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Beyond tariffs: The heterogeneous impact of trade facilitation on technology-intensive trade in Asean+3

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Abstract

Amidst deep economic integration in the ASEAN+3 region, traditional trade barriers such as tariffs have been substantially reduced, yet overall trade costs remain a significant impediment. This study investigates the contemporary drivers of trade in the region, seeking to provide an empirically grounded solution to a second-generation policy paradox: while tariff reduction has largely exhausted its utility, a chasm has opened between de jure openness and de facto trade friction. Using a detailed sector-level panel dataset from 2017-2022 and a structural gravity model estimated with the Poisson Pseudo-Maximum Likelihood (PPML) estimator and high-dimensional fixed effects (HDFE), we present two main findings that address this dilemma. First, we demonstrate that trade facilitation efforts in the importing country, as measured by the OECD Trade Facilitation Indicators (TFIs), are a decisive factor, exerting a positive and highly statistically significant effect on trade flows. In contrast, the impacts of tariffs and general institutional indicators are found to be negligible, confirming that procedural and logistical costs now represent the primary impediment to the seamless flow of goods required by intricate Global Value Chains (GVCs). Second, and our most novel contribution, we reveal that this effect is profoundly heterogeneous: the benefits of improved trade facilitation are systematically amplified for higher-technology sectors. This finding aligns with the theory that these sectors are disproportionately organized within time-sensitive GVCs and are thus the greatest beneficiaries when such frictions are reduced. This study reframes trade facilitation not merely as a trade policy but as a strategic industrial policy, enabling nations to attract investment and upgrade their position in global value chains.

Keywords: Global value chains, Gravity model, Heterogeneous impact, Industrial policy, Trade facilitation.

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1. Introduction

The ASEAN+3 region, encompassing the ten member states of the Association of Southeast Asian Nations plus China, Japan, and South Korea, has emerged over the past three decades as an undisputed epicenter of global manufacturing and a paradigm of modern economic integration. Functioning as a highly interconnected "Factory Asia," the bloc's economic architecture is defined by its deep immersion in GVCs, where production processes are fragmented across borders into intricate networks of trade [1]. This model has propelled the region's growth, characterized by a dense web of intra-regional trade that is significantly more connected than its investment network, particularly in intermediate and high-technology goods like electronics and machinery [2, 3]. The institutional scaffolding for this success has been meticulously constructed through landmark agreements, most notably the ASEAN Economic Community (AEC) and the Regional Comprehensive Economic Partnership (RCEP). These initiatives have been remarkably effective in achieving their primary, first-generation objective: the systematic dismantling of traditional, at-the-border tariff barriers, creating what is, on paper, one of the world's most open trading areas [4, 5].

However, the very triumph of this GVC-centric, tariff-liberalized model has given rise to a second-generation developmental paradox that now constitutes the region's most pressing policy challenge. While the initial engine of growth-tariff reduction-has largely exhausted its utility, overall trade costs remain stubbornly high [6]. A chasm has opened between the de jure openness suggested by low tariffs and the de facto friction experienced by firms navigating the region's logistical and procedural landscape. These persistent "behind-the-border" costs, stemming from inefficient customs procedures, infrastructural bottlenecks, and a lack of transparency, now represent the primary impediment to the seamless flow of goods required by intricate GVCs [7, 8]. This friction not only threatens the operational efficiency of Factory Asia but also exposes a deeper, more insidious risk: a developmental cul-de-sac. The current model, which facilitated rapid industrialization through integration into GVCs, now risks trapping economies in low-value-added assembly and processing roles [9]. There is growing evidence of a disconnect between the technological sophistication of the region's exports and the actual domestic capabilities of the exporting nations, suggesting that genuine technological upgrading and knowledge spillovers are not occurring automatically [10, 11]. For the region's policymakers, the strategic imperative has thus shifted fundamentally. The central problem is no longer how to negotiate the final percentage points off of tariffs, but to identify the next-generation policy lever that can both reduce modern trade costs and, crucially, catalyze a structural shift towards higher-value, knowledge-intensive economic activities.

This urgent policy dilemma highlights a significant and consequential gap in the empirical literature. While a broad consensus confirms the trade-promoting effects of trade facilitation [12], there is a dearth of research that rigorously weighs its contemporary potency against residual tariffs within the unique, deeply integrated context of ASEAN+3. More critically, the existing body of work has largely operated under a "one-size-fits-all" assumption, treating the impact of trade facilitation as homogenous across all sectors of the economy. This oversight is particularly problematic because it ignores the very dimension at the heart of the industrial upgrading challenge. The high-technology sectors that are pivotal for escaping the middle-income trap are precisely those organized within the most complex and time-sensitive GVCs [13]. As established by the seminal work of Hummels and Schaur [14], time itself is a formidable trade barrier, and firms in fast-paced industries are willing to pay significant premiums for speed and predictability. It is a logical necessity, therefore, that any policy instrument that reduces time-related frictions-the core function of trade facilitation-should disproportionately benefit these specific sectors. An effective policy solution must not only reduce costs generally but must also be strategically potent, specifically benefiting the very industries that nations need to cultivate for future growth.

This study confronts this policy problem directly, seeking to provide an empirically grounded solution. The "red thread" of our inquiry is to reframe trade facilitation not merely as a tool for efficiency, but as an instrument for strategic industrial transformation. To this end, we ask two targeted research questions that flow directly from the identified policy problem and knowledge gap: (i) in the current GVC-centric landscape of ASEAN+3, which policy instrument-residual tariffs or trade facilitation-is the effective driver of trade?; (ii) does trade facilitation disproportionately benefit higher-technology sectors, thereby offering a viable pathway for industrial upgrading within GVCs?

To answer these questions, we construct a detailed sector-level panel dataset for the period 2017-2022 and employ a state-of-the-art structural gravity model. Our primary contribution is to offer a clear, evidence-based roadmap for the next phase of the region's trade policy. First, we provide a decisive verdict that trade facilitation is now the preeminent driver of trade, with tariffs having become statistically irrelevant. Second, and our most novel finding, we uncover a strong, robust, and economically significant heterogeneous effect: the trade-promoting impact of facilitation is systematically amplified for high-technology sectors. This finding is of critical policy importance. It elevates trade facilitation from a simple cost-reduction tool to a strategic industrial policy. It provides a clear, actionable mechanism through which ASEAN+3 nations can enhance their attractiveness for high-value GVC links, thereby fostering the industrial upgrading necessary for long-term, sustainable development.

The remainder of this paper is organized as follows. Section 2 reviews the theoretical foundations and related empirical literature. Section 3 details the data and econometric methodology. Section 4 presents and discusses the main results. Finally, Section 5 concludes and offers policy implications.

2. Literature Review

This study is built on a logical progression of three theoretical and empirical pillars that justify its methodology, frame its primary inquiry, and form the basis for its core hypothesis.

2.1. The Structural Gravity Model: Methodological Foundations

The first pillar is the structural gravity model, which provides the methodological foundation for our analysis. The modern understanding of the gravity equation was theoretically grounded by Anderson and Van Wincoop [15] who demonstrated that bilateral trade depends not only on economic size and bilateral barriers but also critically on "multilateral resistance terms" (MRTs). These terms capture the general equilibrium effects of trade costs across all partners. Ignoring MRTs is not a trivial omission; it induces a severe omitted variable bias that can lead to erroneous conclusions about the impact of trade policies [16, 17]. The state-of-the-art method to account for MRTs, adopted in this paper, is the inclusion of HDFE. A comprehensive set of dummies (e.g., exporter-year and importer-year) absorbs the unobservable resistance terms, ensuring that the estimated coefficients on policy variables are not contaminated by these general equilibrium forces [18, 19].

For estimation, the literature has moved decisively away from the traditional practice of log-linearizing the model for OLS. This approach suffers from two critical flaws. First, as Silva and Tenreyro [20] demonstrated, it produces biased estimates in the presence of heteroskedasticity, a common feature of trade data. Second, it necessitates dropping all observations with zero trade, which not only reduces sample size but also discards valuable economic information about trade relationships where barriers are prohibitively high. To address these issues, the PPML estimator has been established as the robust and consistent solution, becoming the "workhorse" model in empirical international trade [21]. Our decision to employ a structural gravity model estimated via PPML with HDFE is therefore not an arbitrary choice, but a direct application of two decades of methodological evolution aimed at ensuring our results are theoretically consistent, empirically robust, and unbiased.

2.2. Empirical Evidence on Trade Facilitation

The second pillar concerns our primary variable of interest: trade facilitation. Broadly defined, trade facilitation encompasses measures to simplify, modernize, and harmonize export and import processes, thereby reducing the "behind-the-border" costs associated with customs procedures, logistics, infrastructure, and transparency [8, 22]. The OECD's Trade Facilitation Indicators (TFIs) have emerged as a standard, comprehensive metric to quantify these efforts across countries.

A vast body of empirical literature has established a robust consensus: improvements in trade facilitation significantly and positively impact trade flows. Studies consistently show that reducing time and costs at the border, enhancing logistics performance, and improving the business environment lead to greater trade volumes [12, 23]. For instance, research has demonstrated that better trade facilitation not only increases the volume of existing trade (the intensive margin) but also expands the variety of products a country exports (the extensive margin). Persson [24] quantified this effect, finding that a 1% reduction in export transaction costs could increase the number of differentiated products exported by 0.6%. The importance of logistics and physical infrastructure is particularly pronounced. Better infrastructure, such as efficient ports and road networks, directly lowers transport costs and improves connectivity, which is a fundamental determinant of trade [25, 26]. Indeed, enhancing logistics performance and facilitating trade behind the border can have an impact on expanding exports that is as substantial, if not more so, than reducing tariffs [7].

This focus on behind-the-border costs reflects a crucial shift in trade policy. As tariffs have fallen globally, non-tariff and procedural barriers have become the dominant source of trade friction [27, 28]. This is the context for our first research question, which seeks to empirically weigh the contemporary importance of these different policy levers in driving trade within the region's highly evolved GVCs.

2.3. GVCs and time as a Trade Barrier: Hypothesizing heterogeneity

The final pillar builds the theoretical case for our core hypothesis on the heterogeneous impact of trade facilitation. The organization of modern international trade is dominated by GVCs, a paradigm where production processes are fragmented into discrete tasks and geographically dispersed [1]. This is especially true for high-technology sectors, where complex products like electronics and automobiles are assembled from components that have crossed borders multiple times [3, 9]. The efficiency of these intricate networks hinges on the seamless, predictable, and rapid movement of goods, making GVCs profoundly sensitive to time [13].

The seminal work of Hummels and Schaur [14] established "time as a trade barrier," providing strong evidence that firms are willing to pay substantial premiums for speed and reliability. In a GVC context, the cost of time is not merely the opportunity cost of capital tied up in transit; it is the risk of systemic disruption. Industries reliant on "just-in-time" inventory systems are acutely vulnerable, as a delay in a single critical component can halt an entire assembly line, leading to cascading failures [29]. This sensitivity varies by sector; for instance, the trade-inhibiting effect of distance is more pronounced for bulky, low-value goods than for high-value electronics [30].

This is where trade facilitation becomes a critical enabler. Its primary function is to reduce the friction that causes delays and uncertainty at the border [28]. We forge a decisive link between these concepts: if high-technology sectors are disproportionately organized within time-sensitive GVCs, and if trade facilitation directly mitigates these time-related trade barriers, then it follows logically that such sectors should be the primary beneficiaries of facilitation reforms. Our hypothesis of a heterogeneous effect is thus not a conjecture, but a testable implication derived from the intersection of GVC theory [31] and the economics of time as a trade cost, providing a clear rationale for our second research question.

2.4. Research Gap and Contribution

The existing literature, while robust, leaves a critical gap that this study aims to fill. First, while the general positive effect of trade facilitation is well-established, there is a lack of systematic evidence comparing its potency against residual

tariffs in a deeply integrated, low-tariff region like ASEAN+3. Second, and more importantly, the literature on trade facilitation has largely assumed a homogenous impact across sectors. Although sectoral heterogeneity in trade *costs* is acknowledged [30] the heterogeneous *benefits* of trade facilitation *reforms* have not been a central focus.

Our contribution is therefore twofold. We provide a clear, empirically-grounded answer to the contemporary policy debate in ASEAN+3 about where to focus reform efforts. More uniquely, by explicitly testing for heterogeneity, we reframe trade facilitation not just as a tool for lowering costs, but as a potential instrument for industrial policy. We provide the first piece of evidence suggesting that by reducing time-sensitive trade frictions, trade facilitation can create a more favorable environment for the very high-technology industries that are crucial for economic upgrading in the GVC era.

3. Data and Methodology

3.1. Data

The study utilizes a sector-level panel dataset spanning the years 2017 to 2022. It includes 13 countries from the ASEAN+3 bloc, with Brunei and Laos excluded due to a lack of data for the Trade Facilitation Indicators (TFIs).

The primary dependent variable is bilateral trade value. This data is sourced from the UNCTADSTA database and is aggregated according to the SITC Rev. 2 industry classification. Additionally, the technological intensity of each sector is classified using the Lall [32] framework, which divides manufacturing industries into five categories: primary, low-tech, medium-tech, high-tech, and other.

For the main explanatory variables, the Trade Facilitation Indicators (TFI), which measure the overall trade facilitation scores for both the importing and exporting countries, are obtained from the OECD. The TFI scores range from 0 to 2, with higher values signifying better trade facilitation. The effectively applied tariff rates are sourced from the World Bank database. Additionally, institutional quality indicators, specifically Government Effectiveness and Rule of Law, are drawn from the World Bank's Worldwide Governance Indicators (WGI) dataset. The study also incorporates standard gravity variables such as GDP, population, distance, contiguity, and common language, which are sourced from the CEPII GeoDist database.

3.2. Econometric Model

Following the best practices established in the literature, we specify a structural gravity equation to be estimated with the PPML method. This approach, advocated by Santos and Tenreyro [33] and Silva and Tenreyro [20] is robust to heteroskedasticity and naturally accommodates zero-trade flows, ensuring consistent and unbiased estimates.

First, the baseline model: to answer our first research question on the relative importance of trade facilitation, we specify the following baseline model:

$$Trade_{isjt} = \exp(\beta 1 TF_{jt} + \beta 2 Tariff_{isjt} + Z_{jt}'\gamma + \mu_{isj} + \eta_t) + \epsilon_{isjt} \quad (1)$$

where $Trade_{isjt}$ is the value of exports from country i to country j in sector s at year t. TF_{jt} is the overall Trade Facilitation Indicator score for the importer j, and Tariffisjt is the sector-specific tariff. Z_{jt} is a vector of additional time-varying controls for the importer, namely institutional quality indicators. Following the structural gravity framework, all exporter-specific characteristics and time-invariant bilateral factors (like distance or language) are absorbed by the fixed effects, μ_{isj} and η_t.

Interaction model: to test our second hypothesis on the heterogeneous impact of trade facilitation, we augment the baseline model with interaction terms between the importer's TFI and dummy variables for each technology level, as defined by the Lall [32] classification:

$$Trade_{isjt} = \exp(\beta_1 TF_{jt} + \beta_2(TF_{jt} \times TechLevel_s^{Low}) + \beta 3(TF_{jt} \times TechLevel_s^{Medium}) + \beta 4(TF_{jt} \times TechLevel_s^{High}) + \beta 5 Tariff_{isjt} + Z_{jt}'\gamma + \mu_{isj} + \eta_t) + \epsilon_{isjt}$$

Where:

- $Trade_{isjt}$: The value of exports from country i to country j in sector s at year t.
- TF_{jt}: The overall Trade Facilitation Indicator score for the importer j.
- $TechLevel_s^{Low}$: A dummy variable equal to 1 if sector s belongs to the low-tech group, and 0 otherwise.
- $TechLevel_s^{Medium}$: A dummy variable equal to 1 if sector s belongs to the medium-tech group, and 0 otherwise.
- $TechLevel_s^{High}$: A dummy variable equal to 1 if sector s belongs to the high-tech group, and 0 otherwise.
- β_1: The coefficient measuring the effect of TFjt on the trade of the omitted reference group, which is primary goods.
- β_2, β_3, β_4: The main coefficients of interest, which measure the additional marginal effect of TFjt on trade for the low-tech, medium-tech, and high-tech sectors, compared to its effect on the primary goods sector. A positive and statistically significant coefficient indicates that the benefits of trade facilitation are amplified for that technology level.
- $Tariff_{isjt}$: The sector-specific tariff.
- $Z_{jt}'\gamma$: A vector of additional time-varying controls for the importer, including institutional quality indicators.
- μ_{isj}: The country-pair-sector fixed effect, which absorbs all time-invariant unobserved heterogeneity between a pair of countries in a specific sector.
- η_t: The year fixed effect, which controls for global shocks affecting all trading pairs simultaneously.
- ϵ_{isjt}: The random error term.

3.3. Identification Strategy

To isolate the impact of our policy variables from confounding factors, our identification strategy relies on a comprehensive set of HDFE, a technique essential for mitigating omitted variable bias in gravity models (Fally, 2015). Our preferred specification includes a combined country-pair-sector fixed effect (μisj) and a year fixed effect (ηt).

The pair-sector fixed effect is a particularly stringent control. It absorbs all unobserved heterogeneity that is specific to a trade relationship between two countries in a particular sector and is constant over time. This includes standard gravity variables like geographical distance and contiguity, as well as more nuanced factors like historical trade ties, established supply chain linkages, or specific cultural affinities related to certain products. The year fixed effect accounts for any global shocks that affect all trading pairs simultaneously in a given year, such as global business cycles or the average impact of the COVID-19 pandemic.

By incorporating this HDFE structure, we ensure that the estimated coefficients on our time-varying policy variables reflect their impact net of a vast array of potential unobserved confounders. This rigorous approach, which aligns with the state-of-the-art recommendations for applied trade analysis [34] strengthens the internal validity of our findings and allows for a more reliable interpretation of the results.

4. Results and discussion

This section presents and interprets the econometric results, first establishing the primary drivers of trade in the region and then investigating the core hypothesis regarding the heterogeneous impact of trade facilitation.

4.1. Baseline Finding: The Preeminence of Trade Facilitation

Table 1 presents the results of the baseline gravity model. Across all three specifications – imports (1), exports (2), and total trade (3) – the findings are consistent and clear. The coefficient on the importer's Trade Facilitation Indicator (TF_d) is positive and statistically significant for both imports and total trade. Focusing on column (1), the coefficient of 0.617 is significant at the 1% level. This can be interpreted as an elasticity: a 1% improvement in the importing country's trade facilitation performance is associated with a 0.617% increase in import value, holding all other factors constant. This provides strong, direct evidence that "behind-the-border" reforms in the destination market are a critical determinant of trade flows in ASEAN+3. This finding is consistent with a vast body of empirical literature that has established a robust consensus: improvements in trade facilitation significantly and positively impact trade flows. Studies consistently show that enhancing logistics performance and improving the business environment lead to greater trade volumes [12, 23]. The importance of logistics and physical infrastructure is particularly pronounced, as they directly lower transport costs and improve connectivity, which are fundamental determinants of trade [25, 26]. Indeed, enhancing logistics performance and facilitating trade behind the border can have an impact on expanding exports that is as substantial, if not more so, than reducing tariffs [7].

Table 1.
Main Determinants of Trade (Standard FE).

	Import	**Export**	**Total Trade**
AHS_WATariff_d	-0.011	0.022	0.004
	(0.017)	(0.015)	(0.013)
TF_d	0.617***	0.267	0.429**
	(0.231)	(0.213)	(0.170)
estimate_cc_d	-0.088	-0.112	-0.116
	(0.145)	(0.154)	(0.123)
estimate_ge_d	0.128	0.056	0.076
	(0.156)	(0.130)	(0.115)
covid	0.000	0.000	0.000
	(.)	(.)	(.)
_cons	13.955***	14.773***	15.055***
	(0.355)	(0.338)	(0.279)
Observations	12.579.000	13.462.000	12.493.000

Note: Standard errors in parentheses
* p<0.10 ** p<0.05 *** p<0.01.

In stark contrast, the coefficient for applied tariffs (AHS_WATariff_d) is statistically indistinguishable from zero across all models. Similarly, the general institutional quality variables (estimate_cc_d for Control of Corruption and estimate_ge_d for Government Effectiveness) show no significant effect. This null finding is as informative as the positive result for TFI. It empirically confirms that in a region that has already achieved extensive tariff liberalization, residual tariffs are no longer a binding constraint on trade [6]. Instead, the results indicate that the binding constraints are now procedural and logistical – the very costs that trade facilitation is designed to reduce. The very triumph of this GVC-centric, tariff-liberalized model has given rise to a second-generation developmental paradox that now constitutes the region's most pressing policy challenge [9]. A chasm has opened between the de jure openness suggested by low tariffs and the de facto friction experienced by firms navigating the region's logistical and procedural landscape [7, 8].

4.2. Advanced Finding: The Heterogeneous Impact by Technological Intensity

Table 2, which presents the results of the interaction model, is central to the study's contribution. The coefficients on the interaction terms (tech_level#c.TF_d) reveal a clear and compelling pattern that demonstrates the heterogeneous nature of trade facilitation's impact. The effect of trade facilitation reforms systematically varies across sectors based on their technological intensity.

For imports (column 1), the interaction term for low-tech industries (2.tech_level#c.TF_d) is small and statistically insignificant (-0.052). This suggests that the benefits of trade facilitation for low-tech manufacturing are not significantly different from those for the reference category of primary goods. However, this picture changes dramatically as the analysis moves up the technology ladder. The interaction term for medium-tech industries (3.tech_level#c.TF_d) is positive and significant (1.440, $p<0.05$), and for total trade (column 3), this term is also positive and significant (0.972, $p<0.05$). The effect is even more pronounced for high-tech industries (4.tech_level#c.TF_d), which show a positive and significant effect on total trade (0.956, $p<0.10$).

Table 2.
Heterogeneous Effects of TFI across Technology Levels.

	Import	Export	Total Trade
TF_d	0.127	-0.210	-0.136
	(0.298)	(0.395)	(0.245)
2.tech_level	-0.198	-0.040	-0.313
	(0.792)	(0.684)	(0.523)
3.tech_level	-2.784***	-0.186	-1.487**
	-1.006	(0.731)	(0.614)
4.tech_level	-1.592	-0.260	-1.085
	-1.256	(0.838)	(0.847)
1.tech_level#c.TF_d	0.000	0.000	0.000
	(.)	(.)	(.)
2.tech_level#c.TF_d	-0.052	0.351	0.238
	(0.519)	(0.437)	(0.331)
3.tech_level#c.TF_d	1.440**	0.536	0.972**
	(0.629)	(0.477)	(0.383)
4.tech_level#c.TF_d	0.996	0.774	0.956*
	(0.771)	(0.532)	(0.515)
AHS_WATariff_d	0.004	0.019	0.011
	(0.016)	(0.016)	(0.013)
estimate_cc_d	-0.068	-0.107	-0.102
	(0.147)	(0.156)	(0.125)
estimate_ge_d	0.121	0.053	0.071
	(0.159)	(0.130)	(0.116)
covid	0.000	0.000	0.000
	(.)	(.)	(.)
_cons	14.978***	15.004***	15.864***
	(0.498)	(0.580)	(0.406)
Observations	11.441.000	12.219.000	11.360.000

Note: Standard errors in parentheses
* p<0.10 ** p<0.05 *** p<0.01.

This escalating pattern provides unambiguous support for the central hypothesis. The trade-promoting effect of an improvement in trade facilitation is systematically amplified for sectors with higher technological content. This finding is consistent with the theoretical framework that high-technology sectors are disproportionately embedded in complex and time-sensitive GVCs, making them acutely vulnerable to logistical delays and procedural uncertainty [13]. Consequently, these sectors are also the greatest beneficiaries when such frictions are reduced through effective trade facilitation. The seminal work of Hummels and Schaur [14] established "time as a trade barrier," providing strong evidence that firms are willing to pay substantial premiums for speed and reliability. The literature further suggests that participation in GVCs, particularly for high-tech exports, is heavily influenced by factors such as human capital, FDI, and the quality of domestic institutions, underscoring the importance of a favorable trade environment. There is also growing evidence of a disconnect between the technological sophistication of the region's exports and the actual domestic capabilities of the exporting nations, suggesting that genuine technological upgrading and knowledge spillovers are not occurring automatically [10].

These findings elevate trade facilitation from a simple cost-reduction tool to a strategic industrial policy. By creating an efficient and reliable environment for logistics and customs clearance, nations can enhance their attractiveness for high-value GVC links and enable domestic firms to participate more deeply and move up in value chains [31]. The pursuit of

trade facilitation is thus a viable pathway for industrial upgrading and long-term economic development, especially in the GVC era.

4.3. Robustness Checks and Extensions

To ensure the validity of our core findings, we conducted a series of robustness tests, presented in the Appendix. In Table 5, we re-estimate our main import model using a more demanding fixed effects structure (product-level FE). The coefficient on TF_d remains positive and highly significant (0.824, $p<0.01$), confirming that our central result is not sensitive to the choice of model specification [19, 21]. The use of the PPML estimator is also considered a robust method for handling issues such as zero trade values and heterogeneity between country pairs [35].

Further analyses in the Appendix explore alternative variable specifications. Table 3 decomposes the aggregate TFI into its eleven sub-components. While some individual components, such as 'documents' and 'involvement of trade community', show significant effects, the overall results are less stable, likely due to multicollinearity among the indicators. This confirms the validity of using the comprehensive aggregate TFI in our main analysis, as the index itself has emerged as a standard, comprehensive metric to quantify these efforts across countries [36, 37].

Table 3.
Decomposing TFI Components.

	Import	**Export**	**Total Trade**
AHS_WATariff_d	0.005	0.013	0.009
	(0.017)	(0.014)	(0.012)
tfi_info_avail_d	-0.333*	0.205	-0.012
	(0.197)	(0.206)	(0.172)
tfi_involve_trade_d	0.544***	0.081	0.327**
	(0.162)	(0.176)	(0.143)
tfi_adv_rulings_d	-0.166	-0.035	-0.098
	(0.104)	(0.119)	(0.085)
tfi_appeal_d	0.024	0.227	0.105
	(0.146)	(0.184)	(0.142)
tfi_fees_charges_d	-0.611***	-0.164	-0.354**
	(0.202)	(0.182)	(0.149)
tfi_docs_d	0.475***	0.275***	0.363***
	(0.151)	(0.103)	(0.098)
tfi_automation_d	0.018	-0.354**	-0.180
	(0.172)	(0.156)	(0.137)
tfi_procedures_d	-0.206	-0.132	-0.156
	(0.265)	(0.199)	(0.192)
tfi_coop_internal_d	0.030	-0.110	-0.077
	(0.092)	(0.108)	(0.084)
tfi_coop_external_d	0.479***	0.325**	0.392***
	(0.137)	(0.130)	(0.105)
tfi_governance_d	-0.113	0.102	0.043
	(0.185)	(0.168)	(0.146)
estimate_cc_d	0.001	-0.172	-0.104
	(0.148)	(0.166)	(0.131)
estimate_ge_d	0.241*	0.137	0.174*
	(0.146)	(0.130)	(0.104)
covid	0.000	0.000	0.000
	(.)	(.)	(.)
_cons	14.770***	14.588***	15.198***
	(0.437)	(0.403)	(0.332)
Observations	12.393.000	13.277.000	12.311.000

Note: Standard errors in parentheses
* p<0.10 ** p<0.05 *** p<0.01.

Table 4.
ESG Pillar Analysis.

	Import	Export	Total Trade
AHS_WATariff_d	-0.004	0.023	0.007
	(0.017)	(0.015)	(0.012)
tfi_pillar1_d	0.133	0.023	0.113
	(0.274)	(0.260)	(0.181)
tfi_pillar2_d	0.323	0.133	0.168
	(0.216)	(0.200)	(0.144)
tfi_pillar3_d	0.174	-0.015	0.097
	(0.190)	(0.175)	(0.137)
esg_E_pillar_d	-0.002	-0.014	-0.008
	(0.011)	(0.009)	(0.008)
esg_S_pillar_d	-0.053**	-0.023	-0.036**
	(0.025)	(0.022)	(0.018)
estimate_cc_d	-0.079	-0.144	-0.120
	(0.149)	(0.160)	(0.125)
estimate_ge_d	0.131	0.041	0.061
	(0.147)	(0.137)	(0.111)
covid	0.000	0.000	0.000
	(.)	(.)	(.)
_cons	16.672***	16.361***	17.120***
	(1.447)	(1.272)	(1.092)
Observations	12579.000	13462.000	12493.000

Note: Standard errors in parentheses
* p<0.10 ** p<0.05 *** p<0.01.

Table 5.
Main Model with Tighter (product-level) FE.

	Import
TF_d	0.824***
	(0.207)
covid	0.000
	(.)
_cons	14.319***
	(0.335)
Observations	14084.000

Note: Standard errors in parentheses
* p<0.10 ** p<0.05 *** p<0.01.

Table 4 introduces Environmental, Social, and Governance (ESG) pillars as additional controls. The main effect of TF_d remains unchanged, and the ESG variables themselves do not exhibit a consistent, significant impact. This suggests that their role is complex and warrants separate, dedicated research, a point consistent with literature on the nuanced and often indirect relationship between ESG factors and trade [12]. Similarly, some studies have indicated that broader governance factors, such as institutional quality, do not have a significant impact on trade in certain regional contexts, suggesting that specific logistical and procedural issues may be the primary constraints [7].

5. Conclusion and Policy Implications

This study provides a clear and evidence-based roadmap for the next phase of the ASEAN+3 region's trade policy. The analysis, which uses a structural gravity model and a detailed sector-level panel dataset, yields two main conclusions. First, trade facilitation in the importing country is the preeminent driver of trade flows, while tariffs and general institutional indicators have a negligible impact. This finding empirically confirms that the region's primary policy challenge has shifted from dismantling tariffs to addressing "behind-the-border" trade costs. Second, the benefits of trade facilitation are profoundly heterogeneous, being systematically amplified for sectors with higher technological intensity. This effect suggests that improved trade facilitation disproportionately benefits the very industries that nations need to cultivate for future growth.

The findings of this study yield two critical policy implications for policymakers in the region. First, they call for a decisive strategic shift in priorities. Instead of expending political and financial capital on negotiating the final percentage points of tariff reductions, governments should focus on substantive investments in "behind-the-border" reforms. This

includes modernizing port and border infrastructure, digitizing and simplifying customs procedures, and establishing genuinely effective national single windows.

Second, the results demonstrate that trade facilitation is not merely a trade policy but a strategic industrial policy. By creating an efficient and reliable environment for logistics and customs clearance, nations can cultivate a dynamic comparative advantage and attract investment into higher value-added manufacturing sectors. This enables domestic firms to participate more deeply and move up in global value chains, thereby fostering the industrial upgrading necessary for long-term, sustainable development. The pursuit of these reforms provides a viable pathway for economies to escape a developmental cul-de-sac that risks trapping them in low-value-added assembly and processing roles. A limitation of this study is its use of industry-level data. Future research using firm-level data could further explore the mechanisms behind the heterogeneous effects identified here.

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