

# Economics and Business Review

Volume 12 (2) 2026

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## Editorial introduction

Against the backdrop of a wide range of theoretical models and a rich empirical toolkit, it is easy to lose sight of the fact that economics is, at its core, a social science concerned with human decision-making. The invited perspective and articles included in this issue of *Economics and Business Review* remind us that economic phenomena are ultimately rooted in the choices made by policymakers, business leaders, and other economic agents. By examining these decisions and their consequences, the current issue provides diverse and valuable insights into the mechanisms shaping contemporary economies across diverse geographical settings and areas of economic activity, while also offering important implications for policymakers.

In addition to the invited perspective by Professor Daron Acemoğlu, this issue features five research articles. Their thirteen authors are affiliated with universities in France, Indonesia, Peru, Poland, and Slovakia. Taken together, these contributions reaffirm that people are at the heart of the economy.

The issue opens with an invited perspective, **AI's biggest secret: We can shape it**, by Daron Acemoğlu, recipient of the 2024 Nobel Prize in Economic Sciences and, since this year, an honorary doctor of Poznań University of Economics and Business. Challenging deterministic and passive views of artificial intelligence, Professor Acemoğlu argues that both its evolution and its economic and societal consequences can be shaped by people, and for the people. According to the author the future direction of AI development lies in decisions made across four interrelated domains. It is easy to imagine a scenario in which business leaders make decisions in these domains that entail high social costs. However, Professor Acemoğlu outlines pathways for steering AI towards socially beneficial outcomes through appropriate governance and policy choices. Overall, Professor Acemoğlu conveys a cautiously optimistic message: although the current trajectory of AI raises serious concerns, its future is not predetermined. Through informed choices and public pressure, AI can be steered towards socially beneficial outcomes while mitigating its potentially harmful consequences.

The first article, **Unlocking digital trade in Southeast Asia: The roles of infrastructure and regulation**, by Zuzana Brinčíková and Andrej Přívara, examines the determinants of digital trade performance in nine ASEAN economies over the period 2010–2022. Using fixed-effects panel regression models, the authors analyse the roles of digital infrastructure and regulatory openness in

shaping Information and Communication Technology (ICT) goods trade, digitally deliverable services, and overall trade openness. The findings challenge conventional assumptions regarding the importance of infrastructure, showing that regulatory restrictiveness and participatory governance are more influential determinants of digital trade performance once macroeconomic factors are considered. The study contributes to the literature on digital trade by highlighting the importance of predictable, open, and inclusive regulatory frameworks for enhancing regional competitiveness.

The next contribution, entitled **Relative institutional maturity of export markets and export performance: The moderating roles of managerial capabilities and export intensity** and written by Piotr Trąpczyński and Tilo Halaszovich, investigates how the institutional characteristics of export destinations affect the export performance of firms from a post-transition economy. Drawing on a sample of 500 Polish exporters and employing regression analysis, the authors examine the effects of export market maturity relative to the home market. The results indicate that a stronger focus on institutionally more mature export markets is negatively associated with export performance only among firms characterised by lower managerial capabilities and lower export intensity. For firms with greater international involvement and stronger managerial capabilities, this negative effect disappears. The findings underscore the importance of organisational capabilities in overcoming institutional challenges in foreign markets.

The third paper, **Unlocking innovation: Governance and firm-level innovation in selected Asian countries**, by Aloysius Gunadi Brata, Pristanto Silalahi, Ronny Prabowo, and Billie Ariyanta Hartono, examines the relationship between governance conditions and firm-level innovation in Indonesia and the Philippines. Using data from the 2023 World Bank Enterprise Surveys and estimating cross-sectional logit models, the authors analyse the effects of formal governance obstacles, informal governance practices, and firm capabilities on innovation outcomes. The findings reveal that burdensome tax administration and informal payments are negatively associated with innovation in Indonesia, whereas informal payments exhibit a positive association in the Philippines, reflecting firms' adaptation to institutional weaknesses. Across both countries, worker training emerges as the most consistent driver of innovation. The study provides important insights into governance reforms and innovation-led growth in middle-income economies.

The fourth article, **Micro and small enterprise survival in contexts of poverty: Evidence from Peru**, authored by Ricardo Rafael Díaz Calderón, Carmen Graciela Arbulú Pérez Vargas, Juan Fernando Yalta Vallejos, Dante Hartman Cieza León, investigates the determinants of business survival in a high-poverty environment. Using a longitudinal cohort of 1,861 micro and small enterprises in Peru and applying Kaplan-Meier survival analysis together with Cox proportional hazards models, the authors examine how firm size, loca-

tion, and economic sector affect closure risk. The results identify firm size as the dominant determinant of survival, with microenterprises facing significantly higher closure risks than small enterprises. While geographic location does not significantly affect business survival, important differences emerge across economic sectors, with essential services proving more resilient than discretionary activities. The findings suggest that standard support mechanisms may be insufficient in poverty-stricken regions and that more targeted policies are required.

The final paper of the issue, **Beyond normality: Capital market Value-at-Risk modelling using symmetric and asymmetric Laplace distributions**, by Jan Kaczmarzyk, examines alternative approaches to modelling extreme market risk. Using daily data from ten major stock market indices covering the period 1998–2025, the author evaluates the performance of symmetric and asymmetric Laplace distributions in Value-at-Risk estimation and back-testing procedures. The findings show that both distributions generally outperform historical simulation and normal-distribution-based approaches in capturing extreme market events. Moreover, the asymmetric Laplace distribution performs particularly well in markets characterised by skewed return distributions at higher confidence levels. The study contributes to the literature on financial risk management by demonstrating the advantages of heavy-tailed distributions in modelling extreme capital market risk.

*Monika Banaszewska  
Konrad Sobański  
Lead Editors*



# AI's biggest secret: We can shape it<sup>1</sup>

 Daron Acemoğlu<sup>2</sup>

## Introduction

Tech leaders and industry insiders are giddy with excitement about the advances under way in artificial intelligence, whether due to the scaling up of existing models and functionalities, new reasoning models, promises of capable AI assistants, or entirely new, emergent capabilities.

Many hopes—and some fears—are centred on “powerful AI” or artificial general intelligence (AGI), which will be reached when AI becomes as smart as humans in almost every way. Some view AGI as an inexorable step towards unprecedented abundance, while others are concerned that such powerful AI could turn against humanity or, at the very least, create dangers for us. Almost everyone in the industry and many in tech journalism see this future as inevitable.

There is one word missing from much of this discussion: choice.

What AI will do to society, to labour and jobs, to misinformation and democracy and to geopolitical tensions is intertwined with the choices we make about how to develop this promising but still nascent technology. There are at least four choices, all of them interrelated. The first choice concerns AGI

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<sup>1</sup> Invited perspective. The text discusses topics related to those presented in Daron Acemoğlu's lecture delivered during the ceremony at which he was awarded the title of Doctor Honoris Causa by Poznań University of Economics and Business. Headings were added to the text by the journal's editors.

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compared to AI designed as a tool for humans. The second centres on the automation of human tasks versus the expansion of human capabilities. The third is about large, all-purpose models—including “foundation models” such as OpenAI’s GPT, which powers ChatGPT—versus domain-specific approaches, which are designed to do one thing well. The fourth turns on whether AI will be developed in international conflict or through a potentially semi-cooperative process.

Let me take each one of these in turn and explain why these choices are currently being made in line with the interests of a small group of companies and executives, intent on making money and boosting their power over the rest of humanity, and why we should object to them.

## **1. Artificial General Intelligence versus AI designed as a tool for humans**

While many industry figures make repeated claims that AGI is just around the corner, there are legitimate doubts about how easily existing models and approaches can achieve truly human-like high-level capabilities in every domain. But the bigger question is whether this is even desirable.

To explore this issue, we can turn to a very different vision of AI, powerfully articulated 65 years ago by JCR Licklider, a leading computer scientist and psychologist. Licklider deserves the accolade “grandfather of the Internet” more than anybody else due to his foundational ideas for the packet-switching architecture, which breaks information into smaller bits and transmits them separately over the network. This architecture was put into practice in an early computer network called Arpanet (Advanced Research Projects Agency Network). In 1960, Licklider wrote: “The hope is that, in not too many years, human brains and computing machines will be coupled together very tightly, and that the resulting partnership will think as no human brain has ever thought and process data in a way not approached by the information-handling machines we know today.”

Licklider’s aspiration was one in which computers would become information systems capable of expanding the potential of the human brain, by providing effective and useful information to human decision-makers. At the time, this was just an aspiration and no more; it continued to be so for the next six decades. The internet would come to contain much of the information of humanity, but nobody could use that information in a reliable, timely and useful manner, because it wasn’t easy for a person to find and process the bits of information that would be useful to them in that moment. Generative

AI, capable of creating new content or information on the basis of prompts, can change that.

With AGI, humans are sidelined and it is machines (or more often, the people who control them) that rule. Such dreams about AGI were present from the beginning of computer science and AI. Leading figures, such as Alan Turing (significant not just for his important mathematical work but for formulating how we can conceptualise computers reaching human-level capabilities) were articulating the possibility of such an AGI as early as 1949. Others, such as Marvin Minsky (one of the early defining figures in the field of AI) were trying to put it into practice in the 1960s.

Minsky's passion overrode repeated setbacks. In 1970, Minsky was still telling *Time*: "In from three to eight years we will have a machine with the general intelligence of an average human being. I mean a machine that will be able to read Shakespeare, grease a car, play office politics, tell a joke, have a fight. At that point the machine will begin to educate itself with fantastic speed. In a few months it will be at genius level and a few months after that its powers will be incalculable."

Generative AI has revived these dreams and given them a greater realism, although whether AGI can be achieved with the current architecture and approaches remains up for debate.

A sharp choice is therefore whether to focus predominantly on AGI or try to make Licklider's vision of machines amplifying human capabilities a reality. You might think that, technically, the cards are stacked against the latter. That would be wrong. In fact, even if overshadowed in the popular press and funding rounds, a drive like Licklider's has been at the root of many of the most important innovations in digital technologies over the last several decades. Ideas centred on human-machine complementarity, not inchoate theories about general intelligence, led to the technologies we routinely depend on today: computer mice, menu-driven computers, hyperlinks, hypertext and, of course, the internet.

It is also important to note that, even if AGI is not feasible in the short term, the relentless pursuit of it could cause significant harm. An important aspect of this harm would be the neglect of alternative directions that could powerfully enhance human capabilities. In this way, even if AGI is nowhere to be found, the mad dash towards it could become self-fulfilling, conjuring its harms into reality.

AGI and its associated aspirations are also bad for democracy, which requires an informed public. The conceit that machines are better decision-makers than humans, along with the centralisation of information that current approaches entail, is inherently anti-democratic. Once you accept that machines—or their designers—are much better than regular people and can gainfully sideline them, it becomes easy to understand why social media was likely to evolve in a way that cultivated misinformation and manipulation.

## **2. The automation of human tasks versus the expansion of human capabilities**

The second choice is related but distinct. It concerns whether, when AI-powered commercial products are developed, they will predominantly strive to automate human tasks or to create new tasks and capabilities for human workers.

The costs of the former can be seen from previous rounds of digital technologies that have been extensively used for automating office work and factory jobs. This automation drive has increased profits and productivity to some degree, but has also boosted inequality. It underpins the declining real wages of a large fraction of the labour force in the United States. In contrast, my work shows that, during periods in which new technologies are used to create new tasks and capabilities for workers, there is an even bigger boost to productivity and a greater likelihood of accompanying wage growth. The bottom line is that an excessive focus on automation would not be consistent with shared prosperity, in which workers of different skill levels also enjoy some of the benefits of improved productivity.

To make matters worse, automation can be pursued relentlessly, even when its effects on productivity are minimal. Just like AGI, large-scale automation can become self-fulfilling even when AI isn't up to the job. Indeed, it is not difficult to find examples of digital technologies being adopted wholesale without a clear idea of how they can increase productivity.

With all the hype surrounding AI, it isn't hard to imagine how many businesses will feel greater pressure to jump on the bandwagon before they know how AI can help them; before they can contemplate how their organisation needs to be restructured for AI and human employees to work together; and before AI is ready for automation—or in fact for anything else.

## **3. Large, all-purpose AI models versus domain-specific approaches**

The third choice is about architecture. Currently, much of the focus is on very large models such as GPT, which are all-purpose and aim to mimic human intelligence. Such foundation models can simultaneously write Shakespearean sonnets and produce marketing material for skin cream. The alternative is the domain-specific models where the industry has practised a degree of bait and switch. Some of the most celebrated successes, such as AlphaFold, are

domain-specific models: AlphaFold has been designed for predicting the 3D structure of proteins; it cannot market your skin cream and you should not ask it for dating advice (then again, you shouldn't ask that of ChatGPT either).

It is not easy to get deep expertise from AI when it is a jack of all trades. It also seems plausible that AI will be more likely to create hallucinations—giving users false, distorted or misleading answers—when asked to process and combine vastly different bits of information from a range of sources. Hence, it is worth investing in domain-specific models, especially given the difficulties the industry faces in monetising the foundation models (in part because they have not produced any applications, beyond coding, that appear particularly useful for the business sector).

## **4. Conflict versus semi-cooperative process in developing AI**

Finally, the direction of AI could be pursued in a zero-sum manner between different countries, especially between China and the US, or there could be more information sharing and common regulatory approaches. Currently, the industry is opting for the first.

While these four choices about AI are distinct, they are also closely linked. AGI is a bedfellow with the foundation model (you wouldn't be able to generate human-like intelligence across the domains with domain-specific models). Both foundation models and AGI encourage automation—after all, if AI is on its way to achieving high-level human capabilities, it should take over tasks from humans. Last but not least, if AGI is the ultimate and near-term destination, a zero-sum approach makes a lot of sense, as it would be reasonable to presume that whichever country reaches AGI (and then artificial superintelligence) first will have a significant strategic advantage. This leaves little room for cooperation.

## **Conclusions**

I disagree with all of these choices. AI can enhance human capabilities, resulting in significantly better social consequences. This objective is more likely to be achieved with domain-specific models that use high-quality data embedding expertise from the best-trained and most experienced human workers. Dreams of AGI can get in the way, and if the aim is to improve productivity

and find solutions to shared issues from pandemics to cancer, there is a lot of room for cooperation between the US and China—and any other country.

So, why are we locked into the AGI-automation, huge-model-conflictual approach to AI? I believe there are two main reasons. The first is economic, and the second is ideological.

Any technology requires corporate champions, and Silicon Valley companies are the natural investors in new digital technologies, possessing the capabilities and experience to scale them up effectively. Silicon Valley giants know how to monetise automation technologies and tools that can be used for digital advertising. It is less clear how to make big bucks from human-complementary technologies in the absence of either the business know-how or a clear market for them.

This mainstream approach also receives a significant boost from tech giants collecting vast amounts of data from people without paying for it, thereby receiving a substantial implicit subsidy for their key input. The antagonistic relationship between capital and labour in the US provides additional support for automation, which reduces the managerial dependence on workers. The fact that automation technologies cut wages and cause joblessness does not seem to concern them.

The ideological factor may be even more important. The belief that machines can and should ultimately surpass humans is an ideology. It might be based on mathematical and philosophical foundations, as Alan Turing's thoughts were. It could be derived from excessive exposure to science fiction books and movies. But more often, it is a different, veiled agenda: the actual subtext may not be so much that machines should surpass and dominate all humans. Rather, that machines designed and controlled by a few people should have dominion over the rest. As such, hidden in the AI decisions being made right now is an elitist, essentially authoritarian ideology, turning technology into a vehicle for the grandiose dreams of a small cadre.

This analysis suggests that the tech sector is making a series of connected choices on the type of AI to develop and its intended purpose. These choices carry a heavy social cost, but are still bolstered by economic and ideological factors. It is the tech sector making these choices, and yet we, as a society, are allowing powerful companies to step up to the plate.

There is an alternative: it is technically feasible and socially desirable to have a different trajectory for AI. This can be achieved if, instead of AGI, we aim for AI tools which are at the service of humans—just as Licklider hoped. Instead of automation, we should strive for pro-worker AI that can expand human capabilities and empower workers. Rather than an endless quest for bigger and bigger models, we should strive to build domain-specific models with greater expertise and higher-quality data. If we eschew the facile zero-sum thinking prevailing in policy circles and Silicon Valley today and attempt to find a more cooperative approach to the development and regulation of AI

globally, we may achieve more effective outcomes. Just like the choices currently being made in Silicon Valley, there are alternative options that could complement each other.

Yet, there is no automatic self-correction to our current path. Democracy, civil society, the labour movement, regulators and independent analysts must work together to improve the narrative (it's not a question of US AGI versus Chinese AGI, but AI that is good versus AI that is bad for humanity) and leverage this to build a research agenda and a regulatory framework to support the more socially beneficial direction of AI.

There is no silver bullet regulation that can take us from here to there, but essential steps can be taken. First, the path of least resistance for the tech industry—to collect as much data as possible and then monetise it via manipulative digital ads—needs to be made less attractive. This requires a digital ad tax imposed on tech platforms for their revenues from digital advertisements (but crucially not from other sources of income, such as subscription or software sales).

Second, domain-specific, pro-worker models require high-quality data. This underscores the need for a well-functioning data market, where companies pay for the day-to-day use of data and individuals are incentivised to generate the high-quality data on which pro-worker AI will have to depend.

Third, existing distortions resulting partly from asymmetries in the tax code—when lower taxes are imposed on capital income than labour income—and from the intense conflict between management and labour need to be resolved with fiscal tools. Both this conflict and existing tax distortions encourage excessive automation, to the detriment of workers.

Most importantly, AI researchers themselves need to recognise that every choice they make has social and ethical consequences. As in many other things, there may not be an absolute right and an absolute wrong, but choices have consequences, some good, some bad, some very bad indeed. Those who make decisions about AI also have responsibilities, whether they are engineers—or entrepreneurs in hoodies.



# Unlocking digital trade in Southeast Asia: The roles of infrastructure and regulation

 Zuzana Brinčíková<sup>1</sup>

 Andrej Příklad<sup>2</sup>

## Abstract

Digital trade is reshaping global commerce, yet the way infrastructure and regulation interact to drive outcomes in Southeast Asia remains poorly understood. We address that gap by combining a new composite index of digital infrastructure with international measures of regulatory openness: the OECD Services Trade Restrictiveness Index, the UN E-Government Development Index, and the E-Participation Index. Using panel data for nine ASEAN economies from 2010 to 2022 and fixed-effects regression models, we examine five outcomes: ICT goods exports and imports, digitally deliverable services exports and imports, and trade openness. The results challenge conventional assumptions. Infrastructure on its own does not reliably predict performance when rules and macroeconomic fundamentals are considered. Instead, institutions, particularly regulatory restrictiveness and participatory governance, emerge as decisive. This finding advances institutional theory in the digital trade domain and offers evidence that predictable, open, and inclusive rules are more powerful than infrastructure alone in shaping regional competitiveness.

## Keywords

- digital trade
- ICT goods
- digitally deliverable services
- trade openness
- ASEAN
- regulatory restrictiveness
- institutional theory

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## Introduction

What counts as trade today is no longer confined to containers stacked on cargo ships or goods passing through customs checkpoints. Increasingly, it takes place through invisible flows of data moving across fibre-optic cables, cloud servers, and digital platforms, with orders, payments, and deliveries occurring in real time. In Southeast Asia, this transformation is especially striking. While a Singaporean design firm can sell its services to a client in Paris before lunch, firms in Cambodia still face basic hurdles in transferring large files abroad. These contrasts shape who benefits from the digital economy and who risks being left behind (OECD, 2023; Suranto et al., 2025).

Digital participation depends on two kinds of capacity. One is tangible: broadband coverage, affordable access, reliable electricity, and logistics that keep e-commerce moving (Berisha-Shaqiri, 2014; Thompson & Garbacz, 2011). The other is institutional: rules for data flows, market entry, licensing, and the treatment of digital services (Ferracane & van der Marel, 2021). When the pipes and the rulebook align, firms connect to global value chains; when they do not, opportunity shrinks (Gao & Chen, 2024; González & Ferencz, 2018).

The relationship between these two kinds of capacity is not linear. Strong networks without enabled regulation leave firms connected yet constrained. Open rules without adequate networks create theoretical access with limited practical use (González & Sorescu, 2021). Evidence that isolates this joint effect for Southeast Asia remains thin, since many studies treat infrastructure and regulation separately or generalise from global samples that blur regional dynamics (OECD, 2023; Zhang et al., 2025). Which matters more for actual trade outcomes in the region: better pipes or better rules?

This study answers that question empirically. It brings together a composite index of digital infrastructure built with principal component analysis and a set of regulatory indicators that capture the policy environment: the OECD Services Trade Restrictiveness Index (STRI) for computer services and telecommunications, the UN E-Government Development Index (EGDI), and the E-Participation Index (EPI) (González et al., 2023; OECD, 2023). The analysis covers nine Southeast Asian economies from 2010 to 2022 and estimates fixed effects panel regressions for five dependent variables that mirror the scope of the paper: ICT goods exports (ICTe), ICT goods imports (ICTi), digitally deliverable services exports (DDSEp), digitally deliverable services imports (DDSIp), and trade openness (OPN).

The contribution is twofold. Firstly, it places infrastructure readiness and regulatory openness in a single empirical frame suited to the region's policy and capacity diversity. Secondly, it shows where the leverage lies. Regulation emerges as the main bottleneck for digital trade, while infrastructure on its own does not reliably predict outcomes once macroeconomic conditions are

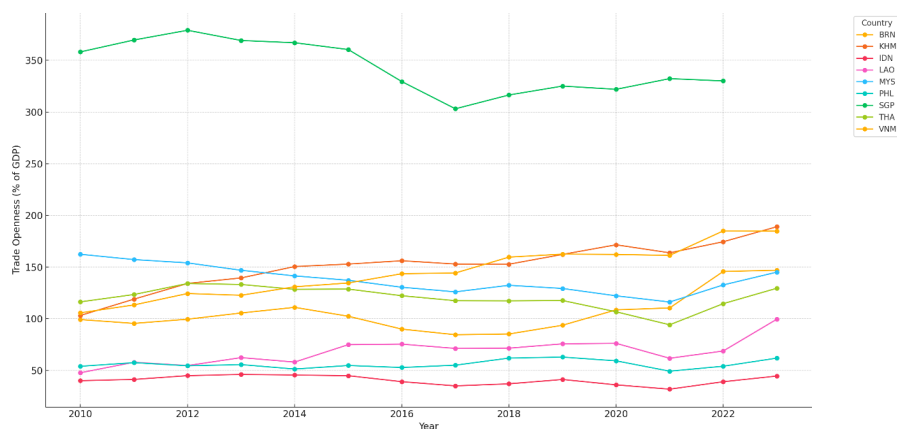
considered. For aggregate openness, income and prices dominate; for digital trade niches, rules carry more weight (González et al., 2023; OECD, 2023; Rahman & Rahman, 2022). The implication for policy is practical: to sequence reforms in such a way that regulatory openness moves with, not after, investment in connectivity.

The paper is organised as follows: Section 1 combines a review of the relevant literature with a brief contextual overview of digital trade development in Southeast Asia, which helps situate the empirical analysis. It sets out the conceptual links between infrastructure, regulation, and trade performance. Section 2 describes the data and empirical design, including the construction of the infrastructure index, and the use of STRI, EGDI, and EPI. Section 3 reports results for ICT goods, digitally deliverable services, and overall openness. Section 4 discusses the findings in light of current research and policy debates. The final section offers implications and outlines the next steps for the region.

## 1. Literature review and institutional context

### 1.1. Digital trade and services integration in ASEAN

Digital trade has shifted from a side issue to a core feature of global commerce. The OECD (2023) defines it as trade in goods and services that are digitally ordered, digitally delivered, or both. This reach spans e-commerce, software and platform services, digitally enabled logistics, and professional



**Figure 1. Trade openness in Southeast Asian countries, measured as total trade in goods and services as a percentage of GDP, 2010–2022**

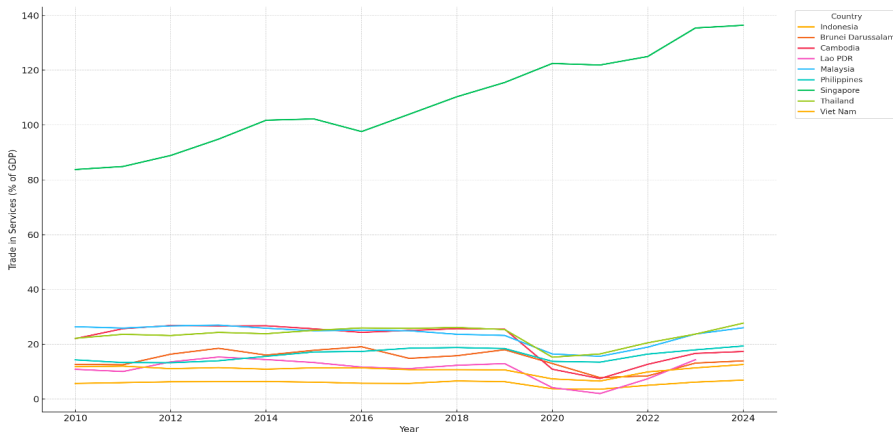
Source: (UNCTAD, 2025).

services. In this frame, digital trade alters how value is created, transferred, and captured rather than simply speeding up existing channels (González & Ferencz, 2018).

The growth in ASEAN is rapid and uneven. Countries that embed digital capabilities into trade systems show stronger exports, deeper value-chain participation, and greater resilience to shocks (Arora et al., 2022; Gao & Chen, 2024). Moreover, gaps in infrastructure, rules and skills risk widening the distance between the leaders and late movers.

Trade openness is commonly used in the literature as a first proxy for integration into global markets and digital readiness. Higher trade-to-GDP ratios are typically associated with stronger international linkages and greater incentives to invest in both digital infrastructure and governance (Ferracane & van der Marel, 2021). As noted in the literature and descriptive evidence, ASEAN displays wide variation, with economies such as Singapore and Brunei Darussalam exhibiting significantly higher levels of trade openness and record ratios well above 150%; Indonesia and the Philippines show more moderate levels given their large domestic markets; Vietnam and Thailand sit between these poles. Figure 1 reports total trade as a share of GDP for 2010–2022 and shows persistent structural divides with gradual improvement among mid-tier performers.

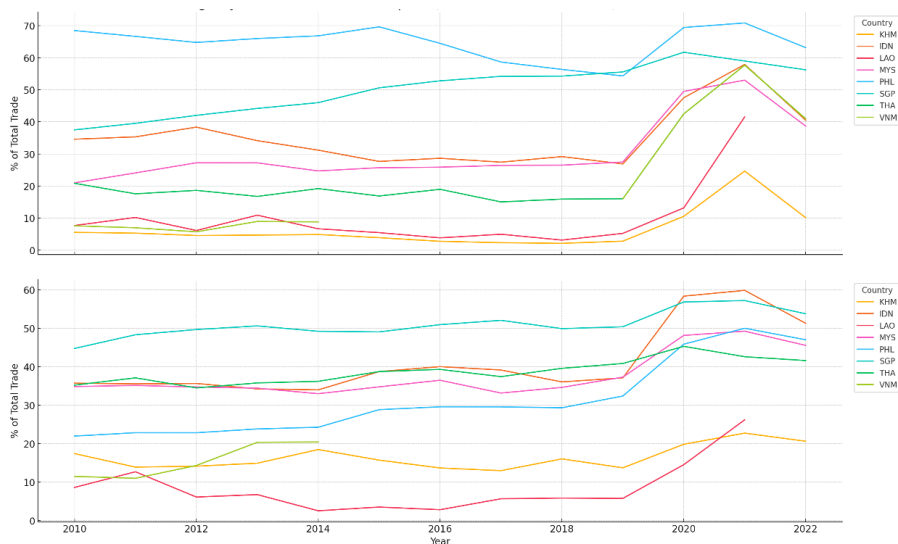
Services are the other pillar. They have grown fastest worldwide, and ASEAN follows that path. Economies that scale digitally deliverable services (DDS) gain resilience because these flows rely less on physical transport routes (Rahman & Rahman, 2022). In Southeast Asia, existing studies and descriptive data indicate uneven development across countries, with more advanced economies



**Figure 2. Trade in services as a share of GDP in Southeast Asian economies, 2010–2024**

Source: (World Bank, 2025).

achieving higher levels of services integration, while others are hampered by their infrastructure, regulatory conditions, and skills gaps. Singapore leads on services intensity; Thailand, Malaysia, and the Philippines have gained ground through targeted infrastructure and reform (OECD, 2023). Figure 2 presents services trade as a share of GDP for 2010–2024 and shows divergence between leaders and others, with clear upward trends for several mid-ranked states.



**Figure 3. Digitally deliverable services exports and imports as a percentage of total trade in services in selected Southeast Asian countries, 2010–2022**

Source: (UNCTAD, 2025).

The DDS share within services provides a sharper view of digital integration. High shares imply strong technology sectors, flexible rules, and skilled labour. Singapore and Malaysia exceed 50%; Cambodia and Lao PDR remain below 10% (OECD, 2023). Figure 3 provides an illustrative overview of DDS exports and imports as a share of total services trade, drawing on UNCTAD data. The patterns shown are consistent with the literature emphasising the role of digital readiness and institutional quality in shaping services trade outcomes.

## 1.2. Infrastructure, regulation, and institutional perspectives

ICT goods still anchor the region’s digital economy. Exports and imports of computers, telecommunications equipment, and components reveal

both production capacity and reliance on global value chains. Evidence links ICT penetration to productivity gains that strengthen external competitiveness once adoption crosses key thresholds (Thompson & Garbacz, 2011). Industry 4.0 shifts in robotics, data, and automation reshape manufacturing geography, enhancing the role of ICT hardware in regional trade (Strange & Zucchella, 2017).

The ASEAN pattern is mixed: Singapore and Malaysia act as hubs for production and re-export; Vietnam has expanded its electronics assembly sector yet still imports high-value parts; Cambodia and Lao PDR remain largely import-reliant. These asymmetries justify modelling ICT goods exports (*ICTe*) and imports (*ICTi*) separately. They also clarify why both macro conditions and rules matter: income and prices shape demand and costs, and regulatory settings determine entry, standards, and data handling that govern participation in technology-intensive trade.

### 1.3. Digital infrastructure and the institutional environment

Digital infrastructure provides the base on which services and goods move. It includes broadband penetration, reliable electricity, secure data storage, cybersecurity, and the skills needed to operate and innovate (Berisha-Shaqiri, 2014). Threshold effects matter: once broadband crosses a certain level, productivity and trade tend to accelerate (Thompson & Garbacz, 2011). Composite measures often outperform single indicators because they combine physical assets with elements of capacity and capability (González & Sorescu, 2021).

Coverage remains uneven across ASEAN. Singapore has a near-universal high-speed access and substantial data-centre capacity; Malaysia and Thailand have expanded rapidly; Cambodia, Lao PDR, and Myanmar, however, still face bottlenecks that constrain the scale of digitally delivered services and hamper ICT integration.

Rules shape whether infrastructure translates into competitiveness. The OECD Services Trade Restrictiveness Index (STRI) captures barriers in data localisation, cross-border transfers, licensing, and foreign equity. Higher STRI scores correlate with weaker outcomes in digitally intensive services, even where infrastructure is strong (Ferracane & van der Marel, 2021). Lower barriers are associated with faster DDS growth, particularly in middle-income economies with improving networks (Zhang et al., 2025).

Regulatory regimes diverge across the region. Singapore follows liberal settings backed by bilateral and regional frameworks; Indonesia and Vietnam apply tighter rules that prioritise sovereignty and security; Malaysia and the Philippines have liberalised selectively yet retain targeted restrictions.

Digital infrastructure also helps narrow the first-level digital divide, which concerns access, or the ability of individuals and businesses to connect to the internet and use basic digital services (Livingstone & Helsper, 2007). After countries clear basic access thresholds, skills, usage patterns, and outcomes become more important for trade-related gains. EGDI and EPI capture parts of this shift by reflecting the quality of digital government and the extent of digital participation, which relate closely to the second- and third-level divides, such as digital literacy, effective use, and meaningful engagement with online platforms (Robinson et al., 2015; Yang & Zhang, 2023). This distinction helps explain why the standalone contribution of infrastructure can shrink once governance and participation factors enter the model.

Institutional theory helps interpret these patterns. Institutions shape costs and uncertainty by structuring interaction (North, 1990). Scott's (Scott, 1995) framework distinguishes between regulative, normative, and cognitive institutions. Regulative institutions include formal rules and enforcement mechanisms that set constraints and permissions. Normative institutions reflect shared expectations and accepted standards that influence what firms and public actors see as appropriate conduct. Cognitive institutions, in turn, capture shared beliefs and mental models that affect trust, perceived legitimacy, and willingness to transact digitally.

Our measures map onto these institutional dimensions. STRI primarily reflects the regulative and formal pillar because it measures codified restrictions that govern data flows, licensing, and market access. EGDI reflects the state's administrative capacity to design and deliver digital public services and implement policy. It links most closely to the regulative pillar through implementation capacity and also supports normative expectations about service reliability and predictability. EPI reflects citizen engagement with digital governance and public decision-making, which links closely to normative and cognitive institutions through trust, perceived legitimacy, and the social acceptance of digital interaction. Taken together, these indicators cover both formal constraints and the informal expectations and beliefs that influence how infrastructure translates into digital trade outcomes.

Digital trade follows a simple sequence. Infrastructure creates the technical capacity to connect, transmit, store, and secure data at scale. Institutions determine whether firms can convert that capacity into cross-border transactions by shaping market entry, data-flow rules, compliance costs, and predictability. Strong networks with restrictive or uncertain rules can leave firms connected but constrained, while open rules without adequate infrastructure limit scale in practice. Digital trade grows most reliably when capacity and rules reinforce each other. Evidence links this alignment to deeper value-chain integration (Strange & Zucchella, 2017) and to stronger trade performance when infrastructure investment is paired with regulatory openness (OECD, 2023).

## **1.4. Trade openness in the digital age**

Trade openness provides a broader perspective on how digitalisation interacts with structure. Defined as total trade over GDP, it reflects both integration and exposure. Highly open economies often move earlier on digital provisions, driven by dense trade links and the need for reliable rules (Rahman & Rahman, 2022). Openness also tends to coincide with investment in connectivity and governance, although channels differ across goods and services (OECD, 2023).

ASEAN shows wide variation. Singapore and Brunei Darussalam record high and persistent openness ratios consistent with hub status; Indonesia and the Philippines maintain moderate levels shaped by large home markets; Vietnam and Thailand have risen with manufacturing-led integration.

Macro conditions shape openness as well as policy. Inflation and income influence import demand and firms' ability to transact across borders (Berisha-Shaqiri, 2014). Exchange-rate movements can pull in opposite directions for exports and imports, which often mutes their net effect. These points justify the inclusion of GDP per capita, the consumer price index (CPI), and the exchange rate (EXR) as controls in the empirical analysis. They also explain why digital indicators can leave a clearer imprint on sectoral flows than on the aggregate trade-to-GDP ratio.

## **1.5. Research gap and study contribution**

ASEAN-focused work often treats infrastructure and regulation as separate domains, which limits policy relevance (OECD, 2023; Suranto et al., 2025). Few studies combine a composite infrastructure index with STRI, EGDI, and EPI to examine their joint influence, and fewer still extend that framework to cover ICT goods and aggregate openness (González & Sorescu, 2021; Zhang et al., 2025). Global analyses sometimes mask the region's structure, where advanced hubs sit alongside emerging economies with very different capacities and rules (Ferracane & van der Marel, 2021; Gao & Chen, 2024).

This study addresses that gap with an integrated model grounded in institutional theory. It tests whether economies with more robust infrastructure and more open regimes achieve better performance across ICT goods, digitally deliverable services, and trade openness. The approach matches the region's diversity and yields policy insights for ASEAN and for other emerging markets seeking to build digital trade capacity.

## 2. Data and methodology

The study examines nine of eleven Southeast Asian economies: Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, the Philippines, Singapore, Thailand, and Vietnam, across the years 2010 to 2022. This period captures the rollout of broadband and mobile networks as well as the spread of new digital trade agreements. Myanmar and Timor-Leste were omitted from the empirical analysis because of insufficient and inconsistent data over the analysed period. Consistent data coverage allowed for the construction of a balanced panel of 117 country–year observations.

Five dependent variables capture different aspects of trade performance: *ICTe* measures ICT goods exports as a share of total merchandise trade, and *ICTi* measures ICT goods imports in the same way; *DDSEp* refers to digitally deliverable services (DDS) exports as a share of total services trade, and *DDSIp* refers to DDS imports. The last variable, *OPN*, represents trade openness, calculated as total trade in goods and services as a percentage of GDP. Expressing these variables as shares allows meaningful comparison across countries of very different sizes.

Explanatory variables cover macroeconomic conditions, infrastructure, and the regulatory environment. *GDP* is GDP per capita in constant US dollars. It proxies productive capacity and purchasing power, which shape demand for ICT goods and the ability to supply digitally deliverable services. *CPI* is the consumer price index and reflects price stability and domestic cost pressures. Higher inflation can raise uncertainty, compress real purchasing power, and weaken cost competitiveness, impacting both goods trade and cross-border services. *EXR* is the exchange rate and captures relative price movements that affect export competitiveness and the domestic currency cost of imported inputs, which is particularly relevant for ICT goods produced within regional and global value chains. These controls help distinguish the role of macro conditions from the roles of infrastructure and institutions in explaining digital trade outcomes (González et al., 2023; Strange & Zucchella, 2017). Digital infrastructure is summarised through a composite index, *Digital infrastructure\_PCA*, constructed using principal component analysis. Ten indicators were initially considered, including broadband subscriptions, mobile penetration, international bandwidth, secure servers, and household internet access. All series were standardised prior to analysis. The first principal component explained 99% of the variance, with international bandwidth and secure servers carrying the largest weights. This component was retained as the consolidated measure of infrastructure. Full PCA diagnostics are reported in Appendix C.

Three indicators capture regulatory and governance conditions. The OECD *Services Trade Restrictiveness Index (STRI)* measures barriers in telecommunications and computer services, with higher values representing more re-

strictive regimes. The *E-Government Development Index (EGDI)* reflects the availability and quality of online public services, and the *E-Participation Index (EPI)* measures the extent of citizen engagement through digital platforms. These indicators reflect the institutional framework that either supports or constrains digital trade.

As robustness checks, the baseline specification is extended with additional variables that capture capabilities and policy exposure often linked to digital trade performance. To account for differences in skills, we add a human capital proxy (HC) (Feenstra et al., 2015), consistent with work on digital inequalities and the role of capabilities beyond access. To capture broader institutional quality beyond the digital governance measures, we add governance indicators based on Government Effectiveness (GE) and Regulatory Quality (RQ), which relate to implementation capacity and the credibility of policy environments (North, 1990; Scott, 1995). To reflect innovation capacity, we include a patent-based proxy (PAT), in line with evidence that innovation capability impacts digital trade outcomes in ASEAN (Zhang et al., 2025). Finally, to capture participation in digital trade commitments, we add a TAPED-based measure of engagement in agreements with e-commerce or digital trade provisions (Burri et al., 2022). Each robustness exercise introduces one additional variable at a time to preserve degrees of freedom in a small panel and to limit collinearity among institutional measures.

The empirical strategy applies fixed effects panel regressions. Country effects capture time-invariant characteristics, such as geography and long-standing production structures, while year effects account for shocks common to all countries. Hausman tests support the choice of fixed effects over random effects. Standard errors are clustered at the country level to correct for heteroskedasticity and serial correlation. The baseline specification is expressed as:

$$Y_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 EXR_{it} + \beta_3 CPI_{it} + \beta_4 DigitalInfrastructure\_PCA_{it} + \beta_5 STRI_{it} + \beta_6 EGDI_{it} + \beta_7 EPI_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

where  $Y_{it}$  represents one of *ICTe*, *ICTi*, *DDSEp*, *DDSIp*, or *OPN* for country  $i$  in year  $t$ .  $\mu_i$  and  $\lambda_t$  denote country and year effects.

Data sources are established international providers. UNCTAD and the World Bank supply trade series for ICT goods, DDS, and openness. Infrastructure indicators come from the International Telecommunication Union, the World Bank, and the International Trade Centre. STRI values are taken from the OECD, while EGDI and EPI scores are provided by the UN e-Government Survey. Appendix A lists all definitions and sources, Appendix B presents descriptive statistics and correlations, and Appendix C reports the PCA results.

A final note is required for interpretation. Ratios mute the effect of scale but remain sensitive to changes in the composition of services. For instance, a sharp rise in travel services can reduce the share of DDS even if DDS vol-

umes are growing. For this reason, results are considered in light of regional events and checked against the raw data series, where context is important.

### 3. Results

Table 1 reports five fixed effects panel regressions for Southeast Asian economies. The dependent variables are ICT goods exports (*ICTe*), ICT goods imports (*ICTi*), digitally deliverable services exports (*DDSEp*), digitally deliverable services imports (*DDSIp*), and trade openness (*OPN*). Models use the same set of regressors, and coefficients appear with standard errors.

**Table 1. Fixed effects panel regression results for ICT goods trade, digitally deliverable services, and trade openness**

Variable	<i>ICTe</i>	<i>ICTi</i>	<i>DDSEp</i>	<i>DDSIp</i>	<i>OPN</i>
Intercept	-5.18 (7.24)	1.82 (8.29)	-26.38 (27.12)	-8.33 (10.25)	-20.33 (40.11)
GDP	0.0004*** (0.000)	0.0003*** (6.79E-05)	0.0002 (0.001)	-6.04E-05 (0.000)	0.0049*** (0.001)
EXR	-0.0015*** (0.000)	-0.0003* (0.000)	-0.0003 (0.001)	0.0007** (0.000)	-0.0009 (0.002)
CPI	0.783*** (0.12)	0.269*** (0.076)	0.548 (0.235) **	0.022 (0.136)	1.267* (0.700)
Digital infra- structure_PCA	-3.78E-09 (3.12E-08)	2.34E-08 (1.97E-08)	2.61E-08 (4.33E-08)	1.67E-08 (2.11E-08)	-1.00E-07 (2.12E-07)
STRI	-93.12*** (9.94)	-45.96*** (6.29)	-92.41*** (23.93)	-44.68*** (11.21)	-32.94 (68.45)
EGDI	-74.16*** (15.8)	-39.93*** (9.98)	-29.43 (31.63)	70.83*** (14.82)	-120.67 (101.11)
EPI	26.01** (8.88)	21.21*** (5.62)	21.61 (19.51)	-13.74 (9.14)	58.24 (58.57)
R-squared	0.336	0.336	0.335	0.481	0.456
Adjusted R-squared	0.320	0.320	0.320	0.460	0.432
F-statistic	20.45	20.45	17.98	20.42	68.18
Probability (F-statistic)	2.34E-09	2.34E-09	2.34E-09	3.31E-12	4.87E-22

**Note:**  $N = 117$  country-year observations. Standard errors in parentheses. Coefficients are unstandardised, \*, \*\*, and \*\*\* denote significance at the 5%, 1%, and 0.1% levels.

Source: own work.

### 3.1. ICT goods trade

GDP per capita is positive and strongly significant in both *ICTe* and *ICTi*. Richer economies produce and consume more ICT goods, which fits their deeper links to global value chains. The exchange rate carries a negative sign in both models; depreciation reduces exports and imports, a pattern consistent with costly imported inputs used in ICT production. CPI is positive and significant for exports and imports, likely capturing strong demand for ICT equipment in inflationary periods.

*Digital infrastructure\_PCA* does not reach significance once the macro and regulatory environment enter the model. Rules matter most here. *STRI* is negative and highly significant in both regressions, indicating that tighter restrictions on data flows, entry, and licensing dampen ICT trade. *EGDI* loads negatively, suggesting that state-facing digitalisation does not automatically translate into private-sector trade intensity. *EPI* is positive and significant, a result consistent with the idea that citizen use of digital channels signals a market that trusts and adopts digital tools.

### 3.2. Digitally deliverable services

A different balance emerges for DDS. GDP per capita predicts *DDSEp* but not *DDSip*, which implies that wealth enables export capacity without necessarily increasing reliance on imported digital services. The exchange rate splits: depreciation lowers exports and raises imports, a plausible outcome in services markets, where price changes and platform frictions affect on outbound and inbound flows differently. CPI is positive for exports and insignificant for imports.

Infrastructure again shows no direct effect once controls and rules are in place. *STRI* remains the key barrier, negative and highly significant for both DDS exports and imports. However, *EGDI* is insignificant for exports yet positive and significant for imports, a fact consistent with public digital services easing domestic uptake of foreign DDS through identification, payments, or procurement systems. *EPI* is positive but not significant, which suggests participatory governance may help the ecosystem without moving cross-border volumes on its own.

### 3.3. Trade openness

For *OPN*, GDP per capita is positive and highly significant. Economies with higher income levels engage more with world markets. CPI is also positive and significant, hinting at stronger import demand or greater use of global supply

chains when domestic prices rise. The exchange rate is not significant, which aligns with offsetting effects on exports and imports at the aggregate level.

None of the digital or regulatory indicators reaches significance in the openness model. That pattern points to a sectoral channel: infrastructure and rules shape ICT goods and DDS directly, yet they do not show a clean, contemporaneous imprint on the broad trade-to-GDP ratio once macro structure is accounted for. What helps most here—pipes or rules? For aggregate openness, income wins; for digital trade niches, rules dominate.

Robustness checks that add controls for human capital, broader governance quality, innovation capacity, and participation in digital trade agreements yield similar qualitative results. The full specifications are reported in Appendix D.

## 4. Discussion

The estimates suggest that macro conditions still set the stage for trade in Southeast Asia. Higher-income economies trade more in ICT goods and digitally deliverable services, a pattern that fits evidence linking ICT diffusion and productivity to global value chain participation (Strange & Zucchella, 2017; Thompson & Garbacz, 2011). Inflation shows a positive association with ICT trade in our models. One interpretation is that higher domestic cost pressures may shift firms toward external markets and may be associated with greater reliance on digital channels for sourcing, sales, and service delivery when local purchasing power weakens.

Institutions then decide how far that potential travels. The Services Trade Restrictiveness Index enters with a consistently negative sign. Studies that track data transfer rules, licensing hurdles, and foreign entry conditions reach the same conclusion: tight regimes mute cross-border activity even when networks look adequate on paper (Ferracane & van der Marel, 2021; Zhang et al., 2025). Rules alter incentives and transaction costs, and those shifts show up in trade performance (North, 1990).

Infrastructure tells a quieter story once regulation and macro factors enter the equation. The composite index does not show a stable, direct effect across models. This contrasts with work that places infrastructure at the centre of digital trade performance and argues that connectivity and related digital assets are foundational for ICT integration (Berisha-Shaqiri, 2014; González & Sorescu, 2021). Our results instead support a sequencing interpretation. While infrastructure creates capacity to connect and deliver, it is institutions that determine whether that capacity becomes cross-border transactions by shaping market entry, compliance costs, data rules, and predictability (Ferracane & van der Marel, 2021; North, 1990). This approach is also supported by the

digital divide literature: access is a first-level constraint, while skills, effective use, and outcomes become decisive at later stages (Livingstone & Helsper, 2007; Robinson et al., 2015; Yang & Zhang, 2023). Consequently, while networks matter, they yield the greatest returns when paired with predictable and open governance, consistent with the OECD's emphasis on complementarity between infrastructure and institutions (OECD, 2023). Pipes without permission, or without trust, rarely drives meaningful development.

Governance quality matters, and the indicators capture different channels. EGDGI appears weak or negative in several specifications, which suggests that expanding online public services does not, by itself, translate into better trade performance when reforms remain state-centred or only loosely connected to business processes. EPI points in the opposite direction: where digital engagement is stronger, ICT-intensive trade outcomes tend to be stronger as well, consistent with the view that participation and transparency improve predictability and perceived legitimacy in the rules that govern digital activity (González et al., 2023; OECD, 2023). The distinction is practical: building administrative portals is not the same as building systems and decision processes that firms can rely on for cross-border exchange.

Exchange rate effects are not uniform. Depreciation can raise the domestic cost of imported components used in ICT production, which can offset the usual competitiveness channel for goods exports in value-chain settings (Strange & Zucchella, 2017). For electronically deliverable services, exchange-rate movements can shift relative prices and sourcing decisions without the same reliance on imported physical inputs, so imports and exports need not respond symmetrically. The mixed signs in the estimates are consistent with these offsetting channels.

Trade openness behaves like a macro barometer rather than a digital one. Income and prices carry the explanatory weight, while digital indicators do not show a clear imprint at the aggregate level. That does not contradict the sector results; it simply reflects the breadth of the trade-to-GDP ratio, where sector-specific channels can be diluted. The sector results still point to rules as the main lever for digital trade measures (González et al., 2023; OECD, 2023).

Taken together, these findings reinforce the importance of institutions. Infrastructure expands capacity, while institutions determine whether that capacity translates into realised flows. The data speak most clearly where rules are measured directly. Digital trade expands when barriers fall, transparency improves, and participation broadens. The next section draws the policy implications and sets out limits and avenues for further research.

## Conclusions

This paper examines how digital infrastructure and regulatory openness shape trade performance in Southeast Asia across five outcomes: ICT goods exports and imports, digitally deliverable services exports and imports, and overall trade openness. The results point to a consistent pattern. Once the models account for structural factors such as income, prices, and exchange rates, rules carry greater weight than networks. By bringing infrastructure and regulation into a single design and testing their effects across both goods and services, the analysis clarifies how digital readiness translates into trade outcomes.

Institutions stand out as the main channel. More restrictive services regimes correlate with weaker performance, while more inclusive and participatory governance aligns with stronger outcomes. Developing e-government does not automatically translate into trade gains, which suggests that state-led digitalisation delivers limited benefits when it does not match private sector needs. While infrastructure remains necessary, it does not show a robust independent effect once controls enter the model. This pattern shifts the discussion away from the volume of infrastructure toward the quality and openness of the institutional environment that surrounds it, in line with an institutional perspective on uncertainty and transaction costs.

A simple mechanism helps interpret these findings. Infrastructure creates the capacity to connect and transact digitally. Institutions determine whether firms can convert that capacity into cross-border activity by shaping market entry, data-flow rules, compliance costs, and predictability. Strong networks with restrictive or uncertain rules can leave firms connected but constrained, while open rules without adequate capacity limit scale. Digital trade expands most reliably when capacity and institutions reinforce each other.

Several limits frame these results. As the study covers nine economies over 2010–2022, external validity remains limited. Trade-share indicators can reflect compositional change rather than shifts in absolute volumes. The regulatory measures, while carefully selected, cannot capture all nuances of policy enforcement. The econometric design reduces bias but does not establish causality. This analysis also does not estimate interaction terms between infrastructure and rules, so complementarities are inferred from the pattern of coefficients rather than tested directly.

Policy implications follow directly from these findings. Regulatory reform offers the most immediate lever for deeper digital trade integration. Moreover, easing restrictions on cross-border data, improving licensing transparency, and clarifying entry conditions can yield larger gains than network investment alone. When governments pursue e-government reforms, they should prioritise tools that traders and firms use in practice, such as secure digital identities, interop-

erable payments, and customs systems that reduce documentation and clearance costs. Participatory channels are also important. Open data platforms, feedback mechanisms, and transparent decision processes can build trust, and higher supports adoption and usage. Infrastructure investment should continue, but it works best alongside predictable governance and rules that firms view as reliable. Macroeconomic stability remains a foundation, since steady growth and low inflation support investment and expansion in digital trade.

ASEAN's diversity makes a single template unrealistic. Economies that rely heavily on ICT goods need to manage cost structures and exchange rate volatility, while those building strength in services can gain more from regulatory openness and governance reforms. Regional coordination adds another avenue for progress. Shared approaches to data flows, identity verification, and payments can reduce fragmentation and support scale. Better statistics would also strengthen policy design. Improved measurement of digitally deliverable services, cross-border data, and infrastructure quality would help governments track progress as technology and trade evolve.

This study contributes to the literature in three ways. Firstly, it models infrastructure and institutions jointly for nine Southeast Asian economies over 2010–2022, rather than treating connectivity and policy as separate explanations. Secondly, it uses multiple institutional proxies that capture distinct channels, including regulatory restrictiveness (STRI), digital government capacity (EGDI), and participatory digital governance (EPI). Thirdly, it extends the outcome set beyond a single trade measure by covering ICT goods and digitally deliverable services on both the export and import sides, alongside overall trade openness. Together, these elements indicate that institutional settings account for more of the cross-country variation in digital trade performance than infrastructure alone once macro fundamentals are considered.

The central message is straightforward. Infrastructure creates capacity, but institutions determine how far that capacity travels. For Southeast Asia, digital trade integration depends not only on building networks and data centres but also on rules that reduce uncertainty, expand participation, and allow firms to connect with confidence.

Future research could extend the analysis in several directions. Firstly, estimating interaction terms between infrastructure and institutional variables would allow complementarities to be tested directly. Secondly, richer outcome data, including sector-level measures of digitally deliverable services, would help distinguish digitally intensive industries from broader service aggregates. Thirdly, policy exposure could be captured more explicitly through indicators of participation in digital trade agreements and the content of their provisions. Finally, additional capability measures, including skills and human capital proxies, could clarify whether institutional effects operate partly through adoption and effective use, especially in economies where basic access constraints have eased.

## Appendix A. Variables, definitions, units, and sources

**Table A1. Variables used in the empirical analysis**

Variable	Acronym	Definition	Unit	Source
ICT goods exports share	ICTe	Exports of ICT goods divided by total merchandise exports	Percent of merchandise exports	UNCTAD
ICT goods imports share	ICTi	Imports of ICT goods divided by total merchandise imports	Percent of merchandise imports	UNCTAD
Digitally deliverable services exports share	DDSEp	Exports of services deliverable through ICT networks (telecommunications, financial, professional, ICT-enabled) divided by total services exports	Percent of services exports	UNCTAD; World Bank (WITS)
Digitally deliverable services imports share	DDSIp	Imports of services deliverable through ICT networks divided by total services imports	Percent of services imports	UNCTAD; World Bank (WITS)
Trade openness	OPN	Total trade in goods and services divided by GDP	Percent of GDP	World Bank, WDI
GDP per capita	GDP	Gross domestic product per capita, constant US dollars	USD (constant prices)	World Bank, WDI
Exchange rate	EXR	Nominal exchange rate, local currency units per US dollar, period average	LC per USD	World Bank, WDI; IMF IFS
Consumer price index	CPI	Consumer price index (2010 = 100)	Index (2010 = 100)	World Bank, WDI; IMF IFS
Digital infrastructure index	Digital infrastructure_PCA	First principal component of ten standardised indicators: fixed broadband subscriptions (FBS), mobile cellular subscriptions (MCS), fixed broadband office (FBO), individuals using the internet (Uoi), population coverage by mobile network (COV), households with internet access (HIA), percentage of the data-only mobile broadband basket (PFB), percentage of mobile broadband subscribers (PMB), secure internet servers (SIS), and international bandwidth capacity (IBC)	Standardised score	ITU; World Bank, WDI; ITC

Variable	Acronym	Definition	Unit	Source
Services Trade Restrictiveness Index	STRI	OECD index for computer services and telecommunications, summarising barriers such as licensing rules, restrictions on foreign entry, and data transfer limits. Higher values indicate greater restrictiveness	Index, 0–1	OECD STRI
E-Government Development Index	EGDI	UN index capturing the scope and quality of online public services, telecommunications infrastructure, and human capital	Index, 0–1	UN e-Government Survey
E-Participation Index	EPI	UN index measuring citizen engagement through digital platforms	Index, 0–1	UN e-Government Survey
Human capital index	HC	Human capital index (education-based), used as a proxy for workforce skills/capabilities	Index	Penn World Table
Government effectiveness	GE	WGI Government Effectiveness (estimate), proxy for state capacity and quality of public services	Estimate, –2.5 to +2.5	World Bank, WGI
Regulatory quality	RQ	WGI Regulatory Quality (estimate), proxy for quality of market-supporting regulation	Estimate, –2.5 to +2.5	World Bank, WGI
Innovation	PAT	Patent applications by residents, proxy for innovation capacity (entered as $\log(1+PAT)$ )	Number	World Bank, WDI
Digital trade agreement participation	TAPED	Cumulative number of in-force trade agreements with e-commerce/digital trade provisions (TAPED coding)	Count	TAPED dataset

Source: based on UNCTAD, World Bank, ITU, ITC, OECD, IMF, UN e-Government Survey, Penn World Table, and TAPED dataset.

## Appendix B. Descriptive statistics and correlations

**Table B1. Descriptive statistics of variables**

Variable	count	mean	standard	min	25%	50%	75%	max
<i>STRI</i>	81	0.24	0.16	0.09	0.09	0.18	0.31	0.56
<i>EGDI</i>	117	0.56	0.18	0.26	0.45	0.53	0.68	0.92
<i>EPI</i>	117	0.47	0.29	0	0.2	0.5	0.69	0.98
<i>FBS</i>	116	8.63	8.43	0.09	1.96	6.56	11.68	37.36
<i>MCS</i>	116	124.92	28.5	51.55	113.58	130.66	143.51	181.77
<i>FBO</i>	49	6.76E+05	8.36E+05	7.09E+02	1.13E+05	4.37E+05	9.33E+05	3.31E+06
<i>UoI</i>	116	52.91	27.34	1.26	31.95	53.69	74.46	99
<i>COV</i>	102	85.63	18.66	17	80	93.3	98	100
<i>HIA</i>	97	55.34	30.99	1.6	24.01	64.38	84	99.32
<i>PFB</i>	117	8.79	19.82	0.44	1.79	3.92	9.11	170.51
<i>PMB</i>	87	1.87	1.63	0.18	0.79	1.44	2.35	8.42
<i>SIS</i>	99	5189.15	2.03E+04	1.62	21.38	143.09	1484.83	1.28E+05
<i>IBC</i>	60	2.29E+07	4.70E+07	2.20E+04	2.52E+05	4.15E+06	2.20E+07	2.61E+08
<i>GDP</i>	117	1.30E+04	1.82E+04	888.91	2539.12	3591.78	1.06E+04	6.79E+04
<i>EXR</i>	117	5245.08	7375.27	1.25	3.22	47.49	8679.41	2.33E+04
<i>CPI</i>	116	120.71	18.56	98.41	107.06	114.91	129.74	182.18
<i>ICTe</i>	111	17.23	15.22	0.02	2.35	15.76	30.77	50.86
<i>ICTi</i>	111	14.43	9.84	1.04	4.96	13.07	23.86	32.88
<i>DDSEp</i>	95	30.62	21.47	2.11	10.15	27.22	50.07	70.87
<i>DDSlp</i>	95	31.51	15.12	2.53	19.14	34.72	42.09	59.84
<i>OPN</i>	116	128.81	83.93	31.94	62.34	118.35	151.12	379.1

Source: own work.

**Table B2. Correlation matrix of variables**

	<i>STRI</i>	<i>EGDI</i>	<i>EPI</i>	<i>FBS</i>	<i>MCS</i>	<i>FBO</i>	<i>UoI</i>	<i>COV</i>	<i>HIA</i>	<i>PFB</i>	<i>PMB</i>	<i>SIS</i>	<i>IBC</i>	<i>GDP</i>	<i>EXR</i>	<i>CPI</i>	<i>ICTe</i>	<i>ICTi</i>	<i>DDSEp</i>	<i>DDSlp</i>	<i>OPN</i>	
<i>STRI</i>	1																					
<i>EGDI</i>	-0.691*	1																				
<i>EPI</i>	-0.754**	0.871**	1																			
<i>FBS</i>	-0.515*	0.855**	0.736**	1																		
<i>MCS</i>	-0.668*	0.653*	0.600*	0.581*	1																	
<i>FBO</i>	-0.219	-0.002	0.149	-0.051	0.565*	1																
<i>UoI</i>	-0.446	0.823**	0.719**	0.752**	0.510*	-0.139	1															
<i>COV</i>	-0.472	0.645*	0.678*	0.542*	0.534*	0.221	0.723**	1														
<i>HIA</i>	-0.402	0.789**	0.727**	0.695*	0.423	-0.047	0.886**	0.7*	1													
<i>PFB</i>	0.651*	-0.415	-0.330	-0.319	-0.395	0.165	-0.436	-0.575*	-0.505*	1												
<i>PMB</i>	0.234	-0.612*	-0.502*	-0.569*	-0.476	0.147	-0.661*	-0.655*	-0.768**	0.505*	1											
<i>SIS</i>	-0.160	0.461	0.398	0.501*	0.196	-0.239	0.379	0.226	0.388	-0.099	-0.282	1										
<i>IBC</i>	-0.292	0.592*	0.575*	0.638*	0.267	-0.196	0.452	0.372	0.489	-0.333	-0.344	0.910***	1									
<i>GDP</i>	-0.222	0.688*	0.508*	0.804**	0.294	-0.489	0.617*	0.380	0.601*	-0.238	-0.482	0.576*	0.671*	1								
<i>EXR</i>	0.153	-0.303	-0.201	-0.205	-0.092	0.086	-0.257	-0.275	-0.293	0.082	0.080	-0.158	-0.107	-0.403	1							
<i>CPI</i>	0.151	-0.055	0.169	-0.103	0.066	0.176	0.046	0.101	0.039	-0.114	0.035	-0.047	0.028	-0.340	0.696*	1						
<i>ICTe</i>	-0.772**	0.573*	0.659*	0.467	0.386	0.019	0.346	0.332	0.293	-0.264	-0.009	0.207	0.421	0.174	-0.110	0.223	1					
<i>ICTi</i>	-0.764**	0.653*	0.697*	0.609*	0.401	-0.009	0.418	0.316	0.420	-0.275	-0.116	0.321	0.543*	0.327	-0.073	0.159	0.924***	1				
<i>DDSEp</i>	-0.685*	0.662*	0.622*	0.460	0.275	-0.115	0.469	0.447	0.567*	-0.270	-0.147	0.321	0.548*	0.402	-0.400	0.015	0.698*	0.677*	1			
<i>DDSlp</i>	-0.696*	0.864**	0.802**	0.709**	0.669*	0.053	0.691*	0.691*	0.729**	-0.369	-0.636*	0.380	0.571*	0.586*	-0.351	0.043	0.521*	0.609*	0.667*	1		
<i>OPN</i>	-0.199	0.566*	0.469	0.803**	0.407	-0.253	0.474	0.353	0.408	-0.195	-0.375	0.483	0.583*	0.755**	-0.191	-0.141	0.319	0.439	0.092	0.382	1	

Note: \*, \*\*, and \*\*\* denote significance at the 5%, 1%, and 0.1% levels.

Source: own work.

## Appendix C. Principal component analysis results

**Table C1. Eigenvalues and variance explained by component**

Principal component	Explained variance (%)	Cumulative explained variance (%)
PC1	99.97	99.97
PC2	0.00025	99.9997
PC3	0.000025	100
PC4	0.000001	100
PC5	0.0000005	100
PC6	0.0000003	100
PC7	0.0000001	100
PC8	0.00000005	100
PC9	0.00000001	100
PC10	0.00000001	100

Source: own work.

**Table C2. Loadings of infrastructure indicators on the first principal component (PC1)**

Indicator	Loading on PC1
FBS	0.385
MCS	-0.057
FBO	-0.247
Uoi	0.364
COV	0.191
HIA	0.366
PFB	-0.264
PMB	-0.358
SIS	0.402
IBC	0.355

Note: Indicators reflecting access and connectivity load positively, while cost-related measures load negatively, which is consistent with their expected effect on digital readiness.

Source: own work.

Table C3. PCA adequacy diagnostics

Test	Statistic	<i>p</i> -value	Interpretation
Kaiser–Meyer–Olkin (KMO) measure	0.93	–	Sampling adequacy excellent
Bartlett's test of sphericity	$\chi^2 = 1450.7$ ( <i>df</i> = 45)	< 0.001	Correlation matrix suitable for PCA

Source: own calculations based on ITU, World Bank, WDI, and ITC indicators listed in Appendix A.

## Appendix D. Robustness checks

Table D1. Robustness checks for ICT goods trade, digitally deliverable services, and trade openness

Panel A. ICTe						
Variable	Baseline	+HC	+GE	+RQ	+log (1 + PAT)	+log (1 + TAPED)
<i>Digital_Infrastructure_PCA</i>	–3.78E-09 (3.12E-08)	–1.02E-08 (2.55E-08)	–1.01E-08 (2.61E-08)	–2.05E-08 (3.20E-08)	3.92E-08 (4.84E-08)	–1.75E-08 (3.15E-08)
<i>STRI</i>	–93.12*** (9.94)	–82.58*** (12.98)	–95.88*** (15.88)	–97.33*** (12.45)	–99.98*** (18.43)	–98.19*** (15.39)
<i>EGDI</i>	–74.16*** (15.8)	–80.32*** (10.00)	–73.27*** (12.58)	–75.98*** (19.66)	–75.16*** (11.86)	–81.32** (12.05)
<i>EPI</i>	26.01** (8.88)	27.32** (9.19)	26.27** (8.70)	26.93** (8.97)	25.70** (8.66)	24.87** (8.87)
Panel B. ICTi						
Variable	Baseline	+HC	+GE	+RQ	+log (1 + PAT)	+log (1 + TAPED)
<i>Digital_Infrastructure_PCA</i>	2.34E-08 (1.97E-08)	2.12E-08 (2.49E-08)	2.57E-08 (2.03E-08)	2.37E-08 (2.28E-08)	2.68E-08 (2.43E-08)	1.76E-08 (2.39E-08)
<i>STRI</i>	–45.96*** (6.29)	–46.06*** (5.83)	–40.44*** (5.60)	–45.68*** (5.42)	–44.01*** (5.72)	–49.42*** (6.42)
<i>EGDI</i>	–39.93*** (9.98)	–41.55*** (9.22)	–41.72*** (8.35)	–40.09*** (8.37)	–36.66*** (7.27)	–44.81*** (10.30)
<i>EPI</i>	21.21*** (5.62)	23.68*** (6.24)	20.69*** (7.12)	21.19*** (7.76)	19.72*** (5.21)	20.43*** (7.56)

Panel C. DDSEp						
Variable	Baseline	+HC	+GE	+RQ	+log (1 + PAT)	+log (1 + TAPED)
<i>Digital_Infra-structure_PCA</i>	-92.41*** (23.93)	-91.02*** (22.67)	-90.59*** (24.20)	-89.04*** (22.22)	-92.46*** (28.38)	-88.84*** (24.90)
<i>STRI</i>	-29.43 (31.63)	-29.41 (30.88)	-31.67 (30.99)	-28.15 (29.35)	30.91 (28.01)	-26.37 (29.49)
<i>EGDI</i>	21.61 (19.51)	26.24 (23.74)	26.62 (19.32)	27.47 (19.36)	-16.58 (19.44)	26.91 (20.14)
<i>EPI</i>	26.01** (8.88)	27.32** (9.19)	26.27** (8.70)	26.93** (8.97)	25.70** (8.66)	24.87** (8.87)
Panel D. DDSIp						
Variable	Baseline	+HC	+GE	+RQ	+log (1 + PAT)	+log (1 + TAPED)
<i>Digital_Infra-structure_PCA</i>	1.67E-08 (2.11E-08)	1.83E-08 (1.53E-08)	2.72E-08 (1.79E-08)	2.84E-08 (2.06E-08)	2.66E-08 (1.96E-08)	1.53E-08 (2.63E-08)
<i>STRI</i>	-44.68*** (11.21)	-42.19*** (10.36)	-42.83*** (13.39)	40.35*** (10.64)	40.58*** (10.69)	-39.12*** (12.72)
<i>EGDI</i>	70.83*** (14.82)	78.57*** (16.64)	78.41*** (14.10)	65.10*** (12.55)	65.55*** (13.19)	67.85** (12.04)
<i>EPI</i>	-13.74 (9.14)	-9.047 (10.12)	-8.737 (10.04)	-10.27 (12.30)	-11.66 (13.87)	-9.53 (13.12)
Panel E. OPN						
Variable	Baseline	+HC	+GE	+RQ	+log (1 + PAT)	+log (1 + TAPED)
<i>Digital_Infra-structure_PCA</i>	-1.00E-07 (2.12E-07)	-9.33E-08 (2.33E-07)	-9.88E-08 (2.68E-07)	-1.21E-07 (2.58E-07)	-7.79E-08 (1.96E-07)	-2.49E-07 (2.58E-07)
<i>STRI</i>	-32.94 (68.45)	-33.82 (66.80)	-36.08 (61.72)	-31.22 (64.76)	-31.25 (65.88)	-36.02 (68.12)
<i>EGDI</i>	-120.67 (101.11)	123.06 (108.58)	-117.59 (109.98)	-125.72 (101.60)	-120.73 (101.61)	-122.90 (105.06)
<i>EPI</i>	58.24 (58.57)	58.75 (60.90)	60.88 (56.66)	60.89 (62.21)	60.69 (80.96)	51.27 (82.19)

Note: Each column adds one additional control to the baseline (shown in the column header). All specifications include GDP, EXR, CPI, *Digital\_Infrastructure\_PCA*, *STRI*, *EGDI*, and *EPI*. PAT and TAPED enter as  $\log(1 + x)$ . Standard errors in parentheses. Coefficients are unstandardised. \*, \*\*, and \*\*\* denote significance at the 5%, 1%, and 0.1% levels.

Source: own work.

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# Relative institutional maturity of export markets and export performance: The moderating roles of managerial capabilities and export intensity

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## Abstract

This study combines institutional theory with the capability perspective to investigate how the institutional characteristics of export markets served by firms from a post-transition economy affect their export performance. We analyse a dataset of 500 exporting firms from Poland, a post-transition economy, by using regression analyses. This research aims to explore how the relative institutional maturity of a firm's export markets affects performance, as well as to establish the moderating role of managerial capabilities and export intensity for this performance effect. Relative institutional maturity is negatively associated with export performance only for exporters characterised by both low managerial capabilities and low export intensity. For firms with greater export exposure, this negative effect disappears, suggesting that accumulated international involvement may partly offset the challenges of operating in more institutionally mature markets.

## Keywords

- relative institutional maturity
- managerial capabilities
- export intensity
- export performance
- post-transition economies

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## Introduction

The issue of foreign market choice in a firm's internationalisation process has preoccupied international business (IB) and international marketing (IM) scholars for a long time (Baena-Rojas et al., 2021; Vahlne & Johanson, 2017). For exporting firms, decisions related to the geographic presence are of vital importance as they affect their export performance (Freeman & Styles, 2014; Freeman et al., 2012). Traditionally, research has concentrated on market entries into specific countries (e.g., Stouraitis et al., 2017) and their performance outcomes (Trąpczyński & Banalieva, 2016), while overlooking the perspective of an exporter's overall geographic presence and its characteristics. These markets can be more or less developed in terms of institutional and economic characteristics than the home market of an exporter, a fact which bears distinct implications for an exporter's performance.

While it has been broadly acknowledged that the institutional characteristics of foreign markets, as well as the institutional distance between countries, affect the patterns and outcomes of firms' international operations (van Hoorn & Maseland, 2016), the majority of existing studies do not take into account whether distance is caused by institutionally more or less developed foreign countries (Hernández & Nieto, 2015; Trąpczyński & Banalieva, 2016; Zaheer et al., 2012). In fact, performance varies greatly between individual firms in markets with less mature institutions. In these, market-based advantages matter less than the ability to cope with a less transparent and stable institutional environment (Chan et al., 2008), and firms from economies which underwent or are undergoing institutional transition might be more capable of coping with less mature environments (Cuervo-Cazurra & Genc, 2008). At the same time, the ability to cope with relatively more developed, mature export markets might be contingent on the exporter's capabilities (Trąpczyński, 2018) or the scale of export operations (Bartożewski & Trąpczyński, 2021).

We address the aforesaid gaps in the export market selection literature by drawing on the institution-based and capability-based perspectives to provide new empirical evidence on how exporters with different degrees of foreign

market maturity relative to their home market perform in their international activities, taking into account the moderating roles of managerial capabilities and export intensity. In doing so, we place our study in the empirical context of exporters from a post-transition economy, since managers of such firms are often enthusiastic about international expansion, particularly towards ambitious, well-developed markets in order to gain legitimacy and absorb new knowledge (Crescenzi et al., 2015). However, success in moving into advanced markets is far from guaranteed, and may be moderated by several firm-level antecedents (Cui & Jiang, 2012). These firms' choices concerning the share of institutionally more mature markets in their export market presence, i.e. the share of more and less developed export markets, may actually differ from the conventional strategic choices of advanced country firms, which is due to the still limited international experience, limited capabilities or a different level of factor market development conditions in their home economies, among other factors (Kim et al., 2015).

This paper is structured as follows. First, we develop a conceptual framework based on institutional theory and the capability perspective, as well as literature on the implications of a firm's internationalisation degree. Next, we present our methodology in order to subsequently proceed with empirical tests of our conceptual model and its hypotheses. After presenting our results, we discuss the theoretical implications, practical recommendations, and directions for future research.

## **1. Theoretical background and hypotheses**

### **1.1. Relative institutional maturity-export performance relationship**

In international business, institutions matter in two closely related ways. Firstly, the institutional quality of a country in itself shapes the opportunities and constraints facing firms operating there. Stronger formal institutions support more predictable transactions, clearer rules, better protection of property rights, and more reliable governance, whereas weaker institutional settings are associated with greater uncertainty, information asymmetries, and higher transaction costs (North, 1990; Scott, 2001). Secondly, beyond the quality of a single environment, firms also face the challenge of operating across countries whose institutional conditions differ from those of their home market. This has given rise to extensive literature on institutional distance, which argues that cross-country institutional differences influence in-

ternational expansion decisions and subsequent performance outcomes. As van Hoorn and Maseland (2016) note, institutional research in international business has largely revolved around these two assumptions: that institutional profiles matter, and that institutional distance matters.

Much of the institutional distance literature has focused on the magnitude of cross-country differences and has reported mixed performance implications. On the one hand, larger institutional distance has often been associated with higher uncertainty, adaptation costs, and liabilities of foreignness, which undermine firm performance (Xu & Shenkar, 2002). On the other, some studies have argued that institutional distance may also create opportunities for arbitrage, capability development, or better strategic decision-making, and thus may enhance performance under certain conditions (Nachum et al., 2008). As Trąpczyński and Banalieva (2016) summarise, these contradictory findings stem in part from treating institutional distance symmetrically and focusing mainly on its magnitude rather than on whether the foreign environment is institutionally more or less advanced than the home country. Konara and Shirodkar (2018) make a similar point by arguing that prior work on institutional distance and performance has largely ignored the issue of direction, even though moving “up” and “down” the institutional ladder may have distinct implications.

Recent studies that do differentiate the direction of institutional distance show that this distinction is consequential. Hernández et al. (2015) demonstrate that the choice implications of regulative distance differ depending on whether firms enter countries with lower or higher levels of regulatory development than their home country. Hernández et al. (2018) likewise argue that firms may not face the same uncertainty when institutional differences have the same magnitude but the opposite direction. Moreover, they report that positive institutional distance makes locations more attractive, whereas negative distance makes them less attractive on average. In a more recent extension, Tang and Buckley (2022) also show that positive and negative institutional distance have asymmetric implications for the location and scale of outward investment. In the performance domain, Konara and Shirodkar (2018) argue that the implications of regulatory institutional distance are relatively more positive, or less negative, when firms are “climbing down” rather than “climbing up” the institutional ladder.

This directional logic is especially relevant for firms from transition economies. Trąpczyński and Banalieva (2016) emphasise that infant multinationals from post-transition economies such as Poland face particular challenges because their constrained firm-specific advantages must be deployed in host countries that may be either more or less institutionally developed than their home market. In this context, host countries with similar or lower levels of institutional development may yield better performances because firms can draw on experience forged under comparable institutional

conditions. Cuervo-Cazurra and Genc (2008) similarly argue that firms from developing countries may convert the disadvantage of operating in institutionally difficult home environments into an advantage when they expand into other difficult environments, due to already being accustomed to dealing with weaker institutions.

By contrast, entry into more institutionally mature economies, which are typically more economically developed and thus more competitive, is likely to impose additional burdens on exporters from post-transition economies. Firstly, more mature environments typically involve clearer and more stringently enforced rules, which raise the demands of compliance, quality assurance, and formal coordination. Secondly, stronger institutions tend to be associated with more sophisticated customers, more demanding intermediaries, and greater pressure to meet internationally recognised product, service, and certification standards (Cui & Jiang, 2012; Sarathy & Banalieva, 2014). Thirdly, routines and non-market capabilities developed in less mature home contexts often travel poorly upward, because relational mechanisms and informal coping strategies become less useful in more formalised environments. Konara and Shirodkar (2018) argue that climbing up the institutional ladder increases both learning and unlearning costs, as firms from weaker home-country environments must not only understand the local rules of the game, but also abandon home-based practices that fit less formal institutional settings. Hernández et al. (2018) likewise note that upward institutional distance can expose firms to greater uncertainty and lower familiarity despite identical absolute distance.

At the same time, most prior studies on the direction of institutional distance have focused on single foreign market entries, FDI locations, or subsidiary-level outcomes rather than on the broader foreign market patterns of exporters (Hernández & Nieto, 2015). Yet exporters rarely operate in only one foreign market. Their export activities unfold across a set of chosen destinations which, when taken together, reveal whether the firm's foreign market presence is concentrated in more or less institutionally developed countries. To capture this broader pattern, we refer to the relative institutional maturity of export markets, defined as the average directional difference between the institutional development of a firm's export markets and that of its home market. We use this label deliberately. In a single-home-country design, van Hoorn and Maseland (2016) warn that institutional distance may become conflated with host-country institutional profile effects. Accordingly, our construct is intended to capture the relative institutional maturity of the exporter's realised set of foreign markets, rather than to make stronger claims about pure distance effects in the abstract.

Building on the above arguments, we expect that as the relative institutional maturity of export markets increases, the export performance of a post-transition economy exporter will decline. A stronger focus on insti-

tutionally more mature export markets exposes exporters to greater demands for formal compliance, more sophisticated stakeholder expectations, and a weaker applicability of routines formed in less mature environments. Although such markets may offer long-term developmental opportunities, they are also likely to impose short-term performance penalties on exporters whose resources and routines were shaped in a post-transition context. Conversely, exporters whose foreign market presence is concentrated in institutionally similar or less mature environments should be better able to leverage home-grown capabilities and cope with contextual uncertainty, thereby achieving stronger export performance. At the same time, while we do not imply that there is an optimal level of institutional maturity, as various countries may adopt different paths leading to economic and social development, our argumentation concentrates on the relative nature of institutional settings as experienced by foreign entrants, and the challenges related to these differences.

Hence, on the whole, we posit that:

**H1:** The relative institutional maturity of export markets is negatively associated with export performance.

## **1.2. The contingencies of the relative institutional maturity-performance relationship**

To explain why some exporters cope better with relatively more institutionally mature export markets than others, we first draw on the capability-based view of the firm. Rooted in the broader resource-based tradition, this perspective holds that firms differ not only in the resources they control but also in their ability to deploy, combine, and leverage those resources effectively in pursuit of superior performance (Barney, 1991; Collis, 1994). Extant international business research explicitly links firm capabilities to international success, while also stressing that such capabilities cannot be considered in isolation from the context in which they are deployed (Trąpczyński, 2018). Thus, the capability-based view and the institution-based view should be regarded as complementary, as the value of firm capabilities depends on the context in which they are implemented (Brouthers et al., 2008), while, conversely, these capabilities determine the ability to succeed in a given market. These capabilities are therefore best understood as organisationally embedded managerial capabilities that help exporting firms interpret foreign market requirements, coordinate external relationships (e.g. with distributors), and support foreign operations. This interpretation is consistent with Trąpczyński

(2018), who emphasises that the competitive advantage of Polish and other post-transition country firms is often increasingly tied to intangible and managerial resources such as relationships with customers, organisational know-how, brand and market image, employee knowledge and skills, and relations with business partners (Ramamurti, 2009).

Exporters differ in the managerial capabilities which they possess, and those differences matter more when firms operate in relatively more institutionally mature markets (Trąpczyński, 2018). Operating in institutionally more advanced markets requires firms to meet higher customer expectations, including the provision of more complex products and higher quality (Sarathy & Banalieva, 2014). Thus, exporters from transition economies may need to catch up and upgrade their capabilities in order to compete effectively in such settings (Ahuja et al., 2012). Moreover, firms from transition economies may find it difficult to adjust to the more formalised labour and capital markets of advanced economies, where market transactions rely more strongly on formal written contracts than on informal agreements. This drives up transaction costs (Ahuja et al., 2012). In consequence, capabilities related to foreign affiliate management, client handling, marketing approaches, product fit, and channel coordination become particularly important in more advanced environments, whereas weaker institutional settings may still allow firms to compensate for capability gaps through non-market tactics or home-grown familiarity with imperfect institutions (Cuervo-Cazurra & Genc, 2011).

This argument also intersects with the institutional notion of legitimacy, which is especially relevant for firms from post-transition and other less advanced home environments. Institutional theory emphasises that foreign firms face pressures to attain legitimacy vis-à-vis host-country stakeholders and institutions. The need to secure such legitimacy intensifies as institutional differences become more pronounced (Scott, 2001). Thus, exporters with superior managerial capabilities should be better equipped to secure legitimacy in relatively more institutionally mature markets. This is because they can manage relationships with customers and intermediaries more professionally, organise distribution channels more effectively, understand local market requirements better, and mobilise qualified employees and experienced managers in ways that signal reliability, professionalism, and local fit (Xu & Shenkar, 2002).

For firms from a post-transition economy, the relevance of such capabilities is even stronger because their home-grown routines do not always travel easily upward. Foreign buyers, distributors, or regulatory actors may expect more formalised and professionalised patterns of conduct, while the home-grown routines of exporters based on informal coping or non-market embeddedness may be less effective (Cuervo-Cazurra & Genc, 2011). Likewise, Konara and Shirodkar (2018) argue that moving upward into institutionally stronger environments increases adaptation costs because firms must not only

understand the host-country rules of the game but also cope with the need to unlearn home-environment practices that fit weaker institutional settings. They explicitly link this challenge to the capabilities developed under home-country regulatory conditions and their transferability abroad.

Accordingly, although the relative institutional maturity of export markets is expected to have a negative direct association with export performance, this adverse relationship should be weaker for exporters possessing stronger managerial capabilities. Firms with superior managerial capabilities should be better able to cope with the formalisation, demanding customers, stricter channel expectations, and legitimacy requirements characteristic of relatively more institutionally mature export markets. Put differently, managerial capabilities should help post-transition economy exporters translate presence in more advanced markets into less severe performance penalties than would be the case for exporters with weaker capabilities. This leads to the following hypothesis:

**H2:** Managerial capabilities moderate the relationship between the relative institutional maturity of export markets and export performance such that the slope becomes less negative as managerial capabilities increase.

Finally, we argue that the moderating effect of managerial capabilities depends on export intensity, such that it is strong for firms with less international exposure and fades away as the complexity of export operations increases. Export intensity reflects the depth of a firm's commitment to foreign markets. Deeper foreign involvement is often expected to allow firms to exploit their capabilities more broadly, spread fixed costs over a larger sales base, and benefit from scale, scope, and learning effects (Dhanaraj & Beamish, 2003; Filatotchev & Piesse, 2009). At the same time, a growing body of work suggests that the effects of stronger foreign commitment are not uniformly positive and that internationalisation may create as many managerial burdens as benefits, especially for firms like those from post-transition economies, which are still early in their international development (Barłózewski & Trąpczyński, 2021; Matysiak & Bausch, 2012; Verbeke et al., 2009).

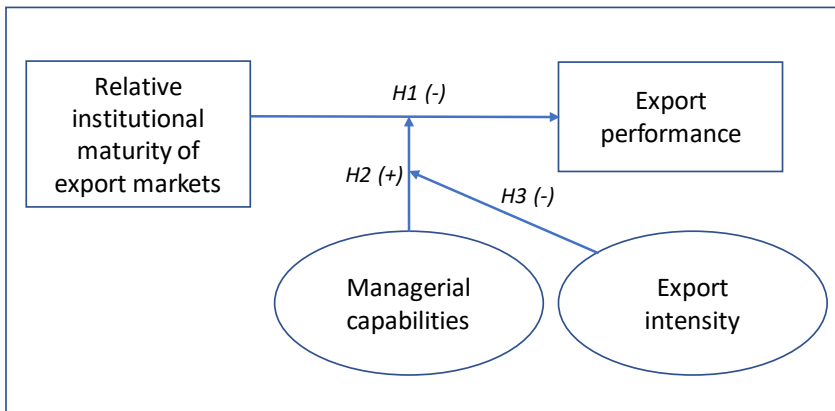
The darker side of increasing export commitment lies in the fact that foreign market expansion heightens the complexity and coordination requirements of operating across borders. As foreign operations constitute a larger part of total sales, firms face stronger pressure to adapt products, service standards, and sales processes to the needs of foreign clients and intermediaries, while also ensuring internal consistency and efficient coordination of these activities (Barłózewski & Trąpczyński, 2021). From a certain point onward, the costs of product and market adaptation, dispersed coordination, and the integration of increasingly heterogeneous foreign activities may outweigh the benefits of further export expansion (Matysiak & Bausch, 2012).

These concerns are especially relevant for post-transition country exporters, which are often relative beginners in international expansion. Firms from such contexts frequently lag behind their advanced-economy counterparts and may face substantial barriers, such as limited information, financing constraints, and shortages of skilled personnel with foreign-market experience (Barłóżewski & Trąpczyński, 2021; Svetličič & Jaklič, 2003). Moreover, firms from post-transition economies have tended to begin their expansion in institutionally or geographically close markets (Barłóżewski & Trąpczyński, 2021; Trąpczyński & Banalieva, 2016). As export intensity rises, these firms become more dependent on foreign revenues and more exposed to the burdens of managing foreign operations on a larger scale. In such a situation, particularly when they move to institutionally more mature yet challenging markets, the marginal contribution of each additional foreign market to performance may decline, while managerial attention becomes increasingly stretched across multiple foreign relationships requiring significant investments in upgrading and adaptation (Barłóżewski & Trąpczyński, 2021).

To sum up, when export intensity increases, managerial capabilities must be deployed across a broader and increasingly demanding set of export markets. The exporter becomes more dependent on foreign buyers and intermediaries, thus its own managerial capabilities remain important. However, their marginal buffering effect on the negative relationship between the relative institutional maturity of export markets and export performance becomes less relevant as export intensity rises. Therefore, we propose that:

**H3:** The moderating effect of managerial capabilities depends on export intensity, such that it becomes weaker for high export intensity.

The hypothesised relationships are presented in Figure 1.



**Figure 1. Conceptual framework of the study**

Source: own work.

## 2. Research design

### 2.1. Data collection and sample

To test the hypotheses, we analysed primary survey data collected from exporting firms located in Poland, a post-transition economy. The sampling frame was constructed using the BISNODE database, which provides comprehensive firm-level information on Polish companies. Firms were included in the sampling frame if they met several criteria. Firstly, firms had to be predominantly controlled by Polish owners. Secondly, they had to operate in industrial manufacturing sectors and generate the majority of their revenues from manufacturing activities. Thirdly, firms were required to export to at least two foreign markets, with exports accounting for a minimum of 10% of total revenues. Fourthly, firms needed to employ at least ten employees and demonstrate financial stability in the period prior to the survey (2017–2019).

Using these criteria, a total of 2,166 exporting firms were identified and contacted by a professional market research agency commissioned by the research team. Given the complexity of the survey and the traditionally low response rates of unassisted online surveys, the agency conducted telephone interviews with export executives responsible for their firms' international operations. Respondents typically held senior positions, such as export manager, international sales manager, or managing director. The use of key informants is consistent with prior export research, where senior managers are typically the most knowledgeable respondents regarding firms' export activities.

Data collection took place between September and November 2020. In total, 500 usable responses were obtained, corresponding to an effective response rate of approximately 23%. Table 1 provides an overview of the sample composition across firm size and technological intensity categories.

**Table 1. Sample composition**

Size	N	Low-Tech (%)	Medium-Tech (%)	High-Tech (%)	Avg. # Export Markets	B2B Market (%)	B2C Market (%)
Small	168	35	32	33	4	71	29
Medium	167	33	33	34	7	77	23
Large	165	33	34	32	14	78	22

Source: own work.

The main difference between small, medium-sized, and large firms concerns the average number of export markets served, which increases with firm size. At the same time, the distribution of technological intensity across firm size categories is relatively balanced. Small firms show a somewhat higher share of B2C markets compared with larger firms, whereas medium-sized and large firms are more frequently active in B2B markets.

Although the data were collected using a single survey instrument, several procedural steps were taken to reduce potential common method bias. Respondents were assured of confidentiality and anonymity, and the questionnaire contained clearly separated sections addressing different aspects of firms' international activities. In addition, a Harman's single-factor test indicates that no single factor accounts for the majority of the variance, with the first factor explaining only 20.35% of the total variance, suggesting that common method bias is unlikely to be a serious concern.

## 2.2. Variable measurement

### 2.2.1. Dependent variable

Our dependent variable, *export performance*, captures firms' perceived export outcomes during the period 2017–2019. Export managers were asked to evaluate their firm's overall export performance relative to expectations using a seven-point Likert scale (1 = "definitely below expectations", 4 = "in line with expectations", 7 = "significantly above expectations"). The overall assessment reflects a broad set of financial and strategic performance dimensions, including sales volume, sales profitability, return on investment in foreign market entries, financial liquidity, growth in foreign market share, marketing effectiveness, distribution effectiveness, firm image among clients, and overall satisfaction with export outcomes. Perceptual performance measures of this type are widely used in export performance research and have been shown to correlate strongly with objective performance indicators.

### 2.2.2. Independent variables

The main independent variable, *relative institutional maturity*, captures the relative institutional development level of export markets in a firm's portfolio of export markets compared with the home market. *Relative institutional maturity* was operationalised using directional institutional distance between Poland and each export market. Institutional distance was calculated using the

Heritage Index of Economic Freedom, which ranges from 0 to 100 and captures multiple dimensions of market-supporting institutional environments, including regulatory efficiency, trade openness, and property rights protection (Holmes et al., 2008).<sup>3</sup> Higher values indicate institutionally more mature market environments. The directional institutional distance between Poland and each export market was calculated using the Kogut and Singh (1988) index, while preserving the direction of distance, following the recommendation of Zaheer et al. (2012). Positive values indicate export markets that are more institutionally mature than Poland, whereas negative values indicate less mature markets. In line with the time frame of the *export performance* measure, index values were averaged over the period 2017–2019.

*Managerial capabilities* were measured using a multi-item scale adapted from Ruiz-Ortega et al. (2013). Export managers assessed the extent to which their firm possessed advantages relative to its closest domestic competitor in several areas, including building relationships with clients, customer database maintenance, access to distribution channels, market knowledge, employee motivation and qualification, and management team experience. Responses were recorded on a seven-point scale ranging from 1 (“much worse than competitors”) to 7 (“much better than competitors”).

The firm’s *export intensity* was captured using foreign sales to total sales in 2019, as reported by survey respondents. This measure is widely used in international business research to capture firms’ export intensity.

### 2.2.3. Control variables

Several control variables were included to account for alternative explanations of export performance. *Firm age* was measured as the number of years since the firm’s founding. *Firm size* was captured using employment in 2019. *Technological capabilities* were measured using a multi-item scale assessing firms’ relative strength in areas such as R&D investment, techno-

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<sup>3</sup> While alternative institutional measures such as the Worldwide Governance Indicators (WGI) are commonly used in international business research, we rely on the Heritage Index of Economic Freedom because it captures broader dimensions of market-supporting institutional maturity that are particularly relevant for exporters, including regulatory efficiency, business freedom, trade freedom, and property rights protection (Holmes et al., 2008). In line with prior research emphasising the role of institutional environments for international business activities (e.g., Cuervo-Cazurra & Genc, 2008; Trąpczyński & Banalieva, 2016), the Heritage Index provides a composite and longitudinally comparable measure of institutional and economic development across countries. Moreover, our theoretical focus concerns exporters’ exposure to institutionally more versus less mature market environments rather than governance quality alone, making the Heritage Index particularly suitable for capturing the broader notion of relative institutional maturity used in this study.

logical equipment, scale economies, manufacturing efficiency, patents, and technological know-how.

*Export planning* was measured using a four-item scale assessing the extent to which firms systematically evaluate export opportunities, define export objectives, and analyse export environments when making export decisions (Souchon et al., 2016). *Export centralisation* captures the extent to which export decisions require approval from top management and was measured using three items assessing the degree of centralised decision-making in export activities. *Foreign market knowledge* reflects firms' knowledge about export markets relative to the home market. Respondents evaluated their knowledge of foreign market conditions, customers, competitors, products, pricing and payment practices, communication practices, and distribution systems.

*Product complexity* was measured using a seven-item scale capturing technological sophistication and adaptation requirements of firms' products. The items capture aspects such as technological advancement, the need for trained sales personnel, product innovativeness, service requirements, country-specific adaptations, specialised logistics requirements, and differentiation from competitors. Finally, *industry* was controlled for using NACE industry codes reported in the survey, which were recoded into three categories (low-tech, medium-tech, and high-tech industries) based on the OECD classification of technological intensity. Table A1 in the Appendix summarises all variable definitions and measurements.

### 2.3. Measurement validation

To assess the reliability and dimensionality of the multi-item constructs used in this study, we conducted reliability analyses and exploratory factor analyses using principal axis factoring (Hair et al., 2010). All multi-item constructs exhibit satisfactory levels of internal consistency. *Export planning* shows a Cronbach's alpha of 0.852, *export centralisation* an alpha of 0.869, *foreign market knowledge* an alpha of 0.932, and product complexity an alpha of 0.783. Exploratory factor analyses further confirm that the items for *export planning*, *export centralisation*, and *foreign market knowledge* load on a single factor, thus supporting the unidimensionality of these constructs. *Product complexity* shows evidence of a common underlying construct capturing overall product sophistication and adaptation requirements. Consistent with the conceptual coherence of the scale and common practice in export research, the items were aggregated into a single composite index. For each multi-item construct, composite variables were calculated as the mean of the corresponding survey items. Table A2 in the Appendix presents the reliability statistics and factor loadings for the multi-item constructs.

## 2.4. Estimation method

Prior to estimating the regression models, continuous predictor variables were mean-centred in order to facilitate the interpretation of interaction effects and reduce potential multicollinearity between interaction terms and their constituent variables (Aiken & West, 1991; Judd et al., 2017). The hypotheses were tested using ordinary least squares (OLS) regression models with heteroskedasticity-robust standard errors. Diagnostic tests indicated the presence of heteroskedasticity in the residuals (White test  $p < 0.001$ ), which justified the use of robust standard errors. As a robustness check, we additionally estimated ordered logit models to account for the ordinal nature of the export performance measure. The results remain consistent with the OLS estimates. We therefore report the OLS models as our main specification due to the more straightforward interpretation of interaction effects. Interaction effects were examined by introducing multiplicative interaction terms between relative institutional maturity, managerial capabilities, and export intensity.

Table 2 reports descriptive statistics and pairwise correlations for all variables used in the analysis. The correlations do not indicate serious multicollinearity concerns among the independent variables, which is further supported by variance inflation factors well below conventional thresholds (mean VIF = 1.53).

## 3. Results

Table 3 reports the results of the OLS regression models explaining *export performance*. All models include heteroskedasticity-robust standard errors to account for potential heteroskedasticity. Model 1 presents the baseline model, including only the control variables. Among the controls, export planning shows a positive and statistically significant association with *export performance* ( $\beta = 0.130, p < 0.01$ ), indicating that firms that engage in more systematic *export planning* tend to achieve better export outcomes. *Product complexity* also exhibits a positive effect ( $\beta = 0.092, p < 0.05$ ), suggesting that firms offering more complex products may benefit from stronger *export performance*. The remaining control variables are not statistically significant.

Model 2 introduces the main independent variables. *Managerial capabilities* show a positive and statistically significant association with *export performance* ( $\beta = 0.122, p < 0.05$ ), suggesting that firms with stronger *managerial capabilities* tend to perform better in export markets. In contrast, the

**Table 2. Descriptive statistics and correlations**

Variable	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13
<i>Export performance</i>	5.026	0.606	1												
<i>Relative institutional maturity</i>	0.000	0.398	-0.098*	1											
<i>Managerial capabilities</i>	0.000	0.795	0.106*	0.063	1										
<i>Export intensity</i>	0.000	0.192	-0.129*	0.175*	0.156*	1									
<i>Technological capabilities</i>	4.937	0.640	0.043	0.036	0.676*	0.097*	1								
<i>Export planning</i>	5.582	0.842	0.214*	-0.002	0.279*	-0.052	0.198*	1							
<i>Firm age (log)</i>	3.058	0.431	-0.075	0.066	0.017	0.184*	-0.079	-0.060	1						
<i>Firm size (log)</i>	4.775	1.249	0.037	0.011	0.642*	0.061	0.512*	0.234*	-0.033	1					
<i>Export centralisation</i>	4.741	1.446	0.002	-0.027	-0.269*	-0.067	-0.234*	0.059	0.006	-0.398*	1				
<i>Foreign market knowledge</i>	5.530	0.754	0.033	-0.009	0.251*	0.096*	0.104*	0.050	-0.036	0.136*	0.129*	1			
<i>Product complexity</i>	4.715	0.897	0.139*	-0.053	0.275*	-0.152*	0.341*	0.320*	-0.045	0.087	0.066	0.090*	1		
<i>Industry (medium-tech)</i>	0.33	0.471	-0.040	0.001	0.007	0.014	-0.051	-0.014	0.019	0.015	-0.062	-0.092*	0.012	1	
<i>Industry (high-tech)</i>	0.33	0.471	-0.005	0.012	0.097*	-0.054	0.124*	0.017	-0.008	0.017	-0.035	0.072	0.389*	-0.493*	1

Source: own work.

coefficient for *relative institutional maturity* is negative but not statistically significant ( $\beta = -0.117$ , n.s.), indicating that higher *relative institutional maturity* does not systematically reduce *export performance* in the full sample. Thus, Hypothesis 1 does not receive direct support in the baseline specification. *Export intensity* exhibits a negative and marginally significant effect ( $\beta = -0.324$ ,  $p < 0.10$ ).

Model 3 adds the interaction term between *relative institutional maturity* and *managerial capabilities* in order to test Hypothesis 2. The interaction coefficient is positive but not statistically significant ( $\beta = 0.080$ , n.s.), suggesting that the moderating role of *managerial capabilities* cannot be fully understood without considering the firm's *export intensity*. Accordingly, Hypothesis 2 is not supported as a stand-alone two-way interaction.

Model 4 introduces the full three-way interaction between *relative institutional maturity*, *managerial capabilities*, and *export intensity*, providing a direct test of Hypothesis 3. The three-way interaction term is negative and statistically significant ( $\beta = -1.045$ ,  $p < 0.01$ ), indicating that the moderating effect of *managerial capabilities* on the relationship between *relative institutional maturity* and *export performance* depends on the *export intensity* of a firm.

To facilitate interpretation of this moderated moderation, we examine conditional marginal effects following the approach suggested by Aiken and West (1991). The results indicate that *relative institutional maturity* negatively affects *export performance* when both *managerial capabilities* and *export intensity* are low ( $\beta = -0.386$ ,  $p < 0.01$ ). Under these conditions, an increasing *relative institutional maturity* of a firm's export markets appears to impose coordination and complexity costs that outweigh potential benefits.

However, this negative relationship disappears when *managerial capabilities* are high ( $\beta = -0.004$ , n.s.) or when firms exhibit higher *export intensity* ( $\beta = 0.209$ , n.s. for low *managerial capabilities*;  $\beta = -0.047$ , n.s. for high *managerial capabilities*). In these cases, the effect of *relative institutional maturity* on *export performance* becomes statistically insignificant. These findings suggest that firms with stronger *managerial capabilities* or greater *export intensity* are better able to manage the complexity associated with increasingly stable, yet demanding markets in their overall geographic presence.

Figures 2 and 3 illustrate these conditional relationships. When *export intensity* is low (Figure 2), *relative institutional maturity* is negatively associated with *export performance* for firms with low *managerial capabilities*, whereas the relationship becomes flat for firms with high *managerial capabilities*. In contrast, when *export intensity* is high (Figure 3), *relative institutional maturity* shows only a weak relationship with *export performance* regardless of the level of *managerial capabilities*. Overall, our empirical evidence supports Hypothesis 3.

Overall, the results suggest that the performance implications of *relative institutional maturity* depend on firms' internal capabilities and their level

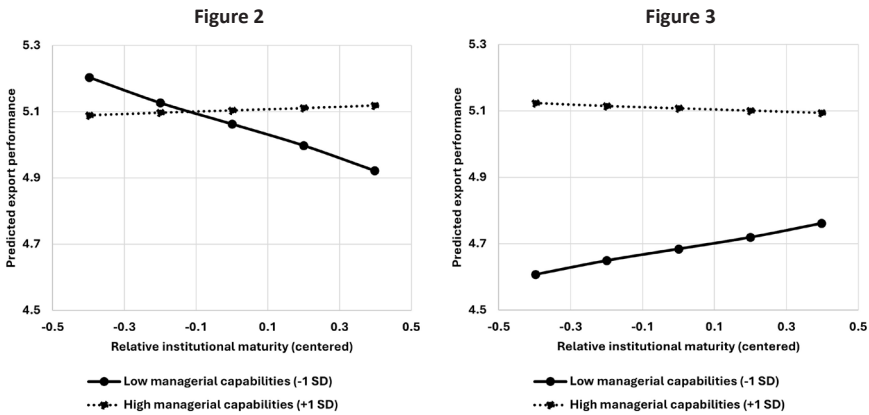
**Table 3. Regression results**

Variable	Model 1	Model 2	Model 3	Model 4
Relative institutional maturity (RIM)		-0.117 (0.073)	-0.121* (0.073)	-0.057 (0.075)
Managerial capabilities		0.122** (0.058)	0.122** (0.058)	0.129** (0.056)
Export intensity		-0.324* (0.166)	-0.317* (0.167)	-0.512*** (0.188)
RIM × Managerial capabilities			0.080 (0.089)	0.040 (0.088)
RIM × Export intensity				0.719 (0.500)
Managerial capabilities × Export intensity				0.688*** (0.168)
RIM × Managerial capabilities × Export intensity				-1.045*** (0.341)
Technological capabilities	-0.038 (0.062)	-0.080 (0.065)	-0.080 (0.065)	-0.090 (0.064)
Export planning	0.130*** (0.034)	0.120*** (0.033)	0.121*** (0.033)	0.117*** (0.034)
Firm age (log)	-0.084 (0.064)	-0.066 (0.064)	-0.064 (0.064)	-0.080 (0.064)
Firm size (log)	-0.008 (0.033)	-0.038 (0.034)	-0.037 (0.034)	-0.031 (0.033)
Export centralisation	-0.019 (0.025)	-0.017 (0.024)	-0.017 (0.024)	-0.025 (0.024)
Foreign market knowledge	0.016 (0.036)	0.005 (0.037)	0.006 (0.037)	0.003 (0.036)
Product complexity	0.092** (0.037)	0.066* (0.038)	0.067* (0.037)	0.051 (0.038)
Medium-tech industry	-0.119* (0.064)	-0.120* (0.064)	-0.125* (0.064)	-0.119* (0.064)
High-tech industry	-0.135* (0.076)	-0.132* (0.076)	-0.131* (0.073)	-0.106 (0.076)
Constant	4.432*** (0.404)	4.960*** (0.476)	4.933*** (0.478)	5.119*** (0.483)
Observations	500	500	500	500
R <sup>2</sup>	0.065	0.088	0.090	0.125

Notes: OLS regression coefficients reported. Heteroskedasticity-robust standard errors are reported in parentheses. Continuous predictors were mean-centred prior to the creation of interaction terms. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.10$ .

Source: own work.

of internationalisation. In particular, *relative institutional maturity* appears to have negative performance implications when firms possess both limited *managerial capabilities* and low levels of *export intensity*. However, this negative relationship weakens as *managerial capabilities* increase. Moreover, the moderating influence of *managerial capabilities* becomes evident only when the exporter’s level of internationalisation is taken into account. Consistent with Hypothesis 3, the influence of *managerial capabilities* on the relationship between *relative institutional maturity* and *export performance* varies depending on the exporter’s level of *export intensity*.



**Figure 2 and 3. Interaction between relative institutional maturity and managerial capabilities at low / high export intensity**

Source: own work.

Finally, the explanatory power of the models increases from Model 1 ( $R^2 = 0.064$ ) to the full interaction model ( $R^2 = 0.125$ ), suggesting that accounting for the interaction between *relative institutional maturity*, *managerial capabilities*, and *export intensity* helps explain additional variation in *export performance*.

### 4. Discussion of results

Much of the extant research on foreign market choice has examined the selection of individual countries or the outcomes of specific foreign operations, while paying less attention to the broader pattern of markets served by exporters as a whole (Freeman & Styles, 2014; Freeman et al., 2012). By focusing on the relative institutional maturity of export markets, our study suggests that export performance depends not only on whether a firm en-

ters one particular market, but also on how its broader foreign market presence is distributed across institutionally more or less developed countries. In this sense, we extend research on international market selection by showing that systematic export market choice patterns, rather than isolated market entries alone, can have important performance implications for exporters from post-transition economies.

Secondly, we contribute to the institutional perspective in international business by emphasising the relative and directional nature of foreign market maturity. Prior work has often concentrated either on the absolute institutional quality of a host country or on the absolute magnitude of institutional distance between countries (van Hoorn & Maseland, 2016; Zaheer et al., 2012). Our findings support the argument that these approaches miss an important distinction, namely, whether exporters are primarily exposed to markets that are institutionally more or less mature than their home environment. This distinction matters because these settings represent different strategic scenarios (Hernández & Nieto, 2015; Konara & Shirodkar, 2018; Trąpczyński & Banalieva, 2016). For firms from post-transition economies, institutionally less mature markets may allow them to leverage routines developed under comparable conditions, whereas institutionally more mature markets may impose stronger demands related to compliance, quality, coordination, and legitimacy, particularly for exporters with limited managerial resources and international experience (Cuervo-Cazurra & Genc, 2008; Trąpczyński & Banalieva, 2016). Our study therefore advances prior research by showing that exporters' foreign market positions should be understood not only in terms of distance or quality in the abstract, but also in terms of the predominance of upward versus downward institutional exposure.

Thirdly, our empirical contribution lies in showing that the performance consequences of export market choices are contingent rather than uniform. The absence of a significant main effect of relative institutional maturity, and likewise of a stand-alone two-way moderating effect of managerial capabilities, suggests that exporters do not face a simple universal penalty from serving relatively more mature markets. Instead, the key insight of our findings is that the performance implications of export market choices depend jointly on managerial capabilities and export intensity. In particular, managerial capabilities appear particularly important for exporters with lower foreign-market exposure, for whom moving toward more stable but more demanding markets creates a challenge that cannot be managed through accumulated international involvement alone. This is consistent with the argument that post-transition economy firms often begin foreign expansion with constrained organisational and managerial capabilities and therefore require stronger internal support to cope with the formalisation and legitimacy demands of advanced markets (Svetličič & Jaklič, 2003; Trąpczyński, 2018). In that sense, our results refine the capability perspective by showing that managerial capabilities do

not generate a general performance premium in more mature foreign markets, but rather serve as a buffering mechanism for relatively novice exporters facing institutionally more demanding environments.

In line with H3, the effect of managerial capabilities becomes less pronounced as export intensity rises. This suggests that the buffering role of managerial capabilities becomes less pronounced as export intensity rises. At higher levels of export exposure, firms can arguably rely on experience accumulated through being present in other mature markets, which may partly compensate for limited managerial capabilities. This interpretation resonates with prior work indicating that organisational experience can mitigate the challenges of institutionally mature markets when firms are more strongly exposed to advanced markets (Trąpczyński & Banalieva, 2016). At high export intensity, coordination complexity can weaken the performance contribution of firms' advantages when managing dispersed operations becomes too demanding (Matysiak & Bausch, 2012). Accordingly, the value of managerial capabilities appears to depend on the exporter's stage of international exposure and on whether those capabilities are used to cope with foreign-market demands or to escalate the firm's commitment to institutionally demanding markets.

## Conclusions

Our quantitative evidence challenges the assumption that entering more institutionally mature markets is beneficial for exporters from mid-range economies, demonstrating that this linkage is contingent on both exporter capabilities and export intensity. Thus, for firms with limited capabilities, it may be more prudent to focus on equally or similarly developed markets, in line with prior research on firms from developing countries. By doing so, we shed some new light on this "glamour" vs. "reality" discrepancy. In fact, whilst reputation reasons might prompt novice exporters from post-transition countries to strive for legitimacy by moving into more advanced economies, subsequent development of export performance is a different matter. Our results suggest that some exporters targeting mature economies as a core tenet of their export strategy might actually experience performance declines due to their limited ability to navigate such environments.

Thus, we caution export executives that prioritising institutionally advanced economies carries ambiguous consequences. On the one hand, it can certainly lead to a substantial upgrade of capabilities and motivate exporters to improve their products in order to satisfy demanding customers. On the other, such upgrading may come at the expense of short-run performance.

Our research has obvious shortcomings, which indicate areas for further inquiry. Firstly, consistent with much prior survey-based research on exporting, our quantitative relies on cross-sectional data to reconstruct the export presence of post-transition firms. As a result, we were unable to conduct longitudinal analyses to identify strategic changes of post-transition economy exporters over time. As additional data become accessible, future studies could evaluate the generalisability of our findings across longer time periods.

Secondly, further studies should use broader samples of exporting firms, both in terms of the number of firms and years of observations. Due to the high cost of administering the survey in mid-range economies, data collection was limited to only 500 exporters in a single year. It is possible that the lack of significance of some variables is due to the fact that their effects occur over longer time horizons than could be captured with our data. Accordingly, caution should be exercised when interpreting our findings beyond the current sample. As we merely analysed the three-year performance of exporters, it could be interesting for future research to extend this perspective by analysing broader performance repercussions of export portfolio choices by post-transition country firms.

Thirdly, in line with prior survey research on firm internationalisation, our data stem from one country. As Poland is a post-transition economy still transitioning towards a fully advanced market, it provides a relevant context for testing the predictions of our theory about relative institutional maturity. We encourage future research to expand and test our model on a larger country sample. It would also be valuable to analyse whether our results hold true for the export market choices of advanced country firms.

Fourthly, our measure of relative institutional maturity encompasses diverse aspects of institutional environments, including those related to monetary or fiscal policy. While our intention was to capture the broad nature of differences which exporters experience in foreign markets at various stages of development, future studies should concentrate on more specific institutional dimensions and their implications for export performance.

## Appendix

**Table A1. Variable definitions and measurement**

Variable	Definition	Measurement / Scale	Source
<i>Export performance</i>	Managers' evaluation of the firm's overall export performance relative to expectations during the period 2017–2019	Seven-point Likert scale (1 = definitely below expectations; 7 = significantly above expectations). The assessment reflects a broad set of performance dimensions, including sales volume, profitability, ROI in foreign markets, growth of foreign market share, marketing effectiveness, distribution effectiveness, financial liquidity, firm image among clients, and overall satisfaction with export outcomes	Brouthers et al. (1999, 2000, 2008)
<i>Relative institutional maturity</i>	Relative institutional development of export markets compared to the home country (Poland)	Directional institutional distance between Poland and each export market calculated using the Kogut & Singh (1988) index based on the Heritage Index of Economic Freedom. Positive values indicate more developed export markets relative to Poland, negative values indicate less developed markets. Index values averaged for 1995–2019	Holmes et al. (2008); Kogut & Singh (1988); Zaheer et al. (2012)
<i>Managerial capabilities</i>	Firm's managerial capabilities relative to its closest domestic competitor	Mean of six items measured on a seven-point scale (1 = much worse; 7 = much better). Items include: ability to build relationships with clients, customer database, access to distribution channels, market knowledge, motivated and qualified employees, experienced management team	Ruiz-Ortega et al. (2013)
<i>Export intensity</i>	Degree of firm internationalisation measured by export intensity	Foreign sales to total sales in 2019 (percentage)	Velez-Calle et al. (2018)
<i>Technological capabilities</i>	Firm's technological capabilities relative to its closest competitor	Mean of six items measured on a seven-point scale (1 = much worse; 7 = much better). Items include R&D investment, modern equipment, scale economies, manufacturing efficiency, patents, technological know-how	Ruiz-Ortega et al. (2013)

Variable	Definition	Measurement / Scale	Source
<i>Export planning</i>	Extent to which firms systematically plan export decisions	Mean of four items measured on a seven-point Likert scale (1 = strongly disagree; 7 = strongly agree). Items capture systematic evaluation of export alternatives, assessment of strategy options, clearly defined export goals, and systematic analysis of export environments	Souchon et al. (2016)
<i>Export centralisation</i>	Degree to which export decisions are centralised at top management level	Mean of three items measured on a seven-point Likert scale (1 = strongly disagree; 7 = strongly agree). Items assess whether export decisions require approval from top management	Adapted from export management literature
<i>Foreign market knowledge</i>	Firm's knowledge about foreign markets relative to the home market	Mean of seven items measured on a seven-point scale (1 = much more limited knowledge than in the home market; 7 = knowledge comparable to the home market). Items include knowledge of market conditions, foreign customers, competitors, products, pricing and payment methods, communication practices, and distribution systems	Adapted from export knowledge literature
<i>Product complexity</i>	Technological sophistication and adaptation requirements of the firm's products	Mean of seven items measured on a seven-point Likert scale (1 = strongly disagree; 7 = strongly agree). Items capture technological advancement, need for trained sales staff, product innovativeness, service requirements, adaptation to country conditions, special logistics requirements, and differentiation from competitors	Adapted from export marketing research
<i>Firm age</i>	Age of the firm	Number of years since founding	Sousa & Tan (2015)
<i>Firm size</i>	Firm size measured by employment	Number of employees in 2019	Hollender et al. (2017)
<i>Industry</i>	Industry technological intensity	NACE industry codes recoded into three categories: 1 = low-tech, 2 = medium-tech, 3 = high-tech (OECD classification)	OECD classification

Source: own work.

**Table A2. Reliability and factor analysis results**

Construct	Number of items	Cronbach's $\alpha$	KMO	Bartlett's test	Factors retained	Variance explained (%)	Operation-alisation
Export performance	9	0.864	0.832	$p < 0.001$	1	48.5	mean of 9 items
Managerial capabilities	6	0.902	0.790	$p < 0.001$	1	67.7	mean of 6 items
Technological capabilities	6	0.862	0.799	$p < 0.001$	1 dominant factor	63.0	mean of 6 items
Export planning	4	0.852	0.781	$p < 0.001$	1	69.4	mean of 4 items
Export centralisation	3	0.869	0.701	$p < 0.001$	1	79.4	mean of 3 items
Foreign market knowledge	7	0.932	0.859	$p < 0.001$	1	71.4	mean of 7 items
Product complexity	7	0.783	0.774	$p < 0.001$	1 dominant factor	47.4	mean of 7 items

Notes: Cronbach's alpha reports internal consistency. Exploratory factor analysis was conducted using principal axis factoring. For all constructs, items were aggregated by calculating their mean scores. For technological capabilities and product complexity, exploratory factor analysis indicated some secondary structure. However, in both cases, the items were retained as single composite indices due to acceptable reliability and conceptual coherence.

Source: own work.

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# Unlocking innovation: Governance and firm-level innovation in selected Asian countries

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## Abstract

This study examines the association between governance and firm-level innovation in Indonesia and Philippines, offering insights for escaping the Middle-Income Trap (MIT). Using the 2023 World Bank Enterprise Surveys (WBES), we estimate cross-sectional logit models with stratified analyses by sector and firm size. Our findings reveal that while burdensome tax administration and informal payments are negatively associated with innovation in Indonesia, these payments paradoxically show a positive association in the Philippines, reflecting firms' strategic adaptation to weak formal institutions. Across both countries, worker training emerges as the most consistent innovation driver, regardless

## Keywords

- innovation
- governance
- middle-income trap

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of sector or firm size. By providing the first 2023 WBES-based comparison of how formal and informal governance obstacles shape firm-level innovation in two ASEAN economies, this study identifies critical pathways for governance reform and innovation-led growth.

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## Introduction

The middle-income trap (MIT) is a crucial problem facing many developing economies (Islam et al., 2023). The World Development Report (World Bank, 2024) emphasises that achieving high-income status necessitates a strategic recalibration around investment, infusion, and innovation (the 3i). To emulate successful development models, countries need to begin with robust investment, followed by the infusion of foreign technologies, and culminating in a balanced strategy that fosters domestic innovation. Central to this transition is the cultivation of a vibrant innovative ecosystem that can sustain long-term growth and global competitiveness.

Existing studies highlight innovation and governance as crucial factors in overcoming MIT. Paus and Robinson (2022) underscore that increased and broad-based innovation is the cornerstone for escaping MIT, in which government support plays a pivotal role. Similarly, Kharas (2013) argues that MIT is fundamentally a governance failure stemming from an inability to adopt a long-term, holistic perspective. Avoiding the trap requires sustained effort over a decade or more, encompassing transparent and accountable public institutions with a necessity to shift the “rule of man” to the “rule of law”. Doner and Schneider (2016) claim that MIT arises from institutional challenges implying that politics is more crucial than economics in explaining MIT. Additionally, Andreoni and Tregenna (2020) also argue that escaping MIT depends not only on innovation capacity but also on a governance structure that supports the implementation of industrial policies. Moreover, Bhattacharya and Rath (2020) suggest the importance of innovation activities in spurring productivity that would bolster firms’ growth.

However, the nexus between governance and innovation remains complex and contested. Specifically, the literature distinguishes between formal governance and informal governance, which can shape firm behaviour in different and sometimes opposing ways (North, 1993; Williamson, 1985). Jia et al. (2019)

highlight the impact of agency risk on innovation, differentiating between the quantity and novelty of innovation and demonstrating how conventional corporate governance tools depend on public governance. Sivak et al. (2011) provide empirical evidence that good governance, while generally beneficial, can have nuanced effects. For instance, bureaucratic barriers can discourage direct innovation, pushing firms towards technology licensing, while corruption represses R&D. Interestingly, they also note a potential negative impact of overly efficient courts on innovation and R&D, suggesting the need for a balanced approach. Furthermore, regional infrastructure, heavily influenced by government policy, also emerges as a decisive determinant of innovation outcomes.

While these studies highlight the importance of governance, much of the literature remains focused on developed economies or broad national-level indicators. Dunyo and Odei (2023), for instance, explain the specific aspects of the business environment that influence firm-level innovation. They find that policy instability, weak legal institutions, corruption, and informal competition negatively impact non-technological innovations. Conversely, formal training, foreign technology licenses, and R&D investments enhance both technological and non-technological innovations. These findings underscore the importance of targeted policy interventions to create a conducive environment for innovation. Similarly, Bobillo et al. (2018), drawing on data from advanced economies, show that corporate governance capability is a key factor in supporting a firm's innovation capacity. Moreover, they reveal that corporate governance drivers such as executive incentives and the presence of independent non-executive directors influence a firm's innovation capacity. Based on case studies from China, Brazil, and South Africa, Andreoni and Tregenna (2020) highlight how innovation policy outcomes are influenced by governance quality. Other interesting findings are from Weng et al. (2021) that find that perceived constraints from the governmental system increase firms' propensity to innovate, while the prevalence of bribery make firms more likely to be non-innovators.

Yet these findings have limited applicability in a context like Southeast Asia, where the institutional capacities, political dynamics, and development stages differ significantly. For instance, focusing on the issues of the MIT for the ASEAN-4 countries (Indonesia, Malaysia, Thailand, and the Philippines), Kumagai (2019) uses the viewpoint of the trade structure, instead of the link between governance and innovation. Importantly, these four countries are defined by the World Bank as countries that failed to overcome the MIT (Ke, 2024)

This study addresses this gap by examining the association between governance and firm-level innovation in two selected Asian countries, namely Indonesia and Philippines, which are struggling with the challenges of the MIT but are situated at different income levels. Indonesia has reached upper middle-income status, while the Philippines remains in the lower middle-income group. Both nations face structural challenges such as archipelagic geogra-

phy, large populations, political contestation, and persistent levels of poverty and inequality. According to the WIPO's Global Innovation Index, out of 139 countries, Indonesia ranks 55th with the score of 31.3 and Philippines ranks 50th with the score of 33.6 (WIPO, 2024).

This paper aims to address four research questions (RQ):

**RQ1:** Are formal governance obstacles associated with firm-level innovation?

**RQ2:** Are informal governance practices associated with firm-level innovation?

**RQ3:** Are firm-level internal capabilities associated with firm-level innovation?

**RQ4:** Do the associations between governance and firm-level innovation differ across sectors (manufacturing, retail services, other services) and firm size (small, medium, large)?

By examining the specific mechanism through which governance is associated with firm-level innovation within Indonesia and the Philippines, this paper offers a contribution to the MIT debate. Specifically, it advances a comparative ASEAN perspective, frames governance through the balance between the "rule of law" and the "rule of man", generating context-specific, policy relevant insights for fostering domestic innovation ecosystems and sustaining long-term economic growth.

This study finds that governance obstacles are negatively associated with innovation in Indonesia, while firms in the Philippines developed coping mechanisms that transform institutional inefficiencies into temporary advantages. Across both countries, worker training remains the factor most consistently associated with innovation, regardless of sector or firm size.

This paper is organised as follows: Section 1 reviews the literature on the association between governance and innovation, with particular attention to the firm level. It outlines the study's hypotheses. This is followed by a section on the data and methodology used in the paper. The next two sections present results and a discussion, and the conclusion to the study, respectively.

## **1. Literature review**

To ground the research questions theoretically, we review the literature on institutions, governance, and firm-level innovation, identifying key debates and conflicting findings that motivate our empirical approach.

### **1.1. Institutions and innovation**

The relationship between governance and firm-level innovation is primarily grounded in Institutional Theory, which states that the quality of the insti-

tutional environment shapes firms' strategic behaviour, including innovation investment decisions (North, 1993). Institutions, which are defined as the formal and informal "rules of the game in society" governing human interactions, establish the degree of certainty, intellectual property protection, and contract enforcement mechanisms that are required for innovative activity (Acemoglu & Robinson, 2012; North, 1993; Rodríguez-Pose & Di Cataldo, 2015). Because innovation is inherently high-risk, with uncertain outcomes and long payback periods, firms are more likely to innovate when the institutional environment guarantees stability and predictability.

The distinction between formal institutions and informal institutions are particularly relevant in developing-country context, where formal and informal governance may operate in opposing directions. For innovation, this duality means that formal and informal governance must be examined simultaneously to accurately reflect the institutional environment within which firms make their investment decisions.

The literature presents conflicting evidence on how formal governance shapes innovation. On one hand, a well-functioning institutional framework is critical for innovative behaviour. This encompasses political stability, legal certainty, and administrative efficiency as its defining features. Rodríguez-Pose and Di Cataldo (2015) show that governance quality is positively associated with regional innovation performance in Europe, while Andreoni and Tregenna (2020), drawing on China, Brazil, and South Africa, demonstrate that industrial policy outcomes depend heavily on the governance structure supporting their implementation. Barra and Ruggiero (2023) further show that rule of law, regulatory quality, and government effectiveness as the dimensions governance are positively associated with distinct types of innovation among Italian manufacturing firms. In a more recent study, Farooq et al. (2025) find that governance quality is positively associated with firm-level innovation across South Asian economies, reinforcing the view that strong formal institutions create a more conducive environment for innovative investment. Similarly, Xu (2024) shows that government transparency reduces information asymmetry and uncertainty, positively associated with firm innovative activity in China, while Persaud and Zare (2022) demonstrate that the significance of governance quality varies across the type of innovation and institutional context in India.

On the other hand, several studies show that formal institutions can hinder innovation. Williamson (1985) and Henisz (2000) argue that complex tax regulations, cumbersome licensing bureaucracies, and slow service systems increase transaction costs, effectively diverting financial and managerial resources away from research and development (R&D). Aghion et al. (2013) similarly find that institutional burdens reduce firms' ability to generate product and process innovation. Political instability and weak public governance can increase the risk to long-term investments. Under conditions of uncertainty,

firms tend to be risk-averse, opting for short-term liquidity over long-term innovative projects (Busse & Hefeker, 2007; Dixit & Pindyck, 1994; Odei, 2024). Corruption, as a formal governance failure, further undermines innovation by increasing the cost and unpredictability of doing business (Cheng et al., 2022; Dunyo & Odei, 2023; Sivak et al., 2011). Informal payments to public officials represent a direct manifestation of such corruption, as firms are compelled to make unofficial payments to navigate administrative or regulatory processes. Sivak et al. (2011) find that the prevalence of bribery represses R&D. Weak judicial systems similarly deter innovation by reducing contract enforcement and intellectual property protection (Rodríguez-Pose & Di Cataldo, 2015; Acemoglu & Robinson, 2012). Other findings from Weng et al. (2021) show that while prevalence of bribery to public officials makes firms more likely to be non-innovators, perceived constraints from the government system can paradoxically increase the propensity to innovate, as firms seek to differentiate and survive.

The relationship between governance and innovation is not always linear. Sivak et al. (2011) find that while governance is generally beneficial, bureaucratic barriers can push firms towards alternative innovation pathways such as technology licensing rather than internal R&D, and that overly efficient courts may even reduce innovation incentives in certain contexts, and R&D, suggesting the need for a balanced approach. While Dunyo and Odei (2023) find that policy instability and weak legal institutions negatively affect non-technological innovations, they also show that certain regulatory pressures stimulate adaptive responses. Mendoza (2023) extends this argument to the Philippines and Thailand, revealing how governance conditions and network embeddedness jointly shape firms' ability to innovate and upgrade within global value chains. These findings suggest that the impact formal governance on innovation is not unambiguous.

The dominant view of the literature on informal governance and innovation holds that informal payments and practices in the informal sector harm innovation. This occurs primarily because rent-seeking behaviour diverts financial and managerial resources away from productive investment in R&D and new product development. Dunyo and Odei (2023) confirm that informal competition negatively affects firm-level innovations in emerging economies.

A strand of the literature highlights that under condition of weak formal institutions, informal practices can serve as functional substitutes. Jia et al. (2019) show that governance mechanisms shape not only the quality but also the pathways of innovation, with firms adapting their strategies depending on the public governance context. In environments where formal channels are inefficient, informal payments may accelerate access to permits, services, or protections that enable firms to innovate. This mechanism is documented particularly in a developing-country setting, where institutional voids are common (Andreoni & Tregenna, 2020).

## 1.2. Firm-level characteristics as drivers of innovation

A firm's innovative capability is associated not only with the institutional environment, but also with its internal characteristics. We consider several characteristics, including size, age, workforce training, foreign ownership, and international certification, as essential determinants of a company's innovative capability. Firm size is associated with innovation through two competing mechanisms. On the one hand, larger firms possess greater R&D resources and enjoy the benefits of economic of scale (Cohen & Levin, 1989; Ipinnaiye et al., 2025; Schumpeter, 1942; Shao et al., 2025); on the other, large organisational structures can also create bureaucracy that stifles creativity (Gobble, 2019). Thus, the balance between efficiency of scale and organisational survival is key for innovation in companies. Over time firms accumulate experience and establish R&D routines (Huerger & Jaumandreu, 2004), though older firms may also become path-dependent and resistant to change (Coad et al., 2016).

The quality of human resources, developed through training, is among the most consistently documented associates of innovation in the empirical literature. Training is positively correlated with absorptive capacity leading to the ability to recognise and integrate external knowledge into innovation (Cohen & Levinthal, 1990; Cozzarin & Percival, 2023; Laursen & Foss, 2003; Zahra & George, 2002). Foreign ownership can further enhance innovation through technology transfer and cross-border knowledge dissemination (Girma et al., 2009; Javorcik, 2004; Keller, 2010). Similarly, international certification encourages continuous learning, operational efficiency, and global market legitimacy (Amundsen & Osmundsen, 2020; Corbett et al., 2005; Du et al., 2023).

## 1.3. Research gaps

Two important research gaps remain. Firstly, most evidence on governance and innovation originates from developed economies or broad national-level indicators. This limits applicability to a developing-country context, where institutional capacity, political dynamics, and development stages differ substantially (Barra & Ruggiero, 2023; Bobillo et al., 2018 ). Furthermore, while recent studies have begun to address this gap (Akpan et al., 2022; Farooq et al., 2025; Odei, 2024; Persaud & Zare, 2022), firm level evidence from Southeast Asian remains scarce.

Secondly, the governance and innovation link in Southeast Asia remains largely unexplored at the firm level, particularly in countries confronting MIT. Kumagai (2019), for instance, examines MIT among ASEAN-4 countries through the lens of trade structure rather than governance and innovation,

while Mendoza (2023) address governance and upgrading in the Philippines and Thailand but focuses on global value chain rather than firm-level innovation determinants using representative survey data. Phan (2024) uses the same WBES database to examine governance quality and firm investment but does not specifically address innovation outcomes nor the formal-informal governance distinction central to the current study. No existing study comparatively examines how formal and informal governance obstacles shape firm-level innovation in Indonesia and the Philippines using comparable, nationally representative survey data.

This study address both gaps. By using the 2023 World Bank Enterprise Surveys (WBES) and applying cross-sectional logit model, we examine how formal governance obstacles (tax rate, tax administration, business licensing, political instability, corruption, courts, and crime) and informal governance (informal payment and informal sector competition) are associated with the probability of firm-level innovation in Indonesia and the Philippines. We further test whether these associations differ across sectors and firm sizes. Building on the theoretical and empirical discussion above, this study establishes four hypotheses:

- H1:** Higher levels of formal governance obstacles are negatively associated with the probability of firm-level innovation.
- H2:** Informal governance practices which include informal payments and informal sector competition are negatively associated with firm-level innovation.
- H3:** Internal firm capabilities are positively associated with the probability of firm-level innovation.
- H4:** The association between governance and firm-level innovation differs across sectors and firm sizes.

## 2. Data and methodology

This study uses the WB Enterprise Surveys (WBES) database, nationally representative firm-level surveys with top managers and owners of businesses in over 150 economies providing insights into business environment. For Indonesia and the Philippines, the latest data is for 2023 and covers nearly 3000 and 1000 enterprises, respectively.

Table 1 provides a description of variables. The focus is placed on innovation, covering product and process innovations. It is based on the question: "During the last three years, has this establishment introduced new or improved products or services?" This is our dependent dummy variable.

**Table 1. Variable description**

Variable	Question	Note
Innovation	H.1. During the last three years, has this establishment introduced new or improved products or services?	Dummy (1 = yes, 0 = no)
<b>Governance</b>		
Formal	J.30. Using the response options on the card; To what degree are each of the following an obstacle to the current operations of this establishment?	0 (no obstacle) 1 (minor obstacle) 2 (moderate obstacle) 3 (major obstacle) 4 (very severe obstacle)
	Tax rate	
	Tax administration	
	Business and licensing permits	
	Political instability	
	Corruption	
	Courts	
Crime		
Informal	J.7.a. Informal payments or gifts (as a percentage of sales)	Dummy (1 = yes, 0 = no) [Yes, if the percentage of informal payments or gifts is not zero]
	E.0. Using the response options on the card; To what degree are practices of competitors in the informal sector an obstacle to the current operations of this establishment?	0 (no obstacle) 1 (minor obstacle) 2 (moderate obstacle) 3 (major obstacle) 4 (very severe obstacle)
<b>Firm characteristics</b>		
Age of firm	B.5. In what year did this establishment begin operations?	Years (in log form)
Workers	L.1. At the end of fiscal year [Insert last complete fiscal year], how many permanent, full-time individuals worked in this establishment? Please include all workers and managers	Number of workers (in log form)
Training for workers	L.11. Over fiscal year [Insert last complete fiscal year], did this establishment have formal training programmes for its permanent, full-time workers?	Dummy (1 = yes, 0 = no)
Share of foreign	B.2. What percentage of this firm is owned by each of the following? Share of private foreign individuals, companies or organisations	%
International certification	B.8. Does this establishment have an internationally recognised quality certification?	Dummy (1 = yes, 0 = no)

Source: on the basis of WBES questionnaire.

Our variables of interest are those capturing governance. They include two groups representing formal governance and informal governance. For formal governance, there are seven indicators, indicating obstacles faced by firms (tax rate, tax administration, business licensing, political instability, corruption, courts, and crime). These formal governance variables have five levels, from no obstacle (0) to a very severe obstacle (4). Meanwhile, for informal governance, we use a question on informal payments or gifts (as a percentage of sales), which we transform into a dummy variable, and the degree of practices of competitors in the informal sector an obstacle to the current operations of the establishment (from no obstacle = 0, to very severe obstacle = 4). Additionally, for control variables, we include five variables representing firm's characteristics.

To investigate association between governance and firm-level innovation, we estimate cross-sectional logit regression separately for each country. We also conduct additional estimations based on sector and size of firms to evaluate whether the associations between governance and firm-level innovation differ across sectors and firm size. The manufacturing, retail services, and other all services sectors with small, medium and large groups become the objects this study. The model aims to estimate the probability that a firm engages in innovative activity, specifically, the introduction of new products or services, given governance dimensions and firm's internal characteristics.

Because innovation outcomes are dichotomous (success or failure), a logit regression model is appropriate, as these models allow for non-linear estimation of probabilities within the range of 0 to 1 (Greene, 2012; Wooldridge, 2019). The dependent variable  $Innovation_i$  takes the value of 1 if the firm successfully introduces an innovation, and 0 otherwise. This approach follows prior empirical studies in innovation economics, which emphasise the complementary role of governance structures and firm-specific factors in shaping innovation outcomes (Hall & Lerner, 2010; Roper & Love, 2002).

We model firm innovation as a binary outcome driven by an unobserved latent variable  $Innovation_i^*$ , representing the firm  $i$ 's propensity to innovate. The observed binary outcome  $Innovation_i$  is related to the latent variable through the following threshold-crossing rule:

$$Innovation_i = \begin{cases} 1 & \text{if } Innovation_i^* > 0 \\ 0 & \text{otherwise} \end{cases}$$

Let  $G_i = (G_{i_1}, G_{i_2}, \dots, G_{i_7})$  denote the vector of formal governance obstacle indicators for firm  $i$ , comprising tax rate, tax administration, business licensing, political instability, corruption, courts, and crime. Let  $I_i = (I_{i_1}, I_{i_2})$  denote the vector of informal governance indicator for firm  $i$ , comprising informal payments and informal sector competition, while  $X_i = (X_{i_1}, X_{i_2}, \dots, X_{i_5})$  denotes the vector of firm-level characteristics, comprising firm age, firm size, work-

er training, foreign ownership, and international certification, as described in Table 1. The parameter vectors  $\beta_1$ ,  $\beta_2$  and  $\beta_3$  are coefficient vectors to be estimated.

The latent variable is a linear function of governance conditions and firm characteristics, with an additive error term assumed to follow a standard logistic distribution:

$$Innovation_i^* = \beta_0 + \beta_1 G_i + \beta_2 I_i + \beta_3 X_i + \varepsilon_i$$

where  $\varepsilon_i \sim \text{Logistic}(0,1)$ . The assumption of a logistic error distribution gives rise to the logit model and implies that the probability that firm  $i$  introduces an innovation is:

$$P(Innovation_i = 1) = l(\beta_1 G_i + \beta_2 I_i + \beta_3 X_i)$$

where  $l(\cdot)$  is the logistic cumulative distribution function (CDF).

To facilitate interpretation and cross-country comparability, we report Average Marginal Effects (AMEs), computed as the sample average of the individual marginal effects, which are directly interpretable as changes in predicted probability (Greene, 2012).

The empirical strategy is subject to several measurement and design considerations that are addressed as follows. Firstly, the governance indicators are drawn from the WBES standardised questionnaire, in which managers or respondents rate the extent to which specific institutional factors constrain their operations. While this ensures cross-country comparability and has been widely adopted in firm-level innovation research (Dunyo & Odei, 2023; Weng et al., 2021), it captures perceived rather than objective governance quality and is thus subject to self-report bias. Managers may underreport sensitive practices such as informal payments or overstate obstacles. The WBES sampling methodology and anonymous reporting protocols are designed to minimise these concerns.

Secondly, governance indicators are analysed separately rather than aggregated into composite indices, as aggregation would suppress the distinct mechanisms through which individual formal and informal governance dimensions relate to innovation. Thirdly, given the cross-sectional nature of the WBES data, all estimated coefficients reflect conditional associations between governance obstacles and innovation rather than causal effects. These findings are discussed accordingly throughout the paper.

### 3. Results and discussion

#### 3.1. Main results of the governance-innovation link

Table 2 reports the AMEs from the logit model for Indonesia and the Philippines. The AMEs represent the change in the probability of innovation associated with a one-unit increase in each explanatory variable, evaluated at the sample means. We discuss these results in relation to H1, H2, and H3.

The results provide partial support for H1, which predicts that higher levels of formal governance obstacles are negatively associated with the probability of firm-level innovation. In Indonesia, tax administration is the only formal governance obstacle that is statistically significant and negative. A one-unit increase in the tax administration obstacle is associated with a 3.1 percentage point reduction in the probability of innovation. This finding is consistent with H1 and confirms that inefficient administrative processes erode firms' resources and discourage innovative investment (Aghion et al., 2013; Williamson, 1985). In the Philippines, no formal governance obstacle is negative and significant. This is inconsistent with H1 and suggests that formal institutional barriers operate differently across the two countries.

Two findings show opposite direction to that predicted by H1. Firstly, business licensing is positively and significantly associated with innovation in both Indonesia and the Philippines. These indicate that rather than suppressing innovation, licensing barriers appear to stimulate adaptive strategies. Firms confronting regulatory hurdles may develop informal mechanisms, streamline internal processes, or leverage networks, to overcome them. A selection effect is also plausible, indicating that surviving firms in heavily regulated markets may already be more capable innovators, independently of any adaptive response to licensing barriers. In other words, firms effectively converted obstacles into innovation triggers. This is consistent with Sivak et al. (2011), who find that bureaucratic barriers can push firms toward alternative innovation pathways. Secondly, political instability is positively and significantly associated with innovation in Indonesia, though insignificant in the Philippines. This counterintuitive finding may reflect a resilience effect. It indicates that under condition of political uncertainty, firms may innovate as a survival strategy to diversify revenue, reduce dependence on stable regulatory conditions, or differentiate from competitors (Dixit & Pindyck, 1994; Timbate et al., 2024). However, this interpretation should be treated with caution, given the cross-sectional design and the perception-based nature of the variable.

For the informal governance, the results show a sharp divergence between the two countries. In Indonesia, informal payments are negatively associated with innovation, consistent with H2. A one-unit increase in informal payment prevalence is associated with a 3.9 percentage point reduction in the proba-

**Table 2. Main regression results on innovation: Average Marginal Effects (AMEs)**

Variable	Indonesia	Philippines
<b>Formal governance</b>		
obstacle:_tax rate	-0.003 (-0.31)	0.034 (1.86)
obstacle:_tax administration	-0.031** (-2.59)	-0.035 (-1.58)
obstacle:_business licensing and permits	0.028** (2.76)	0.041** (2.74)
obstacle:_political instability	0.016* (2.05)	0.022 (1.15)
obstacle:_corruption	-0.002 (-0.28)	0.005 (0.29)
obstacle:_courts	-0.021 (-1.70)	0.009 (0.41)
obstacle:_crime	-0.007 (-0.81)	-0.004 (-0.27)
<b>Informal governance</b>		
obstacle:_informal payment	-0.039* (-2.34)	0.166*** (3.77)
obstacle:_informal sector	0.012 (1.65)	0.022 (1.91)
<b>Firm characteristics</b>		
log(age of firm)	0.001 (0.08)	0.006 (0.38)
log(workers)	0.017** (2.78)	-0.008 (-0.75)
training for workers	0.055** (3.15)	0.093** (3.26)
share of foreign	-0.000 (-0.26)	0.001 (0.95)
international certification	-0.007 (-0.37)	0.012 (0.31)
_cons	-3.237*** (-7.09)	-2.629*** (-6.42)
<i>N</i>	1568	815
chi <sup>2</sup>	57.192	62.802
<i>p</i>	0.000	0.000
r <sup>2</sup> _p	0.076	0.088
Correctly classified (%)	92.09	81.60

Notes: *z* statistics in parentheses; \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

Source: own work.

bility of innovation, suggesting that rent-seeking behaviour diverts resources from productive investment (Dunyo & Odei, 2023; Weng et al., 2021).

In sharp contrast, informal payments in the Philippines are positively and strongly associated with innovation, exhibiting the largest marginal effect in the entire model. This finding directly contradicts H2 and suggests that under the conditions of weak formal institutions, informal payments may function to accelerate access to permits, services, or offer protection that enable firms to innovate. This serves as a functional substitute for formal governance efficiency (Andreoni & Tregenna, 2020; Jia et al., 2019). This interpretation is consistent with the literature, according to which firms in developing economies often develop informal coping strategies when formal channels are unreliable or inaccessible. While this relationship may reflect short-term adaptive behaviour, it raises concerns about long-term institutional sustainability. Reliance on informal payments as a coping mechanism risk entrenching weak governance rather than creating pressure for institutional reform (Kharas, 2013). However, reverse causality cannot be ruled out, as more innovative firms may be larger and more visible, leaving them more exposed to demands for informal payments.

The results also strongly support H3, which predicts that firms with stronger internal capabilities are more likely to innovate. Worker training is robust and consistent determinant of innovation in Indonesia and the Philippines. This confirms that human capital development strengthens absorptive capacity and directly enhances firms' innovative capability, regardless of the governance environment. This finding is consistent with (Cohen & Levinthal, 1990; Kim et al., 2025; Laursen & Foss, 2003; Rakthin et al., 2024; Xiong et al., 2025).

In Indonesia, firm size also matters, which is consistent with the Schumpeterian view that larger firms possess greater R&D resources (Cohen & Levin, 1989; Ipinaiye et al., 2025; Schumpeter, 1942; Shao et al., 2025). In the Philippines, however, firm size is not significantly linked to innovation, suggesting that scale effect is less relevant in this institutional context. Notably, firm age, foreign ownership, and international certification are statistically insignificant in both countries, indicating that these characteristics do not independently predict innovation once governance and training are accounted for. This offers partial support for H3 and highlights the centrality of worker training as a firm-level characteristic associated consistently with innovation across both countries.

### **3.2. Sectoral patterns in the governance-innovation association**

Table 3 reports the AMEs from sector-stratified logit models for manufacturing, retail services, and other services in Indonesia and the Philippines.

**Table 3. Regression results on innovation by sector: Average Marginal Effects (AMEs)**

Variable	Indonesia			Philippines		
	manu- facture	retail services	other services	manu- facture	retail services	other services
<b>Formal governance</b>						
obstacle:_ tax rate	-0.004 (-0.26)	-0.022 (-1.64)	0.004 (0.30)	0.037 (1.37)	-0.006 (-0.09)	0.043 (1.38)
obstacle:_ tax adminis- tration	-0.020 (-1.05)	-0.012 (-0.79)	-0.037* (-2.21)	-0.055 (-1.60)	0.013 (0.18)	-0.020 (-0.57)
obstacle:_ business licensing and permits	0.025 (1.60)	-0.012 (-0.68)	0.038** (2.78)	0.057* (2.19)	0.072** (2.66)	0.004 (0.20)
obsta- cle:_political instability	0.032** (2.79)	0.004 (0.32)	0.001 (0.12)	0.028 (0.86)	-0.003 (-0.05)	0.009 (0.34)
obstacle:_ corruption	-0.015 (-1.16)	0.001 (0.04)	0.005 (0.39)	0.002 (0.08)	0.044 (0.96)	-0.014 (-0.57)
obstacle:_ courts	-0.043* (-2.10)	0.003 (0.25)	-0.017 (-1.00)	-0.036 (-1.14)	0.055 (1.13)	0.050 (1.40)
obstacle:_ crime	-0.011 (-0.82)	-0.009 (-0.53)	0.004 (0.32)	0.011 (0.38)	0.002 (0.04)	-0.014 (-0.59)
<b>Informal governance</b>						
obstacle:_in- formal pay- ment	-0.078* (-2.52)	-0.015 (-0.43)	-0.004 (-0.17)	0.146* (2.43)	0.142 (0.93)	0.188* (2.42)
obstacle:_in- formal sec- tor	0.006 (0.52)	0.025* (2.08)	0.019 (1.62)	0.026 (1.54)	0.011 (0.38)	0.023 (1.11)
<b>Firm characteristics</b>						
log(age of firm)	0.005 (0.28)	-0.032 (-1.15)	-0.006 (-0.40)	0.039 (1.24)	0.036 (1.14)	-0.036 (-1.35)
log(workers)	0.016 (1.84)	0.019 (1.42)	0.019 (1.79)	-0.006 (-0.38)	-0.022 (-0.57)	0.004 (0.21)
training for workers	0.072* (2.48)	0.020 (0.48)	0.044 (1.78)	0.109* (2.28)	0.049 (0.67)	0.092* (1.99)
share of foreign	-0.000 (-0.39)	0.000 (.)	0.000 (0.81)	0.001 (1.03)	0.002 (1.04)	0.000 (0.22)

Table 3 continued

Variable	Indonesia			Philippines		
	manu- facture	retail services	other services	manu- facture	retail services	other services
international certification	-0.012 (-0.38)	0.029 (0.83)	-0.016 (-0.55)	-0.006 (-0.12)	-0.082 (-0.87)	0.053 (0.83)
_cons	-2.775*** (-4.27)	-1.940 (-1.16)	-3.948*** (-5.26)	-3.420*** (-4.41)	-3.675** (-2.96)	-1.975** (-3.25)
<i>N</i>	735	245	579	363	118	334
chi <sup>2</sup>	44.725	28.852	36.461	29.153	28.187	24.762
<i>p</i>	0.000	0.007	0.001	0.010	0.013	0.037
r <sup>2</sup> _p	0.108	0.132	0.104	0.095	0.299	0.081
Correctly classified (%)	90.34	95.51	93.26	80.44	88.98	81.14

Notes: *z* statistics in parentheses; \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

Source: own work.

These results are discussed in relation to H4, which predicts that the relationship between governance obstacles and firm-level innovation differs across sectors.

In Indonesia the governance-innovation association appeared primarily in the manufacturing and other services sectors, while retail services show a limited significant association. In manufacturing, political instability is positively linked to innovation, while courts obstacles and informal payments are negatively associated. The negative relationship with court obstacles suggests that weak reinforcement and intellectual property protection deter firms from committing resources to innovative projects (Rodríguez-Pose & Di Cataldo, 2015), while the positive link with political instability indicates the resilience effect discussed in Section 3.1. For other services, tax administration obstacles are negatively and significantly associated with innovation, while the relationship with business licensing is positive and significant. This suggests administrative burdens suppress innovation while licensing hurdles stimulate adaptive responses (Sivak et al., 2011). In retail services, only informal sector competition is significant, suggesting that retail firms innovate primarily in response to competitive pressure from informal competitors. Worker training is significant only in manufacturing, a point consistent with H3, which corresponds with the greater role of absorptive capacity in production-oriented firms (Cohen & Levinthal, 1990; Kim et al., 2025; Rakthin et al., 2024; Xiong et al., 2025).

In the Philippines, sector-specific patterns are less uniform than in Indonesia, though the results still broadly support H4. Informal payments are positively

and significantly associated with innovation for both manufacturing and other services, while are found to be insignificant for retail services. The consistency of this finding across two sectors strengthens the interpretation from Section 3.1 that informal payments serve as a functional substitute for weak formal governance rather than reflecting sector-specific dynamics (Jia et al., 2019). Business licensing is positively related to innovation in manufacturing and retail services, suggesting that licensing obstacles stimulate adaptive innovation primarily in sectors with higher regulatory exposure. Worker training remains significant in manufacturing and other services, offering further support for H3.

Taken together, these sectoral results provide some evidence in support of H4, namely that the link between governance and innovation differs across sectors in both countries. It should be noted that these comparisons are based on sector-stratified AME estimates from separate subgroup models and do not constitute a formal statistical test of coefficient equality across sectors. Within this limitation, the patterns observed are informative. In Indonesia, innovation in manufacturing is most sensitive to formal governance, particularly judicial quality and political instability, while innovation in retail services responds primarily to informal sector competition. In the Philippines, informal payments emerge as a consistent positive associate of innovation in manufacturing and other services sectors, while formal governance obstacles play a more selective role. These cross-sector differences suggest that governance reform strategies should be tailored to the specific institutional vulnerabilities of each sector.

### **3.3. Firm-size patterns in the governance-innovation link**

Table 4 reports AMEs from firm-size stratified logit models for small, medium, and large firms in Indonesia and the Philippines. In Indonesia, the relationships differ across firm sizes, broadly supporting H4. Large firms show the strongest formal governance association, as business licensing is positively and significantly associated with innovation. This suggests that large firms are most capable of converting regulatory hurdles into adaptive innovation opportunities, consistent with the Schumpeterian argument that larger firms possess greater resources to absorb institutional constraints (Schumpeter, 1942). Medium-sized enterprises show a positive relationship between political instability and innovation, supporting the resilience effect identified in Sections 3.1 and 3.2. For small firms, workforce size is the only significant associate of innovation, indicating that scale rather than governance conditions drive innovative activity among small firms. Worker training is positively associated with innovation among medium- and large size Indonesian firms.

**Table 4. Regression results on innovation by firm size: Average Marginal Effects (AMEs)**

Variable	Indonesia			Philippines		
	small	medium	large	small	medium	large
<b>Formal governance</b>						
obstacle:_tax rate	0.009 (0.67)	-0.011 (-0.56)	-0.020 (-1.17)	0.020 (0.80)	-0.003 (-0.07)	0.111** (2.62)
obstacle:_tax administration	-0.026 (-1.75)	-0.035 (-1.45)	-0.044 (-1.71)	-0.014 (-0.46)	-0.038 (-0.86)	-0.061 (-1.33)
obstacle:_business licensing and permits	0.010 (0.70)	0.028 (1.56)	0.104*** (4.95)	0.069*** (3.72)	0.030 (1.05)	-0.032 (-0.78)
obstacle:_political instability	0.006 (0.56)	0.039* (2.53)	-0.008 (-0.60)	0.023 (0.99)	0.034 (1.02)	0.008 (0.20)
obstacle:_corruption	-0.002 (-0.14)	-0.001 (-0.06)	-0.041 (-1.71)	-0.028 (-1.27)	0.016 (0.71)	0.078* (1.97)
obstacle:_courts	-0.001 (-0.07)	-0.041 (-1.83)	-0.034 (-1.72)	0.010 (0.38)	0.009 (0.26)	-0.058 (-1.25)
obstacle:_crime	-0.016 (-1.25)	0.003 (0.23)	0.011 (0.61)	-0.003 (-0.14)	-0.004 (-0.17)	0.031 (0.78)
<b>Informal governance</b>						
obstacle:_informal payment	-0.046 (-1.95)	-0.057 (-1.68)	0.027 (0.72)	0.220** (2.77)	0.172* (2.39)	0.183* (2.26)
obstacle:_informal sector	0.011 (1.21)	0.009 (0.60)	0.041* (2.31)	0.035* (2.06)	0.037 (1.87)	-0.015 (-0.54)
<b>Firm characteristics</b>						
log(age of firm)	-0.001 (-0.10)	0.024 (1.02)	-0.018 (-0.84)	0.012 (0.57)	-0.019 (-0.52)	0.026 (0.78)
log(workers)	0.042*** (3.30)	0.015 (0.96)	0.051* (2.54)	0.035 (1.23)	-0.026 (-0.99)	-0.039 (-1.55)
training for workers	0.028 (1.06)	0.067* (1.96)	0.069* (2.33)	0.071 (1.83)	0.097 (1.87)	0.049 (0.64)
share of foreign	0.000 (.)	0.000 (0.55)	-0.001 (-1.42)	0.001 (1.38)	-0.001 (-0.40)	0.000 (0.44)
international certification	0.061 (1.86)	-0.037 (-0.97)	0.000 (0.01)	0.110 (1.58)	0.022 (0.28)	-0.030 (-0.53)

Table 4 continued

Variable	Indonesia			Philippines		
	small	medium	large	small	medium	large
_cons	-4.021*** (-5.13)	-3.595*** (-3.85)	-6.997*** (-3.40)	-3.943*** (-5.22)	-1.638 (-1.68)	-1.438 (-1.29)
N	812	489	257	347	255	213
chi <sup>2</sup>	32.036	28.887	38.665	42.255	22.830	27.704
p	0.002	0.011	0.000	0.000	0.063	0.016
r2_p	0.081	0.088	0.300	0.161	0.095	0.123
Correctly classified (%)	94.09	89.78	93.77	84.73	81.96	80.28

Notes: z statistics in parentheses; \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

Source: own work.

Informal payments are consistently negative for small and medium-sized firms, though not statistically significant, while informal competition is significantly linked with innovation only among large firms.

In the Philippines, informal payments are positively and significantly associated with innovation across all firm sizes, namely small, medium, and large. The consistency of this finding across all size categories reinforces the interpretation from Sections 3.1 and 3.2 those informal payments function as a broad institutional coping mechanism rather than a size-specific strategy (Jia et al., 2019) and as such directly contradicting H2. An alternative interpretation is that larger, more profitable firms are simultaneously more innovative and more exposed to rent-extraction. However, the cross-sectional design cannot disentangle whether informal payments enable innovation as a coping mechanism, or whether innovative firms are simply more likely to be targeted for rent-extraction.

Among formal governance variables, business licensing is positively linked with innovation only for small firms, while tax rate and corruption are positively associated with innovation for large firms. This counterintuitive finding likely reflects a selection effect where more profitable large firms face higher tax burdens and are simultaneously more innovative.

The firm-size results offer empirical support for H2. As with the sector-level analysis, these comparisons are taken as descriptive evidence. The patterns suggest that governance reform efforts should be differentiated by firm-size. Large and medium-sized Indonesian firms benefit most from reducing licensing and administrative burdens, while firms across all size in the Philippines face structural exposure to informal payment dynamics. These size-differentiated patterns, alongside findings in Section 3.2, provide cumulative support for H4.

### 3.4. Discussion

This study provides new insights into the relationship between governance and firm-level innovation in Indonesia and the Philippines, two Southeast Asian countries facing the challenges of the MIT. The findings broadly align with, though do not fully confirm, prior evidence on governance and firm-level innovation, with several results departing from theoretical predictions therefore warrant cautious interpretation.

The results for Indonesia broadly support H1. Specifically, tax administration obstacles (most notably in other services) and court obstacles (most notably in manufacturing) are negatively associated with innovation, consistent with the institutional barriers literature (Aghion et al., 2013; Cheng et al., 2022; Farooq et al., 2025; Paus & Robinson, 2022; Williamson, 1985). However, larger firms appear to convert licensing challenges into opportunities for adaptive innovation, consistent with paradoxical governance effects documented by Sivak et al. (2011). This finding also aligns with Mendoza (2023), who documents how governance conditions and network embeddedness are jointly associated with firms' innovative capacity in the Philippines and Thailand, suggesting that formal governance association with innovation are highly context-dependent. The sector- and size-specific patterns observed in Indonesia are also consistent with Barra and Ruggiero (2023).

The Philippines results complicate the interpretation further. Contrary to H2, informal payments are positively and strongly associated with innovation across firms and sectors, suggesting that firms use these payments strategically to navigate bureaucratic inefficiencies (Jia et al., 2019; Phan, 2024). While this reflects short-term adaptive behaviour, reliance on informal payments risks sustaining weak governance and undermining the shift toward "rule of law" that Kharas (2013) identified as key for escaping the MIT. This highlights a critical divergence between the two analysed countries. Governance failures in Indonesia largely suppress innovation, while in the Philippines they may paradoxically sustain it, though in ways that may raise concerns about long-term institutional sustainability.

Despite these differences, worker training consistently emerges as the positive associate of innovation across both countries, sectors, and firm sizes, strongly supporting H3 and confirming the centrality of human capital in strengthening absorptive capacity (Cohen & Levinthal, 1990; Dunyo & Odei, 2023; Farooq et al., 2025). By contrast, foreign ownership and international certifications are statistically insignificant across most specifications, departing from Persaud and Zare (2022) and Odei (2024), who find that ownership type moderates the governance-innovation association in India and other emerging markets. This suggests that the innovation benefits of global linkages may be more context-dependent than previously assumed. Alternatively,

the binary measures of foreign ownership share and certification status may be too crude to detect their relationships within the firm-level data.

## Conclusions

This study examines the association between governance and firm-level innovation in Indonesia and the Philippines, two ASEAN countries facing the persistent challenges of the MIT. To our knowledge, this is the first study to comparatively examine how formal and informal obstacles are associated with firm-level innovation in Indonesia and the Philippines using the 2023 WBES, providing new firm-level evidence from Southeast Asia. The findings reveal contrasting dynamics across distinct governance environments. In Indonesia, tax administration obstacles and informal payments are negatively associated with a firm's capacity to innovate. This highlights how formal and informal governance obstacles function primarily as barriers, consistent with H1 and H2. In the Philippines, informal payments are paradoxically and positively associated with innovation, mirroring firms' strategic adaptation to weak institutions. This finding contradicts H2 and raises important questions about long-term institutional sustainability. Across both countries, worker training emerges as the most consistent driver of innovation regardless of sector, or firm size, strongly supporting H3. This also reaffirms the centrality of human capital development. Governance associations differ meaningfully across sectors and firm sizes, broadly supporting H4.

Based on these findings, Indonesia should prioritise governance reforms to unlock latent innovation potential, while the Philippines should focus on formalising adaptive practices and reducing structural dependence on informal mechanisms. For both countries, investing in human capital, expanding access to global certifications, and strengthening international linkages remain crucial priorities for sustaining innovation-led growth and avoiding MIT.

This study has several limitations. The cross-sectional nature of the WBES data limits inference to conditional associations and precludes causal conclusions. The reliance on perception-based measures introduces self-report bias that cannot be fully eliminated. The country-specific focus on Indonesia and the Philippines also limits the generalisability of the findings to other ASEAN or developing-country context. Future studies could address these limitations by employing panel data, extending the comparative framework to additional ASEAN economies, and exploring causal identification strategies to strengthen the robustness of the findings.

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# Micro and small enterprise survival in contexts of poverty: Evidence from Peru

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## Abstract

This study analyses the determinants of micro and small enterprise survival in a high-poverty setting, drawing on a longitudinal cohort of 1,861 firms registered under REMYPE in Cajamarca province, Peru, where monetary poverty affects 44.5% of the population (2015–2024). Using Kaplan–Meier curves and Cox proportional hazards regression, we assess how firm size, geographic location, and economic sector shape closure risk over time. Firm size is the dominant determinant: microenterprises face a substantially higher closure risk than small enterprises, a gap that persists despite REMYPE benefits. Geographic location shows no significant effect, while the economic sector exerts a substantial influence, with essential services proving more resilient than discretionary ones. Closures cluster in the post-pandemic period rather than during the pandemic, consistent with a delayed crisis. The findings indicate that,

## Keywords

- enterprise
- economic development
- business management
- poverty
- small enterprise

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under structural poverty, standard support mechanisms are insufficient and differentiated, size- and sector-sensitive policies are required.

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## Introduction

Business survival constitutes a multidimensional phenomenon influenced by geographic location, firm size, and economic sector. These dimensions directly affect the design of public policies aimed at supporting micro and small enterprises, especially in contexts of structural vulnerability where business closure affects both the local economy and social fabric (Marshall & Schrank, 2020). In environments characterised by high informality and weak institutions, moderate risk disposition can improve strategic decision-making and organisational stability (Koch & Menkhoff, 2025).

International evidence indicates that small and medium enterprises face significant continuity challenges: in countries such as Spain, New Zealand, and Thailand, approximately half fail within four years. Financial constraints, limited innovation capacity, and deficits in internal control systems systematically appear as the main barriers to survival (Del Campo Villares et al., 2020; Duppati et al., 2021). However, these findings come primarily from urban contexts and middle-to-high income economies, leaving unexplored how poverty may modify business survival dynamics.

In Peru, national studies estimate the business failure rate at 37% in the first year (Pantaleón SantaMaría et al., 2023). However, these estimates may underrepresent the problem in high-poverty provinces. Such is the case of Cajamarca province, where monetary poverty—households whose per capita expenditure falls below the official poverty line—affects 44.5% of the population, well above the national average of 29% (IPE, 2024). In this setting, micro and small enterprises formalised under REMYPE, the national registry granting tax and labour benefits to such firms, sustain much of local economic activity yet remain especially exposed to early closure.

Previous studies have identified multiple determinants of business continuity, including firm type, size, operational strategies, owner experience, location, and economic sector (Li et al., 2023). Despite this accumulated evidence, important gaps persist. Firstly, most empirical studies use cross-sectional data, limiting the capture of temporal dynamics. Secondly, the literature has pre-

dominantly examined metropolitan areas, leaving rural and impoverished regions largely underexplored. Thirdly, survival determinants are usually analysed in isolation, without integrated models that assess their comparative weight. Fourthly, although SDG 8.3 prioritises SME strengthening (United Nations, 2020), empirical evidence from high-poverty provinces remains scarce.

The present study addresses these gaps through a longitudinal analysis of 1,861 micro and small enterprises in Cajamarca province (2015–2024). Using Kaplan–Meier curves and Cox proportional hazards regression, we examine how firm size, geographic location, and economic sector influence closure risk, and whether the effect of location varies across sectors. To account for the observed patterns, the next section develops a theoretical framework—integrating the liabilities of smallness and poorness, agglomeration theory, sectoral competitive structure, and crisis-resilience dynamics—from which four hypotheses are derived. The study is descriptive in nature; the deeper causes of firm closure lie beyond its scope and are left for future research.

The remainder of the article is organised as follows: Section 1 develops the theoretical framework; Section 2 describes the data and methods; Section 3 reports the results; Section 4 discusses the findings. Finally, the Conclusions summarise the main contributions and acknowledge limitations.

## 1. Theoretical framework

### 1.1. The liability of smallness and the amplifying role of poverty

Organisational ecology holds that survival prospects are shaped by structural conditions present at and after founding. Stinchcombe (1965) introduced the *liability of newness*, arguing that young organisations fail at higher rates because they must invent roles and routines, rely on trust among strangers, and lack stable ties to clients and suppliers. Aldrich and Auster (1986) distinguished a *liability of smallness*, showing that small firms face elevated mortality independent of age, owing to restricted access to capital, financing, and skilled labour. In contexts of structural poverty, Morris et al. (2022) extend this logic to a *liability of poorness*, whereby disadvantage and fragility compound. We argue that poverty does not merely add a further handicap but amplifies the liability of smallness through three mechanisms: demand volatility, as constrained purchasing power narrows and destabilises local markets; credit rationing, as information asymmetries disadvantaging small borrowers are magnified where collateral and financial infrastructure are scarce;

and institutional thinness, as the support services that might offset smallness are themselves underprovided. We therefore propose:

**H1:** The liability of smallness is amplified in poverty contexts, where resource constraints intensify survival disadvantages for smaller firms.

## **1.2. Agglomeration economies and threshold effects in impoverished territories**

Agglomeration theory predicts that spatial concentration confers survival advantages through shared infrastructure, deeper markets, and institutional proximity (Wei et al., 2022). Yet these benefits presuppose a minimum threshold of underlying conditions. Tello (2010) shows that peripheral, low-productivity regions become caught in development traps sustained by weak social capital, where competition relies on imitation and low prices, keeping output confined to low-value-added activities. Where such conditions prevail uniformly, the differential advantage of central locations erodes, since core and peripheral firms confront comparable constraints. Saha et al. (2023) confirm that, among rural microenterprises, location exerts only a marginal effect relative to internal capacity. We therefore expect agglomeration advantages to attenuate below a poverty threshold, as homogeneous structural limitations dissolve territorial differentials. We therefore propose:

**H2:** In contexts of homogeneous poverty, agglomeration advantages associated with urban location are attenuated by structural limitations common to all areas.

## **1.3. Sectoral structure and the elasticity of demand**

Industry structure is a primary determinant of firm performance. Porter (1985) argues that industry attractiveness, governed by the five competitive forces conditions the prices, costs, and investment that shape long-run profitability, and hence the risk environment that a firm inherits from its sector. Paéz et al. (2021) synthesise this market-based view with the resource-based view, locating competitiveness alternately in external industry structure and in valuable, rare, and inimitable internal resources. From these perspectives, sectors differ systematically in their exposure to demand shocks: essential services, facing relatively inelastic demand, should retain viability even under contracting purchasing power, whilst sectors dependent on discretionary ex-

penditure should prove more fragile. The heterogeneous sectoral effects of the COVID-19 shock on the Polish economy—a severe contraction in tourism alongside expansion in technology (Kuryłek & Shachmurove, 2025) together with a reallocation of employment that fell most sharply in sectors such as arts, entertainment, and recreation (Kwiatkowski & Szymańska, 2022)—illustrate this divergence. We treat demand elasticity as the theoretical mechanism mediating these patterns, recognising that it is inferred from observed survival rather than measured directly. We therefore propose:

**H3:** Demand elasticity mediates sectoral survival patterns, with essential services showing greater resilience than discretionary sectors.

#### **1.4. Crisis dynamics and the delayed manifestation of failure**

Organisational resilience—the capacity to absorb disruption and adapt—mediates how external shocks translate into closure (Hillmann & Guenther, 2021; Soria et al., 2021). The relationship between an economic shock and observed firm exit is not, however, contemporaneous. Government support can suppress failure during the acute phase of a crisis: Assefa (2023) finds that financial support schemes substantially reduce the probability of small-business failure. Once such support is withdrawn, firms sustained by emergency measures may succumb to accumulated financial strain, producing a lagged wave of closures (Tonetto et al., 2024). This lag is reinforced administratively, since reduced capacity for formal deregistration during a crisis defers recorded closures to subsequent years (Katare et al., 2021). We therefore expect closures to cluster after, rather than during, the pandemic. We therefore propose:

**H4:** Business closures exhibit temporal clustering, with crises producing delayed rather than immediate effects on enterprise survival.

#### **1.5. Poverty as a structural moderator**

Taken together, these mechanisms suggest that poverty operates not as an additional independent variable but as a structural moderator that reshapes the strength and direction of established survival determinants. It magnifies the liability of smallness, dissolves the differential value of location, sharpens the divergence between elastic and inelastic sectors, and conditions the temporal pathway through which crises register as failures. This integrated view frames the empirical analysis that follows.

## 2. Data and methods

### 2.1. Data

This research adopted a quantitative, non-experimental, retrospective longitudinal cohort design with an explanatory-descriptive scope. Variables were not manipulated but analysed from official administrative records (Creswell & Creswell, 2022).

The study was conducted in Cajamarca province, Peru, where monetary poverty—households whose per capita expenditure falls below the official poverty line—affects 44.5% of the population, significantly above the national average of 29% (IPE, 2024). Poverty is therefore treated as a contextual condition of the study setting, measured at the provincial level; it is not a firm- or household-level variable, which limits inferences about its effect on individual enterprises.

The data source was the administrative database of Peru's national tax authority (SUNAT), comprising 11,387 records. From this database, the study population was defined as legally constituted micro and small enterprises registered in REMYPE—the national registry granting tax and labour benefits to formalised firms—located in Cajamarca province. Sole proprietorships and natural persons, enterprises not registered in REMYPE, duplicates, and organisations outside the study window were excluded. Applying these criteria yielded a final sample of 1,861 enterprises (Table 1). Because REMYPE registration is voluntary, the sample comprises only formalised firms that sought regime benefits.

Firm size (micro vs. small) was taken from the REMYPE classification maintained by the Ministry of Production, which assigns categories on the basis of annual sales thresholds.<sup>5</sup> As sales figures were not directly accessible, this administrative classification was used; however, being updated periodically rather than continuously, it may not capture short-term changes in firm scale.

**Table 1. Sample selection: from the SUNAT database to the REMYPE study population**

Total SUNAT database	11,387
Total excluded	(9,526)
Total included	1,861

Source: based on SUNAT administrative records.

<sup>5</sup> Firm size in the REMYPE registry is defined solely by annual sales, measured in Tax Units (Unidad Impositiva Tributaria, UIT) — a reference value set annually by the Peruvian government. Microenterprises are those with annual sales of up to 150 UIT, and small enterprises those with annual sales above 150 and up to 1,700 UIT.

The dependent variable was business survival, defined as operational continuity from registration until formal deregistration or active status as of 31 December 2024, evaluated in two dimensions: duration in years and current status (active / closed). Closure was identified through administrative deregistration; a recognised limitation is that formal deregistration may lag the actual cessation of activity, particularly during periods of administrative disruption. The independent variables were: (a) firm size, coded binary (0 = micro, 1 = small); (b) geographic location, coded as capital district versus other (peripheral) districts; and (c) economic activity, classified into ten sectors following Peru's National Institute of Statistics and Informatics (INEI, 2019).

## 2.2. Methods

Enterprises were observed from their REMYPE registration—the earliest entries dating to 2015—until 31 December 2024; the first recorded closures occurred in 2016. The analysis proceeded in four phases. First, Kaplan–Meier survival curves were estimated and compared across firm size, geographic location, and economic sector using Log-Rank tests. Next, a Cox proportional hazards regression evaluated the simultaneous effect of these three variables on closure risk; with 444 events and 11 parameters (events per variable = 40.4), the sample comfortably exceeded the conventional threshold for stable estimation. Then, chi-square tests examined the temporal distribution of closures across three phases of the COVID-19 shock pre-pandemic (2016–2019), pandemic (2020–2021), and post-pandemic (2022–2024), as well as the interaction between location and sector. The three periods follow the chronology of the pandemic and its official containment in Peru rather than equal intervals. Peru declared a national state of emergency with mandatory social isolation in March 2020 (Decreto Supremo N° 044, 2020), and the national state of emergency was formally lifted only in October 2022 (Decreto Supremo N° 130, 2022). The binding lockdown and the most stringent mobility restrictions, however, were concentrated in 2020 and 2021, after which they were progressively relaxed and economic activity began to recover (Olivera, 2023); 2022 is therefore taken as the onset of the recovery phase. The outer bounds of the window are set by the data rather than by the shock: the pre-pandemic phase begins in 2016, the first year in which closures are observed in the cohort, and the post-pandemic phase ends in 2024, the close of the observation window. The resulting asymmetry in the length of these periods—four, two and three years—thus reflects the official chronology of the pandemic and its containment together with the boundaries of the data, not an analytical choice.

Finally, the proportional-hazards assumption was verified through Schoenfeld residuals (size  $p = 0.827$ ; location  $p = 0.066$ ; sector  $p = 0.155$ ; global  $p = 0.092$ ). Analyses were performed in IBM SPSS Statistics v.29 and R v.4.5.2.

### 2.3. Descriptive statistics

Of the 1,861 enterprises, 444 (23.9%) experienced closure and 1,417 (76.1%) remained active (censored). Table 2 reports the distribution by size, location, and sector.

**Table 2. Sample characteristics and distribution**

Characteristic	<i>n</i>	%	Business closures (events)	Survival rate (%)
<b>Total sample</b>	1,861	100.0	444	76.1
<b>By size:</b>				
Microenterprises	1,766	94.9	439	75.1
Small enterprises	95	5.1	5	94.7
<b>By location:</b>				
Capital district	1,691	90.9	410	75.8
Other districts <sup>1</sup>	170	9.1	34	80.0
<b>By sector:</b>				
Construction	444	23.9	167	62.4
Commerce	435	23.4	77	82.3
Real estate	347	18.6	71	79.5
Transport	190	10.2	30	84.2
Hotels & restaurants	140	7.5	37	73.6
Manufacturing	129	6.9	28	78.3
Education	60	3.2	11	81.7
Health services	44	2.4	3	93.2
Other services	37	2.0	12	67.6
Others <sup>2</sup>	35	1.9	8	77.1

Note: survival rate = percentage still operating at the end of 2024. <sup>1</sup> Peripheral districts within the study province. <sup>2</sup> Groups primary sectors and public services.

Source: own work.

The sample is dominated by microenterprises and by firms located in the capital district, while economic activity concentrates in construction, commerce, and real estate. Closures are unevenly distributed across these categories, with construction and the smallest firms showing the highest exit rates. This descriptive composition frames the survival analysis reported in the following section.

### 3. Results

The analysis included 1,861 formally constituted enterprises registered in REMYPE during the 2015–2024 period in the province of Cajamarca. Of these, 444 (23.9%) experienced closures, whilst 1,417 (76.1%) remained active (censored). The sample showed heterogeneity in organisational characteristics. Table 2 presents the sample distribution.

Kaplan–Meier Log-Rank tests revealed significant survival differences by firm size and economic sector (both  $p < 0.001$ ) but not by geographic location ( $p = 0.356$ ). The Cox proportional hazards model was statistically significant ( $\chi^2(11) = 81.512$ ,  $p < 0.001$ ) with moderate discriminatory capacity (C-index = 0.60, 95% CI: 0.57–0.63) and a pseudo- $R^2$  of 0.287. Table 3 reports the integrated results.

Firm size was the strongest determinant. Microenterprises faced a fivefold higher closure risk than small enterprises ( $HR = 5.00$ , 95% CI: 2.03–11.87,  $p < 0.001$ ), the largest effect in the model, with survival rates of 75.1% versus 94.7% (Figure 1A). This supports H1.

Location showed no significant effect ( $HR = 1.18$ , 95% CI: 0.83–1.68,  $p = 0.356$ ); capital-district firms (75.8% survival) performed similarly to peripheral ones (80.0%) (Figure 1B). No significant location–sector interaction was found ( $\chi^2 = 8.13$ ,  $p = 0.521$ ). This supports H2.

Sector was significant ( $p < 0.001$ ), with a 30.8-percentage-point gap between extremes: health services showed the highest survival (93.2%,  $HR = 0.28$ ,  $p = 0.037$ ) and construction the lowest (62.4%,  $HR = 1.72$ ,  $p = 0.008$ ) (Figure 1C). This supports H3.

Closures clustered significantly over time ( $\chi^2 = 99.77$ ,  $p < 0.001$ ): the post-pandemic period (2022–2024) concentrated 83.3% of closures, against 1.6% during the pandemic (2020–2021) and 15.1% pre-pandemic (2016–2019) (Table 4). This delayed pattern supports H4.

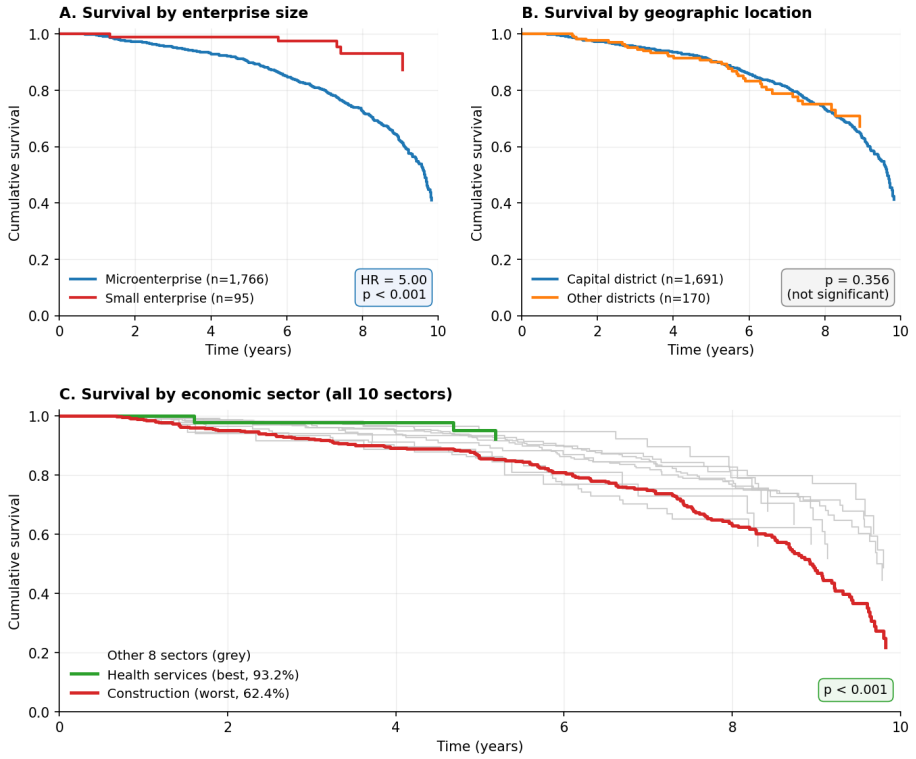
The proportional-hazards assumption held (Schoenfeld residuals: size  $p = 0.827$ ; location  $p = 0.066$ ; sector  $p = 0.155$ ; global  $p = 0.092$ ). No multicollinearity was detected (VIF 1.002–1.004). A sensitivity analysis excluding one influential observation confirmed the stability of the estimates. Table 5 summarises the diagnostics.

**Table 3. Determinants of business survival: Integrated analysis**

Univariate analysis					Multivariate Cox model		
	<i>N</i>	mean years	log-rank <i>p</i> -value	<i>HR</i> (95%CI)	<i>B</i>	<i>SE</i>	<i>P</i>
<b>Enterprise size</b>			<0.001				
Micro-enterprise	1,766	8.47		5.00 (2.03–11.87)	1.591	0.451	<.001
Small (reference)	95	9.61		1.00			
<b>Geographic location</b>			0.356				
Capital	1,691	8.52		1.18 (0.83-1.68)	0.165	0.179	0.356
Other districts (reference)	170	8.62		1.00			
<b>Economic sector</b>			<0.001				
Health	44	9.39		0.28 (0.09–0.92)	–1.270	0.677	0.037
Transport	190	8.99		0.70 (0.30–1.40)	–0.351	0.398	0.183
Commerce	435	8.82		0.89 (0.39–1.69)	–0.114	0.372	0.605
Education	60	8.73		0.77 (0.28–1.74)	–0.265	0.465	0.457
Real estate	347	8.45		0.97 (0.43–1.84)	–0.027	0.373	0.903
Manufacturing	129	8.65		0.91 (0.42–2.00)	–0.092	0.401	0.819
Hotels / restaurants	140	8.21		1.45 (0.61–2.84)	0.369	0.390	0.141
Construction	444	7.92		1.72 (1.15–2.56)	0.539	0.362	0.008
Other services	37	8.10		1.30 (0.48–2.90)	0.261	0.457	0.450
Others (reference)	35	8.46		1.00			

Note: *HR* = hazard ratio. Reference categories: small enterprise, other districts, and the “others” sector. Model statistics:  $\chi^2(11) = 81.512$ ,  $p < 0.001$ ;  $-2 \log$ -likelihood = 5,901.866; *C*-index = 0.60 (95% *CI*: 0.57–0.63); pseudo- $R^2 = 0.287$ .

Source: own work.



**Figure 1.** Kaplan–Meier survival curves by enterprise size (A), geographic location (B), and economic sector (C). Statistical results are shown within each panel

Source: own work.

**Table 4. Temporal and spatial analysis of business closures**

Analysis	Category	<i>n</i>	%	Test statistic	<i>p</i> -value
By year				$\chi^2(8) = 178.97$	$p < 0.001$
	2016	7	1.6		
	2017	7	1.6		
	2018	24	5.4		
	2019	29	6.5		
	2020	7	1.6		
	2021	0	0.0		
	2022	41	9.2		
	2023	49	11.0		
2024	280	63.1			
By period				$\chi^2(2) = 99.77$	$p < 0.001$
	Pre-pandemic (2016–2019)	67	15.1		
	Pandemic (2020–2021)	7	1.6		
	Post-pandemic (2022–2024)	370	83.3		
Location × sector	Active enterprises			$\chi^2(9) = 14.01$	$p = 0.122$
	Closed enterprises			$\chi^2(9) = 8.13$	$p = 0.521$

Note. Closures cluster significantly in the post-pandemic period (83.3%). No significant location–sector interaction was found ( $p > 0.05$ ).

Source: own work.

**Table 5. Model diagnostics summary**

Diagnostic Test	Method	Result	Status
Proportional hazards	Schoenfeld residuals	All $p > 0.05$	Satisfied
Size		$p = 0.827$	
Location		$p = 0.066$	
Economic activity		$p = 0.155$	
Global		$p = 0.092$	
<b>Multicollinearity</b>	VIF	1.002–1.004	Satisfied
<b>Influential observations</b>	DfBeta sensitivity analysis	1 case; estimates stable	Satisfied
Overall fit	LR test	$\chi^2(11) = 81.512$ , $p < 0.001$	Good
Discrimination	C-index	0.60 (95% CI: 0.57–0.63)	Moderate
Explained variation	Pseudo $R^2$	0.287	Acceptable

Source: own work.

Taken together, these diagnostics confirm that the Cox model is statistically sound and that its estimates are stable. The proportional-hazards assumption is satisfied, no multicollinearity is present, and the findings are robust to influential observations. The structural patterns reported above can therefore be interpreted with confidence, subject to the model's moderate discriminatory capacity.

## 4. Discussion

This study examined how firm size, geographic location, and economic sector shape enterprise survival under structural poverty, and how closures distribute over time. Its contribution lies in showing that poverty does not merely add to established survival determinants but reconfigures them: relationships documented largely in urban and middle-income settings behave differently where poverty is pervasive.

Firm size proved the dominant determinant. The survival gap between micro and small enterprises substantially exceeds the roughly twofold differential reported for other Peruvian contexts (Montes-Tocto et al., 2023), and it persists despite the benefits of the REMYPE regime—evidence that the liabilities of smallness and poorness set out above operate jointly rather than in isolation. As Azañero et al. (2023) observe, the typical advantages of larger firms—distribution networks, economies of scale, and financial strength—become amplified in constrained environments, and the ten-employee threshold appears to mark a meaningful transition in access to resources and markets (Audretsch et al., 2025).

Geographic location, by contrast, showed no significant effect. This is inconsistent with the predictions of agglomeration theory but aligns with the threshold logic developed earlier: agglomeration economies presuppose a minimum level of market depth, infrastructure, and institutional density, and where poverty depresses these uniformly as in a province at 44.5% poverty, the advantages of central location fail to materialise.

Sectoral heterogeneity was pronounced, with essential services resilient and construction highly vulnerable. We interpret this primarily through demand elasticity: activities meeting basic needs retain demand as incomes contract, whereas sectors reliant on discretionary or public spending are more exposed, consistent with the evidence of Najib et al. (2021) on discretionary-demand sectors and Mackiewicz and Kurczewska (2023) on adaptability across activities. Two caveats apply. Firstly, demand elasticity is inferred from survival patterns rather than measured directly, and should be read as a theoretically motivated mechanism rather than an empirically isolated one.

Secondly, alternative explanations cannot be discounted: pandemic-period government support such as Peru's *Reactiva Perú* and *FAE-MYPE* programmes may have favoured particular sectors, while differential capital intensity and exposure to public-investment cycles, especially in construction, could also contribute to the observed gap.

The temporal concentration of closures is equally notable: rather than peaking during the pandemic, closures clustered in 2022–2024. We read this as a delayed manifestation of the crisis, whereby emergency support sustained firms that later succumbed once it was withdrawn, compounded by reduced administrative capacity for formal deregistration during the emergency. An alternative is nonetheless plausible: the surge coincides with a period of elevated inflation and the restrictive monetary response that followed; therefore, tighter credit and higher costs may have independently precipitated closures, reinforcing the lagged pandemic effect. Disentangling these channels lies beyond the present descriptive design.

Finally, the model's moderate discriminatory capacity should temper interpretation. With structural variables alone, a substantial share of variance remains unexplained, plausibly reflecting unmeasured intangibles entrepreneurial experience, social networks, and adaptive capacity that administrative data cannot capture. This accords with Higashi et al. (2023), who attribute firm failure largely to macro-level factors, and with Chavez et al. (2022) and Bartlett and Morse (2021) who show that management practices and firm-level capabilities shape resilience beyond the structural determinants captured here. The findings therefore identify robust structural patterns rather than a complete predictive account of firm survival.

## Conclusions

This study analysed the structural determinants of enterprise survival among 1,861 micro and small enterprises in Cajamarca province, Peru, a setting where monetary poverty is pervasive. Firm size emerged as the dominant determinant, with microenterprises markedly more vulnerable than small enterprises even under the preferential *REMYPE* regime; economic sector was also significant, with essential services proving more resilient than discretionary ones; geographic location, by contrast, showed no significant effect; finally, closures were concentrated in the years following the pandemic rather than during it. Taken together, these patterns indicate that structural poverty does not simply add to the difficulties firms face but reshapes the way size, sector, and location influence survival.

These findings carry several policy implications. Because the survival disadvantage of the smallest firms persists despite existing benefits, support should be intensified for microenterprises and oriented towards helping them cross the threshold beyond which access to credit, suppliers, and markets improves; timely financing at critical moments of growth is particularly important (Bohórquez & Bohórquez, 2024). Sectoral targeting is also warranted: essential-service activities can anchor new enterprise formation, while structurally exposed sectors such as construction merit countercyclical support. The delayed concentration of closures suggests that emergency programmes should be designed with longer horizons, since firm vulnerability may peak during recovery rather than at the height of a crisis. Finally, the absence of a location effect implies that resources devoted to place-based incentives might be redirected more effectively towards direct enterprise support, consistent with evidence that centrality advantages erode in peripheral economies (Leurcharusmee et al., 2022). In the short term, feasible measures include cash-flow support and timely financing at critical moments of growth; in the longer term, structural interventions are needed to create viable pathways for microenterprises to scale beyond the threshold at which survival prospects improve.

The study has limitations. It focuses on a single province, which constrains generalisation; it relies on administrative records that omit firm-level variables such as capitalisation and managerial capacity, leaving part of the variance unexplained; REMYPE registration is voluntary, thus the findings apply to formalised firms that sought governmental benefits; and the 2015–2024 window may not span complete economic cycles. Future research could replicate the analysis across provinces with differing poverty levels to test the generalisability of these patterns, incorporate behavioural and organisational variables to explain the residual variance, and track enterprise cohorts through full economic cycles to clarify the temporal dynamics of survival in contexts of poverty.

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# Beyond normality: Capital market Value-at-Risk modelling using symmetric and asymmetric Laplace distributions

 Jan Kaczmarzyk<sup>1</sup>

## Abstract

Evidence on parametric VaR employing both Laplace (exhibiting excessive kurtosis) and asymmetric Laplace (additionally being skewed), “tent-shaped” probability distributions is available, although it remains relatively limited. The research procedure in the paper pursued two primary objectives: to back-test both distributions and assess their ability to capture extreme events, and to determine whether the distribution that best fits the entire empirical distribution is also the one that performs best in back-testing in long-term. The indices considered include WIG30, BVP, CAC, DAX, FTM, HSI, NKX, SHC, SPX and TWSE. The tests were performed using daily data for period between 31 December 1998, and 30 June 2025. Across the ten markets studied, both distributions generally outperformed historical simulation and the normal probability distribution, with the asymmetrical Laplace distribution particularly outperforming the Laplace distribution in capital markets that are likely to be skewed for higher confidence levels (0.99 and 0.975) considered.

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## Keywords

- extreme market risk
- Value-at-Risk
- capital markets

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## Introduction

Financial models frequently assume that an instrument's returns are normally distributed; however, this assumption usually deviates from real-world behaviour. Empirical evidence demonstrates that returns commonly exhibit both skewness and excess kurtosis (Altun et al., 2018; C. F. Lee & Su, 2012). High-frequency returns tend to stray from normality, showing heavier tails and more pronounced peaks (Bormetti et al., 2007). These characteristics lead to higher probabilities of extreme, rare events, as well as to outcomes clustered near zero. Additionally, returns often display volatility clustering and asymmetry (Huang & Lin, 2004), and their elevated peaks may be related to low transaction volumes. Acknowledging that returns are non-normally distributed, fat-tailed and skewed is essential for generating accurate forecasts (Braione & Scholtes, 2016). Excess kurtosis may simply result from incomplete data or instruments with relatively low liquidity and a significant number of zero returns.

Capital markets exhibit extreme events that the normal distribution struggles to capture. There are more realistic probability distributions (closer to empirical distributions, exhibiting skewness and excessive kurtosis) than the normal distribution, but they are more difficult to handle mathematically (Wilmott, 2006, pp. 297–299). From the perspective of computational finance, many open-source tools exist that allow financial analysts to easily handle sophisticated theoretical distributions for risk-related actions. Considering that analysts now operate in an era of copilots and AI agents, deriving VaR scripts in popular computer languages is more widely available than ever before. These theoretical distributions, which better fit empirical changes of assets exposed to market risk, include significantly leptokurtic, tent-shaped Laplace distributions.

The existing research provides rather limited empirical evidence on the use of Laplace distributions in parametric financial risk modelling. Prior studies offer selective findings, focusing either on the Laplace distribution for selected individual stocks (Ullah et al., 2022), on the asymmetrical Laplace distribution in the context of currency (Jing et al., 2022), cryptocurrency markets (Subramoney et al., 2021), or agricultural commodities (Živkov, 2025). While papers on indices behaviour also exist (Chen et al., 2024; Taylor, 2019), they focus on limited indices sets and use semiparametric approach. The main novel contribution to the international literature is conducting comprehensive, long-term Value-at-Risk back-tests (additionally involving distribution fitting) for both the symmetrical and asymmetrical Laplace distributions across a broad set of indices representing major capital markets, including WIG30 (Warsaw), BVP (BOVESPA, Sao Paulo), CAC (CAC40, Paris), DAX (DAX40, Frankfurt), FTM (FTSE250, London), HSI (Hang Seng, Hong Kong), NKX (Nikkei225, Tokio),

SHC (Shanghai), SPX (S&P500, New York) and TWSE (TAIEX, Taiwan), covering all modern market disruptions (the internet bubble, the financial crisis, the Eurozone crisis, Brexit, COVID-19 and war in Ukraine). A diversified set of equity indices from Europe, the US, Latin America, and Asia was selected to test the VaR model across different market environments. The sample includes both developed and emerging markets.

The research procedure of this paper was designed to achieve two primary objectives: (1) to back-test symmetrical and asymmetrical Laplace distributions and assess their ability to capture extreme events, and (2) to determine whether the distribution that best fits the entire empirical distribution is also the one that performs best in back-testing in long-term. A standard Kupiec test was performed using daily data obtained from *stooq.pl* for the period between 31 December 1998, and 30 June 2025 (6,379 daily simple rates of return). The safety level, often referred to as VaR in research, was used as the extreme risk measure. A 250-day window was applied.

The findings support earlier evidence that heavy-tailed models generally provide a more reliable measure of extreme market risk than historical simulation and normal models. Across the ten markets studied, the Laplace distribution and its asymmetrical counterpart generally outperformed historical simulation and the normal probability distribution, with the asymmetrical Laplace distribution particularly outperforming the Laplace distribution in capital markets that are likely to be skewed for higher confidence levels (0.99 and 0.975).

The structure of the paper is as follows: Section 1 reviews the literature on VaR models. Section 2 describes and explains the methodology and data employed. Section 3 presents the empirical results, while Section 4 offers a discussion of these findings. The final section summarises the empirical analysis.

## **1. Literature review**

The empirical probability distribution effectively captures historical extreme events until another ‘black swan’ appears. Markets have become increasingly volatile and another unprecedented disruption always lies ahead (e.g., COVID-19, conflict in Ukraine). Using the empirical probability distribution is referred to as either the non-parametric approach or the historical simulation method. To address the limitations of the former HS method an upgrade called the hybrid approach was developed.

The hybrid approach to VaR combines the best of both worlds: historical simulation (HS, non-parametric approach) and parametric approach (Richardson et al., 1997; Zumbach, 2007). Applying HS for VaR avoids the need

to choose the most appropriate theoretical distribution: fat tails, skewness, and other specific properties are accounted for directly. The two disadvantages of HS are: 1) problems with calculating quantiles on small samples; and 2) the assumption that returns are identically distributed, which excludes time-varying volatility. The hybrid mechanism instead of assuming equal weights for returns (as HS does) attributes exponentially declining weights to returns and may significantly outperform HS in the consequence (Richardson et al., 1997).

Using an appropriate theoretical distribution could theoretically cover the extreme events and could be considered a clear approach. The question is which theoretical distribution addresses the problem of leptokurtosis and fat tails. The normal distribution assumption might be considered here as an adequate solution when simplicity is the key focus (Wilmott, 2006, pp. 297–299). However, while assets that closely follow the normal distribution actually exist, this phenomenon is uncommon. Setting simplicity aside, there are many theoretical distributions that fit better to empirical distributions or/and reflect extreme risk in a more precise way, as has been proven in many papers.

The empirical distributions are either leptokurtic with fat tails or skewed, and both characteristics often occur simultaneously, a fact that seems crucial. The Student's-T distribution, when applied in APARCH model, has been proven to work better than normal probability distribution for higher confidence levels when compared to RiskMetrics or APARCH using normal probability assumption (Huang & Lin, 2004). Involving standard back-testing procedures, it has been demonstrated that using skewed counterparts of the normal, Student's-T, and Multivariate Exponential Power distributions is important and that the skew-T (SST) outperformed others (Braione & Scholtes, 2016). The skew-generalised-T (SGT) distribution, an extension of skew-T distribution, has been shown to be a superior fit to the empirical distributions of stock indices' log returns compared to normal and Student's-T distributions. Consequently, the SGT assumption resulted in more conservative VaR forecasts. The SGT-based VaR model allows for flexible treatment of skewness, leptokurtosis, and fat tails, unlike the symmetrical Student's-T, which results in better accuracy (C. F. Lee & Su, 2012). The generalised alpha-skew-T (GAST) distribution, also an extension of skew-T, brings uni- or bimodal, skewed and fat-tailed shapes and yields more conservative VaR estimates than the normal, Student's-T, and skew-T distributions (Altun et al., 2018). However, the SGT may be less robust than the  $\alpha$ -stable distribution in case of oil price changes (Serrano Bautista & Núñez Mora, 2019).

The Gaussian Mixture Model (GMM) can quickly and adequately adjust to significant and rapid stock market changes when compared with the classic parametric approach, Monte Carlo (both based on the normal distribution assumption), and historical simulation (Morkūnaitė et al., 2024). Research concerning Power GARCH processes assuming stable Paretian or Student's-T distribution indicated that an asymmetrical stable Paretian distributional

assumption may be a better solution in the case of currency risk (Mittnik & Paolella, 2003).

An interesting solution for VaR estimation might be the skewed generalised error distribution (SGE). Evidence suggests that GARCH-SGE models may provide more accurate VaR estimates for both low and high confidence levels than GARCH-N models, which proves that incorporating skewness and kurtosis of returns is critical (M. C. Lee et al., 2008). Another evidence confirms that SGE may fit better to the empirical distribution and introduces SGE for option pricing (Theodossiou, 2015).

The generalised hyperbolic distribution (GH) subclasses can be also considered. Kolmogorov-Smirnoff statistic (K-S) and Akaike Information Criterion (AIC) were applied to choose the optimal GH subclass for USD/ZAR daily changes. The variance-gamma subclass proved to be the best choice compared to the classic gaussian assumption (Kemda et al., 2015). However, other evidence indicates that GH performed worse than the SST when applied to S&P500 daily returns (Guo, 2017).

Both the logistic and hyperbolic secant distributions are leptokurtic and fat-tailed. Evidence suggests that these probability distributions provide a much better fit than their popular alternatives when modelling both unconditional and conditional time series distributions (Bagnato et al., 2015). The “tent-shaped” Laplace distribution (L) is symmetrical, significantly fat-tailed, and should result in conservative VaR estimates. Considering the existing research, the Laplace distribution is applicable for VaR and CVaR through GARCH models when compared to the normal and Gumbel distributions (Ullah et al., 2022). Another study provided evidence on the use of generalised autoregressive score (GAS) combined with heavy-tailed generalised lambda distribution (GAS-GL) against GAS models combined with the asymmetrical Laplace distribution (AL), asymmetrical Student’s t-distribution (AST), and the skew-T distribution (GAS-SST). GAS-GL occurred to be the most suitable for Bitcoin, while GAS-GL, GAS-SST, and GAS-AL were most effective for Ethereum across various VaR levels (Subramoney et al., 2021). There is also evidence on a semiparametric approach based on asymmetrical Laplace in terms of incorporating overnight returns (Chen et al., 2024).

Tempered stable distributions could be considered as a practical evolution of stable distributions. Evidence exists supporting the application of the classical tempered stable (CTS), normal tempered stable (NTS), and rapidly decreasing tempered stable (RDTS) distributions (Bianchi, 2014). This paper focuses on funds and confirms that the CTS model appears more satisfactory for the daily interval than the normal and other tempered stable models. There is also evidence which refers to multivariate cases. A model using the multivariate normal tempered stable (MNTS) distribution may provide more realistic market risk estimates than the normal distribution assumption (Kim et al., 2012).

Within the framework of Extreme Value Theory (EVT), both Gumbel and Fréchet distributions can be considered useful for covering extreme events, as supported by evidence from South-east and East Asian countries (Carvalho & Mendes, 2003). These two distributions have asymmetrical shape, with higher probability of extremely low values and lower probability of extremely high values, which may be suitable for certain assets. Another study shows that the generalised Pareto distribution may be applied in expected shortfall (ES) estimation for indices having leptokurtic and asymmetrical distributions during financial crises (Kourouma et al., 2010). Bali (2003) also suggests that “thin-tailed Gumbel and exponential distributions with rapidly decreasing tails are strongly rejected against the fat-tailed Fréchet and Pareto distributions with slowly decreasing tails.” Further evidence compares models based on EVT, Stable Paretian distributions (both symmetrical and skewed), the normal probability model, and the historical simulation (HS). In the context of VaR, these results showed that fat-tailed models (EVT, Paretian) could predict risk more accurately (Harmantzis et al., 2005). Evidence also suggests that a combination of the normal and Rayleigh probability distributions can be applied to better capture extreme events (Ahmed et al., 2021).

The existing research spans different markets and time periods, supporting the premise that the most suitable model will vary depending on the market, asset, time period, and data interval. According to studies on the Student's-T distribution, the ARCH family of models, and EVT, all of these approaches offer both advantages and limitations. Consequently, no single VaR model can be considered definitive, although all have proven more capable of capturing fat tails than the normal distribution (Lechner et al., 2010).

Whether a theoretical distribution provides a better fit can be assessed using goodness-of-fit statistics, information criteria, or graphical tools such as quantile–quantile plots, probability–probability plots, or density plots. It is even recommended to combine both graphical and non-graphical methods (Vose, 2008), which, when applied to VAR back-testing, seems more appropriate for AI-based systems than for manual analysis. The best-fitting theoretical probability distribution may not necessarily provide the most accurate estimates for VaR or ES.

Recent advances in extreme risk quantification include applications of neural networks and LLMs. Evidence also suggests that a simple neural network incorporating long short-term memory can be an effective model for explaining conditional variance, comparable to traditional approaches. Such models can easily address commonly occurring, non-linear relationships (Buczynski & Chlebus, 2024). The evidence on LLM-generated VaR and ES forecasts produced via prompt interaction tested against standard and extended GARCH and EWMA also shows that LLMs may produce viable results (Pele et al., 2026).

The existing literature clearly demonstrates that skewed and leptokurtic distributions may outperform both the classical Gaussian parametric mod-

el and the historical simulation method. This paper focuses on applying the Laplace distribution (LD) and asymmetrical Laplace distribution (ALD, Kozubowski & Podgórski, 2000) for estimating parametric VaR. The in-depth literature review identifies a research gap: evidence of both symmetrical and asymmetrical Laplace distributions in the context of VaR estimation remains limited.

## 2. Methodology and data

The research procedure aims to achieve two primary objectives: (1) to back-test symmetrical and asymmetrical Laplace distributions and assess their ability to capture extreme events, and (2) to determine whether the distribution that best fits the entire empirical distribution is also the one that performs best in back-testing in the long term.

A long-term standard Kupiec test (Jędrusik et al., 2007; Kupiec, 1995) was performed for the 0.99 confidence level VaR to address extreme market risk, and additionally for the 0.975 and 0.95 to check lower extreme market risk levels. The distributions considered include the empirical distribution (E), normal distribution (N), Laplace distribution (L), and asymmetrical Laplace distribution (AL). In the standard Kupiec test, the LRUC statistic exceeding 3.84 and 6.63 for 0.05 and 0.01 significance levels, respectively, necessitates the rejection of the null hypothesis  $H_0: \pi = \alpha$ , where  $\pi$  is the observed violation rate and  $\alpha$  is the significance level. Alternatively, the  $p$ -value for LRUC can be calculated, and  $H_0$  is rejected whenever it is lower than  $\alpha$ . The significance level applied for the Kupiec test was 0.01. The Kupiec test evaluates accuracy, meaning a model is rejected when the violation ratio is significantly higher or lower than the assumed significance level. These two cases differ fundamentally. When the null hypothesis  $H_0$  is rejected and the violation ratio is lower than the significance level, the model is deemed conservative. Such models tend to overestimate risk, which is still preferable to underestimating. A violation ratio close to 1 classifies the model as neutral. Regarding volatility clustering, the Christoffersen test (1998) is often used alongside the Kupiec test as a conditional coverage measure, as it assesses not only the exceedance rate but also the independence of exceedances. However, given the very long sample period considered in the paper (over 25 years and 6,379 daily returns), which encompasses extended crisis periods such as 2008, a full-sample independence test would be difficult to interpret. The sample is affected by regime changes, volatility clustering, and structural breaks, which would violate the stationarity assumptions underlying the test. As a result, models could fail the Christoffersen test for reasons unrelated to their actual fore-

casting quality. Therefore, the Kupiec test was chosen as the back-testing tool and the unconditional coverage was considered.

The indices (representing respective capital markets) analysed include WIG30 (Warsaw), BVP (BOVESPA, Sao Paulo), CAC (CAC40, Paris), DAX (DAX40, Frankfurt), FTM (FTSE250, London), HSI (Hang Seng, Hong Kong), NKX (Nikkei225, Tokio), SHC (Shanghai), SPX (S&P500, New York) and TWSE (TAIEX, Taiwan). These are mostly classified as large cap indices (except SHC, FTM and TWSE), as well as being commonly perceived or classified as main indices for the markets considered. The indices were chosen to ensure that the long-term VaR test was carried out on a broad and heterogeneous set of equity markets. The set of indices includes major benchmarks from Europe, US, Latin America, and Asia, therefore covering both developed and emerging markets. This range is important because VaR models may behave differently across markets with different volatility patterns and different exposure to extreme events, whether global or local in nature. Altogether, this set allows for a more robust assessment of whether the VaR model using Laplace distribution or its asymmetrical counterpart performs consistently across different market environments in long-term.

The tests were performed using daily data obtained from [stooq.pl](http://stooq.pl) for the period between 31 December 1998, and 30 June 2025 (6,379 daily simple rates of return; the detailed descriptive statistics are provided in Appendix 1, Table A1). Simple rates of return were applied, since these do not alter the substantive conclusions of the analysis, while also allowing for a more straightforward calculation procedure (Jorion, 2007; Miskolczi, 2017). The simple rates cannot be applied for time series models, e.g., geometric Brownian motion which rely on continuous compounding (Black & Scholes, 1973; Brigo et al., 2007; Kaczmarzyk, 2022). The safety level, often referred to as VaR in research, was used as the extreme risk measure. A 250-day window was applied. For each window, the parameters of the theoretical distributions were fitted and then used to calculate the safety level using the respective inverse function of a theoretical cumulative probability distribution function.

Kolmogorov–Smirnov statistics (K-S) and Akaike’s Information Criterion (AIC) (Akaike, 1998; Vose, 2008) were used in parallel on each 250-day window to determine whether the best-fitting theoretical distribution (best fitting to the entire empirical distribution) also performs best in back-testing over the long term. The K-S test considers the maximum distance between the theoretical and empirical cumulative distribution functions (focusing on a single point, but scanning the whole distribution), while AIC evaluates the overall distribution fit. While the Anderson–Darling statistic explicitly emphasises tail behaviour, the Schwarz (BIC) and Hannan–Quinn (HQC) information criteria impose stricter penalties on model complexity (stronger than AIC). These harsh penalties may discourage the selection of additional parameters such as skewness, even when these parameters improve tail representation. AL would be then

penalised more easily with BIC and HQC, making AIC preferable when sensitivity to distributional asymmetry is desired (Appendix 2, Table A2).

The financial data were obtained from *stooq.pl*. Both the parameter fitting and inverse function calculations were carried out using the SciPy 1.13.1 library.

Additionally, periods of significant market decline, interpreted as crisis periods, are highlighted in the figures. Figures 1–10 provided in Supplementary materials, Appendix A present each capital market and include (1) standardised index value ( $PV = 1$ ), (2) AIC values, and (3) the results of back-testing (0.99 confidence level). The periods marked include the Internet bubble (A), the financial crisis (B1, B2), the Eurozone crisis (C), Brexit (D), COVID-19 (E) and the war in Ukraine (F). The visualisation of back-testing for 0.975 and 0.95 confidence levels is provided in Supplementary materials, Appendix B and C.

### 3. Results

Considering the extreme risk at the 0.99 confidence level (Table 1), neither E nor N passed the Kupiec test for any of the analysed indices. Both L and AL passed the test for WIG30, CAC, DAX, FTM, HSI, NKX, and SHC (7 out of 10 analysed indices). Additionally, AL passed the test for SPX and TWSE, increasing its coverage for 9 out of 10 indices. The  $LR_{UC}$  value for AL was lower than that for L for BVP, CAC, FTM, SHC, SPX, and TWSE. AL outperformed L, which may indicate skewness of the index (and the respective market). The Violation Ratio (VR) was less than or equal to 1 for both L and AL for WIG30 and BVP. L and AL can thus be considered conservative options, with closely matching VR values (0.894 and 0.894 respectively) for WIG30. For BVP, both VR values were significantly lower (0.627 and 0.643 respectively). A VR lower than 1 was calculated for DAX for AL.

Regarding the slightly lower extreme risk at the 0.975 confidence level (Table 2), neither E nor N passed the Kupiec test for CAC, DAX, FTM, NKX, SPX, and TWSE (6 out of 10 analysed indices). Additionally, N did not meet the critical  $LR_{UC}$  value for WIG30, HSI, and SHC. Either L or AL recorded the lowest  $LR_{UC}$  value for CAC, DAX, FTM, HSI, NKX, SHC, SPX, and TWSE (8 of the 10 indices considered), beating E and N as a VaR model. All these indices passed the critical criterion of the Kupiec test except SPX. The  $LR_{UC}$  value for AL was lower than that for L for CAC, DAX, FTM, HIS, SHC, SPX and TWSE. While the tent-shaped models did not pass the Kupiec test for WIG30 and BVP, they did offer VRs significantly lower than 1 (all lower than 0.8 for both indices), being a very conservative choice in the case of these indices. Among the indices that passed the Kupiec test, the only index with a VR lower than 1 was HSI.

Considering the 0.95 confidence level (Table 3), E and N passed the Kupiec test for all indices except DAX (9 out of 10). Both tent-shaped L and AL satisfied the back-testing criterion for BVP, CAC, FTM, HSI, NKX, SHC, SPX, and TWSE (8 out of 10 analysed indices). Additionally, AL alone met the test criterion for DAX. In the case of CAC, DAX, and FTM, either L or AL indicated the lowest  $LR_{UC}$ , beating E or N (with AL beating L for all 3 indices). AL was the best option for SPX and TWSE, and L the best for NKX. WIG30 did not pass the Kupiec test for the 0.95 confidence level VaR, despite having a VR lower than 1 (0.812 for L and 0.856 for AL), the lowest violation ratio among the indices considered. In terms of the Kupiec test, L and AL are too conservative for WIG30. A VR lower than 1 was observed for BVP and NKX for both L and AL (0.919 and 0.906 for BVP, respectively, and 0.919 and 0.959 for NKX). Additionally, AL proved to be a reliable conservative option for CAC and FTM.

In summary, the tent-shaped L or AL models passed the long-term Kupiec test for all confidence levels for CAC, FTM, HSI, NKX, and SHC (5 out of 10 indices). They offered  $LR_{UC}$  values lower than E or N for 0.99 and 0.975 confidence level VaR for CAC, DAX, FTM, HSI, NKX, SHC, SPX, and TWSE (8 out of 10 indices). They recorded the lowest LRUC for all confidence levels for CAC, DAX, and FTM. Given that the test was carried out on a broad and heterogeneous set of equity markets, L or AL seem to be reliable models for VaR. Generally, the higher the level of extreme risk, the more strongly this claim is supported. Given the shape of L and AL, and the back-testing results, extreme market risk for the analysed indices can be characterised as predominantly tent-shaped especially in term of higher confidence levels (0.99 and 0.975).

Regarding the back-testing results, the tent-shaped distributions work best for the highest level of market risk considered. The next question is whether the AIC and K-S criteria can correctly identify the best parametric model for the highest extreme risk measurement. According to AIC, L was most frequently the best-fitting model for all indices except WIG30 and BVP, where N was identified as offering the best fit. Although  $LR_{UC}$  indicated that AL often outperformed L, AIC did not confirm this, as AL was less frequently selected as the best fit. AIC confirmed the relationship between  $LR_{UC}$  and model fit (meaning the distribution with the lower  $LR_{UC}$  tends to be more often best-fitting) for DAX, HSI, and NKX (3 out of 10 indices). These results suggest symmetrical market risk characteristics for those indices.

The AIC criterion favoured N over AL for WIG30, BVP, CAC, DAX, FTM, HSI, NKX, and SPX (8 out of 10 indices). Both N and L are symmetrical distributions. The AIC criterion evaluates how closely a probability distribution fits the overall data (based on the sum of log-likelihood values). Nonetheless, AIC results also support the tent-shaped nature of market risk. Combining the frequency with which L or AL were identified as the best-fitting models, they outperformed N for 9 out of 10 indices (all except BVP). Considering the combined frequency (the total percentage of observations with minimum AIC for L and AL, Table 1),

**Table 1. Back-testing results with 0.99 confidence level for safety level (VaR) and moving AIC and K-S**

Market / index	WIG30				BVP				CAC				DAX				FTM			
PD Type	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL
Observations	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379
Significance	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%
Observed	1.50%	1.60%	0.90%	0.90%	1.40%	1.60%	0.60%	0.60%	1.60%	2.30%	1.20%	1.00%	1.60%	2.20%	1.10%	0.90%	1.70%	2.60%	1.30%	1.10%
Expected violations	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79
Actual violations	98	101	57	57	88	103	40	41	105	145	75	65	103	139	68	58	108	168	85	71
Violation Ratio	1.536	1.583	0.894	0.894	1.38	1.615	0.627	0.643	1.646	2.273	1.176	1.019	1.615	2.179	1.066	0.909	1.693	2.634	1.332	1.113
L0	-514.43	-528.22	-326.03	-326.03	-468.48	-537.41	-247.92	-252.51	-546.60	-730.40	-408.75	-362.79	-537.41	-702.83	-376.58	-330.63	-560.38	-836.09	-454.70	-390.37
L1	-506.47	-518.91	-325.65	-325.65	-464.33	-527.15	-242.75	-247.80	-535.35	-692.02	-407.80	-362.78	-527.15	-669.33	-376.44	-330.35	-547.57	-776.75	-451.47	-389.97
LRUC	15.922	18.624	0.757	0.757	8.299	20.525	10.332	9.416	22.506	76.759	1.884	0.023	20.525	67.007	0.275	0.548	25.622	118.681	6.451	0.794
p-value	0	0	0.384	0.384	0.004	0	0.001	0.002	0	0	0.17	0.879	0	0	0.6	0.459	0	0	0.011	0.373
Violation Ratio (VR) <= 1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
p-value > 0.01	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
LRUC(AL) < LRUC(L)				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>
Obser. with min (AIC)		2,822	2,479	1,078		3,509	2,277	593		2,022	3,097	1,260		1,743	3,614	1,022		1,931	2,879	1,569
%		44.24	38.86	16.90		55.01	35.70	9.30		31.70	48.55	19.75		27.32	56.65	16.02		30.27	45.13	24.60
AIC conf. LRUC				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>
Observ. with min (K-S)		2,720	1,431	2,228		2,832	1,343	2,204		1,927	1,472	2,980		1,229	1,433	3,717		2,019	2,051	2,309
%		42.64	22.43	34.93		44.40	21.05	34.55		30.21	23.08	46.72		19.27	22.46	58.27		31.65	32.15	36.20
K-S conf. LRUC				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>

Market	HSI				NKX				SHC				SPX				TWSE			
	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL
PD Type	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL
Observations	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379
Significance	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%
Observed	1.60%	2.00%	1.10%	1.10%	1.60%	2.20%	1.10%	1.20%	1.40%	2.10%	1.30%	1.30%	1.70%	2.60%	1.60%	1.30%	1.50%	2.20%	1.40%	1.30%
Expected violations	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79	63.79
Actual violations	104	129	67	73	104	141	70	78	87	134	81	80	110	164	99	85	95	142	89	84
Violation Ratio	1.63	2.022	1.05	1.144	1.63	2.21	1.097	1.223	1.364	2.101	1.27	1.254	1.724	2.571	1.552	1.332	1.489	2.226	1.395	1.317
L0	-542.00	-656.88	-371.98	-399.56	-542.00	-712.02	-385.77	-422.53	-463.89	-679.86	-436.32	-431.72	-569.57	-817.71	-519.03	-454.70	-500.65	-716.62	-473.08	-450.10
L1	-531.25	-630.91	-371.90	-398.91	-531.25	-676.92	-385.47	-421.04	-460.06	-650.22	-434.16	-429.80	-555.68	-762.26	-510.63	-451.47	-493.94	-680.71	-468.60	-447.16
LRUC	21.506	51.943	0.161	1.283	21.506	70.2	0.592	2.986	7.66	59.285	4.321	3.85	27.793	110.899	16.802	6.451	13.408	71.818	8.962	5.882
p-value	0	0	0.689	0.257	0	0	0.442	0.084	0.006	0	0.038	0.05	0	0	0	0.011	0	0	0.003	0.015
Violation Ratio (VR) <= 1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
p-value > 0.01	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
LRUC(AL) < LRUC(L)				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>
Obser. with min (AIC)		1,102	4,618	659		1,277	4,635	467		3	5,189	1,187		1,378	4,481	520		275	5,474	630
%		17.28	72.39	10.33		20.02	72.66	7.32		0.05	81.35	18.61		21.60	70.25	8.15		4.31	85.81	9.88
AIC conf. LRUC				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>
Observ. with min (K-S)		1,059	1,941	3,379		904	1,909	3,566		39	2,648	3,692		966	1,793	3,620		247	2,573	3,559
%		16.60	30.43	52.97		14.17	29.93	55.90		0.61	41.51	57.88		15.14	28.11	56.75		3.87	40.34	55.79
K-S conf. LRUC				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>

Source: own work.

**Table 2. Back-testing results with 0.975 confidence level for safety level (VaR)**

Market / index	WIG30				BVP				CAC				DAX				FTM			
	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL
PD Type	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379
Observations	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379
Significance	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%
Observed	3.00%	3.00%	1.80%	2.00%	2.90%	3.00%	1.80%	1.90%	3.30%	3.70%	2.70%	2.50%	3.40%	3.80%	2.70%	2.60%	3.30%	3.70%	3.00%	2.60%
Expected violations	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475
Actual violations	191.000	193.000	115.000	125.000	185.000	192.000	115.000	123.000	209.000	235.000	170.000	161.000	216.000	244.000	174.000	166.000	213.000	238.000	192.000	166.000
Violation Ratio	1.198	1.210	0.721	0.784	1.160	1.204	0.721	0.771	1.311	1.474	1.066	1.010	1.354	1.530	1.091	1.041	1.336	1.492	1.204	1.041
L0	-861.243	-868.570	-582.812	-619.448	-839.261	-864.906	-582.812	-612.120	-927.187	-1022.439	-784.308	-751.336	-952.832	-1055.411	-798.962	-769.654	-941.841	-1033.430	-864.906	-769.654
L1	-858.234	-865.179	-575.778	-615.324	-837.267	-861.709	-575.778	-607.482	-919.991	-1006.395	-783.959	-751.328	-943.566	-1035.591	-798.303	-769.518	-933.492	-1016.166	-861.709	-769.518
LRUC	6.018	6.781	14.068	8.247	3.988	6.394	14.068	9.277	14.392	32.089	0.698	0.015	18.530	39.641	1.318	0.270	16.698	34.528	6.394	0.270
p-value	0.014	0.009	0.000	0.004	0.046	0.011	0.000	0.002	0.000	0.000	0.404	0.903	0.000	0.000	0.251	0.603	0.000	0.000	0.011	0.603
Violation Ratio (VR) <= 1	☒	☒	☑	☑	☒	☒	☑	☑	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒
p-value > 0.01	☑	☒	☒	☒	☑	☑	☒	☒	☒	☒	☑	☑	☒	☒	☑	☑	☒	☒	☑	☑
Market	HSI				NKX				SHC				SPX				TWSE			
PD Type	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL
Observations	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379
Significance	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%
Observed	3.00%	3.20%	2.40%	2.40%	3.30%	3.60%	2.70%	2.70%	2.90%	3.30%	2.80%	2.60%	3.40%	3.90%	3.30%	3.10%	3.00%	3.60%	2.80%	2.80%
Expected violations	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475	159,475
Actual violations	192.000	204.000	151.000	156.000	210.000	232.000	171.000	174.000	188.000	208.000	179.000	165.000	215.000	251.000	210.000	195.000	193.000	232.000	181.000	177.000
Violation Ratio	1.204	1.279	0.947	0.978	1.317	1.455	1.072	1.091	1.179	1.304	1.122	1.035	1.348	1.574	1.317	1.223	1.210	1.455	1.135	1.110
L0	-864.906	-908.869	-714.700	-733.018	-930.850	-1011.449	-787.971	-798.962	-850.252	-923.523	-817.280	-765.990	-949.168	-1081.056	-930.850	-875.897	-868.570	-1011.449	-824.607	-809.953
L1	-861.709	-903.003	-714.465	-732.979	-923.373	-996.584	-787.554	-798.303	-847.775	-916.603	-816.100	-765.893	-940.213	-1058.060	-923.373	-872.103	-865.179	-996.584	-823.178	-808.999
LRUC	6.394	11.733	0.470	0.078	14.954	29.730	0.835	1.318	4.954	13.840	2.360	0.194	17.910	45.994	14.954	7.587	6.781	29.730	2.857	1.908
p-value	0.011	0.001	0.493	0.780	0.000	0.000	0.361	0.251	0.026	0.000	0.124	0.659	0.000	0.000	0.000	0.006	0.009	0.000	0.091	0.167
Violation Ratio <= 1	☒	☒	☑	☑	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒
p-value > 0.01	☑	☒	☑	☑	☒	☒	☑	☑	☑	☒	☑	☑	☒	☒	☒	☒	☒	☒	☑	☑

Source: own work.

**Table 3. Back-testing results with 0.95 confidence level for safety level (VaR)**

Market / index	WIG30				BVP				CAC				DAX				FTM			
PD Type	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL
Observations	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379
Significance	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Observed	5.30%	4.60%	4.10%	4.30%	5.40%	5.30%	4.60%	4.50%	5.70%	5.50%	5.20%	4.90%	6.00%	6.20%	5.90%	5.40%	5.70%	5.70%	5.60%	5.00%
Expected violations	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95
Actual violations	339.000	291.000	259.000	273.000	346.000	339.000	293.000	289.000	364.000	354.000	333.000	314.000	380.000	398.000	374.000	344.000	364.000	364.000	355.000	316.000
Violation Ratio	1.063	0.912	0.812	0.856	1.085	1.063	0.919	0.906	1.141	1.110	1.044	0.984	1.191	1.248	1.173	1.079	1.141	1.141	1.113	0.991
L0	-1325.365	-1184.032	-1089.810	-1131.032	-1345.976	-1325.365	-1189.921	-1178.143	-1398.976	-1369.531	-1307.698	-1251.754	-1446.087	-1499.087	-1428.420	-1340.087	-1398.976	-1398.976	-1372.476	-1257.643
L1	-1324.714	-1182.705	-1083.489	-1127.377	-1344.799	-1324.714	-1188.780	-1176.617	-1395.766	-1367.571	-1307.377	-1251.713	-1440.276	-1489.495	-1423.670	-1339.076	-1395.766	-1395.766	-1370.404	-1257.628
LRUC	1.301	2.653	12.640	7.310	2.353	1.301	2.282	3.053	6.419	3.921	0.643	0.081	11.621	19.184	9.499	2.022	6.419	6.419	4.144	0.029
p-value	0.254	0.103	0.000	0.007	0.125	0.254	0.131	0.081	0.011	0.048	0.423	0.776	0.001	0.000	0.002	0.155	0.011	0.011	0.042	0.865
Violation Ratio (VR) <= 1	☒	☑	☑	☑	☒	☒	☑	☑	☒	☒	☒	☑	☒	☒	☒	☒	☒	☒	☒	☑
p-value > 0.01	☑	☑	☒	☒	☑	☑	☑	☑	☑	☑	☑	☑	☒	☒	☒	☑	☑	☑	☑	☑
Market	HSI				NKX				SHC				SPX				TWSE			
PD Type	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL	(2) E	(3) N	(4) L	(5) AL
Observations	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379	6,379
Significance	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Observed	5.20%	5.00%	4.60%	4.80%	5.50%	5.30%	5.10%	5.40%	5.30%	5.00%	5.20%	5.10%	5.50%	5.70%	5.60%	5.40%	5.60%	5.40%	5.30%	5.40%
Expected violations	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95	318,95
Actual violations	333.000	317.000	293.000	306.000	348.000	338.000	328.000	342.000	341.000	318.000	333.000	326.000	349.000	363.000	359.000	345.000	356.000	342.000	341.000	343.000
Violation Ratio	1.044	0.994	0.919	0.959	1.091	1.060	1.028	1.072	1.069	0.997	1.044	1.022	1.094	1.138	1.126	1.082	1.116	1.072	1.069	1.075
L0	-1307.698	-1260.587	-1189.921	-1228.198	-1351.865	-1322.420	-1292.976	-1334.198	-1331.254	-1263.532	-1307.698	-1287.087	-1354.809	-1396.031	-1384.254	-1343.031	-1375.420	-1334.198	-1331.254	-1337.142
L1	-1307.377	-1260.581	-1188.780	-1227.918	-1350.510	-1321.832	-1292.842	-1333.341	-1330.468	-1263.530	-1307.377	-1287.006	-1353.361	-1392.960	-1381.705	-1341.939	-1373.234	-1333.341	-1330.468	-1336.210
LRUC	0.643	0.013	2.282	0.561	2.708	1.176	0.268	1.715	1.571	0.003	0.643	0.163	2.895	6.142	5.096	2.184	4.373	1.715	1.571	1.865
p-value	0.423	0.911	0.131	0.454	0.100	0.278	0.605	0.190	0.210	0.956	0.423	0.686	0.089	0.013	0.024	0.139	0.037	0.190	0.210	0.172
Violation Ratio <= 1	☒	☑	☑	☑	☒	☒	☒	☒	☒	☑	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒
p-value > 0.01	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑

[128]

Source: own work.

WIG30 exhibits the second-lowest value, whereas TWSE and SHC record the highest values (exceeding 90%). Brazilian and European markets are associated with the five lowest outcomes, while Asian and American markets account for the five highest. Nevertheless, the L and AL approaches perform best for WIG30 and BVP when applied for extreme VaR calculations. According to AIC, these models achieve the lowest combined frequency.

Graphical assessments reveal that AIC might become significantly lower for both L and AL at the onset of a crisis, thus favouring these distributions. This appears to be a recurring phenomenon (Table 4; Supplementary materials, Appendix A: Figures 1–10). Considering AIC, the most of analysed indices gave a clear response to COVID-19 (7 out of 10). According to the AIC criterion, most of the analysed indices reacted significantly to the COVID-19 pandemic (7 out of 10). However, the Polish index was the only one to exhibit an evident response to the war in Ukraine; it was also the only index showing a clear reaction to the Eurozone crisis. A similar pattern was observed for Brexit, where an evident response occurred only in the United Kingdom. Furthermore, based on AIC, most analysed indices displayed no reaction or only a slight reaction during the dot-com bubble and the global financial crisis.

**Table 4. Differences in AIC values for the considered distributions during crisis periods**

Crisis	WIG30	BVP	CAC	DAX	FTM	HSI	NKX	SHC	SPX	TWSE
A: Internet bubble	☒	☒	☒	☒	☑	☒	☒	☑	☒	☒
B1: Financial crisis	☒	☒	☒	☒	☒	☑	☑	☑,☒	☑	☑
B2: Financial crisis	☒	☑,☑	☑	☑	☒	☑	☑,☑	☒	☑	☒
C: Eurozone crisis	☑,☑	☒	☒	☑	☒	☑	☑,☒	☒	☑	☑
D: Brexit	☒	☒	☒	☒	☑,☑	☒	☑,☒	☒	☒	☑,☒
E: COVID-19	☑,☑	☑,☑	☑,☑	☑,☑	☑,☑	☑	☑,☑	☑,☒	☑,☑	☑,☑
F: War in Ukraine	☑,☑	☒	☑	☑	☒	☑	☒	☑	☒	☒

☑,☑ evident, ☑ slightly evident, ☒ no reaction, or AIC started receding earlier, ☑,☒ hard to decide

Source: own work.

The Kolmogorov–Smirnov test is easier to implement and different, because it focuses only on the maximum difference between cumulative distribution functions at a specific point scanning the entire distribution. The K-S test confirmed the relationship between  $LR_{UC}$  and model fit (more frequently chosen probability distributions correspond to lower  $LR_{UC}$  values) for BVP, CAC, FTM, SHC, SPX, and TWSE (6 out of 10 markets), which had lower  $LR_{UC}$  values for AL, indicating asymmetrical characteristics for the highest level of extreme market risk considered.

According to K-S statistics, L or AL consistently outperformed the normal distribution for all 10 analysed indices. In terms of the combined frequency (the total percentage of observations with minimum K-S for L and AL, Table 1), WIG30 and BVP registered the lowest values, whereas TWSE and SHC recorded the highest values (exceeding 90%). As observed again, Brazilian and European markets are associated with the five lowest outcomes, while Asian and American markets account for the five highest. Again, the L and AL approaches performing best for WIG30 and BVP when applied for extreme VaR calculation have the lowest combined frequency according to K-S.

The VaR back-testing results reveal clear differences across the analysed markets and across confidence levels. Although both the Laplace and asymmetric Laplace distributions generally outperformed the empirical and normal distributions, their relative effectiveness was not uniform across indices or risk levels. In the case of WIG30, both Laplace-based models passed the Kupiec test at the 0.99 confidence level with a violation ratio slightly below 1, suggesting a relatively balanced and conservative fit; however, for lower confidence levels (0.975 and 0.95), both models became overly conservative and did not pass the test despite maintaining violation ratios below 1. A similar pattern was partially observed for DAX, where symmetric behaviour was evident, although the asymmetric Laplace distribution additionally met the Kupiec criterion at the 0.95 level.

In several other markets, the asymmetric Laplace distribution achieved lower  $LR_{uc}$  values than the symmetric Laplace distribution, indicating that market risk was not only fat-tailed but also asymmetric in terms of extreme downside risk. This was particularly visible for BVP, CAC, FTM, SHC, SPX and TWSE, where the asymmetric specification more accurately captured tail risk, especially at the 0.99 and 0.975 levels, and often remained competitive at 0.95. By contrast, in markets such as DAX, HSI and NKX, the evidence more often pointed to the symmetric Laplace distribution, suggesting a more symmetric tent-shaped risk profile, although this distinction became less pronounced at lower confidence levels, where both specifications frequently produced similar and acceptable back-testing outcomes.

Overall, the inclusion of multiple confidence levels confirms that while excess kurtosis is a common feature across all markets, the degree of asymmetry and the relative advantage of the asymmetric Laplace distribution are more pronounced at higher confidence levels, whereas at lower levels the differences between symmetric and asymmetric specifications tend to diminish, and model conservatism becomes more relevant than distributional shape.

These cross-market differences were also reflected in the goodness-of-fit results. According to AIC, the symmetric Laplace distribution was more frequently selected as the best-fitting model, whereas the K-S criterion more often favoured the asymmetric Laplace distribution, especially in markets where the VaR back-testing results indicated stronger asymmetry. At the same

time, the dynamic behaviour of AIC during crisis episodes showed that both Laplace-based distributions tended to improve their relative fit when market stress intensified. This pattern was particularly visible during the COVID-19 period, which generated the clearest and most widespread response across the analysed indices, while other crises were more market-specific, such as Brexit in the UK market or the war in Ukraine, which was most clearly reflected in WIG30.

Overall, the results suggest that although excess kurtosis is a common feature across all analysed capital markets represented by respective indices, the degree of skewness, the preferred distributional fit, and the sensitivity to crisis episodes all differ substantially across markets. The back-testing results and distribution fitting consistently support the interpretation that market risk is predominantly tent-shaped in most of the capital markets analysed, especially for the higher levels of extreme market risk.

## 4. Discussion

The results obtained for the 0.99 confidence level are consistent with previous research on applying L for extreme market risk measurement (Ullah et al., 2022). Selecting L or AL is generally preferable to relying on E or N. This study further confirms that relying on E is consistently more effective than using N for all 10 analysed indices, a result commonly observed in existing research. Whenever L outperforms E or N, it indicates a market/index characterised by fat tails (leptokurtosis). However, AL (Kozubowski & Podgórski, 2000) can be considered a more appropriate choice than L. Specifically, L or AL outperformed E or N for 9 out of 10 indices, while AL outperformed L for 6 indices (5 if excluding BVP, where N was better than AL). This clearly indicates that main indices representing respective markets are often not only leptokurtic but also exhibit skewness, fully aligning with previous research findings on extreme risk measurement using non-Laplace distributions (e.g., Altun et al., 2018; Bormetti et al., 2007; Braione & Scholtes, 2016; C. F. Lee & Su, 2012). Extending the analysis to lower confidence levels (0.975 and 0.95) provides additional insight into the robustness of these findings. At the 0.975 level, the superiority of the Laplace-based models over the empirical and normal distributions remains evident, although their performance becomes less uniform across markets and, in some cases, more conservative, as reflected in violation ratios below 1. At the 0.95 level, the differences between models diminish further, with the empirical and normal distributions more frequently passing the Kupiec test, while L and AL still often provide competitive or superior  $LR_{UC}$  values for several indices. These results suggest that the rela-

tive advantage of tent-shaped distributions is strongest in modelling extreme market risk, whereas at lower confidence levels the choice of distribution becomes less critical and model conservatism plays a more prominent role.

Applying moving probability distribution fitting is not a common practice in back-testing procedures. Although using criteria such as AIC or K-S in back-testing does not conclusively determine the best parametric extreme risk model, it does clearly indicate the fat-tailed nature of the analysed indices and consequently, of the capital markets they represent. According to the AIC, L was identified as the best-fitting model for 8 out of 10 indices, while according to the K-S criterion, AL was best-fitting for 8 out of 10 markets for the highest extreme market risk level considered. The AIC criterion coincided with markets where  $LR_{UC}$  values were lower for L, whereas the K-S criterion coincided with markets where  $LR_{UC}$  values were lower for AL. Additionally, graphical analysis revealed instances (aligned with crises) where the AIC of L or AL deviated significantly from the AIC of N.

## Conclusions

Capital markets exhibit extreme events that the normal distribution struggles to capture. While the simplicity of the normal distribution is an argument in its favour, estimating extreme risk ad hoc could prove problematic. Much of the research so far confirms that relying solely on the empirical distribution or normal distribution is an unreliable solution. However, the empirical distribution is usually a better choice than its normal counterpart.

This research procedure confirmed the superiority of tent-shaped Laplace and asymmetrical Laplace distributions over empirical and normal distributions in extreme market risk measurement for 0.99 confidence level. These can be considered reliable parametric models. Across the ten markets studied, considering the 0.99 confidence level, the Laplace distribution and its asymmetrical counterpart generally outperformed historical simulation and normal distribution, with the asymmetrical Laplace distribution particularly outperforming the Laplace distribution in capital markets that are likely to be skewed. This was also confirmed for the 0.975 confidence level VaR. However, the superiority of tent-shaped distributions was not confirmed for VaR calculated with a 0.95 confidence level.

In the case of the Polish capital market, the Laplace and asymmetrical Laplace distributions not only pass the back-testing procedure for the 0.99 confidence level, but with a violation ratio slightly lower than 1, they could also be classified as convenient conservative/neutral models for extreme risk measurement. For lower confidence levels, while violation ratios were low-

er than 1, the long-term Kupiec test failed. The tent-shaped distributions occurred to be too conservative models for lower extreme risk levels.

Moving goodness-of-fit tests were not consistent between AIC and K-S: AIC identified the best choice mostly when the Kupiec test favoured Laplace, whereas K-S did so mostly when it favoured the asymmetrical Laplace distribution. Although using criteria such as AIC or K-S in back-testing does not conclusively determine the best risk model, it does clearly indicate the fat-tailed nature of the analysed capital markets.

The main limitation of this study lies in the long-term character of the back-testing procedure, which, although useful for evaluating model performance across multiple market regimes, may also mask shorter-term changes in distributional properties, structural breaks, and regime-specific dynamics. For this reason, the study focuses on unconditional coverage assessed with the Kupiec test. In a more detailed setting, especially with shorter subperiods, it would be possible to account for volatility clustering. In particular, the results obtained for the Polish capital market suggest that both the Laplace and the asymmetric Laplace distributions perform well in modelling very high extreme risk (0.99 confidence level for VaR) serving as conservative models, but these findings should be interpreted with caution. Another limitation is that the study focuses primarily on major stock indices; therefore, future research should extend the analysis to all relevant indices and/or major individual stocks in order to assess the broader applicability of Laplace-based VaR modelling in the capital market. More detailed tests involving individual stocks should also be conducted in those markets where the Laplace and asymmetric Laplace distributions proved to be a good choice for all the confidence levels considered.

## Appendix 1

**Table A1. Descriptive statistics for daily returns obtained from stooq.pl for the period between 31 December 1998, and 30 June 2025**

Market / index	Count	Mean (%)	Standard deviation (%)	Min (%)	1%	5%	95%	99%	Max (%)
WIG	6,379	0.035	1.263	-12.652	-3.419	-1.908	2.045	3.282	7.716
WIG30	6,379	0.022	1.449	-13.090	-3.848	-2.252	2.331	3.913	8.421
^BVP	6,379	0.049	1.704	-14.780	-4.300	-2.667	2.581	4.373	14.658
^CAC	6,379	0.015	1.395	-12.277	-3.968	-2.188	2.072	3.611	11.176
^DAX	6,379	0.031	1.433	-12.239	-4.155	-2.258	2.196	3.710	11.402
^FTM	6,379	0.025	1.075	-9.353	-3.044	-1.668	1.560	3.085	8.371
^HSI	6,379	0.016	1.487	-13.223	-4.051	-2.271	2.250	3.937	14.348
^NKX	6,379	0.022	1.444	-12.396	-3.939	-2.233	2.151	3.604	14.150
^SHC	6,379	0.025	1.449	-8.841	-4.500	-2.248	2.237	3.952	9.857
^SPX	6,379	0.031	1.227	-11.984	-3.432	-1.860	1.746	3.416	11.580
^TWSE	6,379	0.023	1.302	-9.700	-3.854	-2.116	1.984	3.700	9.247

Source: own work.

## Appendix 2

**Table A2. Penalties in information criteria, the dependency between size ( $n$ ) of the window and the number of theoretical distribution parameters ( $k$ )**

AIC							
$k/n$	100	250	400	550	700	850	1000
2	4.12	4.05	4.03	4.02	4.02	4.01	4.01
3	6.25	6.10	6.06	6.04	6.03	6.03	6.02
4	8.42	8.16	8.10	8.07	8.06	8.05	8.04
5	10.64	10.25	10.15	10.11	10.09	10.07	10.06
BIC							
$k/n$	100	250	400	550	700	850	1000
2	9.21	11.04	11.98	12.62	13.10	13.49	13.82
3	1.82	16.56	17.97	18.93	19.65	20.24	20.72
4	18.42	22.09	23.97	25.24	26.20	26.98	27.63
5	23.03	27.61	29.96	31.55	32.76	33.73	34.54
HQC							
$k/n$	100	250	400	550	700	850	1000
2	6.11	6.83	7.16	7.37	7.52	7.64	7.73
3	9.16	10.25	10.74	11.05	11.28	11.45	11.60
4	12.22	13.67	14.32	14.74	15.04	15.27	15.46
5	15.27	17.09	17.90	18.42	18.80	19.09	19.33

Source: own work.

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