Free Trade Agreements and development trade-offs: On the Growth-Environment nexus, evidence from Asian countries

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ABSTRACT

This study investigates the multifaceted effects of Free Trade Agreements (FTAs) on the Growth-Environment nexus in Asia. Employing an augmented Environmental Kuznets Curve (EKC) framework, the research analyses a comprehensive panel dataset spanning 52 Asian countries from 2000 to 2020 employing a one-step system Generalized Method of Moments (GMM) to address endogeneity. The findings suggest that the direct effects of FTAs on CO2 emission per capita are not clear and only get enhanced in robustness by the introduction of interaction terms of FTAs and GDP per capita in the EKC model. The empirical results also confirm an inverted U-shaped relationship between income and environmental degradation, in which FTAs, albeit accelerating pollution, play a crucial moderating role in tempering the environmental cost of income growth at the early stage of development, and expediting the transition to a greener growth threshold. Turning point investigation, in which we generate changes of EKC functions and their turning points along the increasing level of FTA participation, uncovers the potential of increased FTAs engagement to facilitate structural shift of the function curve towards better environment outcomes. These insights offer valuable policy recommendations for harmonizing trade liberalization with sustainable environmental practices in Asia.

Keywords: Asia; Free Trade Agreement; Growth-Environment nexus; Environmental Kuznets Curve.

JEL classification: F18, F64, O44, Q56.

CHAPTER 1: INTRODUCTION

Trade, albeit not a new concept to both economists and academics, yet gaps and undiscovered aspects still exist. The modern global economy is inherently connected to trade, since it is propelled by the essential need for nations to get resources, technology, and markets outside their domestic boundaries. Trade basically facilitates the flow of goods and services, allowing economies to specialize according to their comparative advantage. Throughout history, the exchange of commodities and services has been essential for the advancement of the economy, as it has fostered innovation, increased productivity, and ultimately resulted in improved living standards. Commerce has facilitated the dissemination of ideas, cultures, and technology, interweaving the fabric of human advancement, from historic trade routes like the Silk Road to contemporary transport channels and internet markets. International commerce is crucial since it disseminates advantages across boundaries, enabling countries to access a wider array of resources, markets, and technology. Participating in international commerce allows nations to attain economies of scale, lower expenses, and improve competitiveness globally. Moreover, international commerce fosters cultural interchange and diplomatic contacts, enhancing global peace and stability. The positive correlation between economic development and trade openness is underscored by academic research across regions (Intisar et al., 2020, Sghaier, 2021) and countries (Kong et al., 2021, Upadhyaya et al., 2023).

The modern global economy is inherently interconnected through trade, which is driven by the essential need of civilizations for resources, technology, and markets beyond their borders. This has led to a significant transformation in the intricacy and breadth of business due to globalization. The integration of global markets has reduced barriers and increased interdependence among countries, enabling the circulation of products, money, ideas, and culture, so reshaping economic landscapes and establishing a new paradigm of interconnection. This has reduced obstacles and increased interdependence among nations. To further develop this, nations with the same trade interests sign Free Trade Agreements (FTAs) and other forms of Trade Agreements, as a facility with pivotal role in enhancing international trade. FTAs are also more in-depth than just about goods and services flows, encompassing investments, regulations and technologies.

The economic impacts of FTAs are abundantly embodied in the modern strand of the literature. The growth effects of trade agreements are generally more widely accepted to be positive, with the main mechanisms of increased trade volumes and economic activities. Reductions of trade barriers after FTAs, followed by more efficient resource allocations, are instrumental to enhanced productivities of member parties and thus become an important driver of national income (Thirlwall, 2000; Egger & Larch, 2011; Hossain, 2018). However, the growth of economic development does come along with certain limitations and challenges, some of which involve the environment (Arrow et al., 1995; Dinda and Pal, 2000; Sun et al., 2019; Hunjra et al.,2024). FTAs can also play a moderating role in environmental degradation (Yoo & Kim, 2016; Yao et al., 2019; Song, 2021; Grigoras, 2024), and such effects are nuanced by layering an indirect channel of the trade-induced growth. Therefore, impacts of FTAs are multifaceted, including direct effects on growth and on the environment, as well as indirect effects on the growth-environment nexus.

Despite a growing body of literature on FTA's impact and environment matter, important gaps remain. First, existing studies that involve FTAs, Growth and Environment predominantly target certain FTAs to isolate effects and primarily using dummy FTAs in the econometrics approach (Ghosh & Yamarik, 2004; Yamanouchi, 2019; Timsina & Culas, 2020). This paper attempts to compose a unique proxy called the Accumulated number of FTAs to observe the vast effects of trade agreements in general. Second, while previous research has intensively focused on how FTAs directly impact Growth and Environment (Liu, 2016; Opoku-Mensah et al., 2021; French & Zylkin, 2024), the moderating role of FTAs through indirect channels has yet to be fully examined. By adding a different angle, this study aims to set light on the multidimensional impacts of FTAs on the Growth-Environment nexus. Together, these contributions will try to to advance the understanding of the trade-offs of Growth and Environment under the lens of trade liberalization.

CHAPTER 2: LITERATURE REVIEW

2.1. FTAs on Growth

FTAs are initially and mostly designed to eliminate trade barriers, including tariffs, quotas, and subsidies. Originated from classical trade theories, the theory of comparative advantage, assuming the removal of tariffs, or free trade (Salvatore, 2019), applies in explaining how signing FTAs supports economic growth. According to the theory, FTAs and international trade enable countries to specialize the production that they hold comparative advantage, thereby boosting efficiency, encouraging competition and promoting economic development. Also, with the market expansion and maximized production efficiency, countries that are party to FTAs often experience increases in exports and imports, thereby surging national income.

Studies have demonstrated the critical link between FTAs and economic growth with the mentioned above mechanisms. NAFTA, one of the most integrative regional FTAs, has granted Mexican plants with significant productivity gains through increased import competition and reduced tariffs, with more incentives offering to fully integrated firms than others (De Hoyos & Iacovone, 2013). Similarly, Khan (2020), in an attempt to revisit the effects of NAFTA, found evidence that the FTA has brought about positive trade shocks that support the increase in output, wages and equity prices in all parties. Comparing statistics of countries had they not engaged in the FTAs using the synthetic control method, Colla-De-Robertis and Rivera (2021) concluded that signing FTAs with one of the largest and most developed economies in the world, the US, has exert heterogeneous, mostly positive or insignificant, effects on the partner nations' per capita GDP, hinging on how much they depend on the US for their trade. Studies on FTAs with leading Asian countries, such as Korea, with different settings of computable general equilibrium model, agreed that the member parties of the FTAs are expected to enjoy welfare gains as well as GDP gains, albeit unevenly distributed (Wei et al., 2018) or coming along with damage to non-member trade partners (Yi, 2023). Liu (2016) used a large comprehensive dataset of 270 RTAs to present stronger growth increasing effects of RTAs on non-member than members of WTO, pointed out the limited synergy of the two trade liberalization approaches.

2.2. FTAs on Environment

The environmental impacts of FTAs are highly contested in both theory and practice, with theoretical frameworks supporting two contrasting ideas: whether FTAs do good or harm to the environment. Dominating the debate, the Pollution-Haven Hypothesis (PHH) posits that by eliminating trade barriers between nations, FTAs may enable pollution-intensive firms to relocate from countries with strict environment regulations to those with more lenient ones, in attempt to minimize costs in compliance with protecting the environment. Exploiting such regulation disparities, developed countries, with stringent environmental standards, succeed in exporting their pollution overseas through comparative advantages, thus escalating environmental degradation in destination countries and at global levels.

The PPH attracts scholar agreements in various perspectives. Yu et al. (2011) compared the effects of NAFTA on the greenhouse gas emission of the US and Mexico in a trade model. The results imply that the PHH may hold and put forward the argument from Sanchez (2002) that questions the green aspects of NAFTA. Empirical evidence on the causal relationships in the context of the African Continental Free Trade Area (AfCFTA) identified trade openness as the most significant long-term driver of CO2 emissions in 25 countries that have ratified the RTA (Opoku-Mensah et al., 2021). Similarly, FTAs are found generally correlated with increased bilateral CO2 emissions by Yao et al. (2019) in a gravity framework. They also confirmed PHH via an income-level analysis by discovering that high-income countries often shift pollution-intensive industries to lower-income partners. In their trade liberation process, China has stood out to draw scholar attention as a prime example for PPH analysis. With the Belt and Road Initiative (BRI), considered as China's greatest attempt in international trade (Huang, 2016), Cai et al. (2018) provides a two-way validation to PHH as more developed countries with more stringent environmental laws are more likely to export pollution-intensive productions to their counterparts. Decomposition of emissions embodied in trade trading partners in WTO show that import from China is becoming more emissions intensive (Levitt et al., 2019). Investigating ACFTA, an impressive demonstration of how FTA with China turns developing countries into pollution havens, research shows vast PHH recognition in various aspects such as marine transportation (Mulatsih, 2019) or palm oil industry (Natalia & Mursitama, 2021).

However, there are other theories with substantial evidence in the literature pointing out that FTAs do not necessarily accelerate environmental deterioration. Even pollution haven phenomenon varies in different countries, with different pollutants under different trade patterns (Zhang & Wang, 2021). Kolcava et al (2019) pointed out mismatched import-export environmental footprints from low-income countries to high-income countries via PTAs, implying that trade liberalization does not inherently speed up resource plundering process in low-income countries by affluent ones. Trade from resource-rich countries, despite possibly turning some countries into pollution havens, facilitates the reduction of emissions in a global scale (López et al., 2018). Net global emission savings through international trade can also be generated from production fragmentation (Zhang et al., 2017), or reallocation of emission-intensive production to trading partners along with promoting green technology spillovers there (Hotak et al., 2020). Those findings offer counter evidence for PPH, following the foundation laid by the Porter Hypothesis (PH), whose core idea suggests that stringent domestic environmental regulations would simultaneously act as a catalyst, spurring innovation and leading to greener technologies, which later carried by international trade to reach other countries. Accordingly, studies that agree on PH often involve FTAs of countries with different development categories. Australia's FTAs with South Korea and Japan can present classic examples for that, as scenario projections claimed that the parties can meet a certain emission reduction targets with green trade, although an Emissions Trading Scheme (ETS) could not be a viably economical option (Siriwardana, 2015). With environmental provisions, PTAs can help counter pollution haven effects, increasing green exports from developing countries, and playing the role of targeted policy tools (Brandi et al., 2020).

2.3. FTAs on the growth-environment nexus

As discussed above, theoretical viewpoints for both growth and environment aspects of FTAs differ. Growth frameworks vary once there is difference of development levels among parties, whereas perspectives of environmental impacts of trade liberalization depend on the central focus of the theories' core ideas themselves. PHH is a trade-intensive model, concerning about the relocation of polluting production and the formation of pollution havens, mainly short-term with potential implicit long-term consequences. Meanwhile, PH is more regulation-oriented, analyzing medium to long term innovation-driven gains and increased competitiveness.

For the scope of this study, it is necessary to consider both short- and long-term effects of FTAs, applying theories that enable the connection of growth and environment. Therefore, we consider the hypothesis of Environmental Kuznets Curve (EKC). As a growth-centered theory, EKC proposes a non-linear relationship analysis to economic development and environmental degradation, characterized as an inverted u-shaped curve. This dates back to when the seminal work of Grossman and Krueger (1991) succeeded in adapting the broader groundworks about the relationship between economic growth and income inequality first laid by Kuznets (1955) into environment economics. The concept of EKC suggests that growth initially consumes an excessive amount of resources, resulting in increased pollution until an income turning point, where environmental damages start to heal as incomes rise.

EKC applied in the concept of FTAs has captivated a multitude of testing from the research community across different countries, regions and aspects. Investigating NAFTA countries with an environmental view, Miranda et al. (2020) found support for EKC in the US and Mexico but not Canada, and highlighted the important role of increasing renewable energy sources to reduce CO2 emissions. Pollution reduction could also be implemented in carbon motivated RTAs, albeit the mitigation effects can be small (Dong & Whalley, 2011). The results from Balogh (2023) present an inverted U-shaped of EKC, suggesting that WTO membership relatively outperforms cumulative RTAs in force in global emission limiting process. Similarly, Heyl et al. (2021) pointed out that the limitations of recent RTAs include the lack of comprehensive environmental protection and weak dispute settlement mechanisms, implying a long way ahead to the transition of trade compatible with environment goals. Environmental provisions via PTAs can help speeding up greening process (Brandi et al., 2020) by enabling developed countries instigate environmentally friendly policies in their trade partners, with US PTAs being effective during negotiations due to the fear of sanctions, while EU PTAs are effective during implementation through policy dialogue (Bastiaens, 2017), whilst coming with some side-payments for recipients (Brandi et al., 2022). Korea is one of the emerging economies to soon realize the benefits of including environmental provisions in their free trade agreements (Song, 2021). East Asian countries, contrary to the traditional view, are gravely more concerned about the environment and have been incorporated environmental provisions in their bilateral FTAs with like-minded trade partners (Koo & Kim, 2018). Coming to investigate FTAs, Dou et al. (2021) took the China-Japan-ROK FTA into consideration, revealing that although trade openness is a significant driver in promoting CO2 emissions in these countries, the advent of the FTA can reduce such promotion effects. Realizing that EKC effects may not be inclusive to countries or regions, Nemati et al. (2018) examined three FTAs with three cases indicating difference in the types of parties of FTAs, uncovering that FTAs among only developed or developing countries causes no environmental damage and can be healthy to the environment, whereas the agreement of developed and developing countries increases emissions.

Incorporating FTAs into the EKC model complicates the relationships and makes the growth-environment nexus depend on the status of trade. If trade follows the path of PHH, which states that deeper trade liberalization levels speed up the pollution and worsen the environment, more intense engagement in FTAs will cause incomes to growth together with environmental degradation until forever and there will be no turning point where increased incomes start to benefit the environment. According to this, the inverted U-shaped relationship will turn into a linear relationship, where growth is negatively correlated with environment. On the other side, if trade agrees on the PH effects, in other words, facilitates spillovers of greener technologies and regulations, it will align with the latter part of EKC model, which support the existence of the turning point. Moreover, with greater participation in FTAs pursuits, countries could witness the earlier arrival of such turning point and, to some extent, pull the point closer enough to transform an inverted U-shaped into an inverted V-shaped curve.

The EKC is widely acknowledged for its validity in the literature, which, however, depends a lot on the context. The contextual factors may include pollutant types, methodological approaches, and regional dynamics, most notably in Asia, where mixed results highlight the influence of diverse economic structures and environmental policies. In methodologies, the scholars rely heavily on gravity models and panel regressions, which offer strong analytical tools for investigating trade flows and environmental impacts. Yet, they are also vulnerable to similar challenges such as data limitations, data unavailability and especially endogeneity, necessitating rigorous model specification and validation. This is where approaches like instrumental regression or GMM are utilized. This study inherits a similar process, where we apply a panel setting, then addressing endogeneity is necessary and GMM is employed.

CHAPTER 3: RESEARCH METHODOLOGY

3.1. Data

In this study, we investigate a dataset that covers the period from 2000 to 2020 of 52 Asian countries across three regions, namely East Asia, Central & West Asia and South Asia. Some countries with absolutely no FTAs participation history should be excluded.

FTAs data is obtained from RTA database of WTO, with some of author's own assessments. We only take in to account the trade agreements that had come into force or become inactive in the year investigated. Other data is derived from World Bank Group's databank, under the World Development Indicators database; and the HDI reports from the UNDP. There are some missing values across countries and years, however, for the scope of this study, we decide to stay genuine to the data sources.

The below table lists the use of each variable in the literature:

Table 1: Table of variables

Variables	**Abbreviation**	**Reference**	**Data source**
CO2 Emissions per capita	CO2pc		World Bank
GDP per capita (constant 2015 $US)	GDPpc	Grossman and Krueger (1991)	World Bank
Accumulated number of FTAs	No_FTAs		WTO
Energy use (kg of oil equivalent per capita)	En_Use	Akram et al. (2020)	World Bank
Fossil fuel energy consumption (% of total energy)	Fos_En	Caglayan-Akay & Guler (2019)	World Bank
Oil rents (% of GDP)	Oil_Rent	Mahmood et al. (2023)	World Bank
Natural gas rents (% of GDP)	Gas_Rent	Mahmood et al. (2023)	World Bank
Population density (people per sq. km of land area)	Pop_den	Hanif & Gago-De-Santos (2017)	World Bank
Urban population (% of total population)	Pop_Urb	Maneejuk et al., 2020	World Bank

The countries are classified based on sub-regions as followed:

Table 2: Asian countries based on sub-regions

Category	**Sub-category**	**Country**
Region	East Asia	American Samoa, Australia Brunei Darussalam Cambodia China, Fiji, French Polynesia, Guam, Hong Kong, Indonesia, Japan, Kiribati, Korea, Lao PDR, Macao, Malaysia, Marshall Islands, Micronesia, Mongolia, Myanmar, Nauru, New Zealand, Northern Mariana Islands, Palau, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Thailand, Timor-Leste, Tonga, Tuvalu, Vanuatu, Viet Nam.
	Central & West Asia	Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyz Republic, Tajikistan, Turkiye, Turkmenistan, Uzbekistan.
	South Asia	Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka.

3.2. Analytical framework

As introduced in the previous section, this study will primarily utilize the EKC model to investigate the impacts of FTAs on the growth-environment nexus. Basically, environmental degradation can be expressed as a function of income:

$$E=f(Y)$$

And specified as:

$$E = \alpha + \beta_1 Y + \beta_2 Y^2 + \varepsilon$$

Where:

E represents the level of environmental degradation (e.g., pollution, CO2 emissions, deforestation), Y is the income factor (typically GDP per capita) and Y^2 is the squared term of Y, representing the non-linear relationship. The ε represents the error term.

3.3. Econometric model

The baselines

This research employs a panel data approach to analyze the impact of FTAs on the growth-environment nexus. Panel data is appropriate as it allows us to control for unobserved country-specific heterogeneity and time-invariant factors that may influence environmental outcomes.

To fully address the research objectives set earlier in this study, we need to have the equation built as an augmented version of the baseline EKC model to incorporate FTAs expressed along with energy use, fossil energy consumption, oil rent, natural gas rent, population density and urban population as control factors. They are presented as followed:

$$CO2pc_{it} = \alpha + \beta_1 GDPpc_{it} + \beta_2 GDPpc^2_{it} + \beta_3 No\_FTAs_{it} + \beta_4 Control\ variables_{it} + \varepsilon_{it} \quad (1)$$

Where:

The subscripts denote country i at time t. The abbreviations are decoded in the Table 1, and ε_{it} represents the error term.

The regression section will start with the OLS estimation for the very first look of the baseline results. Moreover, to shed light on the moderating effects of FTAs on the non-linear relationship of growth and environment, we incorporate the interaction terms of FTAs with GDPpc and its squared term to form Equation 2 as an enhanced version of Equation 1. Equation 2 will be specified as:

$$CO2pc_{it} = \alpha + \beta_1 GDPpc_{it} + \beta_2 GDPpc^2_{it} + \beta_3 No\_FTAs_{it} + \beta_4 GDPpc * No\_FTAs_{it} + \beta_5 GDPpc^2 * No\_FTA \quad (2)$$

In view of addressing endogeneity, we consider including one lag of the dependent variable (Log of CO2pc) into Equation 1 and Equation 2 to allows accounting for the dynamic and persistent effects, and also to enable the use of system GMM estimation. Hence, we obtain the dynamic models of the EKC models for which the functions are:

$$CO2pc_{it} = \alpha + \eta CO2pc_{it-1} + \beta_1 GDPpc_{it} + \beta_2 GDPpc^2_{it} + \beta_3 No\_FTAs_{it} + \beta_4 Control\ variables_{it} + \varepsilon_{it} \quad (3)$$

And

$$CO2pc_{it} = \alpha + \eta CO2pc_{it-1} + \beta_1 GDPpc_{it} + \beta_2 GDPpc^2_{it} + \beta_3 No\_FTAs_{it} + \beta_4 GDPpc * No\_FTAs_{it} + \beta_5 GD \quad (4)$$

CHAPTER 4: RESEARCH RESULTS

4.1. Descriptive statistics

CO2 emissions per capita

We illustrate the heat map of CO2 emissions per capita of the countries in Figure 1. Top three emitters of this category are those with fairly less populous in the region, which are Palau, Brunei and Australia. Asian giant economies, including Korea, Japan and China, recorded per capita emissions at 0.000244, 0.000204 and 0.000132 Mt CO2e, respectively.

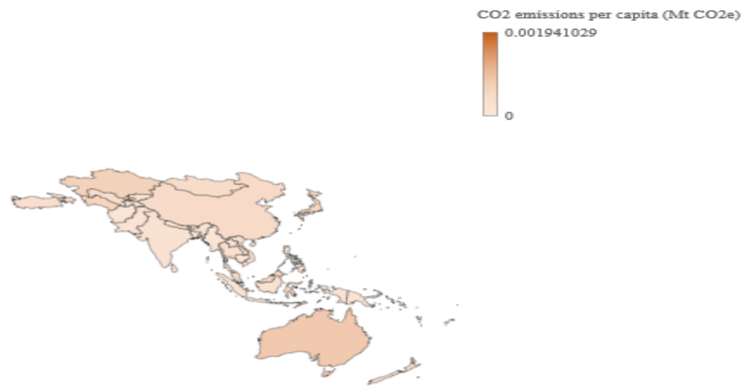


Figure 1: Map of CO2 emissions per capita of Asian countries

FTAs participation

In the examined period, there were 143 FTAs that entered into force, and 6 of which turned inactive. More than 85% of the trade agreements are bilateral type, with 19 of which involving one party as an RTA. There were 19 times entities participated in plurilateral trade agreements, with at least a party being an RTA in 4 out which. Coverage of the trade agreements also saw a structural change, from solely Goods-based to the dominance of Goods and Services in the later part.

Other variables

Summary statistics of other variables are provided in Table 3. Constant GDP per capita records the max of $98,998 compared to the min of $277.1, indicating an immense and cardinal income gaps within the countries. The demographic and natural factors also show clear disparities. High overall energy consumption and dependency on fossil fuel, as well as broad difference in importance of oil and natural gas economic sectors, signals potential environmental sustainability challenges. Coupled with the variation in population density and urbanization, this underscore diverse stages of development and economic reliance across regions.

Table 3: Summary statistics

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
GDP per capita (constant 2015 US$)	987	10,118	15,689	277.1	98,998
Population density (people per sq. km of land area)	987	871.3	3,006	1.543	21,530
Urban population (% of total population)	987	49.93	25.46	12.98	100
Oil rents (% of GDP)	907	2.326	5.889	0	39.58
Natural gas rents (% of GDP)	950	1.244	4.079	0	55.01
Energy use (kg of oil equivalent per capita)	489	1,887	1,964	81.60	9,697

Fossil fuel energy consumption (% of total)	470	66.37	30.01	0	100

4.2. Baseline results

Table 4: Baseline results

Dependent variables: Log of CO2pc		
	Equation 1	Equation 2
LogGDPpc	0.598	0.173
	(0.602)	(0.564)
LogGDPpc_sq	-0.0246	0.00538
	(0.0381)	(0.0359)
Accumulated number of FTAs	-0.00306	0.192
	(0.00518)	(0.240)
LogGDPpcxFTA		-0.0354
		(0.0534)
LogGDPpc_sqxFTA		0.00150
		(0.00293)
Energy use (kg of oil equivalent per capita)	0.000162***	0.000157***
	(5.39e-05)	(4.62e-05)
Fossil fuel energy consumption (% of total)	0.0262***	0.0261***
	(0.00340)	(0.00310)
Oil rents (% of GDP)	0.00346**	0.00295**
	(0.00139)	(0.00118)
Natural gas rents (% of GDP)	0.0189**	0.0158**
	(0.00763)	(0.00641)
Population density (people per sq. km of land area)	7.67e-05	9.19e-05
	(7.63e-05)	(8.18e-05)
Urban population (% of total population)	0.0144***	0.0134***
	(0.00515)	(0.00461)
Constant	-19.09***	-17.67***
	(2.330)	(2.223)
Observations	465	465
R-squared	0.751	0.768
Number of Country	37	37

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Baseline results after of Equation 1 and 2 show insignificant results for the relationship of number of FTAs and environment degradation (Table 4). The EKC inverted U-shaped curve also exhibits no sign of existence as neither GDPpc nor its squared term statistically correlates with total CO2 emissions in both of the regressions. Likewise, the two interaction terms of GDPpc and its squared terms with Accumulated number of FTAs reflect no significant relationship to CO2 emissions. The control variables prove their relevance in a model of CO2 per capita by being positive correlated at 1% and 5% significant levels.

4.3. Endogeneity treatments and main results

Table 5 contains the regression results from GMM approach. We first notice the high autoregressive coefficient on lagged CO2 emissions, which illustrates the persistence of emissions over time. With high p-value (> 0.05), the set of the post-estimation tests of the AR(2) test, the Sargan test, the Hansen test, and the difference-in-Hansen tests for the subsets, produce desirable results that confirm and bolster the validity of the instruments used. With the current GMM estimation, which addresses the endogeneity of GDPpc, GDPpc_squared and the number of FTAs, we can confirm compelling evidence consistent with the direct and indirect impacts of FTAs on growth and environment. For greater depth, in Equation 3, neither GDPpc nor its squared term achieve statistical meanings. Notably, the direct effects of FTAs are positive but not robust in this equation. When interaction terms are incorporated in Equation 4, the GDPpc elements are statistically significant, reaffirming an inverted U-shaped relationship between income and CO2 emissions -suggesting that emissions increase with economic growth up to a threshold, after which they decline. The correlation of FTAs and CO2 per capita becomes positively significant, implying that greater participation in FTAs is generally associated with higher emissions, for every extra FTAs associating with a 0.709 increase in log(CO2pc), or a 70.9% increase of CO2 emissions per capita. The effects are more nuanced since both of the interactions have statistical meanings. This indicates that the environmental impact of economic development is conditional on the extent of trade agreement integration. In particular, although FTAs and GDP per capita do accelerate the degradation of the environment, it can be inferred, through the positive correlation of their interaction, that signing FTAs can help moderate such acceleration effects, which in turn attenuates the adverse environmental impacts of economic expansion. The other interaction term indicates a negative coefficient, suggesting that in the presence of EKC, or an inverted U-shaped relationship of growth and environment in the context of this study, FTAs seem to modulate the curvature of the relationship, amplifying the reversal of the growth-environment curve, and dragging the turning point a bit closer. In other words, economies with more intense engagement in trade agreements may reach the income threshold, at which increased income starts to benefit the environment, at an earlier stage of economic development. Collectively, the findings can reflect the essential role of FTAs in facilitating the spillover effects of cleaner technologies, promoting stringent environmental standards, and enhancing regulatory practices, all of which contribute to a more pronounced non-linear mitigation of trade-offs in the growth-environment nexus.

Table 5: GMM results

Dependent variable: Log of CO2pc		
	Equation 3	Equation 4
L.LogCO2pc	0.859***	0.858***
	(0.0797)	(0.0965)
LogGDPpc	0.829	2.197**
	(0.690)	(0.969)
LogGDPpc_sq	-0.0472	-0.132**
	(0.0473)	(0.0654)
Accumulated number of FTAs	0.00169	0.709***
	(0.00397)	(0.272)
LogGDPpcxFTA		-0.159***
		(0.0612)
LogGDPpc_sqxFTA		0.00883***
		(0.00340)
Energy use (kg of oil equivalent per capita)	5.54e-05	0.000117
	(7.50e-05)	(0.000101)
Fossil fuel energy consumption (% of total)	0.00148	-0.000867
	(0.00241)	(0.00313)
Oil rents (% of GDP)	-0.00177	-0.00190
	(0.00249)	(0.00372)

Natural gas rents (% of GDP)	0.000557	0.000974
	(0.00478)	(0.00705)
Population density (people per sq. km of land area)	1.18e-06	1.44e-05
	(2.78e-05)	(4.08e-05)
Urban population (% of total population)	0.00101	0.00485
	(0.00349)	(0.00487)
Constant	-5.612*	-11.19***
	(3.126)	(4.305)
Observations	437	437
Number of Country	37	37
Observations	437	437
AR(1) test	-3.57	-3.38
	[0.000]	[0.001]
AR(2) test	0.90	0.96
	[0.367]	[0.339]
Sargan test (Chi2)	34.95	17.52
	[0.004]	[0.320]
Hansen test (Chi2)	18.64	13.45
	[0.228]	[0.492]
Diffrence-in-Hansen test -internal (Chi2)	2.89	3.81
	[0.576]	[0.432]
Diffrence-in-Hansen test -external (Chi2)	8.14	6.75
	[0.228]	[0.344]

The p-value of post-estimation tests are reported in square brackets.
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Follow the results from the GMM estimation, we construct Tables 6 that records the value of the turning point in accordance to the number of FTAs. For the majority of countries (45 out of 52) engaging at the level of not exceeding 14 FTAs, we will focus on the range of 0 to 14 FTAs and ticked marks will be placed at 0, 5, 10 and 14.

Table 6: FTAs engagement and turning points

No_FTAs	0	5	10	14
Turning point (LogGDPpc)	8.322	7.980	6.945	-1.730
Turning point (LogCO2pc)	-1.634	-1.637	-1.577	-0.824

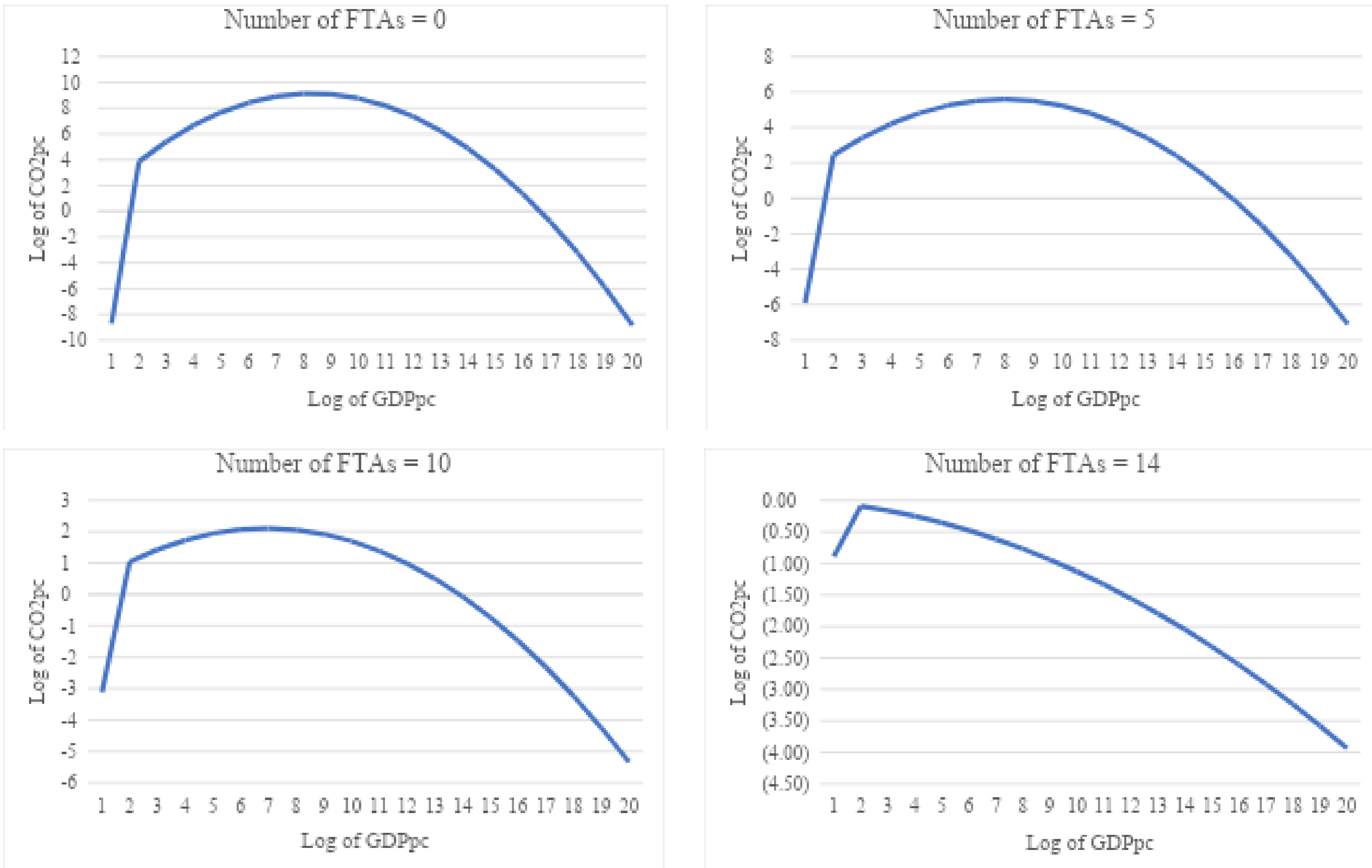
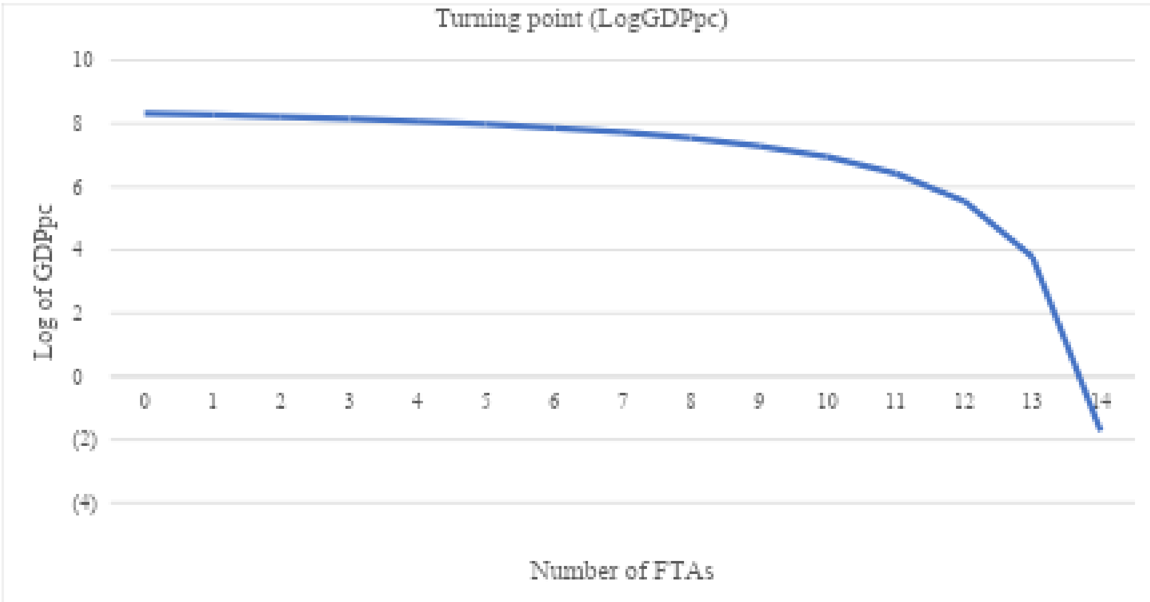


Figure 2: EKC functions and number of FTAs

We then establish series of figures for visualization. Figure 2 gives an overall look of how the functions fluctuates as countries pursue more FTAs, at the ticked marks. Figure 3 demonstrates the the change of turning points as of value of log of CO2pc along increased number of FTAs in the form of two-way line graphs.



4.4. Discussion

Comparing the results, we see that failure to account for endogeneity may have substantially denigrated the impacts of FTAs on the growth-emissions nexus as shown in the baseline estimate. Thus, the use of GMM estimation is efficient as it offers more precise estimates by properly addressing the endogenous variables. According to the empirical findings, the incorporation of FTAs into the conventional EKC model reveals a multifaceted interplay between income growth, environmental degradation, and the moderating role of trade liberalization in Asia. This robustly supports the EKC hypothesis through statistically significant coefficients on both GDP per capita and its squared term, suggesting an inverted U-shaped relationship between income and environmental impact. Importantly, while the direct effects of FTAs on income is positive, clear and robust, those on the environment appear ambiguous. The significant interaction terms, yet, imply the existence of the indirect effects of FTAs on the environmental ramifications through the channel of moderating the growth-environment nexus. In other words, this study produces strong evidence concluding that the environmental impacts of income growth are contingent upon the intensity of trade liberalization. To elaborate, signing more FTAs help reducing the pace at which growth of income depletes natural resources and harm the environment, as well as dragging the turning point closer. These findings mirror the themes in existing literature by aligning with results from Dong & Whalley (2011) and Dou et al. (2021), where FTAs are found to exert certain mitigation effects. Moreover, we also underscore the need for a nuanced exploration of the trade on the growth-environment nexus, as further delineated in the ensuing discussion.

The modifying effects of trade liberalization is more coherent utilizing the computation of the turning points. As can be seen clearly in the visualization, the deeper countries engage in FTAs pursuits, the smoother their EKC's inverted U-shaped curves become. This finding also suggests that higher level of FTAs participation can accelerate the green transition toward reduced CO2 emissions per capita to achieve environmental improvements. In essence, FTAs appear to moderate the conventional EKC by facilitating earlier environmental improvements. This is likely attributable to the spillovers of enhanced technology and the stricter environmental standards brought about by greater trade integration. Revising what we have hypothesized in the Theoretical frameworks section, these implications validate the hypothesis that the investigated FTAs situation support the PH effects. The alignment is extended further to the idea of the transformation of the inverted U-shaped to the inverted V-shaped along the increased FTAs pursuit process of countries in Asia.

CHAPTER 5: CONCLUSION

5.1. Key findings

This paper aims to examine the impacts of FTAs on Growth and Environment through the moderating effects on the nexus of Growth and Environment, utilizing the analysis of two equations, including the augmented EKC model. We manage to address endogeneity of potential reverse causality of Log of CO2 per capita with Log of GDP per capita and Accumulated number of FTA, using one-step system GMM on a panel dataset of 21-year period from 2000 to 2020 of 52 Asian countries.

Regression results suggest that the direct effects of FTAs environment degradation are ambiguous and only positively significant when adding the interaction elements. We also found evidence supporting the existence of the inverted U-shaped relationship of GDP per capita and CO2 per capita. The interaction terms also imply the underlying indirect effects of FTAs on the trade-offs of Growth and Environment. To elaborate, FTAs pursuit not only has mitigation effects on the pace at which increased income per capita raise CO2 per capita, but also brings the turning point, at which income growth begins to benefit the environment, to come closer. Further investigation on the turning point also reveals that with deeper FTAs participation, the turning point may arrive sooner and sooner, to an extent that the inverted U-shaped curve can potentially turn into an inverted V-shaped curve.

5.2. Policy recommendations

From the empirical results of this study, several policy recommendations could be derived as practical implications for policymakers, especially governors in Asian areas. Trade liberalization is confirmed to helps boost the economic growth, which is a vital priority in all countries' development strategies, particularly for developing economies. The primary key findings of this study imply evidence for the effects of FTAs engagement in controlling the undesired environmental consequences of growth. Countries should continue pursuing FTAs, with more attention to devote in environmental provisions in negotiations. This suggest increased efforts in upholding environmental standards, promoting sustainable practices, and facilitating green technology transfer in future FTAs formation. For economies that are in the early stage of economic development, the damages on the environment are often overlooked, and the increased participation in trade liberalization may be less efficient out of concern over PHH effects. However, as discussed on the results of this study, FTAs support the PH effects with environmentally friendly regulatory and technology spillovers, contributing to greening process. These developing countries can derive more advantages from this by seeking FTAs with parties with advanced environmental policies. Overall, before entering into new FTAs, it is important to consider thorough impact assessments that look at both the economic and environmental implications. Countries with FTAs in effect need to keep an eye on and evaluate them often so that they may make changes to their policies. This will help them manage the trade-offs between growth and the environment.

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