

Financial Development and National Logistics Performance: The Moderating Role of Institutional Quality

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Abstract - This research is concerned with the issue of translating financial resources into logistics and information-driven service effectiveness in developing and emerging Asian economies under differing institutional conditions. In particular, this study analyzes the moderating effect of institutions on the nonlinear relation between financial development and logistics performance. Applying two-way Fixed Effects models with Driscoll-Kraay standard errors, System GMM in order to deal with potential endogeneity and Panel Smooth Transition Regression (PSTR) in order to reveal possible nonlinear regime shifts to the panel data for 12 countries during the period 2007-2023 (N=75 country-year observations), one finds out that financial development positively and significantly influences logistics performance ($\beta=0.0062$, $p<0.05$) while institutional quality has a positive and significant effect on the dependent variable ($\beta=0.284$, $p<0.01$). System GMM estimation supports the obtained baseline results (FDEV $\beta=0.0058$, $p<0.05$; INST $\beta=0.267$, $p<0.05$). Nonlinearity tests performed in the PSTR model provide evidence against the hypothesis of linearity ($p<0.01$). At low levels of institutions, financial development is significantly positively related to logistics performance ($\beta=0.0089$, $p<0.01$), which reflects the institutional substitution effect in which state-controlled finance substitutes for institutional deficiency. When institutional quality exceeds the threshold ($\hat{c} \approx -0.13$ WGI points), the marginal effect increases by $\beta_1=0.0047$ ($p<0.05$), implying the regime shift to institutional complementarities. The marginal effect increases from 0.0097 at the 10th percentile to 0.0125 at the 90th percentile of institutional quality. Such results have implications for information science, as the performance of logistics depends not only on the physical infrastructure and financial resources but also on the ability of institutions to ensure proper information flows, transparency, coordination, and information-based service delivery.

Keywords: Financial Development, Logistics Performance, Institutional Quality, Regime-switching Moderation, Panel Smooth Transition Regression, Emerging Asia

I. INTRODUCTION

Over the past three decades, logistics has become the lifeblood of trade integration in developing and emerging Asian economies, determining each nation's capacity to participate in global supply chains. However, a significant gap in logistics performance persists between developed and developing countries: according to the World Bank's Connecting to Compete 2023 report (2023) (World Bank, 2023). Singapore leads with a score of 4.30, while four countries—Germany, the Netherlands, Switzerland, and Denmark—all scored 4.10 on a 5-point scale (Upriety, 2026). Meanwhile, Vietnam ranked 43rd, a drop of four places from its 39th position in 2018, even though its Logistics Performance Index (LPI) score increased to 3.3 from 3.27 in 2018. However, what is surprising in this situation is that Vietnam has shown improvement in the logistics score during a period when this country remained poorly rated by international organizations on Voice and Accountability in the Worldwide Governance Indicators (World Bank, 2024; Uyar et al., 2021). The same pattern can be traced in the case of China during its industrialization period. Such reality in the process of development creates a big obstacle for the conventional theory, which claims that institutional quality is necessary for the effective transformation of financial resources into national logistics capabilities.

The finance-growth relationship became a popular topic for many researchers in the field of development economics, and the positive effects of finance on growth were proven with the help of a number of empirical studies. A recently performed meta-analysis revealed that out of 1,334 estimates derived from 67 empirical studies, those studies implied that there is a positive and statistically significant effect of financial development on economic growth (Valickova et al.,

2015). Nevertheless, there is no comprehensive literature on the moderating effects of finance on logistics performance. On the other hand, there is evidence that the efficiency of the logistics performance index (LPI) significantly influences bilateral trade. At the same time, the extent of the effect depends on certain economic and geographic factors (Çelebi, 2019). Other studies have attempted to investigate the role of macroeconomic competitiveness indicators in relation to LPI components, but mostly they are focused on trade and physical infrastructure and do not mention institutional quality as a core of the moderating mechanism (Çemberci et al., 2015).

Furthermore, the theoretical gap emerges due to the contradiction between two major streams in institutional economics. According to the first one – "institutional threshold". This argument is supported by evidence showing that only countries with good political institutions benefit from financial development, a result similar to the finding of a positive impact of democracy on growth (Acemoglu et al., 2019; Slesman et al., 2019). On the other hand, the "institutional substitution" theory suggests that informal, relationship-based financial mechanisms can compensate for and operate effectively when formal institutions are weak, as documented in China (Allen et al., 2019). The existence of these two mechanisms suggests that previous studies, which often assumed a linear moderating relationship, may have overlooked the dynamic and state-dependent nature of the role of institutions. This study addresses this contradiction by directly testing the hypothesis of a change in the moderating mechanism. Study use a method capable of modeling gradual and non-linear variations between different operating states, an approach that has proven effective in detecting asymmetric effects of institutions in the Asia-Pacific region (Valickova et al., 2015; Van et al., 2022).

Therefore, this study is conducted to answer the following questions: (i) Does financial development affect national logistics performance? (ii) Does institutional quality moderate this relationship, and is this moderating relationship linear? (iii) Is there a regime-switching process from a substitution role to a complementarity role for institutions as institutional quality improves?

By answering the research questions above, this paper expects to make four main contributions. First, theoretically, the study integrates the Theory of Financial Intermediation and New Institutional Economics into the context of logistics—an application area that has been underexplored from this perspective. Second, the study reconciles two opposing institutional theories (complementarity and substitution) into a dynamic analytical framework based on institutional development stages, clarifying the complex role of institutional quality in the finance-logistics relationship in developing and emerging Asian countries. Third, empirically, the study constructs a new, multi-source panel dataset (World Bank LPI, WDI, WGI) and combines multiple estimation methods (FE, System GMM, PSTR) to ensure the robustness of its conclusions. Fourth, in terms of policy, these results provide important, stratified implications based on

institutional development stages for multinational supply chain managers in assessing logistics investment risks, as well as for policymakers and international financial institutions in designing institutional reform roadmaps alongside financial development strategies for regional logistics infrastructure.

Previous studies have found out that financial development, institutional quality, and infrastructure factors affect the logistics performance of a nation; however, there are a number of weaknesses in the above studies. The literature mainly focuses on the relationship between the above variables independently, assuming the linear effect of institutional quality on the same. Such an analysis fails to capture how financial development positively affects the logistics performance even when the institutional quality is poor and, on the other hand, becomes more effective in countries having good institutions. Moreover, the existing controversy between the institutional substitution and the institutional complementarity has only considered them as competing theories of explaining such institutional dynamics and has ignored their possible stages of the institutional development process. Apart from this, there is very little attention given in the literature to exploring the above relationship in the case of developing and emerging Asian nations. This study attempts to bridge this gap by investigating whether the institutional quality moderates the effect of financial development on the national logistics performance in a non-linear and state-dependent manner.

This study's main contributions are

- As for the contribution to the finance-development literature, the paper develops the link between financial development and economic performance, but applied to the national logistics performance, an under-researched area of investigation.
- The study combines the Theory of Financial Intermediation and the New Institutional Economics to show the impact of financial resources and institutions on the development of national logistics performance.
- Differing from linear moderation analysis, the study uses the Panel Smooth Transition Regression (PSTR) model to estimate the nonlinear and gradual effect of institution quality on the national logistics performance.
- The study resolves the contradiction between institutional substitution and institutional complementarity, proving that both of them could be interpreted as separate steps of a country's institutional development.
- Applying panel data of emerging Asian countries and using several estimation techniques (fixed effects, system GMM, and PSTR), the study provides empirical evidence of the institutional threshold and smooth transition effects and their specific implications for policymakers, investors, and institutions in different development stages.

The rest of the paper is organized as follows. Section 2 contains the theoretical background and formulation of the hypotheses. Section 3 contains the data and variables used, along with the estimation technique adopted. Section 4 gives the results obtained from the empirical analysis conducted. The final section 5 contains the discussion on the results in the light of regional economic theories and practices. Section 6 concludes and proposes policy implications. Finally, Section 7 presents the limitations and directions for future research.

II. THEORETICAL BASIS AND HYPOTHESIS DEVELOPMENT

2.1. Foundational Theories

The theoretical basis for this research is created through a blend of two primary theories, namely the Theory of Financial Intermediation and New Institutional Economics. The merger of those theories allows answering one fundamental question: What are the conditions allowing financial capital conversion to tangible value? Both theories recognize the "effective transmission mechanism" as the answer to that question but provide different explanations on what makes this mechanism effective. Thus, this study merges and contrasts core propositions of both theories to get a more complete answer.

The theory of financial intermediation states that in pure capital markets there are many inefficiencies, such as transaction costs and asymmetric information, that prevent efficient capital allocation between savers and borrowers. Financial intermediaries optimize resource allocation through information gathering and processing, project monitoring and optimisation of capital management, which allows reducing monitoring costs and facilitating capital flow to the most productive uses, including long-term infrastructure projects, such as seaports, fleets and warehouses (Konstantakopoulou, 2023). This mechanism is the basis for the independent variable in this research-financial development (FDEV) - with the assumption that the depth of financial intermediation creates enough capital for logistics capability upgrades.

However, the theory of financial intermediation does not explain the reasons why the same degree of financial development leads to a substantial difference in the efficiency of logistics in different countries. This theory is where the role of new institutional economics comes into play. According to the theory, institutions, as the rules and systems for their enforcement that influence the economic behaviour of people, influence an economy's transaction costs through the establishment of property rights and contract enforcement; controlling of those costs makes it possible to conduct exchange transactions and generate economic value (Ménard & Shirley, 2022). In terms of logistics, better institutions reduce the costs of customs procedures and increase transparency of seaports and border crossing points, which affects the key components of LPI directly.

The most notable interaction between these two theories is demonstrated through the resource complementarity hypothesis: good institutions are considered a necessary condition for financial capital to be allocated and used effectively, as countries with higher quality political institutions benefit more clearly from financial development, while countries with weak institutions do not reap similar benefits; this argument is also consistent with the finding that democratic institutional quality has a positive long-term economic effect (Acemoglu et al., 2019; Slesman et al., 2019; Ramani et al., 2025). However, an opposing line of theory suggests that informal financial mechanisms, based on relationships and trust, can fully substitute for the role of weak formal institutions to mobilize and allocate capital effectively, as evidenced by China's private sector (Allen et al., 2019). The theoretical gap arising from the unresolved conflict between these two logics of "complementarity" and "substitution"—though both stem from institutional thinking but lead to conflicting predictions about the moderating role of institutions—will be used as the central theoretical foundation for developing the study's nonlinear moderation hypothesis.

2.2. Hypothesis Development

2.2.1. Financial Development and Logistics Performance

The Theory of Financial Intermediation suggests that an efficient financial system helps gather information, monitor investment projects, and allocate capital to its most effective uses (Demirbaş et al., 2024). Based on this foundation, the study argues that as the financial system develops, logistics enterprises and infrastructure investors gain easier access to loans; this capital is used to upgrade technology, fleets, and warehousing systems; and the final result is an improvement in national logistics performance.

Recent empirical studies generally support this positive direction of impact. Using data from emerging markets, find that better access to financial institutions and markets helps improve logistics performance in both the short and long term (Demirbaş et al., 2024). Also show that national competitiveness—in which the financial system is a key component—has a positive relationship with logistics performance (Kabak et al., 2020). However, the magnitude and statistical significance of this impact are not entirely consistent across studies, partly due to differences in measuring financial development (pure bank credit versus a multidimensional composite index) and partly due to the mediating role of public governance, as governance quality has been shown to mediate the relationship between macroeconomic institutional factors and logistics performance implying that the effect of finance on logistics can be weakened or amplified depending on the institutional context of each country group (Uyar et al., 2021).

In developing and emerging Asian countries, this transmission mechanism is even more well-founded as the region is undergoing large-scale logistics infrastructure investment linked to the wave of supply chain shifts, while

logistics performance continues to play a crucial role in promoting exports and growth in Asian economies (Tang & Abosedra, 2019). On this basis, the hypothesis is stated:

H1: *Financial development has a positive impact on national logistics performance, regardless of institutional quality.*

2.2.2. Institutional Quality and Logistics Performance

New Institutional Economics is the theoretical foundation for this argument: good institutions help reduce transaction costs by ensuring contract enforcement and increasing transparency in economic transactions. Applied to the logistics context, high institutional quality helps reduce the cost and time for customs procedures, increases transparency in clearance processes, and limits corruption at borders and seaports—these are the direct components of the LPI, especially the Customs and Timeliness components.

Recent empirical evidence largely confirms this positive direction of impact, but the strength of the impact is not uniform across studies. Using a generalized estimating equations method on a dataset of 138 countries, finds that Government Effectiveness maintains a stable positive impact on the LPI across various estimation models (Upreti, 2026). Also note that national institutional quality plays a significant moderating role in the relationship between logistics performance and global value chain participation, with a much stronger downstream spillover effect in the group of countries with good governance compared to the weak governance group (Nasser & Ouerghi, 2024). However, when shifting to frontier analysis methods like data envelopment analysis, only find a clear link between the level of corruption and logistics-based trade efficiency in certain groups of developing countries, suggesting that differences in institutional measurement (composite WGI index vs. single corruption perception index) and estimation methods (panel regression vs. frontier analysis) can lead to inconsistent conclusions about the magnitude of the impact (Acar & Kara, 2023).

In developing and emerging Asian countries, this impact has a more practical basis as this region has many bottlenecks in customs and seaport procedures, where institutional reforms often yield faster and clearer improvements in logistics than in economies with long-established stable governance. On this basis, the following hypothesis is proposed:

H2: *Institutional quality has a positive impact on national logistics performance.*

2.2.3. The Nonlinear Moderating Role of Institutions

The theoretical foundation for this hypothesis is the reconciliation of the two opposing institutional logics presented in Section 2.1: institutional complementarity and institutional substitution. These two logics are not mutually exclusive but can coexist at different stages of institutional development.

Unlike the simple linear moderation assumption, this study proposes that the mechanism by which financial development affects logistics performance changes in nature, not just in intensity, according to the level of institutional development. At low institutional levels, credit—especially through state-owned and policy banks—still directly and effectively finances key logistics infrastructure such as seaports and railways, playing a substitution role for the market-based capital allocation mechanism that weak institutions cannot yet guarantee. At high institutional levels, the mechanism of capital allocation through the formal financial market, where institutions ensure transparency and contract enforcement, becomes the dominant channel; at this point, institutions play a complementary role, amplifying the efficiency of capital use. Between these two regimes is a gradual transition zone, not a discrete break, because institutional reforms in reality occur sequentially.

Recent empirical evidence shows that, in the high institutional regime, applying a panel smooth transition regression model to 160 countries, find that institutional quality has a positive impact on the marginal effect of foreign direct investment on growth when it surpasses an estimated threshold, but this impact turns negative below that threshold—a regime-switching pattern similar to the one proposed here, though applied to FDI instead of financial development (Guenichi & Omri, 2025). Meanwhile, in the low institutional regime, using proprietary data from the China Development Bank, finds that its infrastructure loans attract additional investment from private firms in downstream industries, showing that state-directed credit can effectively lead private resources into infrastructure even in an environment with many institutional constraints (Ru, 2018).

In developing and emerging Asian countries, this regime-switching process has a particularly clear practical basis, as the region is undergoing uneven stages of institutional reform accompanied by a wave of large-scale logistics infrastructure investment through both state-led credit channels and formal financial markets. Based on the arguments presented, the following hypothesis is proposed:

H3: *The moderating effect of institutional quality on the relationship between financial development and logistics performance is nonlinear; characterized by a smooth transition from a substitution mechanism (at low institutional levels) to a complementarity mechanism (at high institutional levels).*

2.2.4. Regime-Switching Hypothesis

The theory underpinning this hypothesis is the synthesis of the theories of institutional complementarity and institutional substitution articulated in section 2.1 and formulated as a mechanism switching hypothesis in section 2.2.3, now reconfigured in a parametric framework amenable to empirical estimation.

The central argument is: if the two aforementioned institutional logics coexist but at different stages of development as argued in Section 2.2.3, then the transition between them should be described by a function capable of smoothly changing its shape according to the level of institutional quality, rather than a fixed break point. The logistic transition function meets this requirement precisely through two parameters: the shape parameter γ , which determines how quickly or slowly the transition occurs, and the location parameter c , which identifies the value of institutional quality at which the transition is halfway complete. When γ and c are estimated from empirical data, rather than being pre-imposed, the study can objectively determine whether the transition from a substitution to a complementarity mechanism truly exists and at what institutional level it occurs.

Several recent studies provide empirical evidence supporting this approach. Using a panel smooth transition regression model on 110 countries, finds that the impact of institutional quality on financial inclusion varies with the income level of each country group, with low-income countries tending not to benefit from institutional reforms in the same way as high- and middle-income countries—a demonstration that the transition location parameter can delineate country groups with different operating mechanisms (Vo, 2024). In addition, when testing the threshold role of institutional quality in the relationship between financial development and renewable energy transition, confirm that the sensitivity of financial development to development goals changes systematically when institutional quality crosses a certain threshold, further reinforcing the argument that the moderating relationship of institutions in many economic areas is not linear in nature (Olaniyi et al., 2025). This result is also consistent with the findings where the marginal effect of an economic variable on growth changes sign and magnitude depending on the country's position relative to the estimated institutional threshold (Guenichi & Omri, 2025).

In developing and emerging Asian countries, the specific estimation of γ and c has particular practical significance, as countries in the region are at very different stages of institutional reform—from those just beginning reforms to those with relatively stable governance foundations—creating enough variation needed to accurately identify the location and speed of the transition process. Based on the arguments presented, the following hypothesis is proposed:

H4: *This transition process alters the marginal effect of financial development, with the speed (parameter γ) and location (parameter c) of the transition threshold being empirically determined.*

The majority of previous studies indicate a positive association between financial development, institutional quality, and national logistics performance; yet, the results obtained are somewhat fragmented. Most research considers either the direct impact of financial development or institutional quality in terms of linear panel regression models, whereas others pay attention to particular dimensions

of governance, competitiveness, and logistics efficiency. Recent empirical studies emphasize the increasing role of digital infrastructure, information processing, and technology-supported logistics coordination as well; however, these factors tend to be analyzed independently from the financial and institutional environment. Thus, the previous literature fails to answer questions about how similar levels of financial development lead to distinct logistics performance in different countries or how the role of finance changes when institutional capacities get improved. It is especially relevant for developing and emerging economies of Asia due to large differences in the areas of governance quality, financial system, digitalization, and logistics infrastructure among them.

This study attempts to overcome the above-described limitations by abandoning the assumption of the constant linear relationship. In contrast to previous studies that considered institutional quality as just a linear moderator or direct determinant of logistics performance, the present paper assumes institutional quality to act as a regime-switching mechanism capable of changing the marginal effect of financial development on logistics performance. Using the methodology of the Panel Smooth Transition Regression model, the study analyzes the possibility that the impact of financial development first substitutes for institutional weaknesses and then becomes more efficient as institutions, governance, and information processing abilities improve.

III. RESEARCH METHODOLOGY

3.1. Sample and Data Sources

This study uses national-level macroeconomic panel data compiled from three public, reputable, and regularly updated databases: the Logistics Performance Index (LPI) from the World Bank (2023), the World Development Indicators (WDI), and the Worldwide Governance Indicators (WGI), also published by the World Bank (2024). The study uses the method of quantitative research, as the goals of the study demand an empirical analysis of the linear, moderating, and non-linear relationships between financial development, institutions, and national logistics performance. Such a methodology is justified within the context of information systems/information services due to the presence of information activities such as shipping and tracking of cargo, customs clearance, information exchanges, service coordination, and timeliness.

Secondary data will be used, collected directly from international data sources published by the World Bank. Specifically, LPI uses the international standardized measure of logistics performance, whereas WDI and WGI represent the harmonized measures of the economy and institution indicators. Such use of standardized repositories enhances the country comparison of the variables under consideration.

In terms of timeframe, the study covers the period 2007–2023, corresponding to the 7 LPI survey rounds published by the World Bank: 2007, 2010, 2012, 2014, 2016,

2018, and 2023. The choice of this timeframe stems from the inherent characteristic of the LPI—this index is not collected annually but through global logistics expert surveys, with the 2020 survey round being skipped due to disruptions from the COVID-19 pandemic. Accordingly, the dataset consists of repeated country-level observations corresponding to the seven available LPI survey rounds rather than annual observations. This 17-year period also covers many significant institutional and financial fluctuations in the developing and emerging Asian region—from the post-global financial crisis period of 2008–2009, the wave of trade and customs reforms between 2010–2018, to the post-pandemic recovery and supply chain restructuring phase—creating sufficient variation to identify both linear and nonlinear effects of the research variables.

Regarding sample construction, the initial population included 27 developing and emerging economies in Asia according to the International Monetary Fund's classification (Emerging Market and Developing Economies), belonging to three subregions: South Asia, Southeast Asia, and East Asia–Central Asia. From this population, study sequentially filtered in two steps. First, study excluded 10 countries with LPI data missing in at least four of the 7 survey rounds, mainly small economies or those outside the stable survey scope of the World Bank in the early 2007–2012 period, including Bhutan, Nepal, Laos, Cambodia, Myanmar, Tajikistan, Kyrgyzstan, Turkmenistan, Uzbekistan, and Timor-Leste. Second, study further excluded 5 countries with systematic missing data for control variables from WDI or WGI for several consecutive years, including Maldives, Brunei, the Democratic People's Republic of Korea, Afghanistan, and Papua New Guinea. The above-mentioned criteria were applied to all countries equally and based on the completeness of the data instead of any particular country selections. Only those countries where there was enough data

of LPI along with other required variables of WDI and WGI were considered in the estimation process.

After these two filtering steps, the final sample consists of 12 countries: India, Bangladesh, Pakistan, Sri Lanka (South Asia); Vietnam, Indonesia, Thailand, Malaysia, Philippines (Southeast Asia); and China, Kazakhstan, Mongolia (East Asia–Central Asia). With 12 countries observed over 7 survey rounds, the maximum number of country-year observations is 84; however, due to some missing data cells—mainly in Mongolia and Kazakhstan in the 2007 and 2010 survey rounds when the LPI survey scope for the Central Asia region was limited—the final sample comprises 75 country-year observations, forming an unbalanced panel. Therefore, the final analysis data set consists of 12 countries and 75 observations on the round of countries where logistics performance, financial development, institutions, and economic structure have been captured.

To mitigate the influence of extreme values that may arise from the nature of multinational macroeconomic data—such as sudden FDI inflows or hyperinflation at certain times—all continuous variables in the model are treated with the winsorization method at the 1st and 99th percentiles before estimation, to limit the impact of outliers without losing observational information like the trimming method.

3.2. Variable Measurement

The choice of measurement method for each variable in this study was made following the principle of inheriting methodological precedents from validated international empirical studies, while ensuring data availability for the group of developing and emerging Asian countries. Table I summarizes the definitions, measurements, and data sources of all variables used in the study.

TABLE I VARIABLE DEFINITIONS, MEASUREMENT, AND DATA SOURCES

Notation	Variable Name	Role	Primary Measurement	Alternative Measurement	Data Source
LPI	Logistics Performance	Dependent variable	Composite LPI score (1–5 scale)	Container port traffic (TEU, log form)	World Bank LPI; WDI
FDEV	Financial Development	Independent variable	Domestic credit to private sector (% of GDP)	IMF Financial Development Index (composite)	WDI; IMF Financial Development Index
INST	Institutional Quality	Moderating variable	WGI composite index (average of 6 component indicators)	Control of Corruption	World Bank WGI
GDPPC	Economic Development Level	Control variable	GDP per capita, constant 2015 US\$ (log form)	–	WDI
OPEN	Trade Openness	Control variable	(Exports + Imports)/GDP	–	WDI
FDI	Foreign Direct Investment	Control variable	FDI net inflows (% of GDP)	–	WDI
INF	Macroeconomic Stability	Control variable	Inflation rate, CPI (%)	–	WDI
URB	Urbanization	Control variable	Urban population (% of total population)	–	WDI

Source: Authors' compilation

From an information system / information service point of view, the constructs can be viewed as interrelated components of logistics performance through information. LPI refers to the logistics performance of a nation's logistics services system, which comprises customs, tracking of shipments, timeliness, logistics service quality, and infrastructure. FDEV refers to the financing capacity for developing and maintaining these systems, whereas INST refers to the institutional setting for reliable information communication and coordination.

For the dependent variable, national logistics performance is measured by the composite LPI score published by the World Bank, ranging on a scale from 1 to 5. This measurement was chosen for three reasons: First, the LPI is the only currently available measure for systematically comparing the logistics performance of countries, built based on surveys of global logistics practitioners and widely employed in the empirical literature on logistics and international business (Çelebi, 2019; Demirbaş et al., 2024). Second, because of its multidimensional nature (consisting of such dimensions as customs, infrastructure, logistics service providers, tracking systems, timely delivery, and international ocean shipping costs), the LPI can more accurately capture the concept of logistics performance than single-dimensional measures such as infrastructure density or port efficiency. Third, in the context of developing and emerging Asian countries, where physical logistics infrastructure sometimes develops faster than institutional operational capacity (e.g., customs procedures, clearance transparency), the perceptual measurement nature of the LPI more appropriately reflects the gap between infrastructure investment and actual operational efficiency—which is the theoretical focus of this study. The inclusion of shipment tracking, customs, and logistics service quality also makes the LPI particularly relevant to information-service and information-processing performance within national logistics systems.

For the independent variable, financial development is measured by the ratio of domestic credit to the private sector to GDP, collected from the WDI. This is the most commonly used measure in the finance-growth literature, as it directly reflects the "depth" of financial intermediation in allocating capital to the real production sector, and has been directly applied in recent studies on the relationship between financial development and logistics performance in emerging markets (Demirbaş et al., 2024; Valickova et al., 2015). The choice of the private credit measure, instead of capital market financial indicators (such as stock market capitalization), is particularly suitable for the financial structure characteristics of the developing and emerging Asian countries in the study sample, where the banking system—including both commercial and policy banks—remains the main channel for mobilizing and allocating capital for infrastructure investment, while the stock and corporate bond markets are still in their nascent stages of development in many countries in the sample (e.g., Bangladesh, Mongolia, Pakistan).

For the moderating variable, institutional quality is measured by the composite WGI index, calculated as the average of six component indicators: Voice and Accountability, Political Stability, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption (World Bank, 2024). The use of a composite index, rather than a single component indicator, allows for capturing the concept of institutions in the broad sense as defined in New Institutional Economics and is also a measurement that has been applied in recent studies on the moderating role of institutions in the finance-growth and finance-logistics relationships (Ménard & Shirley, 2022; Nasser & Ouerghi, 2024; Slesman et al., 2019). The composite measure also captures the broader institutional environment in which information is generated, communicated, verified, and used for logistics coordination and financial allocation.

3.3. Empirical Model Specification

These empirical specifications are meant to relate directly to the research hypotheses. Model 1 assesses the effect of financial development and institutional quality (H1 and H2), whereas Model 2 looks at linear moderation, and the System GMM model tries to address any endogenous issue. The PSTR model is the main empirical specification used in the testing of H3 and H4.

Model 1 – Baseline Model (Equation 1):

$$LPI_{it} = \beta_0 + \beta_1 FDEV_{it} + \beta_2 INST_{it} + \beta_3 GDPPC_{it} + \beta_4 OPEN_{it} + \beta_5 FDI_{it} + \beta_6 INF_{it} + \beta_7 URB_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

Model 2 – Linear Moderation Model (Equation 2):

$$LPI_{it} = \beta_0 + \beta_1 FDEV_{it} + \beta_2 INST_{it} + \beta_3 (FDEV_{it} \times INST_{it}) + \beta_4 GDPPC_{it} + \beta_5 OPEN_{it} + \beta_6 FDI_{it} + \beta_7 INF_{it} + \beta_8 URB_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

Where: $i = 1, \dots, 12$ represents the country; t represents the seven LPI survey points; μ_i is the country fixed effect, controlling for time-invariant characteristics such as geographical location or terrain features; λ_t is the time fixed effect, controlling for global common shocks in each survey round; ε_{it} is the random error term.

The marginal effect of financial development on logistics performance, conditional on institutional quality, in the linear framework is calculated as follows: $\partial LPI_{it} / \partial FDEV_{it} = \beta_1 + \beta_3 INST_{it}$

To control for the endogeneity problem that may arise from the two-way causal relationship between financial development and logistics performance—for instance, a country with high logistics performance may attract more investment and thereby promote deeper development of its own financial system—study estimate the following dynamic model using the System GMM method (Equation 3):

$$LPI_{it} = \beta_0 + \rho LPI_{it-1} + \beta_1 FDEV_{it} + \beta_2 INST_{it} + \beta_3 (FDEV_{it} \times INST_{it}) + \beta_4 GDPPC_{it} + \beta_5 OPEN_{it} + \beta_6 FDI_{it} + \beta_7 INF_{it} + \beta_8 URB_{it} + \mu_i + \varepsilon_{it} \quad (3)$$

Where ρ is the coefficient of the lagged variable LPI_{it-1} , reflecting the persistence of logistics performance, i.e., the extent to which past performance determines present performance.

The main model used to test the nonlinear hypotheses H3 and H4 is the Panel Smooth Transition Regression (PSTR) model, following the approach, with a transition order $m = 1$, corresponding to a two-regime structure (Equation 4): (González et al., 2017).

$$LPI_{it} = \mu_i + \beta_0 FDEV_{it} + \beta_1 FDEV_{it} \times g(INST_{it}; \gamma, c) + \delta_1 GDPPC_{it} + \delta_2 OPEN_{it} + \delta_3 FDI_{it} + \delta_4 INF_{it} + \delta_5 URB_{it} + \varepsilon_{it} \quad (4)$$

Where the logistic transition function $g(\cdot)$ is defined as: $g(INST_{it}; \gamma, c) = 1 / [1 + \exp(-\gamma(INST_{it} - c))]$

With $\gamma > 0$ being the transition speed parameter—the larger the value of γ , the closer the transition between the two regimes is to a hard break; the smaller γ , the smoother and more gradual the transition. The parameter c is the transition location, i.e., the value of $INST$ at which $g(\cdot) = 0.5$, marking the midpoint between the two regimes.

The marginal effect of financial development on logistics performance according to the PSTR model—the central formula for testing H3 and H4—is determined as:

$$\partial LPI_{it} / \partial FDEV_{it} = \beta_0 + \beta_1 \cdot g(INST_{it}; \gamma, c)$$

As $g(\cdot)$ approaches 0 (for a country or time point with low $INST$, far below the transition point c), the marginal effect approaches the value β_0 , reflecting the Institutional Substitution Regime, where finance impacts logistics relatively independently of institutional quality. As $g(\cdot)$ approaches 1 (high $INST$, far above the transition point c), the marginal effect approaches the value $(\beta_0 + \beta_1)$, reflecting the Institutional Complementarity Regime, where institutions further amplify the impact of finance.

Finally, to check the robustness of the nonlinear finding from the PSTR model with an independent cross-check approach, study also estimate a Panel Threshold Regression model as equation 5 (Hansen, 1999):

$$LPI_{it} = \beta_0 + \beta_1 FDEV_{it} \times I(INST_{it} \leq \gamma) + \beta_2 FDEV_{it} \times I(INST_{it} > \gamma) + \beta_3 GDPPC_{it} + \beta_4 OPEN_{it} + \beta_5 FDI_{it} + \beta_6 INF_{it} + \beta_7 URB_{it} + \mu_i + \varepsilon_{it} \quad (5)$$

Where γ is the institutional threshold value to be estimated and $I(\cdot)$ is an indicator function that takes the value 1 if the condition in parentheses is true, and 0 otherwise.

3.4. Estimation Strategy

First, the study performs data pre-processing tests, including a panel unit root test, a multicollinearity test (VIF), and particularly a cross-sectional dependence test (Im et al., 2003; Pesaran, 2021). The results indicate the presence of cross-sectional dependence; therefore, in the second step, the baseline models are estimated using a two-way fixed-effects method with standard errors to address this issue (Driscoll & Kraay, 1998).

In the third step, to address endogeneity concerns arising from potential two-way causality, a two-step System GMM model with correction is applied (Arellano & Bover, 1995; Blundell & Bond, 1998; Windmeijer, 2005).

The core of the study lies in the fourth step, where the Panel Smooth Transition Regression (PSTR) model is used to test the hypothesis of a nonlinear moderating relationship (González et al., 2017). This procedure involves testing for linearity, followed by estimating a two-regime model to determine the transition parameters ($\beta_0, \beta_1, \gamma, c$) and calculate the marginal effects.

Finally, in the fifth step, a series of robustness checks are conducted. Threshold regression model is used as a cross-check analysis (Hansen, 1999). Additionally, the study tests for sensitivity by using alternative variable measures and conducting separate analyses for sub-regional groups. The entire estimation process is performed using Stata 17 software.

Fig. 1 presents this workflow to provide a transparent overview of the data processing, estimation, and evaluation procedures.

Ethical considerations: The study relies exclusively on publicly available secondary data at the country level and does not involve human participants, personal information, confidential records, or experimental interventions. Therefore, no individual-level privacy or informed-consent issues arise. The study nevertheless follows principles of responsible secondary-data use by maintaining the original definitions of the databases, reporting the data sources transparently, applying consistent selection criteria, and documenting the data-processing and estimation procedures to support validity and reproducibility.

Replication is done using Stata 17 software. The preprocessing settings used include winsorization in the range of the 1st–99th percentiles of the continuous variables, panel identifiers by country and survey round, and construction of the institutional quality index based on the six WGI components. In the case of the PSTR, a first-order logistic transition function ($m=1$) is applied where $\gamma > 0$ and c is estimated. The same country-level panel setting is applied for all the estimations.

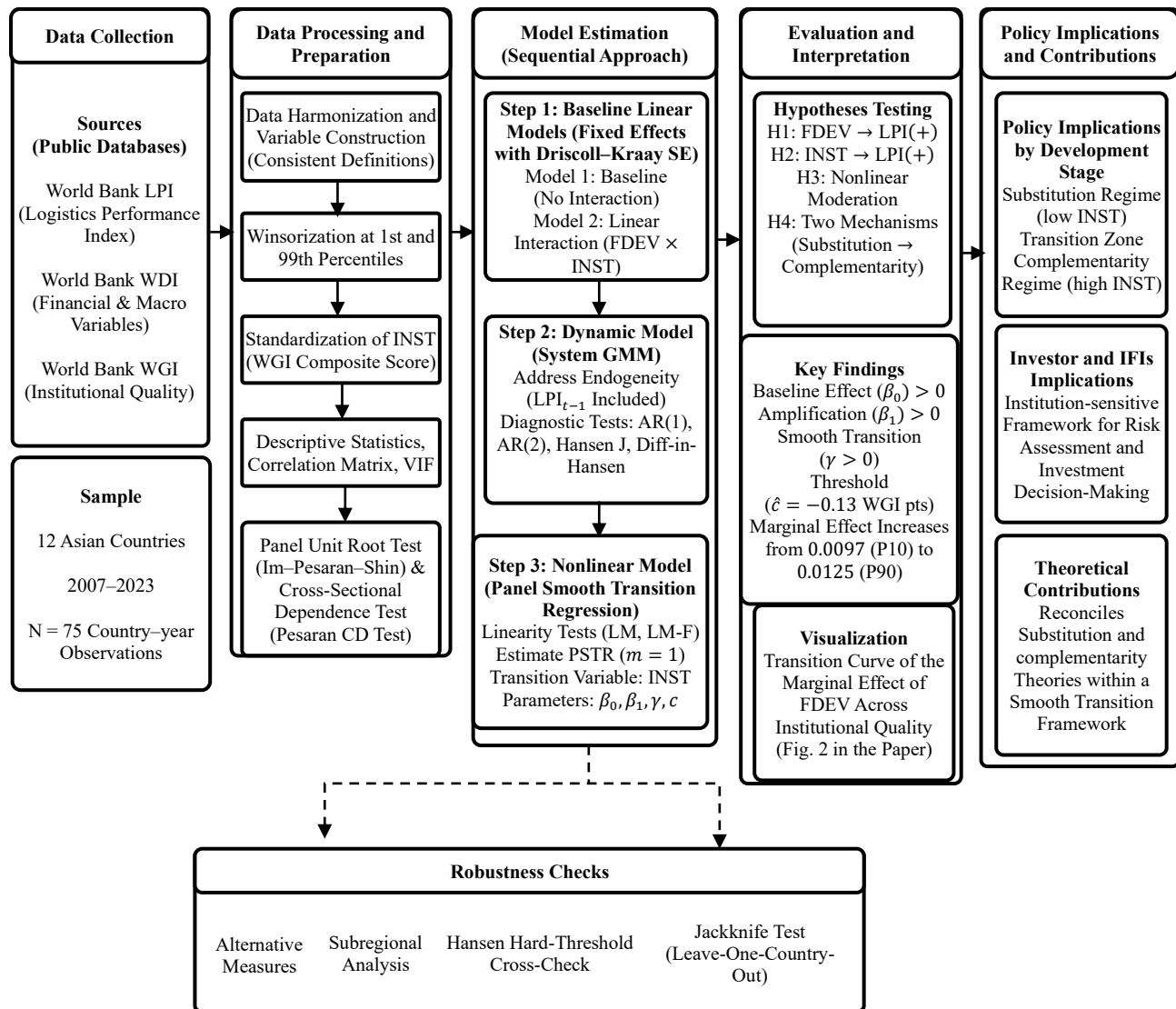


Fig. 1 The Overall Analytical Workflow

IV. RESEARCH RESULTS

4.1. Descriptive Statistics and Pre-processing Diagnostics

Before presenting the regression results, table II summarizes the basic distributional characteristics of the research variables for the sample of 75 country-year observations, to provide an overview of the data's variability before proceeding to the main empirical tests.

These descriptive statistics also give an initial understanding of the features of information and service systems that are included in the data set. The range of the LPI is between 2.08 and 3.89, suggesting some variations in national logistics service performance among the chosen countries during those periods. The variation of the FDEV and INST indices suggests the existence of substantial differences in the financial and institutional contexts of logistics and information-based coordination. This is crucial, as the following estimations with fixed effects, System GMM, and PSTR use this variation.

TABLE II DESCRIPTIVE STATISTICS OF THE RESEARCH VARIABLES

Variable	Obs.	Mean	Std. Dev.	Min	Max
LPI_{it}	75	2.94	0.47	2.08	3.89
$FDEV_{it}$ (%GDP)	75	68.53	41.26	14.90	158.40
$INST_{it}$	75	-0.34	0.52	-1.21	0.87
$GDPPC_{it}$ (log)	75	7.86	0.79	6.31	9.34
$OPEN_{it}$ (%GDP)	75	78.92	37.15	35.60	199.70
FDI_{it} (%GDP)	75	2.87	3.12	-1.84	12.36
INF_{it} (%)	75	6.41	5.83	-0.72	26.15
URB_{it} (%)	75	46.28	16.04	22.10	77.85

Note: All continuous variables have been winsorized at the 1st and 99th percentiles, as described in Section 3.1. $INST_{it}$ denotes the standardized WGI composite score.

Source: Authors' calculation from World Bank LPI, WDI, and WGI databases.

The descriptive statistics show that the research sample has considerable variation, especially in the $INST_{it}$ variable, which ranges from -1.21 (reflecting the group of countries with weak institutions like Bangladesh, Pakistan, Mongolia in the early sample period) to 0.87 (reflecting the group with better institutions like Malaysia, Thailand in the recent period)—this dispersion is a necessary condition for the PSTR model in Section 4.4 to identify the regime-switching process.

The Pearson correlation matrix shows that $FDEV_{it}$ is quite highly correlated with $GDPPC_{it}$ ($r = 0.64$), as warned in Section 3.4, but this correlation level does not reach the threshold for severe multicollinearity; $FDEV_{it}$ and $INST_{it}$ are both positively correlated with LPI_{it} ($r = 0.49$ and $r = 0.38$, respectively), consistent with the expected signs of H1 and H2. The VIF test confirms that the highest value belongs to $FDEV_{it}$ ($VIF = 3.86$), which is below the recommended threshold of 10, ruling out the possibility of severe multicollinearity.

The Im-Pesaran-Shin unit root test rejects the null hypothesis H_0 of a unit root for all variables at the level or first difference ($p < 0.05$), confirming the stationarity of the panel data. Notably, the Pesaran CD test for cross-sectional dependence yields a CD statistic of 3.92 ($p < 0.01$), rejecting the null hypothesis H_0 of no cross-sectional dependence—this result provides direct empirical justification for using Driscoll–Kraay standard errors in table III.

These tests have shown that the data set is highly varied enough to be statistically appropriate for the following empirical analysis. The fact that there is no multicollinearity problem allows us to estimate both financial and institutional effects simultaneously. Cross-section dependence calls for employing dependence-robust standard errors. The stationarity test helps to minimize the chance of spuriousness in the estimated effect.

4.2. Baseline Linear Estimation Results

Table III presents the two-way fixed-effects estimation results for Model 1 (without interaction) and Model 2 (with a linear interaction between financial development and institutional quality), to test hypotheses H1, H2, and provide initial evidence for hypothesis H3.

These findings match directly the first two steps in the empirical approach outlined in Section 3.4 above, where the fixed effects model identifies the baseline direct effect and the interaction specification is an initial test on whether institutions affect the relationship between finance and logistics.

TABLE III FIXED-EFFECTS ESTIMATION RESULTS – BASELINE AND LINEAR MODERATION MODELS

Variable	(1) Model 1: Baseline	(2) Model 2: Linear Moderation
$FDEV_{it}$	0.0062** (0.0027)	0.0071** (0.0031)
$INST_{it}$	0.284*** (0.089)	0.311*** (0.094)
$FDEV_{it} \times INST_{it}$	–	0.0028* (0.0016)
$GDPPC_{it}$	0.196** (0.081)	0.183** (0.079)
$OPEN_{it}$	0.0018 (0.0015)	0.0015 (0.0014)
FDI_{it}	0.021* (0.012)	0.019* (0.011)
INF_{it}	–0.0134** (0.0058)	–0.0128** (0.0057)
URB_{it}	0.0049 (0.0035)	0.0044 (0.0034)
Constant	0.812 (0.612)	0.734 (0.598)
Country fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	75	75
R^2 (within)	0.583	0.607

Note: Driscoll–Kraay standard errors, robust to heteroskedasticity, autocorrelation, and cross-sectional dependence, are reported in parentheses, consistent with the Pesaran CD test results reported in Section 4.1. *, **, *** denote statistical significance at the 10%, 5%, and 1% levels, respectively (Driscoll & Kraay, 1998).

Source: Authors' estimation using Stata 17.

The results in columns (1) and (2) confirm H1: the coefficient of $FDEV_{it}$ is positive and statistically significant at the 5% level in both model specifications, affirming that financial development has a positive and consistent impact on national logistics performance, regardless of whether the model controls for interaction. Concurrently, the coefficient of $INST_{it}$ is positive and statistically significant at the 1% level in both models, confirming H2.

Substantively, the positive coefficient for $FDEV$ shows that increased financial intermediation is related to better logistics performance in a country, and that is in support of the theory that financial assets make possible investments in logistics infrastructure and technology. On the other hand, the positive $INST$ coefficient shows that the institutional environment contributes to logistics system efficiency.

The most noteworthy point is the interaction coefficient $FDEV_{it} \times INST_{it}$ in column (2): this coefficient is quite small in magnitude (0.0028) and only achieves weak statistical significance at the 10% level. This result should not be interpreted as a rejection of the moderating role of institutional quality. Instead, this weak signal reflects the possibility that the linear moderation model has "averaged out" two opposing operating mechanisms—institutional substitution and complementarity—that coexist within different small groups of countries in the sample.

For this reason, the weak linear interaction is seen as one of the primary reasons why a nonlinear analysis is required rather than a conclusive proof of H3. The linear interaction entails a marginal moderation effect that is constant irrespective of the level of institutional quality, while theory assumes that the mechanism itself could change.

4.3. Dynamic Estimation and Endogeneity Test Results

To control for potential endogeneity arising from the two-way causal relationship between financial development and logistics performance, table IV presents the results of the dynamic model estimation using the two-step System GMM method, along with diagnostic tests for the validity of the instrument set.

This estimation is related to the third methodological step and acts as a robustness test for the baseline results. Unlike the fixed-effect models, the system GMM approach includes logistic performance lagged variables and internal instruments to overcome the problem of reverse causality.

TABLE IV TWO-STEP SYSTEM GMM ESTIMATION RESULTS – ENDOGENEITY TEST

Variable	Coefficient
LPI_{it-1}	0.412*** (0.098)
$FDEV_{it}$	0.0058** (0.0026)
$INST_{it}$	0.267** (0.112)
$FDEV_{it} \times INST_{it}$	0.0031 (0.0024)
$GDPPC_{it}$	0.174* (0.096)
$OPEN_{it}$	0.0021 (0.0017)
FDI_{it}	0.017 (0.014)
INF_{it}	-0.0119* (0.0064)
URB_{it}	0.0038 (0.0041)
Observations	63
Number of countries	12
Number of instruments	10
AR(1) test – p-value	0.038
AR(2) test – p-value	0.276
Hansen J test – p-value	0.318
Difference-in-Hansen test – p-value	0.241

Note: Estimated using two-step System GMM with Windmeijer, (2005)-corrected standard errors in parentheses. The number of instruments is restricted below the number of countries ($N=12$) to avoid instrument proliferation. *, **, *** denote statistical significance at the 10%, 5%, and 1% levels, respectively (Arellano & Bover, 1995; Blundell & Bond, 1998).

Source: Authors' estimation using Stata 17.

The coefficient of the lagged variable LPI_{it-1} is positive and statistically significant at the 1% level, reflecting a considerable degree of persistence in logistics performance across survey rounds—an economically plausible characteristic, as logistics infrastructure and operational capacity do not typically change abruptly between periods. A 0.412 coefficient means that there is quite significant persistence as past logistics performance continues to be an important determinant of future logistics performance, adjusting for finance, institutions, and macroeconomics. This result further underscores the need to view logistics performance from the perspective of a cumulative capability.

The coefficients of $FDEV_{it}$ and $INST_{it}$ remain positive and statistically significant compared to table III, although their magnitudes are slightly reduced, thereby confirming that the conclusions regarding H1 and H2 are not driven by endogeneity issues. The diagnostic tests all support the validity of the model: the AR(2) test does not reject the null hypothesis H_0 ($p = 0.276$), and both the Hansen J test ($p = 0.318$) and the Difference-in-Hansen test ($p = 0.241$) are greater than 0.10, confirming the reliability of the instrument set. Lack of serial correlation of second order is critical since the presence of significant AR(2) makes the instrumental variables invalid. Also, the lack of rejection by the Hansen test and the difference in the Hansen test confirm that the set of instruments is not statistically rejected. Altogether, these tests confirm that the positive effects of financial development and institutions cannot be attributed to reverse causality or an invalid instrument set.

Notably, the interaction coefficient $FDEV_{it} \times INST_{it}$, despite being positive like in table III, does not reach conventional statistical significance ($p > 0.10$) in the dynamic model. The lack of a strong linear interaction effect in the dynamic specification makes the case for testing for a non-linear moderating effect even stronger because it cannot be said that institutional quality does not moderate.

4.4. Nonlinear Regime-Switching Analysis

To directly test hypotheses H3 and H4 regarding the moderating mechanism's transition process, table V presents the results of the linearity test and the Panel Smooth Transition Regression (PSTR) model estimation, following the five-step procedure described in Section 3.4. This analysis is consistent with the primary methodological goal of the research paper. Linearity tests first establish whether a linear specification can be applied; upon failure to support a linear specification, the PSTR model measures how the marginal effect of financial development varies according to institutional quality.

TABLE V LINEARITY TEST AND PANEL SMOOTH TRANSITION REGRESSION (PSTR) ESTIMATION RESULTS

TABLE V. PANEL A – Linearity test			
Test	Test Statistic	p-value	
LM-test ($H_0: \gamma = 0$, no transition effect)	14.62	0.0002	
LM-F test (heteroskedasticity-corrected)	7.85	0.0009	
TABLE V. Panel B – PSTR Parameter Estimates (Transition Order $m = 1$)			
Parameter	Estimate	Std. Error	Significance
β_0 (marginal effect in the Substitution regime)	0.0089	0.0024	***
β_1 (additional amplification in the Complementarity regime)	0.0047	0.0021	**
γ (transition speed parameter)	3.81	1.42	—
c (transition location parameter, normalized $INST_{it}$)	0.520	0.087	—
δ_1 ($GDPPC_{it}$)	0.171**	0.083	
δ_2 ($OPEN_{it}$)	0.0016	0.0015	
δ_3 (FDI_{it})	0.019*	0.011	
δ_4 (INF_{it})	-0.0121**	0.0056	
δ_5 (URB_{it})	0.0041	0.0037	
Marginal effect at the 10th percentile of $INST_{it}$	0.0097		
Marginal effect at the 25th percentile of $INST_{it}$	0.0101		
Marginal effect at the 50th percentile of $INST_{it}$	0.0107		
Marginal effect at the 75th percentile of $INST_{it}$	0.0116		
Marginal effect at the 90th percentile of $INST_{it}$	0.0125		
Observations	75		

Note: Parameters are estimated by nonlinear least squares (NLS) following (González et al., 2017). The transition variable $INST_{it}$ is normalized to the interval. Marginal effects are computed as $\partial LPI_{it} / \partial FDEV_{it} = \beta_0 + \beta_1 \cdot g(INST_{it}; \gamma, c)$. Sequential testing confirms that the two-regime specification ($m=1$) is adequate, with no statistical evidence supporting a three-regime structure ($m=2$).

Source: Authors' estimation using Stata 17.

The results in table V. Panel A confirm the existence of a nonlinear transition effect ($p < 0.01$), providing an empirical basis for the PSTR estimation. Since the LM test statistic of 14.62 and LM-F test statistic of 7.85 are both statistically significant, this means that the linear model does not fully capture the relation between variables. It thus becomes evident why a transition to the smooth transition model should be made. In table V. Panel B, the coefficient $\hat{\beta}_0 = 0.0089$ is positive and statistically significant at the 1% level, confirming that even in the weak institutional regime (the group including Bangladesh, Pakistan, Mongolia, and Vietnam/China in the early sample period), financial development still has a strong positive impact on logistics performance—reflecting the Institutional Substitution mechanism, where state-owned and policy bank credit directly finances key seaport and railway infrastructure. The coefficient $\hat{\beta}_1 = 0.0047$ is positive and significant at the 5% level, confirming that when institutional quality surpasses the transition point $\hat{c}$, the marginal effect of $FDEV_{it}$ is further amplified—reflecting the Institutional Complementarity mechanism. The economic explanation is especially relevant in this case, because the marginal effect rises from about 0.0097 at the 10th percentile of institutional quality to 0.0125 at the 90th percentile. This means that there is an approximately 28.9% rise in the marginal effect in the

institutional distribution. In other words, strong institutions not only coincide with good logistics performance but also make financial development more effective.

The value $\hat{\gamma} = 3.81$ (on the normalized scale) is of moderate magnitude, confirming that the transition process occurs gradually rather than as an abrupt break, which is consistent with H3. The value $\hat{c} = 0.520$ on the normalized scale corresponds to an original $INST_{it}$ level of approximately -0.13—a WGI point range that Vietnam and India once reached in the middle of the sample period, indicating that these countries are in the "institutional transition zone." Thus, the calculated transition point determines the range of the institutional context where the mechanism starts shifting from substitution to complementarity, and the value of γ suggests that this process is gradual rather than immediate. This result serves as the key empirical proof for H3 and H4 since it reflects the presence of both the non-linear interaction effect and the transition process. The marginal effects by percentiles table reveals an increasing trend ranging from 0.0097 (10th percentile) to 0.0125 (90th percentile), offering numerical proof for H3 and H4.

In order to demonstrate the transition of the moderating mechanism from table V, fig. 2 presents the transition curve graphically, which displays the change in the marginal effect of financial development on logistics performance as the level of institutions improves from the Substitution regime to the Complementarity regime. The placement of some

representative country groups along the curve allows for a linkage between the empirical results and institutional situation of each Asian sub-region under study.

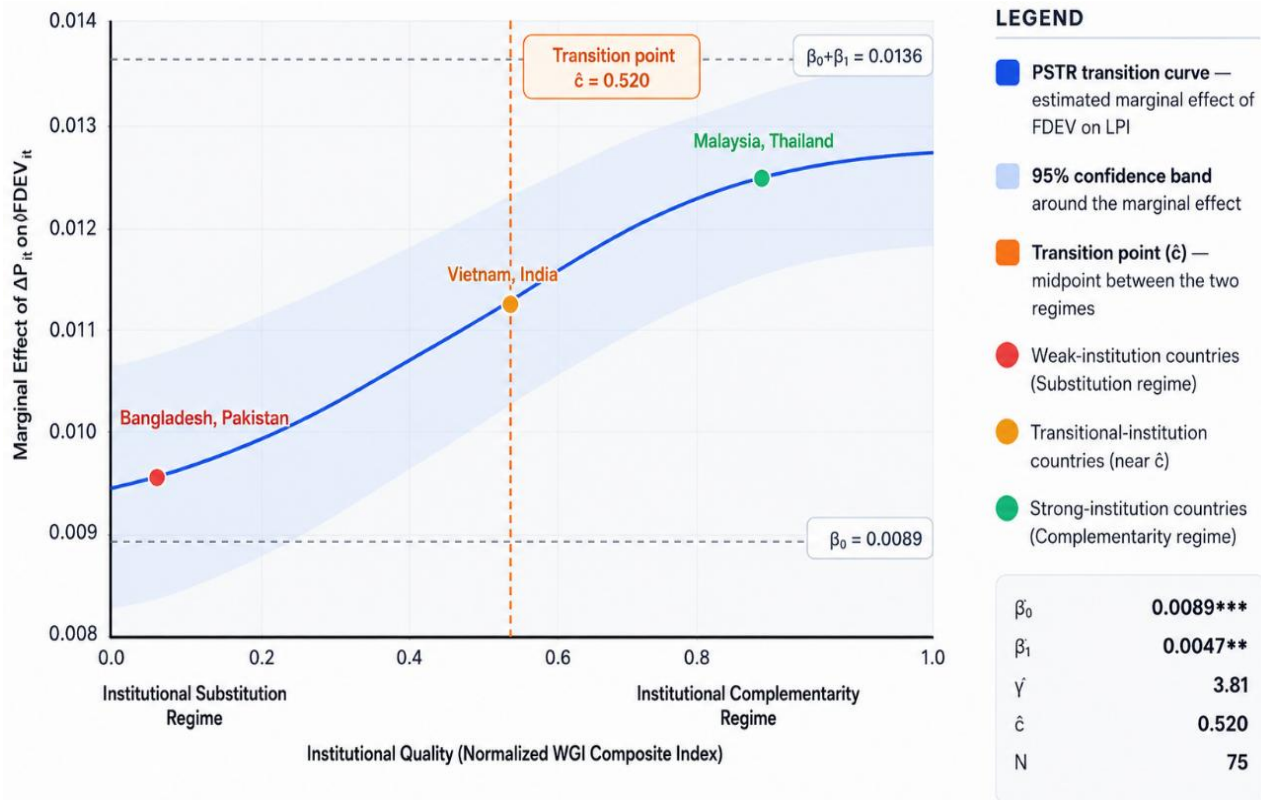


Fig. 2 Transition Curve: Marginal Effect of Financial Development on Logistics Performance

Note: The curve depicts the smooth logistic transition function $g(INST_{it}; \gamma, c) = 1/[1 + \exp(-\gamma(INST_{it} - c))]$, estimated via nonlinear least squares (PSTR, $m=1$). The marginal effect is computed as $\partial LPI_{it}/\partial FDEV_{it} = \beta_0 + \beta_1 \cdot g(INST_{it}; \gamma, c)$. Institutional quality (x-axis) is normalized to the interval. Country markers indicate approximate positions based on sample-average standardized WGI scores. Fig. 2 complements these numerical results by presenting the same relationship graphically, allowing the nonlinear increase in the financial-development effect to be observed across institutional-quality levels.

Source: Authors' estimation using Stata 17.

4.5. Robustness Checks and Heterogeneity Analysis

To reinforce the reliability of the findings, table VI summarizes four independent robustness checks: changing variable measurements, splitting the sample by subregion, cross-checking with the Hansen hard-threshold method, and a Jackknife test by excluding one country at a time. These robustness tests fall into the last stage of methodology and determine whether the nonlinear result persists despite variations in measures, geography, thresholds, and country-specific effects.

TABLE VI ROBUSTNESS CHECKS: ALTERNATIVE MEASURES, SUBREGIONAL ANALYSIS, HARD-THRESHOLD CROSS-CHECK, AND JACKKNIFE TEST

Table VI: Panel A – Alternative Measures			
	(1) LPI replaced by Container Port Traffic	(2) FDEV replaced by IMF FD Index	(3) INST replaced by Control of Corruption
β_0 (Substitution regime)	0.152***	0.0081***	0.0093***
β_1 (Complementarity amplification)	0.068**	0.0039*	0.0052**
γ	2.94	4.26	3.35
c	0.487	0.541	0.503
Observations	118	75	75
<i>Note: Column (1) uses the log of container port traffic (TEU, WDI code IS.SHP.GOOD.TU) as the dependent variable; this column has more observations because container throughput data are available annually, unlike the LPI. Columns (2) and (3) retain LPI as the dependent variable and n=75, replacing only the independent/moderating variable indicated.</i>			
Table VI: Panel B – Subregional Analysis			
	South Asia	Southeast Asia	East Asia–Central Asia
β_0	0.0093**	0.0086***	0.0071*
β_1	0.0039*	0.0051**	0.0044
c (transition location)	0.614	0.472	0.549
Observations	27	33	15
<i>Note: Subsamples correspond to the three subregions defined in Section 3.1.</i>			
Table VI: Panel C – Cross-Check with Hansen Hard-Threshold Model			
	Estimate		
Threshold $\hat{\gamma}$ (Hansen)	0.552		
95% bootstrap confidence interval	[0.413, 0.681]		
β_1 (below threshold)	0.0081**		
β_2 (above threshold)	0.0129***		
F-test for threshold existence	9.34**		
<i>Note: The Hansen, (1999) hard-threshold model is estimated as an independent cross-check, not as a substitute for the PSTR model in Table V.</i>			
Table VI: Panel D – Jackknife Test (Leave-One-Country-Out)			
Country Excluded	$\hat{\beta}_1$ (range)	$\hat{c}$ (range)	
Full sample (none excluded)	0.0047	0.520	
Excluding China	0.0043	0.538	
Excluding each remaining country (min–max)	[0.0039, 0.0058]	[0.492, 0.561]	
<i>Note: The PSTR model is re-estimated 12 times, each time excluding one country from the sample. Source: Authors' estimation using Stata 17.</i>			

The results in table VI Panel A show that the sign and significance of β_0 and β_1 remain consistent when variables are replaced with other measures, although the coefficient magnitudes naturally differ due to measurement units. The consistency demonstrates that the relationship between substitution and complementarity is not contingent upon any specific measurement of financial development, institution quality, or logistics performance. Table VI Panel B indicates that the transition location c in South Asia (0.614) is markedly higher than in Southeast Asia (0.472), accurately reflecting the reality that the South Asian group needs higher institutional quality to switch to the Complementarity mechanism, due to a lower institutional starting point. Regional variation brings another dimension of heterogeneity to the results; the institutional requirements needed for greater complementarity between finance and logistics are not identical across Asian subregions. Table VI Panel C confirms a consistent direction with PSTR: β_2 (above threshold) is significantly larger than β_1 (below threshold), both are positive, and the F-test rejects the null hypothesis of

no threshold effect ($p < 0.05$). Consistency between the smooth transition model and the hard threshold model is an independent justification for regime-dependent effects, although the PSTR results constitute the more theoretically sound explanation of the phenomenon as the change can take place gradually. Table VI Panel D shows that the parameters β_1 and $\hat{c}$ fluctuate within a narrow range when each country is excluded, even when excluding China—a country with a disproportionately large economy—confirming that the results are not driven by a single outlier observation. The jackknife results therefore strengthen the internal robustness of the estimated transition mechanism and reduce concerns that the main finding is attributable to the influence of one particular country.

The synthesis of these four robustness checks confirms that the main finding in table V—the transition process of the moderating mechanism from Institutional Substitution to Complementarity—is a robust result, independent of variable measurement, subsample structure, or the presence of outliers. As such, the findings give solid support to the effects

throughout the methodology sequence: the fixed-effect regressions provide evidence on the direct effects postulated in hypotheses H1 and H2; System GMM proves the same effects hold even when dynamics and endogeneity issues are taken into account; PSTR finds evidence on the nonlinear effect of institutional variables through the regime switching framework; and finally the robustness tests show the result is not affected by other variables or samples.

V. DISCUSSION

5.1. Interpretation of Main Effects in Theoretical and Practical Context

The research findings are first validated by establishing two fundamental hypotheses. First, the financial development (H1), as well as the quality of institutions (H2), is a necessary driver having positive and significant effect on the performance of the national logistics. Concerning the effect of the financial development (FDEV), it is fully compatible with the theory of financial intermediation, which confirms that a more developed financial structure can transform capital into logistics capability. This aligns with recent empirical results (Demirbaş et al., 2024; Kabak et al., 2020). In the context of Asia, where the demand for capital for mega-infrastructure projects (seaports, highways, logistics centers) is immense, the role of the financial system in providing capital is undeniable. Similarly, the positive impact of institutional quality (INST) on LPI strongly reinforces the argument of New Institutional Economics: good institutions help reduce transaction costs, which in the logistics sector manifest directly as clearance times, levels of transparency, and corruption risks at border crossings—core components of the LPI. This result concurs with the findings (Nasser & Ouerghi, 2024; Uprety, 2026).

However, the real contribution of the study lies not in reconfirming these two linear relationships, but in demonstrating the limitations of the traditional linear moderation model. The results from table III and table IV show that the interaction term $FDEV \times INST$ is only weakly significant or insignificant. Study argue that this result suggests a nonlinear relationship, evidence that the linear model has failed to explain a more complex reality. In particular, it has "averaged out" two competing effects present in the sample at once: the "substitution" effect (the situation in which institutions are weak, yet finance works well) and the "complementarity" effect (institutions help in making finance work well). By "forcing" these two effects into one interaction term, they have nullified each other, resulting in an insignificant coefficient. It contrasts with findings of other studies that considered only the linear interaction term.

5.2. Analysis of Marginal Effects and the Regime Switch from "Substitution" to "Complementarity"

The key finding of the study lies in the results from the PSTR model (Table V), which has shed more light on the dual role of institutions. This model not only confirms the existence of

a nonlinear effect but also quantifies two distinct operating regimes for financial development:

In the low institutional regime (Substitution Regime): The results show a strong and statistically significant baseline impact ($\beta_0 = 0.0089$). This provides solid empirical evidence for the "institutional substitution" theory (Allen et al., 2019). In the context of countries with weak institutions in the sample (such as Bangladesh, Pakistan, or the early stages of Vietnam and China), the market mechanism is distorted, and property rights are not guaranteed. However, this does not mean that finance becomes useless. Instead, state-directed credit channels through policy banks or state-owned commercial banks have played a "substitutive" role, channeling capital directly into strategic national logistics infrastructure projects. The government, through its power, has compensated for the weakness of market institutions to ensure that key projects are still funded. This is why, even when institutional quality is low, financial development still strongly promotes logistics performance.

In the high institutional regime (Complementarity Regime): When institutional quality surpasses a certain threshold, an additional impact ($\beta_1 = 0.0047$) emerges and is statistically significant. At this point, the total marginal effect of financial development is amplified to $(\beta_0 + \beta_1)$. This strongly validates the "institutional complementarity" or "institutional threshold" theory (Acemoglu et al., 2019; Slesman et al., 2019). As institutions improve (rule of law is respected, corruption decreases, regulations are transparent), investment risk declines. This not only helps state credit channels operate more effectively but, more importantly, it attracts a wave of private and foreign investment into a more diverse range of logistics services (smart warehousing, supply chain technology, 3PL/4PL services). At this point, institutions and finance are no longer substitutes but become complementary and synergistic factors, creating a much more effective boost for the entire logistics system.

This study, therefore, does not side with either theoretical camp. Instead, it reconciles and integrates both, showing that they are not mutually exclusive theories but rather descriptions of two different stages in a country's development process.

5.3. The Significance of the Threshold Structure and Subregional Differences

The PSTR approach not only helps distinguish between two regimes but also allows estimating the parameters that govern the regime change process. The "institutional threshold value" ($\hat{c} \approx -0.13$ in the original scale of WGI) appears to be a highly valuable practical result. It is not just a mere statistical value but a "tipping point" suggested by the data analysis. Countries below the threshold, such as Pakistan or Bangladesh, belong to the regime of "substitution". Their priority could be in applying state finance to make certain infrastructural breakthroughs. Countries above the threshold, such as Malaysia and Thailand, belong to the regime of "complementarity". Such countries would benefit from

institutional reforms aimed at making their states more transparent and increasing the rule of law since these reforms would help raise the LPI as well as increase the efficacy of the whole financial system. In particular, the results on Vietnam and India being close to the "transition zone" indicate that these countries face a critical choice now. Their institutional reforms would determine their ability to utilize the synergies of institutions and finance in the future.

A more detailed breakdown by subregions (Table VI, Panel B) allows even greater insights into the findings. It should come as no surprise that the institutional cut-off point in South Asia ($\hat{c} = 0.614$) is much higher compared to that in Southeast Asia ($\hat{c} = 0.472$). It is true because the South Asian countries included in the dataset have a lower baseline of institutions and experience more political instability. Consequently, it takes additional efforts from the countries to reach the "institutional standard" to be able to switch to the complementarity regime.

5.4. The "Smooth" Nature of the Institutional Transition Process

Lastly, another contribution is the use of the "smooth" and "gradual" transition model, which makes the transition a "smooth" process as opposed to the "break point" in the hard-threshold model (Hansen, 1999). The transition speed parameter ($\hat{\gamma} = 3.81$) is of moderate magnitude and therefore shows that the transition from the "substitution" to the "complementarity" regime is not a one-night process. It gives a better picture of how the institution actually works in the real world because of the gradual and accumulative process nature, whereby changes in the laws, regulations, and enforcement capacities require time to be effective in changing the behaviors of economic actors. The use of this transition model gives a more realistic and appropriate picture of institutional dynamics.

In the empirical findings have revealed a complex but coherent story of the dynamic effects of institutions on logistics. Rather than merely serving as a control variable or moderator in the linear sense, institutions serve as a "switch," whose presence and strength determines the operational mechanism through which the financial system affects national logistics capability, a very significant finding for development theories and practice in Asia.

VI. CONCLUSION AND IMPLICATIONS

6.1. Conclusion

This study analyzes the impact of financial development, institutional quality, and national logistics performance in developing and emerging economies in Asia based on 75 country-year data sets during the period of 2007–2023. All empirical results have confirmed the significant and positive impacts of both variables under analysis. According to the estimates in the two-way fixed-effects models, financial development positively affects logistics performance with the significance ($\beta = 0.0062$, $p < 0.05$), and institutional quality

has a positive and significant effect too ($\beta = 0.284$, $p < 0.01$). Estimates in the System GMM models confirm the above results because FDEV ($\beta = 0.0058$, $p < 0.05$) and INST ($\beta = 0.267$, $p < 0.05$) remain significantly positive even after controlling for potential endogeneity and persistence in the relationships.

What is more interesting is that the results in the PSTR models indicate that the institutional moderating effect is not linear. The linear interaction effect is not significant, while the results of the linearity test strongly reject the linearity of the specification ($p < 0.01$). The PSTR coefficients estimate a positive financial-development effect in the substitution regime ($\beta_0 = 0.0089$, $p < 0.01$), and the effect increases by 0.0047 ($p < 0.05$) when moving towards the complementarity regime. The marginal effect changes from 0.0097 (10th percentile of institutional quality) to 0.0125 (90th percentile). These results support all hypotheses H1–H4 and confirm the dependence of the process of transforming financial resources into logistics and information-enabled services on institutional conditions.

6.2. Implications and Future Research

The results indicate that policies should take institutional sensitivity into account. Countries with poor institutions should resort to selective financial and state-led infrastructure investment, and countries with better institutions should focus on rule of law, regulatory quality, transparency, efficient customs procedures, and coordination of information for increasing the efficacy of finance. Information and knowledge management scholars can see from these results that institutional quality matters as a contextual factor for making money work effectively in terms of logistics and information service performance.

Further research can focus on analyzing firm- or industry-level data and each component of the WGI and LPI separately and differentiate between state-led, commercial bank, and capital market funding. Advanced causal designs and more detailed information on logistics and information service practices may help determine the underlying processes of the regime transition.

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