

## Article

# Environmental Sustainability, Financial Conditions, and Export Performance in Thailand's Textile and Clothing Industry Under Trade Liberalization and the Post-ATC Era

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## Abstract

This study investigates the impact of environmental factors, financial conditions, and trade-related policy on Thailand's textile and clothing exports under the ASEAN–China Free Trade Agreement (ACFTA) and the WTO's Agreement on Textiles and Clothing (ATC), focusing on export performance and trade creation between 1990 and 2024, using strong panel data across 31 countries from 11 ASEAN–China member countries and 20 non-member countries. This study has been guided by Porter's competitive advantage theory and the gravity trade framework. The analysis was conducted using STATA 18 to analyze the fixed-effects regression alongside a robust Poisson Pseudo-Maximum Likelihood (PPML) estimation. The results indicate that (1) improvements in environmental, trade, and financial conditions are associated with higher export performance, (2) the results do not support trade creation under ACFTA, with the estimated ACFTA coefficient being negatively associated with export volume, and (3) the post-ATC effect is not consistently supported across model specifications and is not statistically significant in the combined specification. The findings suggest that export performance is jointly influenced by these dimensions rather than by trade liberalization and the post-ATC agreement alone. We recommend that policymakers support firms in managing the transition costs associated with green production, strengthen international trade cooperation, and maintain macroeconomic stability to enhance the long-term export performance of Thailand's textile and clothing industry. These findings provide evidence that environmental sustainability and macro-financial conditions remain important determinants of export performance under changing global trade conditions. Future research may incorporate additional variables, broader datasets, and alternative econometric approaches to further validate the robustness of the findings.

**Keywords:** environmental sustainability; financial conditions; trade liberalization; export performance; textile and clothing



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## 1. Introduction

The textile and clothing industry has been an important and longstanding source of labor in many countries. It has a long history and remains one of the world's major manufacturing industries, especially in Asia, which impacts the labor sector, industry sector, and domestic economy (Y. Yang & Zhong, 1998). However, the textile and clothing industry has a negative impact on the environment and human health, such as carbon emissions due to increased renewable costs. Moreover, the textile and clothing industry is influenced not only by environmental sustainability but also by macro-financial conditions. For example, exchange rates and inflation increase costs, pricing, and financial decisions in the industry. Financial resources and green investment will be the part of sustainable production cost. As a result, financial conditions, environmental sustainability, and trading have become interrelated determinants of export performance in the global textile and clothing industry.

The textiles and clothing industry is one of the main export sectors in Thailand, and it impacts the economy, labor market, and industrial sector. The export performance becomes the main economic driving force and employs more than 570,000 workers from 2011 to 2016 (Lilavanichakul et al., 2025; Jongwanich, 2024). However, the trade challenges have been caused by a sharp increase in competition in the global market and trade-related policies. Although the textile and clothing industry has been the main key driver of economic growth and employment in many countries, the production processes involved in these industries have damaged ecosystems through the release of toxic chemicals and human health (Rofi & Rahman, 2025; Desore & Narula, 2018; Yusuff & Sonibare, 2004). In terms of ecosystems, the textile and clothing industries have increased renewable energy, green innovation, and technology to reduce emission release and increase environmental quality. This green transition has increased renewable energy and eliminated emission release, leading to industries' deep concern about ecosystems and export performance. To compete in an intensive global market, many industries try to apply global value chains (GVCs) to business and productivity with increasing renewable energy, supply chain, and environmental guarantee standards (Imbruno et al., 2024; Solingen, 2025; Li et al., 2025; Gorodnyi et al., 2025). Environmental factors, therefore, are one of the determinants of export performance in the global market.

Additionally, financial conditions have a major impact on export performance, especially in pricing and cost. The exchange rate has a substantial effect on price competitiveness in the global market (Wani, 2025), while the inflation rate influences the work of entrepreneurs, costs, and prices through export performance (Nahabwe & Kagarura, 2026; Aisyah et al., 2026; Výškrabka & Bodea, 2026). Rising inflation may reduce the competitiveness of textile and clothing exports through increased production costs and weaker price competitiveness in global markets (Výškrabka & Bodea, 2026). Hence, financial factors, particularly exchange rate stability and inflation control, are essential determinants of export performance, as they directly affect production costs, pricing strategies, and firms' ability to compete in international markets (Porter, 1990).

Beyond affecting production costs and export pricing, financial conditions also influence firms' ability to adapt to increasingly stringent environmental requirements and changing international trade conditions. Consequently, financial conditions serve as an important channel through which environmental sustainability and trade liberalization influence export performance. This perspective extends Porter's Competitive Advantage Theory by highlighting the complementary role of financial conditions in shaping export performance. These findings suggest that financial conditions should not be viewed as isolated macroeconomic factors but as key mechanisms through which trade policies and environmental transitions influence export performance. Recent changes in the global economy have highlighted the growing importance of macro-financial conditions in sustaining

international trade. Fluctuations in exchange rates and inflation increasingly influence firms' production decisions, pricing strategies, and export performance. These issues have become particularly important for export-oriented industries operating under evolving international trade arrangements and changing geopolitical conditions.

In 2008, many countries, particularly those in East Asia, experienced a financial crisis that caused economic development to decrease in Thailand. However, Thailand has used trade as a tool to boost its economy. Therefore, exports are one of the main economic driving forces in Thailand, contributing to GDP growth and employment (World Bank, 2022). Thailand's economy depends on many export industries, including agriculture, manufacturing, machinery, and cultural products (Tonsakunthaweeteam, 2024). However, local products have been restricted by trade barriers in the global market through high-tax import duties and customs procedures, unfairly affecting small- and medium-sized exporters (UNCTAD, 2021). In response to these barriers, economic integration has been established, and a free trade agreement (FTA) has been used as a tool to solve these trade and product problems.

Although textiles and clothing make up an important export sector in Thailand, representing some of the country's most famous cultural traditional products, this industry still faces global market competition (Gereffi & Frederick, 2010). The most important aspect of this sector is expertise and specialist labor (Y. Yang & Zhong, 1998), which leads to high costs and a lack of labor. Economic integration causes many countries to increase their export value, and Thailand has signed and joined more than 23 trading agreements (Charoenchang, 2018). A free trade agreement (FTA) aims to reduce trade barriers and tariffs between members (Nguyen et al., 2026), with many agreements also supporting increasing economic integration and environmental conservation at the same time (Ngan et al., 2026). Importers, hence, are influenced to purchase green products rather than using plastics, carbon, or fossil fuels (Berry et al., 2026). However, allowing free tax for trade agreement members has led to issues such as dumping the market, cheap pricing, similar products, and the loss of copies and licenses by members (Tonsakunthaweeteam, 2024). The textile and clothing industry has tried to adopt a new method of competing in the global market through agreements, but trade is declining.

It is obvious that trade liberalization has become an important driver of export performance and competitiveness in the textile and clothing industry. The ASEAN–China Free Trade Agreement (ACFTA) has had a substantial influence on Thailand's exports and imports. This agreement has aimed to reduce tariffs and trade barriers and support trading between 10 ASEAN member countries and China since 2001, with zero tax since 2010 (Tonsakunthaweeteam, 2024). Thailand, therefore, gains the benefit of expanding textile and clothing exports to the Chinese market and increasing its supply chain through economic integration. However, ACFTA has also intensified competition from Chinese textile manufacturers, who possess significant advantages in terms of production scale, technological capability, and cost efficiency (Y. Wang, 2026). As a result, the overall impact of ACFTA on Thailand's textile and clothing exports remains ambiguous and warrants further empirical investigation, though some studies have found trade diversion under ACFTA (Romadona & Pujiati, 2018).

To conserve cultural production in the global market, the ATC agreement has also been used to declare and eliminate quotas and tariffs in trade. The post-2005 period of the World Trade Organization's Agreement on Textiles and Clothing (ATC) represents the most important transition in the textile and clothing industry worldwide. After the quotas and tariffs of the Multi-Fibre Arrangement (MFA) were eliminated, textiles and clothing were integrated into bilateral trading, increasing market and trade liberalization. However, Wattanapruttipaisan (2005) argued that the post-2005 ATC has increased the

intensity of competitiveness in export sectors such as China and India, which have more comparative advantage in their economies of scale, low costs, and a high number of productive manufacturers than others, particularly in Thailand. The ATC has created both opportunities and challenges for exporters worldwide.

Porter's competitive advantage theory was proposed by Porter (1990), explaining how export performance has been increased by productivity, innovation, conditions, and government. It leads to the factors of ecosystem, financial conditions, and trading having become the main driving forces for improving performance in the global market. Meanwhile, the gravity model is used for an international trade framework explaining economic integration and the impact of trade on exports. The combining of Porter's competitive advantage theory and the gravity model, therefore, enables a comprehensive assessment of how ecosystems, financial conditions, and trading have a significant impact on textile and clothing export performance under the ACFTA and post-ATC agreement over 30 years.

The previous studies have examined the flow of international trade under free trade agreements (FTAs) for various products (Jongwanich, 2024; Darma, 2017; Jayasinghe & Sarker, 2008; S. Yang & Martínez-Zarzoso, 2014). However, there are a limited number of studies that have explored international trade, ecosystem, or financial condition under the ACFTA, which has caused trade creation, and no study has been conducted on the post-ATC period. Moreover, research on financial development, environmental factors, and trade in textiles and clothing has also been limited.

Therefore, Porter's Competitive Advantage Theory and the gravity model are used to examine framework how environmental factors, financial conditions, and trade policy indicators influences export performance in Thailand, and apply the ACFTA since 2010 and the post-ATC 2005 dummy variables to examine the effect of trade creation and the post-ATC regime on textile and clothing export performance from 1990 to 2024 across 31 countries, including 11 ACFTA member countries and 20 non-member countries. Accordingly, this study has three objectives: (1) to examine how environmental sustainability, financial conditions, and trade policy influence Thailand's textile and clothing export performance; (2) to assess the effects of the ACFTA on export performance and provide evidence regarding trade creation; and (3) to evaluate the effect of the post-ATC agreement on Thailand's textile and clothing export performance using an augmented gravity-model framework. Our study explores the following research questions:

- (1) What environmental sustainability, financial, and trade-related factors influence Thailand's textile and clothing export performance?
- (2) To what extent has ACFTA contributed to trade creation in Thailand's textile and clothing exports?
- (3) How has the post-ATC period influenced Thailand's textile and clothing export performance?

## 2. Literature Review

According to previous studies, many gaps still exist in the literature; therefore, our review will depend on these research gaps and our framework. In this study, we will explore the main effects of three indicators on textile and clothing export volumes—namely, environmental indicators, financial indicators, and trade indicators—under ACFTA and the WTO's ATC from 1990 to 2024, guided by Porter's competitive advantage theory and the gravity model.

### 2.1. Ecological System and Export Performance

Previous studies have examined the increasing market consumption of renewable energy, demonstrating that consumers are increasingly influenced by trends such as con-

serving the environment. The textile and clothing industries could additionally benefit by changing to green trading. Dogan et al. (2024) found that renewable energy consumption was the main factor in the OECD's transition to green energy to solve climate change. B. Wang et al. (2025) also confirmed that the importance of renewable energy policy has a substantial influence on energy transition in China. Green innovation and renewable energy have increased exports and finance by conserving the environment (Wei, 2026). Renewable energy has increased green innovation in technology and energy production, supporting exports and demonstrating competitiveness in emerging economies and the global market (Yu & Ma, 2025). Research has revealed that export diversification has enhanced renewable energy consumption in private enterprises (Lin & Li, 2026). While empirical studies have shown the advantage of renewable energy for exports at the firm level, they have not focused on products, economic growth, and industries.

According to Porter's Competitive Advantage Theory (Porter, 1990), firms can achieve superior export performance by improving productivity, resource efficiency, and innovation. Environmental sustainability practices, including cleaner production and renewable energy adoption, can reduce production inefficiencies and strengthen firms' long-term competitive capabilities. Therefore, environmental sustainability is expected to positively influence export performance.

Therefore, in this study, we will examine the impact of environmental indicators, including renewable energy consumption in partner countries and carbon emissions, on textile and clothing exports in Thailand, using the following formulation (1) and hypothesis (H1):

$$LNexp_{ijt} = \beta_0 + \beta_1 LNcar_{it} + \beta_2 LNrenew_{it} + \pi_{ij} + u_{ijt} \quad (1)$$

**H1.** *Environmental sustainability significantly influences Thailand's textile and clothing export performance.*

Environmental sustainability has become an important factor influencing export performance, particularly in environmentally sensitive industries (Porter & van der Linde, 1995). Carbon emissions are commonly interpreted as a proxy for industrial production intensity rather than a direct measure of export performance (Rofi & Rahman, 2025; Desore & Narula, 2018), while renewable energy consumption reflects firms' progress toward green production and sustainable manufacturing (Wei, 2026). These environmental conditions may influence production efficiency, compliance with environmental standards, and ultimately Thailand's textile and clothing export performance.

## 2.2. Financial Development, Environment, and Export Performance

Green innovation not only involves policies for conserving ecosystems but also involves increasing economic growth and financial strategies in the long term. Firms are more competitive in industries and global markets that focus on the environment and economic growth (Wei, 2026). In terms of tourism exports, inflation increased the negative effect of the ecosystem on tourism in 90 countries from 2011 to 2020 (Rastogi et al., 2024). Using panel data from 11 industries between 1977 and 2011, Bailliu and Fujii (2004) argued that the monetary policies on the exchange rate and low inflation have improved and conserved the environment. Zheng et al. (2024) explored monetary indicators, particularly inflation, which caused a decline in carbon emissions, using nonlinear autoregressive distributed lag (NARDL). The authors showed that the correlation between financial risk and the environment depends on the stage of economic development and energy. High inflation might decrease consumer purchasing power, leading to reduced carbon emissions in China. The study of financial development explains that finance and the environment

interact in multiple ways. Firstly, financial support has increased industries' expansion and production, causing the release of more carbon emissions. On the other hand, methods for improving the environment, such as green energy transitions, green investment, and renewable energy, have been developed by the financial system, leading to reduced carbon emissions. Therefore, the environmental impact of financial development largely depends on the allocation of financial resources and the effectiveness of environmental governance in using domestic credit for the private sector (% of GDP) (Rahman & Salimullah, 2026). According to previous studies, financial development has improved export performance, economic growth, and the environment on an entrepreneurial scale. However, no studies have focused on the effect of financial development on both export production and the environment, and domestic credit in the private sector (% of GDP) has shown multicollinearity in the model. In this study, we will examine the effect of financial indicators, including the exchange rate and inflation rate, on textile and clothing exports, using the following formulation (2):

$$LNexp_{ijt} = \beta_0 + \beta_1 LNexch_{it} + \beta_2 LNinf_{jt} + \pi_{ij} + u_{ijt} \quad (2)$$

Financial conditions also play an important role in determining export performance. Exchange rate movements directly affect export prices, while inflation influences production costs and firms' operating efficiency (Bailliu & Fujii, 2004; Zheng et al., 2024). Stable macroeconomic conditions, therefore, provide a more favorable environment for improving export performance.

### 2.3. The Free Trade Agreement (FTA)

Many scholars have investigated the relationship between trade and FTAs by studying economic development. In the long run, trade and the economy bring benefits to the domestic economy and productivity (Larson, 2015). International trade not only has advantages for the domestic economy but also has a major effect on the global market. However, the problem of unfair trade barriers still occurs in many countries (Marshall, 2013), and free trade agreements (FTAs) can be used to destroy and control business and trading. In Thailand, trading is one of the main driving forces for the economy, increasing living standards and wealth. Although Thailand has signed 23 free trade agreements (FTAs) and 13 World Trade Organization (WTO) agreements (Charoenchang, 2018), there is a lack of studies showing which agreements are best for Thailand.

Many FTAs have established a relationship between national welfare and cultural models. In cases where culture is an externality, trade liberalization may reduce national welfare due to the loss of cultural benefits (Suranovic & Winthrop, 2014). Conversely, free trade can have a positive impact on the welfare of cultural affinity. The FTA between the EU and India has had a positive influence on the textile sector in India, increasing market share, investment, and employment opportunities (De Coster, 2009). Meanwhile, free trade has led to the offshore production of packaging and instructional materials, negatively affecting the local printing industry in the US (Burmeister, 2004). Furthermore, the USA–Australia FTA has had significant negative consequences for Australia's cultural industries, including film, television, and music, as the agreement favored US intellectual property rights, limiting Australia's ability to develop its cultural sectors. This led to reduced employment and creative opportunities for local artists and producers, challenging their human rights (Breen, 2010). Although many countries benefit in terms of cultural products, these cases do not show the positive effects of agreements.

The ASEAN–China Free Trade Agreement (ACFTA) separates international trade products into four groups, with each group having its own plan for lowering tariffs. The first group is made up of primary goods from the Early Harvest Program (EHP), which

include crops, fruits, and vegetables. Since 1 October 2003, this group has had a 0% tariff rate. By 1 January 2006, the entire process was complete, and the ASEAN-6 countries and China had no tariffs on these goods by 2010. For CLMV countries, tariffs kept going down until 2018. The third group includes sensitive goods, including meats, eggs, timber, textiles (like polyester), and electrical parts. The tax on these goods was 20% in 2012 and 0–5% in 2018. Lastly, the tariffs on highly sensitive goods, such as sugar, vegetable oils, rice, maize, cars, and car parts, were reduced more slowly. Rates were limited by 50% or declined over a longer period of time (Wong & Chan, 2003). A considerable research gap still exists on how ACFTA liberalization would affect cultural goods like textiles, which are a major part of Thailand's cultural sector, even though these tariff cuts are broad.

Recent studies have increasingly emphasized the role of global value chains (GVCs) in shaping trade patterns and industrial competitiveness (Imbruno et al., 2024; Gorodnyi et al., 2025). Participation in GVCs is closely associated with foreign direct investment, production fragmentation, and cross-border production networks (Imbruno et al., 2024). In addition, export diversification and pricing strategies have been identified as key factors influencing resilience and firm performance in global markets, particularly under external shocks and changing economic conditions (Gorodnyi et al., 2025). These developments suggest that modern trade dynamics extend beyond tariff reduction, highlighting the importance of structural and competition-related factors in explaining export performance.

#### 2.4. Cultural Textile and the ASEAN–China Free Trade Agreement (ACFTA)

Textiles and clothing are not only major economic commodities for Thailand but also represent the cultural industry and Thailand's soft power on the global stage. Thailand's local communities, particularly those in the northeast of Thailand, preserve traditional textiles (Larson, 2015). Textile and clothing products of HS code 50 to 63, and SITC 26 and 84 are tariff classifications. While ACFTA has made it easier for member countries to trade in many sectors, such as electronics, industrial goods, and farm goods, studies have not yet addressed cultural products such as textiles and handicrafts. These products are more than just economic goods; they reflect the culture, identity, and creativity of local communities (Yudice, 2004). Thai silk and handwoven fabrics are two examples of textiles and clothing that are important to Thailand's cultural industries and that have made the country well known across the world. The ACFTA identifies textiles as sensitive goods, but will reduce tariffs on these goods in its final stage (J. Wang, 2006).

The textile and clothing industry is also a crucial form of soft power for achieving a sustainable competitive advantage, especially in the era of e-commerce, where flexibility, speed, and cooperation are key. Soft power refers to the intangible assets and resources of an enterprise, such as intellectual property, brand reputation, and stakeholder relationships, contrasting with hard power, which includes tangible assets like machinery and financial capital (Tang & Zhang, 2011).

Some studies have argued that FTAs damage local and cultural products. The ACFTA, for example, has had a huge effect on local batik fabric makers, who have lost their competitiveness to China-imported fabric products (Kurniawan & Syah, 2017). Furthermore, FTAs have the potential to promote cultural homogenization, leading to the copying or loss of crafts' cultural value (Yudice, 2004). Previous studies have shown that free trade agreements have both advantages and disadvantages for cultural products. While reducing tariffs and trade barriers provides more benefits, lower tariffs can also harm domestic producers due to low-cost imports. In this study, we will investigate the gap in the literature of how ACFTA has affected Thailand's exports of textiles and clothing, with a focus on trade creation or diversion.

### 2.5. The Gravity Model and Trade Creation

The structural gravity model developed by [Anderson and van Wincoop \(2003\)](#) is a significant advancement in the empirical modeling of trade flows from [Isard \(1954\)](#). This model addresses the “border puzzle” by incorporating multilateral resistance terms, which account for the relative trade costs between countries and their trading partners ([Balistreri & Hillberry, 2007](#)).

Moreover, the gravity model is used to analyze international trade frameworks. The concept of gravity concerns the bilateral trade among trading partners as follows: the following formulation

$$T_{ij} = C \cdot \frac{G_i G_j}{D_{ij}} \quad (3)$$

Whereas (3),  $T_{ij}$  represents the export volume between countries  $i$  to  $j$ .  $C$  shows the constant of the model. While  $G_i G_j$  defines the gross domestic product (GDP) of a country  $i$  and  $j$ . Moreover, the distance is one of the international trade factors that is used to analyze the transportation cost in trading between countries  $i$  and  $j$ , which represents  $D_{ij}$  in this model. The international trade variable in many studies consists of institutions, culture, science, and geography, such as locked land and common borders ([Anderson & van Wincoop, 2003](#)). Some use economic indicators and international trade factors to investigate trading. For instance, gross domestic product per capita (GDPP) and distance are used to explore exports in agricultural products under TTIP and NFTA ([Karemera, 2021](#)). Moreover, GDP, population, distance, and the FTA dummy variable are used to investigate export and import in food, beverage products, agricultural raw materials, manufactured goods, chemical products, and machinery and transport equipment under ACFTA, AKFTA, and AIFTA ([Darma, 2017](#); [S. Yang & Martínez-Zarzoso, 2013](#)). Moreover, many studies also use free trade agreements (FTAs) as dummy variables and identify trade creation and diversion in international trade ([S. Yang & Martínez-Zarzoso, 2014](#); [Jongwanich, 2024](#); [Schaak, 2015](#); [Darma, 2017](#)). However, although there are many studies that find the international trade under free trade agreements in many products, limited attention has been given to the cultural industry, such as textiles and clothing, which is the main local product in the whole world. Therefore, this study follows the previous studies and the gravity model to investigate Thai textile and clothing exports under free trade agreements (FTAs) and to find trade creation in trading as follows the formulation (4).

$$LNexp_{ijt} = \beta_0 + \beta_1 LNpngdp_{ij} + \beta_2 LNptrade_{ij} + \phi_1 FTA + \phi_2 ATC + \pi_{ij} + u_{ijt} \quad (4)$$

The development of economic integration has been divided into trade creation by [Viner and Oslington \(2014\)](#). Free trade agreements (FTAs) can be used to establish trade creation in many regions. In terms of trade creation, FTAs can be used to create trade activities and economic capacity related to the customs union community through improved welfare and production based on comparative advantage. Previous studies have shown that trade creation has occurred only among member countries under FTAs, and that the benefits of trading among member countries are greater than those when trading with non-member countries. Moreover, member countries will gain in terms of low-cost production ([Salvatore, 2019](#)).

When activity occurs between FTA member countries and non-member countries, the trader cannot avoid high tariffs or trade barriers, which leads to increased costs for goods and expensive prices ([Salvatore, 2019](#)). There are many studies that have investigated trade creation in international activities under free trade agreements. [Jošić and Bašić \(2021\)](#) found that CEFTA motivated trade creation in terms of international trade, while trade diversion was found for trading under the EU. Moreover, Thailand, Vietnam, and Malaysia have

gained trade creation in export activities under ACFTA, but this was not found among Cambodia, Thailand, and Vietnam (Soumatsa, 2020). Charoenchang (2018) has investigated trade creation and trade diversion in Thailand under ACFTA, AJCEP, ASEAN+1, TPCEP, ITFTA, JTEPA, and TCFTA, showing trade creation for all free trade agreements except for the ITFTA, which only caused trade diversion. It is evident that the effect of trade creation and diversion can be used to analyze the impact of free trade agreements (FTAs) on international trade in many countries. Romadona and Pujiati (2018) found only trade diversion in non-oil production under ACFTA in Indonesia.

From the perspective of the gravity model, reducing trade barriers lowers transaction costs and improves market access between trading partners. The ACFTA is therefore expected to facilitate bilateral trade and promote trade creation by enhancing economic integration among member countries. Accordingly, ACFTA is expected to facilitate trade creation by strengthening bilateral trade between member countries.

In summary, previous studies have shown the impact of FTAs on international trade for many products, but have not focused on cultural products, such as textiles and clothing, in terms of trade creation. Hence, panel data on Thailand's textile and clothing exports under ACFTA have been studied in this paper, as the following represents that trade creation will occur when the positive direction in the model.

## **H2.** *ACFTA is associated with trade creation in Thailand's textile and clothing exports.*

Trade-related variables are selected based on the gravity model of international trade. Partner-country GDP represents market size, while trade openness reflects market accessibility and the degree of international integration (Anderson & van Wincoop, 2003; Baier & Bergstrand, 2007). In addition, the ACFTA and post-ATC dummy variables capture major trade policy changes that may influence Thailand's textile and clothing export performance through trade liberalization and quota removal (Baier & Bergstrand, 2007).

### *2.6. The Post-2005 Agreement on Textiles and Clothing (ATC)*

The Agreement on Textiles and Clothing (ATC) was established by the World Trade Organization (WTO) in 1995, and, since 2005, has eliminated textile quotas and bilateral trade tariffs in the global market, which includes 166 members. The ATC was used to replace the Multi-Fibre Arrangement (MFA) and aimed to integrate the textile and clothing sector into a multilateral trading system and eliminate quantitative restrictions on textile trade, promoting global trade liberalization in the textile and clothing industry (Nordås, 2004). While ACFTA focuses on product trade facilitation within 11 intra-bloc trading countries, the post-2005 ATC has adopted a quota-based trading regime for new textiles and clothing, allowing them to be competitive in the global market. It has increased the competitiveness of exporters such as China, India, Bangladesh, and Vietnam, creating several potential competitors in the post-ATC era (Akhtar & Wahab, 2011).

Although the textile and clothing industries have been integrated into the WTO framework and have eliminated quota restrictions since 2005, some studies have argued that the agreement has not been as successful as expected after 2005. Malaga et al. (2003) contended that developed countries largely complied with the agreement by liberalizing low-value textile products while postponing the removal of restrictions on high-value clothing products until the final stage. Therefore, the ATC increased market value benefits for many developing country exporters only for the period from 1995 to 2004 and failed after 2005.

Consistent with the gravity model, reducing trade barriers and eliminating quota restrictions improve market access and facilitate bilateral trade flows. The implementation

of the WTO's Agreement on Textiles and Clothing (ATC) is therefore expected to influence export performance by promoting a more liberalized trading environment.

The impact of the ATC on Thailand's textile and clothing exports remains ambiguous. While the removal of quotas expanded market access opportunities, intensified competition from highly efficient exporters such as China and India may have offset the benefits of trade liberalization (Wattanapruttipaisan, 2005). In this study, we examine the effect of the Agreement on Textiles and Clothing (ATC) in Thailand after 2005 as shown in the hypotheses below.

**H3.** *The post-ATC period is significantly associated with Thailand's textile and clothing export performance.*

### 2.7. Porter's Competitive Advantage Theory

The framework of Porter's competitive advantage is used to explain competitiveness in export performance in this study. Porter (1990) argued that national wealth is not only established by infrastructure, technological capability, supporting industries, market conditions, and policy environments, but also by entrepreneurs' needs to increase competitiveness, use up-to-date technologies, and improve productivity. Therefore, improving internal firm aspects such as atmosphere, technologies, efficiency, and competitiveness will create a competitive advantage through a high export performance.

Taghizadeh and Khorshidi Behzadi (2026) reveal that the improvement of supply chains, innovation, and pricing has a substantial direct impact on petrochemical export performance and increases sustainable competitive advantage in the global market. Septiawan et al. (2026) apply Porter's competitive advantage theory to explain the increase in MSME Sentul drums' export performance in Indonesia, confirming that digital marketing literacy, process innovation, and government support increase export performance and MSME competitiveness through support for Sustainable Development Goals (SDGs) 8 and 9 in Indonesia under Porter's diamond theory (Wulandari et al., 2026).

Our study, therefore, uses Porter's competitive advantage to analyze textile and clothing export performance in Thailand while considering environmental indicators, financial indicators, and trade indicators. Renewable energy consumption and carbon emissions have shown positive efficiency in the global market due to the green trend. The exchange rate and inflation rate explain the cost of production and price competitiveness, while trade openness and the ACFTA and WTO's ATC dummy variables are used to demonstrate market and performance conditions.

According to Porter's competitive advantage theory, national export performance is shaped by productive capabilities, market conditions, and policy environments. In this study, environmental variables (carbon emissions and renewable energy consumption) capture production capability and environmental sustainability. Financial variables (exchange rate and inflation) represent macroeconomic conditions affecting production costs and export prices. Trade-related variables, including partner-country GDP, trade openness, the ACFTA, and the post-ATC dummy, capture market characteristics and trade policy environments influencing Thailand's textile and clothing export performance.

Therefore, Porter's Competitive Advantage Theory and the gravity model jointly provide the theoretical foundation for examining the proposed relationships between environmental sustainability, macro-financial conditions, trade liberalization, and Thailand's textile and clothing export performance. These theoretical perspectives underpin the research hypotheses (H1–H3) and the empirical model specified in Equation (5).

*Export Performance* =  $f(\text{Environmental Sustainability, Financial Conditions, Trade Liberalization})$   
and,

$$\text{LNexp}_{ijt} = \beta_0 + \beta_1 \text{LNcar}_{it} + \beta_2 \text{LNrenew}_{it} + \beta_3 \text{LNexch}_{it} + \beta_4 \text{LNinf}_{jt} + \beta_5 \text{LNptrade}_{ij} + \phi_1 \text{FTA} + \phi_2 \text{ATC} + \pi_{ij} + u_{ijt} \quad (5)$$

### 3. Methodology

#### 3.1. Data and Empirical Framework

In this study, we investigate the implications of environmental factors, financial factors, and trade-related factors on Thailand's textile and clothing exports from 1990 to 2024, using ACFTA and ATC dummy variables. Statistical data were collected from the World Bank (WDI) and the UN Comtrade Database from SITC 26 and 84. The method used is quantitative analysis, and the data include 31 trading partners, consisting of 11 partners under the ASEAN–China Free Trade Agreement (ACFTA) and 20 non-ACFTA partners. The study also applies Porter's competitive advantage theory (Porter, 1990) as a national competitive framework. Prior to estimation, STATA18 was used to investigate multicollinearity among models. The analysis includes the following explanatory variables: environment indicators (renewable energy consumption and carbon emission), the inflation rate (exchange rate and inflation rate), and trade indicators (partner's GDP, trade openness, the ACFTA, and the post-ATC) under Porter's competitive advantage theory framework.

Following the augmented gravity model presented in Section 2.5, the empirical analysis is conducted using fixed-effects and robust PPML estimators to examine the effects of environmental sustainability, financial conditions, and trade policy on Thailand's textile and clothing exports.

The explanatory variables are selected based on Porter's competitive advantage theory and the gravity model of international trade. Environmental variables (carbon emissions and renewable energy consumption) represent production conditions and environmental sustainability. Financial variables (exchange rate and inflation) capture macroeconomic conditions affecting production costs and international price competitiveness. Trade variables, including partner-country GDP and trade openness, represent market size and trade accessibility, while the ACFTA and post-ATC dummy variables capture major trade policy changes affecting Thailand's textile and clothing exports.

In addition, a variance inflation factor (VIF) is used to analyze the multicollinearity problem, and its result should not be more than 5 (Hair et al., 2013). Subsequently, we will use the unit root test, including the cross-sectional IPS (CIPS), the cross-sectional Fisher-augmented Dickey–Fuller unit root test (CADF), and the Fisher–Phillips–Perron unit root test (PP), to investigate the stationarity of data. After the data are stable, the Kao panel cointegration will be used to confirm no spurious regression and long-term equilibrium among variables (Kao, 1999). Moreover, our investigation will provide the results of fixed-effects regression and the robust PPML, following the research questions and the hypotheses.

Our study uses the textile and clothing export volume between Thailand and partner countries as a dependent variable, while the independent variables consist of renewable energy consumption, carbon emissions, exchange rate, inflation rate, and trade openness. Moreover, we use FTA and ATC as free trade agreement dummy variables, as shown in Table 1.

The year 2010 is a very important year in this study, as it was when the ACFTA fully came into effect. This meant that the members of ASEAN and China had no tariffs on any products. Therefore, the FTA dummy variable will be observed beginning in 2010: if it is 1, it means that ACFTA is in effect, increasing export volume; otherwise, it is 0.

**Table 1.** Variable definitions.

| Variables | Definitions                                                         | Unit                                      |
|-----------|---------------------------------------------------------------------|-------------------------------------------|
| LNexp     | The logarithm of the textile and clothing export volume in Thailand | USD Thousand                              |
| LNpngdp   | The logarithm of the partner's gross domestic product               | USD Thousand                              |
| LNcar     | The logarithm of carbon dioxide emissions                           | Metric tons per capita                    |
| LNrenew   | The logarithm of renewable energy consumption                       | % of total final energy consumption       |
| LNexch    | The logarithm of the official exchange rate                         | LCU per USD                               |
| LNinf     | The logarithm of inflation, consumer prices                         | Percentage                                |
| LNptrade  | The logarithm of the partner's trade openness                       | Percentage                                |
| FTA       | Dummy variable                                                      | 1 if ACFTA member<br>0 if otherwise       |
| ATC       | Dummy variable                                                      | 1 if post-WTO agreement<br>0 if otherwise |

Source: Authors' own work based on the World Bank (WDI) and the UN Comtrade Database (SITC 26 and 84).

In addition, ATC represents the period after the WTO's Agreement on Textiles and Clothing, with data beginning in 2005, when quotas were removed from the global market. It is used as a dummy variable: if it is 1, it means that the agreement is efficient and supports export performance; otherwise, it is 0.

The original dataset consists of a strongly balanced panel of 31 trading partners observed annually from 1990 to 2024. Continuous variables were transformed into natural logarithms to improve scale comparability, reduce skewness, and mitigate potential heteroscedasticity. However, some explanatory variables contain missing observations for certain countries and years (e.g., renewable energy consumption). Consequently, the effective estimation sample and the number of observations differ across model specifications after excluding observations with missing values.

As a robustness check, the fixed-effects model was re-estimated by including year fixed effects to control for common time-specific shocks. The results were compared with the baseline specification to assess the robustness of the estimated coefficients. Because the post-ATC dummy represents the post-2005 period, its coefficient should be interpreted cautiously, as part of its estimated effect may capture broader global time trends rather than the ATC agreement alone. Furthermore, because the combined specification requires complete observations for all explanatory variables, it is estimated using only complete cases. Therefore, the unbalanced panel structure results from missing observations due to data availability rather than the logarithmic transformation. Consequently, the estimation sample is smaller than the original balanced dataset, and the remaining sample does not contain sufficient common observations across partner countries to implement the Pesaran cross-sectional dependence test.

The empirical analysis employs both the fixed-effects (FE) model and the Poisson Pseudo-Maximum Likelihood (PPML) estimator. The FE model controls for unobserved time-invariant heterogeneity and spurious correlation from omitted variables across partner countries (Baier & Bergstrand, 2007; Wooldridge, 2004), while the PPML estimator provides robust estimates under heteroskedasticity and accommodates zero trade flows. The two estimators are jointly employed to evaluate the robustness of the empirical findings.

### 3.2. Panel Correlation Matrix

A correlation matrix is used to eliminate multicollinearity and standard error among variables in the model, which is not more than 0.80 (Hair et al., 2013). To completely establish the model, we use a correlation matrix to solve the problem, as shown in Table 2. There is no multicollinearity or standard error among the variables.

**Table 2.** The results of the correlation matrix.

| Variables    | (1)    | (2)    | (3)    | (4)    | (5)    | (6)    | (7)   | (8)   | (9)   |
|--------------|--------|--------|--------|--------|--------|--------|-------|-------|-------|
| (1) LNexp    | 1.000  |        |        |        |        |        |       |       |       |
| (2) LNpngdp  | 0.665  | 1.000  |        |        |        |        |       |       |       |
| (3) LNcar    | 0.531  | 0.320  | 1.000  |        |        |        |       |       |       |
| (4) LNrenew  | −0.404 | −0.715 | −0.059 | 1.000  |        |        |       |       |       |
| (5) LNexch   | −0.328 | −0.568 | −0.297 | 0.382  | 1.000  |        |       |       |       |
| (6) LNinf    | −0.141 | −0.129 | −0.079 | −0.014 | −0.004 | 1.000  |       |       |       |
| (7) LNptrade | 0.018  | 0.220  | −0.407 | −0.517 | −0.020 | −0.078 | 1.000 |       |       |
| (8) FTA      | 0.050  | −0.124 | −0.009 | 0.100  | 0.287  | −0.084 | 0.276 | 1.000 |       |
| (9) ATC      | 0.334  | 0.291  | 0.140  | 0.009  | −0.006 | −0.235 | 0.188 | 0.400 | 1.000 |

Source: The STATA18 output. Note: LNexp: the logarithm of textile and clothing export volume in Thailand; LNpngdp: the logarithm of partner's gross domestic product; LNcar: the logarithm of carbon dioxide emissions; LNrenew: the logarithm of renewable energy consumption; LNexch: the logarithm of exchange rate; LNinf: the logarithm of consumer price inflation; LNptrade: the logarithm of partner's trade openness; FTA: the bilateral trade dummy variables of ACFTA member countries; ATC: the dummy variables for the WTO textile and clothing agreement.

The results of the correlation matrix, as shown in Table 2, demonstrate that there are no variables greater than 0.8, with no multicollinearity among the models. Carbon emissions have a major effect in a positive direction on the export volume, while renewable energy consumption, the exchange rate, and the inflation rate always have a negative impact on exports. Moreover, trade openness in partner countries is the main negative impact on carbon emissions and renewable energy consumption, with values around −0.41 and −0.52, respectively. The relationship between the inflation rate and ACFTA has a positive direction: if the FTA increases by 1%, it will lead to the exchange rate rising by 0.23. However, trade indicators, including trade openness, the ACFTA dummy variable, and the ATC dummy variable, have a negative effect on the inflation rate, especially ATC, at around −0.24. Meanwhile, there is a positive correlation among trade indicators.

#### 4. Result

In our study, we show the impact of environment, finance, and trading, including trade-related policy, on Thailand's textile exports from 1990 to 2024. The results of the ASEAN–China Free Trade Agreement (ACFTA) dummy variable will identify trade creation in trade after 2010, while the WTO's Agreement on Textiles and Clothing dummy variable represents the effectiveness of the policy after removing quotas in 2005. The STATA18 tool was used to analyze fixed-effects regression in this experiment, along with a robust PPML. The statistical data, shown in Table 3, illustrate strongly balanced panel data and variable descriptions. Before testing, the data were analyzed for multicollinearity in the model using the variance inflation factor (VIF), which was 2.25 and not more than 5 (Hair et al., 2013). Then, the unit root test demonstrated the stationarity of the data, as shown in Table 4, and Table 5 shows the results of fixed-effects regression, while Table 6 shows the robust PPML.

Table 3 illustrates the descriptive statistics, which were analyzed using STATA 18. However, because of limited data in some countries, observations were missing. Therefore, the number of observations ranges from 956 to 1085 across 31 countries due to missing observations for some variables. Continuous variables were transformed into logarithms to reduce skewness, improve scale comparability, and mitigate potential heteroscedasticity. The unbalanced panel structure results from data availability and is addressed through the fixed-effects estimation.

The data on export volume (LNexp) showed a mean value of roughly 17.37%. The logarithm of a partner's gross domestic product (LNpngdp) has a mean of around 8.88%. The logarithm of carbon emissions and renewable energy consumption had effects of

approximately 2.36% and 2.3%, respectively, on Thai textile exports. The exchange rate (LNfin) and inflation rate (LNinf) were nearly the minimum values, at 2.96% and 0.87%, respectively. It can be predicted that those variables have a negative correlation with Thailand's textile and clothing exports. The dummy variable of the ASEAN–China Free Trade Agreement (ACFTA) also had values nearly at the minimum, at 0.14%, and it can be predicted that this variable will have a negative effect on the export volume. Meanwhile, the variable for the WTO's Agreement on Textiles and Clothing (ATC) had a value of around 0.57%, which was nearly the maximum, showing positive benefits on exports. Although the data in Table 3 can be used to predict the direction of implication, the data are still in an unstable condition. The unit root test, therefore, is used to analyze the stationarity of the data in the next step.

**Table 3.** Summary descriptive statistics.

| Variable | N    | Mean  | SD   | Min    | Max   |
|----------|------|-------|------|--------|-------|
| LNexp    | 1075 | 17.37 | 1.75 | 8.11   | 21.61 |
| LNpngdp  | 1083 | 8.88  | 1.73 | 3.94   | 11.42 |
| LNcar    | 1085 | 2.36  | 2.08 | −4.32  | 7.35  |
| LNrenew  | 956  | 2.3   | 1.76 | −2.3   | 4.51  |
| LNexch   | 1080 | 2.96  | 3.27 | −10.43 | 10.09 |
| LNinf    | 961  | 0.87  | 0.94 | −1.67  | 2.14  |
| LNptrade | 1022 | 4.17  | 0.72 | 2.72   | 6.09  |
| FTA      | 1085 | 0.18  | 0.39 | 0      | 1     |
| ATC      | 1085 | 0.57  | 0.5  | 0      | 1     |

Source: The STATA18 output. Note: LNexp: the logarithm of textile and clothing export volume in Thailand; LNpngdp: the logarithm of partner's gross domestic product; LNcar: the logarithm of carbon dioxide emissions; LNrenew: the logarithm of renewable energy consumption; LNexch: the logarithm of exchange rate; LNinf: the logarithm of consumer price inflation; LNptrade: the logarithm of partner's trade openness; FTA: the bilateral trade dummy variables of ACFTA member countries; ATC: the dummy variables of the WTO textile and clothing agreement.

**Table 4.** The results of the unit root test.

| Variable | CIPS Test   |              | Fisher–ADF Test (CADF) |              | Fisher–PP Test (PP) |               | Decision |
|----------|-------------|--------------|------------------------|--------------|---------------------|---------------|----------|
|          | I(0)        | I(1)         | I(0)                   | I(1)         | I(0)                | I(1)          |          |
| LNexp    | −4.3929 *** | −14.9001 *** | 144.5480 ***           | 425.4148 *** | 116.4689 ***        | 934.8943 ***  | I(0)     |
| LNpngdp  | 0.5560      | −11.4339 *** | 46.8409                | 303.2219 *** | 42.4943             | 519.7205 ***  | I(1)     |
| LNcar    | 0.5563      | −14.4141 *** | 66.7677                | 426.0390 *** | 84.9752 **          | 849.4675 ***  | I(1)     |
| LNrenew  | -           | -            | 53.968                 | 321.9661 *** | 64.6948             | 675.1924 ***  | I(1)     |
| LNexch   | −1.8631 **  | −12.4953 *** | 114.4284 ***           | 355.0961 *** | 140.1716 ***        | 545.9687 ***  | I(0)     |
| LNinf    | −2.2388 **  | −15.5957 *** | 70.7192                | 430.5384 *** | 419.3082 ***        | 1082.6722 *** | I(0)     |
| LNptrade | −4.0706 *** | −17.4153 *** | 137.1813 ***           | 500.9841 *** | 107.0502 ***        | 686.0697 ***  | I(0)     |
| FTA      | -           | -            | -                      | -            | -                   | -             | Dummy    |
| Post-ATC | -           | -            | -                      | -            | -                   | -             | Dummy    |

Source: The STATA18 output. Note: (1) LNexp: the logarithm of textile and clothing export volume in Thailand; LNpngdp: the logarithm of partner's gross domestic product; LNcar: the logarithm of carbon dioxide emissions; LNrenew: the logarithm of renewable energy consumption; LNexch: the logarithm of exchange rate; LNinf: the logarithm of consumer price inflation; LNptrade: the logarithm of partner's trade openness; FTA: the bilateral trade dummy variables of ACFTA member countries; ATC: the dummy variables of the WTO textile and clothing agreement. (2) Standard errors in parentheses: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ . CIPS refers to cross-sectional Im–Pesaran–Shin; CADF is cross-sectional Fisher-augmented Dickey–Fuller; PP test is Fisher–Phillips–Perron unit root test. (3) The order of integration was determined based on the preponderance of evidence from IPS, Fisher–ADF, and Fisher–PP tests. (4)—indicates that the test statistic could not be computed due to insufficient observations or because the variable is a dummy variable.

**Table 5.** The result of the Kao panel cointegration.

| Statistic                           | Test Statistic | Prob       |
|-------------------------------------|----------------|------------|
| Modified Dickey–Fuller t            | −0.745         | 0.2281     |
| Dickey–Fuller t                     | −2.4136        | 0.0079 *** |
| Augmented Dickey–Fuller t           | −2.5313        | 0.0057 *** |
| Unadjusted Modified Dickey–Fuller t | −4.4009        | 0.0000 *** |
| Unadjusted Dickey–Fuller t          | −4.5163        | 0.0000 *** |

Source: The STATA18 output. Note: \*\*\*  $p < 0.01$  indicates rejection of the null hypothesis at the 1% significance level.

**Table 6.** Baseline and Robustness Results of the Fixed-Effects Estimation.

| Variables             | Baseline Fixed Effects |                       |                      |                       | Fixed Effects with Year Fixed Effects |                       |                      |                       |
|-----------------------|------------------------|-----------------------|----------------------|-----------------------|---------------------------------------|-----------------------|----------------------|-----------------------|
|                       | (1)<br>Env             | (2)<br>Fin            | (3)<br>Trade         | (4)<br>Combine        | (5)<br>Env                            | (6)<br>Fin            | (7)<br>Trade         | (8)<br>Combine        |
| LNcar                 | 0.781 ***<br>(0.048)   |                       |                      | −0.002<br>(0.069)     | 0.172 ***<br>(0.054)                  |                       |                      | 0.024<br>(0.069)      |
| LNrenew               | −0.106<br>(0.067)      |                       |                      | −0.278 ***<br>(0.064) | −0.626 ***<br>(0.065)                 |                       |                      | −0.241 ***<br>(0.071) |
| LNexch                |                        | 0.352 ***<br>(0.026)  |                      | 0.222 ***<br>(0.020)  |                                       | 0.307 ***<br>(0.022)  |                      | 0.230 ***<br>(0.020)  |
| LNinf                 |                        | −0.164 ***<br>(0.032) |                      | 0.009<br>(0.026)      |                                       | −1.167 ***<br>(0.137) |                      | 0.403<br>(0.296)      |
| LNpngdp               |                        |                       | 1.021 ***<br>(0.059) | 1.031 ***<br>(0.089)  |                                       |                       | 1.045 ***<br>(0.069) | 1.040 ***<br>(0.115)  |
| LNptrade              |                        |                       | 0.542 ***<br>(0.120) | 0.588 ***<br>(0.128)  |                                       |                       | 0.506 ***<br>(0.135) | 0.511 ***<br>(0.144)  |
| FTA                   |                        |                       | −0.084<br>(0.103)    | −0.237 **<br>(0.118)  |                                       |                       | −0.107<br>(0.104)    | −0.266 **<br>(0.118)  |
| Post-ATC              |                        |                       | 0.018<br>(0.079)     | 0.128<br>(0.093)      |                                       |                       | 0.170<br>(0.229)     | 0.874<br>(0.604)      |
| Constant              | 15.726 ***<br>(0.223)  | 16.417 ***<br>(0.088) | 5.993 ***<br>(0.703) | 5.810 ***<br>(0.920)  | 17.311 ***<br>(0.265)                 | 17.359 ***<br>(0.189) | 5.745 ***<br>(0.848) | 5.139 ***<br>(1.281)  |
| Observations          | 946                    | 947                   | 1010                 | 808                   | 946                                   | 947                   | 1010                 | 808                   |
| Country Fixed Effects |                        |                       | Yes                  |                       |                                       |                       | Yes                  |                       |
| Year Fixed Effects    |                        |                       | No                   |                       |                                       |                       | Yes                  |                       |
| R-squared             | 0.248                  | 0.193                 | 0.473                | 0.607                 | 0.497                                 | 0.474                 | 0.494                | 0.628                 |
| Countries             | 30                     | 30                    | 30                   | 30                    | 30                                    | 30                    | 30                   | 30                    |

Source: The STATA18 output. Note: (1) LNexp: the logarithm of textile and clothing export volume in Thailand; LNpngdp: the logarithm of partner's gross domestic product; LNcar: the logarithm of carbon dioxide emissions; LNrenew: the logarithm of renewable energy consumption; LNexch: the logarithm of exchange rate; LNinf: the logarithm of consumer price inflation; LNptrade: the logarithm of partner's trade openness; FTA: the bilateral trade dummy variables of ACFTA member countries; ATC: the dummy variables of the WTO textile and clothing agreement. (2) Columns (1)–(4) report the baseline fixed-effects estimates. Columns (5)–(8) present robustness checks, including year fixed effects to control for common time-specific shocks. (3) Standard errors in parentheses: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ . (4) The original dataset contains 31 partner countries. However, due to missing observations for some explanatory variables, the combined specification is estimated using 30 partner countries.

The result of the panel unit root test, using the cross-sectional IPS (CIPS), the cross-sectional Fisher-augmented Dickey–Fuller unit root test (CADF), and the Fisher–Phillips–Perron unit root test (PP), is shown in Table 4. The result of CIPS reveals that there are insufficient and non-significant outputs in renewable energy consumption. We then use the second-generation unit root test and serial correlation in the estimation instead, which are considered in the CADF and PP tests. The results demonstrate that LNexp, LNfin, LNinf, and LNptrade are stationary at level  $I(0)$ , and other variables become stationary after first differencing at  $I(1)$ . Table 5 represents the Kao panel. Cointegration results have confirmed that there is no spurious regression and long-term equilibrium among variables before. showing the results of fixed-effects regression (FE) in Table 6. And Table 7 shows the robust PPML estimator, used to analyze how environment indicators (1), financial indicators (2),

and trade indicators (3) influence textile and clothing exports in Thailand from 1990 to 2024, using FTA and ATC dummy variables.

**Table 7.** The results of robust PPML estimation.

| Variables    | (1)<br>Envi           | (2)<br>Fin            | (3)<br>trade         | (4)<br>Combine       |
|--------------|-----------------------|-----------------------|----------------------|----------------------|
| LNcar        | 0.026 ***<br>(0.005)  |                       |                      | 0.020 ***<br>(0.004) |
| LNrenew      | −0.020 ***<br>(0.005) |                       |                      | −0.002<br>(0.008)    |
| LNexch       |                       | −0.009 *<br>(0.005)   |                      | 0.003<br>(0.005)     |
| LNinf        |                       | −0.012 ***<br>(0.004) |                      | −0.001<br>(0.002)    |
| LNpngdp      |                       |                       | 0.034 ***<br>(0.008) | 0.033 ***<br>(0.009) |
| LNptrade     |                       |                       | −0.028 *<br>(0.015)  | 0.001<br>(0.015)     |
| FTA          |                       |                       | 0.004<br>(0.041)     | 0.019<br>(0.023)     |
| Post-ATC     |                       |                       | 0.037 **<br>(0.018)  | 0.018<br>(0.012)     |
| Constant     | 2.838 ***<br>(0.014)  | 2.887 ***<br>(0.021)  | 2.642 ***<br>(0.073) | 2.490 ***<br>(0.120) |
| Observations | 946                   | 947                   | 1,010                | 808                  |
| R-squared    | 0.411                 | 0.084                 | 0.382                | 0.591                |

Source: The STATA18 output. Note: (1) LNexp: the logarithm of textile and clothing export volume in Thailand; LNpngdp: the logarithm of partner's gross domestic product; LNcar: the logarithm of carbon dioxide emissions; LNrenew: the logarithm of renewable energy consumption; LNexch: the logarithm of exchange rate; LNinf: the logarithm of consumer price inflation; LNptrade: the logarithm of partner's trade openness; FTA: the bilateral trade dummy variables of ACFTA member countries; ATC: the dummy variables of the WTO textile and clothing agreement. (2) Standard errors in parentheses: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

The Kao panel cointegration test confirms the existence of a long-run equilibrium relationship among the variables, as shown in Table 5 (Kao, 1999). Both the Dickey–Fuller  $t$  statistic ( $p = 0.0079$ ) and the Augmented Dickey–Fuller  $t$  statistic ( $p = 0.0057$ ) reject the null hypothesis of no cointegration. Thus, the fixed-effects estimations are unlikely to be affected by spurious regression.

After checking the VIF and using the unit root test, we utilize pooled OLS regression, fixed-effects regression, and random-effects regression to explore our findings. However, pooled OLS regression can still be biased and inconsistent. Therefore, fixed-effects regression and random-effects regression are used to control for the unobserved heterogeneity problem. The Hausman test is a diagnostic test used to determine the distinct slope coefficient between fixed-effects regression (FE) and random-effects regression (RE). The null hypothesis means that random-effects regression (RE) is appropriate, and the alternative hypothesis means that fixed-effects regression (FE) is appropriate. The Hausman test statistic is 38.67, with a  $p$ -value of 0.0000 at the 5% significance level. Therefore, fixed-effects regression (FE) is preferred for our study's estimates, and the null hypothesis is rejected (Hausman, 1978).

As shown in Table 6, our model includes country and year fixed effects, with 808–1012 observations. The R-squared of the fixed-effects regression explains approximately 53.8%. There are four models used in the study: the models for environmental factors (1), financial factors (2), and trading factors (3), and the combination model (4). We start with environmental factors, consisting of the logarithm of renewable energy consumption and carbon emissions. Emissions have a positive and significant effect at the 1% level

on the export volume, meaning that 1% increase in carbon emissions is associated with a 0.781% increase in export volume. On the other hand, renewable energy consumption is not significantly associated with export performance.

The correlation between financial indicators and the export volume has shown the significance of the exchange rate and inflation rate on textiles and clothing at a 1% level. A 1% increase in the exchange rate is associated with a 0.352% increase in export volume. In contrast, a 1% increase in inflation is associated with a 0.164% decrease in export volume. Meanwhile, the results of the trading model (3) show all positive and significant factors at the 1% level, indicating a substantial effect on the export volume. A 1% increase in partner-country GDP and trade openness is associated with approximately a 1.045% and 0.506% increase in export volume, except for the ACFTA dummy variable, which has a negative effect on export performance.

The combined model (4) shows all factors that have been analyzed in relation to textile and clothing export performance. The results demonstrate that renewable energy consumption is significant at the 1% level, which means that it has an increasingly negative effect on the export volume. The model also predicts that trade openness is the main factor affecting renewable energy consumption, as shown in Table 2. The inflation rate has less significance than in model 3. In terms of trade indicators, trade openness remains important for trading, while the FTA dummy variable obviously is not significantly associated with export performance. This suggests that, although the variable has a positive direction, the data are nearly beyond 0 to the negative side. The estimated ACFTA coefficient does not provide robust evidence supporting trade creation, as the negative association observed in some fixed-effects specifications is not consistently confirmed by the PPML estimates. The post-ATC coefficient is positive in some fixed-effects specifications; however, this relationship becomes statistically insignificant after controlling for year fixed effects and is not confirmed in the combined specification. Therefore, the post-ATC effect should be interpreted with caution. Therefore, the analysis does not provide robust evidence that the post-ATC period has improved Thailand's textile and clothing export performance. The results of fixed-effects regression have illustrated the important factors related to textile and clothing exports in Thailand. To increase export performance, the focus should primarily be placed on trade-related factors, ecosystems, and financial factors under Porter's competitive advantage theory and the gravity model. However, to ensure the robustness and reliability of the findings, an additional robustness check using the Poisson Pseudo-Maximum Likelihood (PPML) estimator is conducted, and the results are reported in Table 7.

The robustness check, including year fixed effects, produced qualitatively similar results to the baseline specification. The principal findings remained broadly consistent in terms of the direction and statistical significance of the key explanatory variables. Although the magnitude of some coefficients changed after controlling for common time effects, the overall conclusions remain unchanged. Notably, the post-ATC dummy remained statistically insignificant, suggesting that its estimated effect should be interpreted with caution.

Table 7 shows the results of the robust PPML estimation and illustrates the importance of three models, including environmental factors (1), financial factors (2), and trade indicators (3), combining them in model (4). Model (1) shows the significance of carbon emissions and renewable energy consumption on the export volume, where emissions have an opposite direction and increase productivity. Meanwhile, the negative effect of renewable energy consumption has been demonstrated, and ecosystem conservation and protection trends have led to a decrease in export volume at a 1% level of significance. Model (2) shows the negative effect of financial indicators, including the exchange rate and inflation

rate, on the export volume. The results of PPML show that the exchange rate has a negative and significant impact only on model (2), but a positive impact is found when combining models. Both the exchange rate and the inflation rate represent pricing and consumer purchasing through conserving environmental support. Although financial indicators decrease productivity, they reduce emission releases (Bailliu & Fujii, 2004; Zheng et al., 2024). Model (3) reports that the positive impact of a partner's gross domestic product and trade openness supports export performance. Trade openness will not affect any organization or any agreement; the market will follow demand and supply without disruption. However, textiles and clothing are traditional and cultural products that require protection (François & van Ypersele, 2002). In addition, the FTA dummy variable has a negative direction in the fixed-effects regression and no significance in robust PPML, which means that we can reject H2, and the estimated ACFTA coefficient does not support trade creation. Neither coefficient is statistically significant in the fixed effect and robust PPML demonstrate the post-ATC has no support export performance which reject H3. The combined model (4) shows a significant result in the fixed-effects regression and robust PPML estimation, which means ecosystem factors, trade conditions, and financial indicators, respectively, are the main support factors for export performance, and the findings support H1.

Overall, the PPML estimates remain broadly consistent with the fixed-effects results for the main environmental variables, while some financial and trade-related variables exhibit changes in sign or statistical significance. These differences are expected because PPML is robust to heteroskedasticity and estimates the conditional mean in levels rather than the log-linear specification adopted in the fixed-effects model (Santos Silva & Tenreyro, 2006). Therefore, the PPML results are used as a robustness check rather than as a direct replacement for the baseline estimates.

## 5. Discussion

In this study, we employ panel data and quantitative analysis to examine the impact of environmental factors, financial factors, and trade indicators on Thailand's textile exports over the period 1990–2024, while analyzing the effects of the ACFTA and the ATC.

The cointegration results further support the reliability of the estimated coefficients, suggesting that the identified relationships reflect long-run economic associations rather than spurious correlations. The econometric findings in Table 7 focus on the ecosystem, trade indicators, and financial factors, respectively, which will support export performance. These results answer research question (1) on how the environment, finance, and trading have impacted textile and clothing exports in Thailand over 30 years. Textile and clothing manufacturing normally uses chemicals during production, leading to the release of carbon emissions, specifically as air pollution and water effluent, affecting human health (Rofi & Rahman, 2025). Therefore, carbon emissions always have a positive relationship with the export volume, in accordance with the findings of Rofi and Rahman (2025). The positive coefficient of carbon emissions does not imply that higher emissions improve export performance. Rather, carbon emissions are interpreted as a proxy for industrial production intensity and the current production structure of Thailand's textile and clothing industry, where export expansion remains closely associated with energy-intensive manufacturing processes. This finding is broadly consistent with previous studies suggesting that export expansion in developing economies remains closely associated with carbon-intensive manufacturing during the early stages of industrial development (Rofi & Rahman, 2025; Desore & Narula, 2018). However, unlike previous studies that focused primarily on environmental outcomes, our findings suggest that environmental indicators should be interpreted together with financial conditions and trade policy when explaining export performance. However, the global market is intensely concerned with the environment and sustainable

trading (Sun et al., 2026). The negative direction of renewable energy consumption has revealed that textile and clothing production remains non-environmentally friendly in Thailand, causing a further decrease in the number of consumers who are concerned about the ecosystem. And the negative coefficient of renewable energy consumption may reflect the transition costs associated with green production. During the adjustment period, firms may face higher investment costs and production restructuring before the long-term benefits of renewable energy can be realized. Therefore, this result should be interpreted as a short- to medium-term association rather than evidence that renewable energy weakens export performance. This interpretation is consistent with the green transition literature, which argues that firms often incur substantial adjustment and investment costs before the long-term productivity gains from renewable energy can be achieved (Wei, 2026). Our findings, therefore, complement previous evidence by highlighting the short-run adjustment challenges faced by the textile and clothing industry. Environmental sustainability has become an important source of competitive advantage, as consumers increasingly value environmentally responsible products. The growing emphasis on sustainability-related information and environmental claims may influence market demand and export performance, particularly in environmentally sensitive industries such as the textile and clothing industry (Buvár et al., 2026). Although the estimated short-run coefficient is negative, renewable energy adoption may contribute positively to export performance in the long run through improvements in environmental sustainability and market competitiveness, according to the findings of Yu and Ma (2025).

In terms of financial factors, while our study tried to use domestic credit in the private sector (% of GDP), multicollinearity was found in the model. Therefore, the financial indicators used consisted of the exchange rate and the inflation rate. Our results have shown the significant and negative impact of the exchange rate and inflation rate on Thailand's textile and clothing exports. This is related to pricing and consumer purchasing power, in accordance with the findings of Bailliu and Fujii (2004). An unstable exchange rate and a high inflation rate increase costs, pricing, and loss of competitiveness in the global market. However, some scholars have argued that a high inflation rate decreases carbon emissions, which reduces production, in accordance with the findings of Zheng et al. (2024). According to Porter's (1990) competitive advantage theory, a stable exchange rate and a controlled inflation rate will improve cost efficiency and productivity, which will increase competitiveness in Thailand's textile and clothing industry. These findings are generally consistent with previous studies emphasizing that macroeconomic stability plays an important role in maintaining export competitiveness through production costs and pricing decisions (Porter, 1990; Wani, 2025).

The results related to trading conditions have demonstrated mixed implications for export performance. The positive direction of a partner's gross domestic product and trade openness is an important way to improve export performance. The result of the FTA dummy variables can be analyzed in relation to research question (2). Our findings do not provide evidence supporting trade creation under ACFTA in the textile and clothing sector, in agreement with the findings of Romadona and Pujiati (2018). This finding contrasts with previous studies, which have suggested that free trade agreements typically enhance trade flows through tariff reductions (S. Yang & Martínez-Zarzoso, 2014, 2013; Nowak-Lehmann et al., 2007). Unlike previous studies that focused mainly on the average effects of FTAs, the finding suggests that the ACFTA effect is not consistently supported across model specifications, highlighting that the effectiveness of FTAs may vary across industries and countries, consistent with Baier and Bergstrand (2007). However, our findings answer the research question (3) that the findings do not provide robust evidence of a positive post-ATC effect. Although some fixed-effects specifications report a positive coefficient,

this relationship is not consistently supported across model specifications, particularly in the combined specification.

Overall, this study extends the existing literature by jointly examining environmental sustainability, financial conditions, and trade policy within an augmented gravity framework. Unlike previous studies that primarily investigated these dimensions separately, our findings suggest that Thailand's textile and clothing export performance is jointly associated with environmental, financial, and trade-related factors rather than trade liberalization alone.

## 6. Conclusions

In our quantitative study, we investigate how ecosystem, financial, and trading factors have influenced Thailand's textile and clothing exports under the ASEAN–China Free Trade Agreement (ACFTA) and the WTO's Agreement on Textiles and Clothing (ATC) from 1990 to 2024, focusing on export performance and trade creation. The STATA18 was used to analyze strong panel data from across 31 countries, combining 11 ACFTA member countries and 20 non-member countries, using fixed-effects regression and a robust PPML estimation. Textile and clothing data were collected from UN Comtrade SITC 26 and SITC 84, while other data were collected from the World Bank indicator. This study has been guided by Porter's competitive advantage theory together with gravity-type trade determinants. The combined model, after being made robust through PPML estimation, indicates the priority for improving environmental factors, trade conditions, and financial indicators, which enhance Thailand's textile and clothing industry's export performance in the global market. Moreover, the results related to the dummy variable revealed that the results do not provide robust evidence supporting trade creation with the ACFTA member countries. The analysis does not provide robust evidence of a positive post-ATC effect on Thailand's textile and clothing export performance. Although positive coefficients are observed in some specifications, these results are not consistently confirmed after controlling for year fixed effects or in the combined specification.

According to the results shown in Table 6, we propose three recommendations for the government to increase export performance. Firstly, given the significant negative association between renewable energy consumption and export performance, policy should focus on reducing firms' transition costs through financial incentives and technological support rather than expecting immediate export gains from green transformation. Secondly, the government should conduct research, expand the market, and develop strong relationships with other countries under the ATC to increase competitiveness and export volume. Thirdly, because exchange rate stability is positively associated with export performance, maintaining a stable macroeconomic environment may help reduce uncertainty faced by exporters. These actions will support export performance.

Beyond its implications for Thailand's textile and clothing industry, this study contributes to the broader discussion on global finance by highlighting the role of macro-financial conditions in supporting export performance under changing international trade arrangements. While this study does not directly measure geopolitical risk, its findings suggest that maintaining macroeconomic stability and environmental sustainability becomes increasingly important as exporters operate in a more uncertain global trade environment shaped by evolving geopolitical developments.

Furthermore, this study employs an augmented gravity model to examine export performance, while the ACFTA dummy is used to provide indirect evidence on trade creation. Therefore, the estimated ACFTA effect should be interpreted with caution as indirect evidence of trade creation rather than definitive evidence under a standard gravity-

model specification. Future research may adopt a standard gravity specification with additional bilateral trade variables to provide more direct evidence on trade creation.

Finally, this study has several limitations to acknowledge. The selected variables may not fully represent all determinants of textile and clothing exports, and data availability constraints resulted in missing observations for some countries and years. Although the fixed-effects and PPML estimators help mitigate some econometric concerns, the potential influence of cross-sectional dependence and endogeneity cannot be entirely ruled out. In addition, cross-sectional dependence was not formally examined using the Pesaran CD test because of the unbalanced structure of the panel dataset. Future research may employ balanced panel data, appropriate cross-sectional dependence tests, and alternative approaches to address potential endogeneity to further validate the robustness of the findings. It also may employ balanced panel data, appropriate cross-sectional dependence tests, and alternative approaches to address potential endogeneity to further validate the robustness of the findings.

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## Abbreviations

The following abbreviations are used in this manuscript:

|       |                                                                |
|-------|----------------------------------------------------------------|
| ACT   | The post-agreement textile and clothing (ATC) by the WTO       |
| ACFTA | ASEAN–China Free Trade Agreement                               |
| AIFTA | ASEAN–India Free Trade Agreement                               |
| AKFTA | ASEAN–Korea Free Trade Agreement                               |
| AJCEP | ASEAN–Japan Comprehensive Economic Partnership                 |
| CADF  | Cross-sectionally Augmented Dickey–Fuller test                 |
| CEPII | Centre d’Études Prospectives et d’Informations Internationales |
| CIPS  | Cross-sectionally Im–Pesaran–Shin test                         |
| EHP   | Early Harvest Program                                          |
| FE    | Fixed Effects                                                  |
| FTA   | Free Trade Agreement                                           |
| GDP   | Gross Domestic Product                                         |
| GVC   | Global Value Chain                                             |
| HS    | Harmonized System                                              |
| IPS   | Im–Pesaran–Shin test                                           |
| PP    | Phillips–Perron test                                           |

|        |                                                    |
|--------|----------------------------------------------------|
| PPML   | Poisson Pseudo-Maximum Likelihood                  |
| RE     | Random Effects                                     |
| SMEs   | Small and Medium-sized Enterprises                 |
| STATA  | Statistical Software for Data Analysis             |
| T&C    | Textile and Clothing                               |
| TTIP   | Transatlantic Trade and Investment Partnership     |
| UNCTAD | United Nations Conference on Trade and Development |
| VIF    | Variance Inflation Factor                          |
| WDI    | World Development Indicators                       |
| WITS   | World Integrated Trade Solution                    |
| WTO    | World Trade Organization                           |

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