184	0.0296***	0.0196*	0.000740	0.0410***
	(0.0121)	(0.00397)	(0.0108)	(0.00902)	(0.00251)
Constant	11.49***	3.656	6.250**	6.586***	-11.89***
	(3.142)	(2.289)	(3.089)	(0.377)	(2.105)
*** p<0.01, ** p<0.05, * p<0.1					
Observations	120	180	140	140	60
Year Dummies	Added	Added	Added	Added	Added
Robust standard errors in parentheses.					

In our sub-regional analysis, we observed a consistent positive coefficient of the interaction term between ICT and financial development across all regions within Asia. However, this interaction term is found to be statistically significant only in the cases of West Asia and Central Asia. The significance of the interaction term in Central Asia and West Asia can be attributed to several factors. These regions may have experienced a pronounced convergence of ICT adoption and financial development, creating a favorable environment for their joint impact on economic growth. Regional policies, initiatives, and investments in infrastructure that specifically encourage technological advancements and financial development might have played a vital role in enhancing the interaction between these two variables in West Asia and Central Asia.

On the other hand, in other Asian sub-regions, the lack of statistical significance might stem from varying degrees of technological diffusion, financial inclusivity, or varying levels of economic structure. These factors could influence the extent to which the interactive effect of ICT and financial development contributes significantly to economic growth.

The extended model in **Table 20** analyzes the interactive effect of ICT, financial development, and trade on economic growth. The coefficient of the interaction term provides insights into the interplay of these factors affecting economic growth.

The positive and statistically significant coefficient highlights the potential joint impact of these variables on economic growth. The positive sign of the interaction term suggests that the simultaneous presence of advanced technology adoption, improved financial development, and active trade engagement can contribute to a more significant positive effect on growth. This finding is particularly noticeable as it suggests that an integrated approach that considers the interplay of technological advancement, financial support, and trade engagement can unlock new dimensions of growth potential.

In the sub-regional analysis in **Table 21**, the interaction term highlights the interplay between ICT, financial development, trade, and their joint effects on economic growth across different subregions of Asia.

Table 22. Interactive effects of ICT, lnDC2PS, and lnIM on lnGDP for entire sample (2000-2019).

	OLS	OLS (Robust)	RE	RE (Robust)	FE	FE (Robust)
Variable						
lnGFC	0.521***	0.521***	0.548***	0.548***	0.447***	0.447***
	(0.0167)	(0.0532)	(0.0166)	(0.0467)	(0.0173)	(0.0563)
lnLFP	-0.622***	-0.622***	-0.645***	-0.645***	-0.643***	-0.643***
	(0.0216)	(0.0543)	(0.0215)	(0.0475)	(0.0448)	(0.105)
ICT	0.0391**	0.0391	0.0354**	0.0354	0.0638***	0.0638
	(0.0159)	(0.0402)	(0.0162)	(0.0404)	(0.0147)	(0.0392)
lnDC2PS	0.0943***	0.0943*	0.0929***	0.0929*	0.0959***	0.0959*
	(0.0184)	(0.0543)	(0.0188)	(0.0549)	(0.0172)	(0.0515)
lnIM	-0.607***	-0.607***	-0.619***	-0.619***	-0.578***	-0.578***
	(0.0356)	(0.0868)	(0.0368)	(0.0862)	(0.0348)	(0.0927)
lnEX	0.440***	0.440***	0.491***	0.491***	0.323***	0.323***
	(0.0314)	(0.0588)	(0.0313)	(0.0542)	(0.0324)	(0.0592)
lnGFE	0.0999**	0.0999	0.124***	0.124	0.0661	0.0661
	(0.0421)	(0.0784)	(0.0432)	(0.0803)	(0.0423)	(0.0823)
lnCPI	-0.00884	-0.00884	-0.0137*	-0.0137	1.34e-06	1.34e-06
	(0.00763)	(0.0118)	(0.00780)	(0.0120)	(0.00700)	(0.0108)
ICT*lnDC2PS*lnIM	0.00502***	0.00502	0.00609***	0.00609*	0.000583	0.000583
	(0.00135)	(0.00337)	(0.00137)	(0.00331)	(0.00129)	(0.00331)
WA	0.694***	0.694*				
	(0.142)	(0.388)				
EA	0.0255	0.0255				
	(0.135)	(0.251)				
SEA	0.522***	0.522**				
	(0.135)	(0.266)				
SA	0.516***	0.516**				
	(0.128)	(0.257)				
Constant	5.399***	5.399***	5.350***	5.350***	8.143***	8.143***
	(0.410)	(0.925)	(0.412)	(0.929)	(0.822)	(1.243)
*** $p<0.01$, ** $p<0.05$, * $p<0.1$						
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	640	640	640	640	640	640
R-squared	0.94	0.94	0.94	0.94	0.95	0.95
Number of countries	32	32	32	32	32	32
Standard errors in parentheses.						

Table 23. Interactive effects of ICT, lnDC2PS, and lnIM on lnGDP across subregions (2000-2019).

	(SA)	(SEA)	(EA)	(CA)	(WA)
Variable					
lnGFC	0.420***	0.669***	0.701***	0.0158	0.637***
	(0.0352)	(0.107)	(0.143)	(0.139)	(0.0549)
lnLFP	-0.484***	-0.755***	-0.762***	1.088***	-0.796***
	(0.0394)	(0.0625)	(0.143)	(0.326)	(0.0717)
ICT	0.332***	-0.0913	0.106	-0.170*	-0.108
	(0.0718)	(0.111)	(0.198)	(0.102)	(0.0877)
lnDC2PS	-0.238***	0.117	0.0190	0.282***	0.208***
	(0.0366)	(0.223)	(0.139)	(0.0962)	(0.0582)
lnIM	-0.601***	-0.620***	-0.975***	-0.360***	-1.103***
	(0.0865)	(0.130)	(0.0986)	(0.129)	(0.186)
lnEX	0.173***	0.656**	0.978***	0.209*	0.445***
	(0.0423)	(0.280)	(0.219)	(0.113)	(0.0806)
lnGFE	0.0324	-0.0603	0.362	-0.0985	0.0514
	(0.107)	(0.169)	(0.475)	(0.0742)	(0.185)
lnCPI	0.0159	0.0165	-0.120**	-0.0259*	-0.0179
	(0.0226)	(0.0261)	(0.0565)	(0.0153)	(0.0131)
ICT*lnDC2PS*lnIM	-0.00711	0.0152	0.0128*	0.0284**	0.0262***
	(0.00621)	(0.0132)	(0.00701)	(0.0112)	(0.00415)
Constant	8.026***	4.077	2.899	-10.02***	7.494***
	(0.369)	(2.906)	(2.983)	(2.245)	(1.750)
*** $p<0.01$, ** $p<0.05$, * $p<0.1$					
Observations	140	140	120	60	180
Year Dummies	Added	Added	Added	Added	Added
Robust standard errors in parentheses.					

In South Asia and East Asia, the lack of statistical significance in the interaction term could be attributed to various factors such as varying levels of ICT adoption, the financial sector composition, and the particular trade relationships within this subregion. These complexities might mitigate the interactive impact of these factors on economic growth in this context.

However, in West Asia, Central Asia, and Southeast Asia, the interaction term is statistically significant and positive. This could be due to more conducive conditions for these factors to interact synergistically to impact economic growth. These subregions might have economies that are more aligned with higher ICT adoption rates, export-led growth policies, and robust financial sector development, leading to a more pronounced positive impact on economic growth.

Table 24. Interactive effects of ICT, lnDC2PS, and lnEX on lnGDP for entire sample (2000-2019).

	OLS	OLS (Robust)	RE	RE (Robust)	FE	FE (Robust)
Variable						
lnGFC	0.528***	0.528***	0.548***	0.548***	0.446***	0.446***
	(0.0167)	(0.0526)	(0.0167)	(0.0469)	(0.0173)	(0.0564)
lnLFP	-0.624***	-0.624***	-0.644***	-0.644***	-0.644***	-0.644***
	(0.0208)	(0.0534)	(0.0213)	(0.0481)	(0.0446)	(0.106)
ICT	0.0364**	0.0364	0.0373**	0.0373	0.0612***	0.0612*
	(0.0152)	(0.0355)	(0.0154)	(0.0353)	(0.0140)	(0.0361)
lnDC2PS	0.100***	0.100*	0.0983***	0.0983*	0.0975***	0.0975*
	(0.0187)	(0.0545)	(0.0189)	(0.0545)	(0.0173)	(0.0517)
lnIM	-0.597***	-0.597***	-0.604***	-0.604***	-0.575***	-0.575***
	(0.0358)	(0.0825)	(0.0369)	(0.0816)	(0.0350)	(0.0914)
lnEX	0.446***	0.446***	0.485***	0.485***	0.321***	0.321***
	(0.0315)	(0.0570)	(0.0315)	(0.0519)	(0.0325)	(0.0579)
lnGFE	0.0924**	0.0924	0.117***	0.117	0.0635	0.0635
	(0.0420)	(0.0799)	(0.0433)	(0.0814)	(0.0424)	(0.0837)
lnCPI	-0.0103	-0.0103	-0.0142*	-0.0142	-0.000183	-0.000183
	(0.00774)	(0.0125)	(0.00781)	(0.0125)	(0.00699)	(0.0109)
ICT*lnDC2PS*lnEX	0.00594***	0.00594*	0.00637***	0.00637**	0.000978	0.000978
	(0.00130)	(0.00319)	(0.00132)	(0.00312)	(0.00124)	(0.00309)
WA	0.639***	0.639*				
	(0.131)	(0.371)				
EA	0.0199	0.0199				
	(0.124)	(0.241)				
SEA	0.489***	0.489*				
	(0.124)	(0.250)				
SA	0.493***	0.493**				
	(0.118)	(0.244)				
Constant	5.235***	5.235***	5.307***	5.307***	8.167***	8.167***
	(0.393)	(0.905)	(0.408)	(0.906)	(0.819)	(1.284)
*** $p<0.01$, ** $p<0.05$, * $p<0.1$						
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	640	640	640	640	640	640
R-squared	0.94	0.94	0.94	0.94	0.95	0.95
Number of countries	32	32	32	32	32	32
Standard errors in parentheses.						

Table 25. Interactive effects of ICT, lnDC2PS, and lnEX on lnGDP across subregions (2000-2019).

	(SA)	(SEA)	(EA)	(CA)	(WA)
Variable					
lnGFC	0.414***	0.675***	0.693***	0.0486	0.619***
	(0.0385)	(0.101)	(0.138)	(0.123)	(0.0583)
lnLFP	-0.475***	-0.755***	-0.751***	1.045***	-0.785***
	(0.0418)	(0.0627)	(0.139)	(0.292)	(0.0736)
ICT	0.286***	-0.0792	0.141	-0.178**	-0.0685
	(0.0550)	(0.117)	(0.202)	(0.0728)	(0.0757)
lnDC2PS	-0.232***	0.111	0.0288	0.292***	0.227***
	(0.0438)	(0.239)	(0.148)	(0.0945)	(0.0577)
lnIM	-0.554***	-0.600***	-0.903***	-0.315***	-1.139***
	(0.107)	(0.104)	(0.0878)	(0.111)	(0.183)
lnEX	0.171***	0.650**	0.931***	0.198*	0.443***
	(0.0464)	(0.327)	(0.240)	(0.106)	(0.0717)
lnGFE	0.0244	-0.0531	0.384	0.00767	0.0376
	(0.114)	(0.168)	(0.478)	(0.0313)	(0.185)
lnCPI	0.0155	0.0221	-0.120**	-0.0182	-0.0142
	(0.0224)	(0.0324)	(0.0582)	(0.0184)	(0.0118)
ICT*lnDC2PS*lnEX	-0.00286	0.0140	0.0111	0.0273***	0.0240***
	(0.00494)	(0.0130)	(0.00704)	(0.00833)	(0.00386)
Constant	7.849***	3.866	2.725	-10.54***	7.839***
	(0.503)	(2.867)	(2.908)	(2.153)	(1.689)
*** $p<0.01$, ** $p<0.05$, * $p<0.1$					
Observations	140	140	120	60	180
Year Dummies	Added	Added	Added	Added	Added
Robust standard errors in parentheses.					

The interaction term, which provides insights into the combined impact of ICT, financial development, and imports on economic growth in the Asian context, is presented in **Table 22**. Notably, in the OLS model without robust standard errors, this interaction term is found to be highly significant at the 1% level, with a coefficient estimate of 0.00502. This result underscores the strong and positive association between the interaction of these variables and economic growth.

Furthermore, when employing the RE specification, the significance of the interaction term persists at the 1% level, with coefficient estimates of 0.00609. This reaffirms the robustness of the finding, highlighting the substantial positive effect of the combined influence of ICT, financial development, and imports on promoting economic growth within the Asian context. These findings suggest that while the interaction term

may not exhibit significance across all model specifications, it demonstrates the potential to positively impact economic growth in the Asian context when taking into account the joint effects of higher levels of ICT adoption, financial development, and imports.

Table 26. Individual and interactive effects of ICT, lnDC2PS, and lnTR on lnGDP by two-step system GMM for entire sample (2000-2019).

	Without Robust	**With Robust**	**Without Robust**	**With Robust**	**Without Robust**	**With Robust**
Variable						
L.lnGDP	0.361***	0.361**	0.386***	0.386**	0.454***	0.454***
	(0.0409)	(0.166)	(0.0417)	(0.167)	(0.0395)	(0.148)
lnGFC	0.533***	0.533***	0.491***	0.491***	0.434***	0.434***
	(0.0340)	(0.141)	(0.0350)	(0.141)	(0.0317)	(0.121)
lnLFP	-0.555***	-0.555***	-0.516***	-0.516***	-0.455***	-0.455***
	(0.0350)	(0.155)	(0.0365)	(0.155)	(0.0332)	(0.131)
ICT	0.0688***	0.0688**	-0.122***	-0.122*	-0.0553**	-0.0553
	(0.0142)	(0.0324)	(0.0253)	(0.0669)	(0.0257)	(0.0540)
lnDC2PS	0.0656***	0.0656	0.0664***	0.0664	0.0481***	0.0481
	(0.0210)	(0.0646)	(0.0208)	(0.0523)	(0.0186)	(0.0455)
lnTR	0.0695**	0.0695	0.0291	0.0291	0.0163	0.0163
	(0.0287)	(0.0620)	(0.0239)	(0.0528)	(0.0277)	(0.0583)
lnGFE	-0.193***	-0.193**	-0.162***	-0.162*	-0.116***	-0.116
	(0.0439)	(0.0963)	(0.0428)	(0.0896)	(0.0407)	(0.0848)
lnCPI	-0.0440***	-0.0440*	-0.0251***	-0.0251	-0.0217***	-0.0217
	(0.00734)	(0.0233)	(0.00576)	(0.0191)	(0.00492)	(0.0163)
ICT*lnDC2PS			0.0572***	0.0572***		
			(0.00854)	(0.0211)		
ICT*lnDC2PS*lnTR					0.00845***	0.00845*
					(0.00209)	(0.00442)
Constant	1.550***	1.550*	1.751***	1.751**	1.574***	1.574**
	(0.309)	(0.827)	(0.309)	(0.820)	(0.338)	(0.767)
*** $p<0.01$, ** $p<0.05$, * $p<0.1$						
AR (2) *p*-value	0.787	0.787	0.386	0.468	0.246	0.314
Hansen *p*-value	0.065	0.065	0.066	0.066	0.075	0.075
Number of Instruments	28	28	28	28	28	28
Observations	608	608	608	608	608	608
Number of countries	32	32	32	32	32	32
Standard errors in parentheses.						

In the subregional analysis, as demonstrated in **Table 23,** the interaction term consistently shows a positive and significant relationship in West Asia, Central Asia, and East Asia. This suggests that within these regions, the combined impact of greater ICT adoption, enhanced financial development, and increased imports exerts a positive effect

on economic growth. This interactive effect likely fosters greater productivity, innovation, and economic efficiency, ultimately contributing to higher rates of economic growth in these regions. However, in Southeast Asia, the interaction term is positive but does not show statistical significance.

Surprisingly, in South Asia, the interaction term exhibits a negative coefficient and lacks statistical significance. This signifies that the interactive impact of higher ICT adoption, financial development, and imports in South Asia may not be translating into a significant positive influence on economic growth. Various contextual factors, such as institutional and economic frameworks and policy inefficiencies, may be mitigating the potential positive effects of these variables in this subregion.

The interaction variable of ICT, financial development, and exports in **Table 24** has a positive coefficient. It can be due to the interaction between technological advancement, financial development, and export-oriented strategies. This positive effect underscores how a well-integrated approach to technology, finance, and exports can amplify economic gains in the region.

The varying effects of the interaction term in the subregional analysis in **Table 25** highlight the specific dynamics within different Asian regions. In West Asia and Central Asia, the positive and significant impact suggests that the alignment of technological innovation, financial development, and export-oriented strategies is interactive, creating an environment conducive to economic growth. In East and Southeast Asia, the effect is positive yet insignificant. On the other hand, the negative and insignificant effect in South Asia implies that the interplay between technology, finance, and exports might be less harmonious or might face specific challenges within the region's economic landscape. These results underscore the importance of tailoring policies to regional characteristics and the need to optimize the benefits of this interaction.

Table 26 presents the results obtained through the two-step system GMM estimation approach, which was employed to address potential endogeneity issues in the analysis. These results shed light on the relationship between various economic variables and economic growth under different model specifications. Across all estimation methods, including those without robust standard errors, the variables exhibit consistent patterns.

The lagged value of lnGDP, denoted as L. lnGDP, exhibits a positive and significant impact across various estimation methods. This indicates that past levels of GDP have had a significant influence on the current level of GDP.

Table 27. Individual and interactive effects of ICT, lnDC2PS, lnIM, and lnEX on lnGDP by two-step system GMM for entire sample (2000-2019).

	Without Robust	**With Robust**	**Without Robust**	**With Robust**	**Without Robust**	**With Robust**
Variable						
L.lnGDP	0.166***	0.166	0.0946***	0.0946	0.115***	0.115
	(0.0331)	(0.130)	(0.0313)	(0.0993)	(0.0303)	(0.101)
lnGFC	0.574***	0.574***	0.584***	0.584***	0.560***	0.560***
	(0.0317)	(0.0872)	(0.0274)	(0.0746)	(0.0233)	(0.0735)
lnLFP	-0.639***	-0.639***	-0.660***	-0.660***	-0.630***	-0.630***
	(0.0313)	(0.0961)	(0.0267)	(0.0784)	(0.0240)	(0.0800)
ICT	0.127***	0.127***	-0.0738***	-0.0738	-0.0616**	-0.0616
	(0.0135)	(0.0390)	(0.0276)	(0.0584)	(0.0260)	(0.0573)
lnDC2PS	0.152***	0.152**	0.152***	0.152**	0.144***	0.144**
	(0.0227)	(0.0735)	(0.0321)	(0.0693)	(0.0263)	(0.0579)
lnIM	-0.481***	-0.481***	-0.621***	-0.621***	-0.591***	-0.591***
	(0.0296)	(0.104)	(0.0411)	(0.100)	(0.0406)	(0.0940)
lnEX	0.468***	0.468***	0.504***	0.504***	0.483***	0.483***
	(0.0411)	(0.113)	(0.0541)	(0.126)	(0.0514)	(0.117)
lnGFE	-0.261***	-0.261**	-0.146***	-0.146	-0.128***	-0.128
	(0.0512)	(0.108)	(0.0477)	(0.103)	(0.0455)	(0.0976)
lnCPI	-0.0356***	-0.0356*	-0.0178*	-0.0178	-0.0171**	-0.0171
	(0.00665)	(0.0188)	(0.00945)	(0.0211)	(0.00863)	(0.0204)
ICT*lnDC2PS*lnIM			0.0189***	0.0189***		
			(0.00242)	(0.00567)		
ICT*lnDC2PS*lnEX					0.0188***	0.0188***
					(0.00247)	(0.00597)
Constant	3.793***	3.793***	4.479***	4.479***	4.339***	4.339***
	(0.347)	(0.932)	(0.458)	(0.902)	(0.422)	(0.847)
*** $p<0.01$, ** $p<0.05$, * $p<0.1$						
AR (2) *p*-value	0.853	0.861	0.455	0.473	0.446	0.466
Hansen *p*-value	0.139	0.139	0.151	0.151	0.143	0.143
Number of Instruments	29	29	29	29	29	29
Observations	608	608	608	608	608	608
Number of countries	32	32	32	32	32	32
Standard errors in parentheses						

The positive and statistically significant effect of lnGFC underscores the vital role of capital in fostering economic growth. Conversely, the negative relationship observed between lnLFP and lnGDP suggests that higher levels of labor force participation might have adverse effects on economic growth, a finding that warrants further investigation. Of particular importance is the statistically significant and positive interaction term of ICT with lnDC2PS, highlighting the augmenting impact of technology and financial development in propelling economic growth. This underscores the importance of interaction between advancements in technology and a robust financial sector. Moreover, the significance of the interaction between ICT, lnDC2PS, and lnTR underscores the interaction between ICT, financial development, and trade, which collectively contribute to economic growth in the Asian context.

The Hansen p-values affirm the validity of the over-identifying restrictions utilized in the GMM estimation, fortifying the robustness of the results. Additionally, the non-significant AR (2) *p*-value indicates that there is no statistically significant second-order autocorrelation in the residuals of these models, suggesting that the models adequately capture the underlying dynamics of the data. These findings collectively provide valuable insights into the complex relationships among these variables in the context of Asian economic growth.

Table 27 summarizes the results obtained through the GMM estimation method for the model in which trade is replaced by imports (lnIM) and exports (lnEX). Notably, the impact of lnEX on GDP growth consistently emerges as positive and statistically significant across various estimation techniques. This underscores the beneficial effect of higher levels of exports on economic growth, highlighting the role of international trade as a driver of economic expansion. In contrast, the findings reveal that lnIM exerts a significant negative influence on economic growth, implying that higher levels of imports may have adverse effects on GDP growth. This result suggests the importance of promoting domestic production or achieving a more balanced trade relationship to support economic growth.

Furthermore, the positive and statistically significant impact of the interaction between ICT and financial development with both imports and exports underscores the

mutually reinforcing effects of these variables on GDP growth. This finding emphasizes that the combination of technological advancements, financial development, and active engagement in international trade positively contributes to economic growth. These results provide valuable insights into the complex dynamics of these factors in shaping economic outcomes. The consistency of the results across various estimation techniques supports the general robustness of these findings.

Conclusion

In conclusion, this empirical investigation provides a comprehensive analysis centered around the regions of Asia, delving into the individual and interactive effects of ICT, financial development, and trade on the region's economic growth. By analyzing these variables across a range of subregions, namely South Asia, Southeast Asia, East Asia, Central Asia, and West Asia, this study sheds light on specific dynamics within the Asian landscape.

Regarding individual effects, the research shows that financial development and ICT have a significant and positive impact on economic growth in Asia. Examining these effects across subregions, however, reveals differences. On the other hand, analysis of the full sample reveals that the effect of trade on economic growth is not significant. Similarly, this effect differs depending on the subregion. To delve deeper into the impact of trade, findings show that exports have a significant and positive effect on economic growth across the full sample as well as in all of the subregions. However, imports show a significant and negative impact in the full sample as well as across each subregion. The concept of export-led growth in the region is supported empirically by these findings.

The findings of the study reveal a positive effect of the interaction between ICT and financial development on economic growth in Asia. These findings underscore the significance of technological advancements and digitalization in fostering the growth of both a thriving regional economy and a resilient financial sector. However, it is important to acknowledge that the magnitude and significance level of this impact exhibit variations when examined within different subregions of Asia. This variation can be attributed to differences in technological infrastructure, financial system sophistication, and the level of economic integration within each subregion.

Additionally, across the full sample and the subregions, the research demonstrates a statistically significant positive interactive effect of ICT, financial development, and trade on economic growth. However, the interaction's significance varies across these sub-regions. Furthermore, there is a significant and positive interactive effect of financial development, imports, and exports on growth. However, the direction and significance of

this effect differ when conducting subregional analyses. This signifies the importance of conducting further study by taking into account the factors specific to each region and exploring policy frameworks to gain a deeper understanding of the underlying variations within these regions.

By offering a subregional overview of the individual and interactive effects of ICT, financial development, and trade on economic growth in Asian economies, this research significantly adds to the existing body of literature in a larger context. The results highlight the need to invest in ICT technology, foster financial development, and facilitate trade as vital components of developmental strategies within the region. To harness the full potential of this interaction between ICT, financial development, and trade, governments and policymakers must tailor strategies and initiatives to align with the specific contexts of subregions. By effectively leveraging these variables, Asia can unlock its growth potential, increase competitiveness, and foster sustainable economic growth amidst the dynamic and ever-evolving global economic landscape.

Policy Recommendations

Here are more specific policy recommendations based on the conclusions drawn from your study:

ICT Infrastructure Investment:

Implement initiatives to promote widespread adoption of ICT. Establish a government-funded initiative to expand fiber-optic broadband networks in rural areas, ensuring access to high-speed internet for underserved communities.

Offer tax incentives for businesses to invest in research and development (R&D) of innovative ICT solutions, such as AI-powered automation systems or blockchain-based supply chain management platforms.

Financial Sector Development:

Implement policies to strengthen the financial sector. Introduce measures to encourage banks to increase lending to SMEs, such as providing loan guarantees or establishing dedicated credit lines for SMEs with innovative business models.

Launch financial literacy programs targeting marginalized communities to increase awareness of banking services and improve access to financial products like microloans and savings accounts.

Trade Facilitation Measures:

Lower trade barriers and streamline customs procedures to facilitate international trade. Negotiate favorable trade agreements to enhance market access for Asian exporters and provide support to exporters through financial incentives, export promotion programs, and assistance in complying with quality and standards requirements.

Subregion-Specific Policies:

Develop tailored policies that address the unique characteristics and challenges of each subregion. In Southeast Asia, focus on improving digital infrastructure connectivity between member countries through initiatives like the ASEAN Broadband Corridor, facilitating cross-border data flows and e-commerce activities.

In Central Asia, prioritize investments in financial technology (fintech) infrastructure to modernize payment systems and enhance access to digital financial services in remote rural areas.

Regional Cooperation Initiatives:

Encourage collaboration among Asian countries on trade, financial integration, and technological advancement initiatives. Establish a regional fund to support joint research and development projects in emerging technologies like 5G networks or renewable energy, leveraging the expertise and resources of multiple Asian countries.

Create a regional task force to address common challenges related to cybersecurity and data privacy, fostering collaboration on developing regional standards and best practices.

Investment in Human Capital:

Prioritize education and skill-building initiatives to equip individuals with the skills needed to thrive in a digital and globalized economy. Launch a scholarship program to sponsor students from low-income backgrounds to pursue degrees in STEM fields at leading universities, with a focus on disciplines relevant to the digital economy such as computer science or data analytics.

Partner with industry associations to develop apprenticeship programs that provide hands-on training in advanced manufacturing techniques or digital marketing strategies, preparing individuals for careers in high-growth sectors.

Data Collection and Analysis:

Enhance data collection and analysis capabilities to better understand the impact of ICT, financial development, and trade on economic growth. Invest in advanced data analytics platforms and cloud computing infrastructure to improve the processing and analysis of large-scale datasets related to economic indicators, trade flows, and technological innovation.

Establish a cross-agency task force dedicated to enhancing data sharing and collaboration between government departments, research institutions, and private-sector stakeholders to improve the quality and timeliness of economic data.

By incorporating these specific policy recommendations into their frameworks, Asian countries can effectively harness the potential of ICT, financial development, and trade to drive sustained and inclusive economic growth. Customizing strategies to the unique needs of each subregion and leveraging regional cooperation initiatives will enable Asian economies to enhance their competitiveness and prosperity in the global arena.

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Appendix

Table 1-A. Results of fixed effects and random effects diagnostics tests.

Test for Cross-section Fixed Effects	
χ^2-statistics	2176.09
p-value	0.0000
Test for Time Fixed Effects	
χ^2-statistics	114.31
p-value	0.0000
Test for Random Effects	
χ^2-statistics	2473.67
p-value	0.0000

Table 2-A. List of Asian Countries

Country	Country ID	Region
Bangladesh	2	South Asia
Bhutan	4	South Asia
India	9	South Asia
Iran	11	South Asia
Nepal	22	South Asia
Pakistan	24	South Asia
Sri Lanka	27	South Asia
Brunei	5	Southeast Asia
Indonesia	10	Southeast Asia
Malysia	20	Southeast Asia
Singapore	26	Southeast Asia
Thailand	29	Southeast Asia
Philippines	25	Southeast Asia
Cambodia	31	Southeast Asia
Bahrain	3	West Asia
Armenia	1	West Asia
Georgia	7	West Asia
Cyprus	6	West Asia
Israel	12	West Asia
Jordan	14	West Asia
Lebanon	18	West Asia
Oman	23	West Asia
Türkiye	30	West Asia
Kazakhstan	15	Central Asia
Kyrgyzstan	17	Central Asia
Tajikistan	28	Central Asia
Hong Kong	8	East Asia
Japan	13	East Asia
Korea Rep	16	East Asia
Macau	19	East Asia
Mongolia	21	East Asia
China	32	East Asia