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Pollution Haven or Pollution Halo? Green Investment and Environmental Outcomes in Asia

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Abstract

This study examines the dynamic association between greenfield investment projects and the quality of institutions to environmental performance in 40 countries of Asia on the years 2000-2024. While the presence of foreign direct investment has often been linked to increased environmental degradation under the pollution haven hypothesis, new thinking places the focus on the role of foreign direct investment in promoting greater sustainability by transferring new, cleaner technologies and best practices in accordance with the pollution halo hypothesis. Using a model of an autoregressive distributed lag panel framework supplemented with causality analysis, this study attempts to analyze the interaction of new foreign capital inflows and governance structures with human capital and economic growth in influencing outcomes on the environment (as measured in the Environmental Performance Index). The results show that greenfield investment has a positive link to the environmental performance, but the impact is only statistically significant if mediated by good institutional quality, underlining the importance of governance to the shaping of sustainable performance. Economic growth has an Environmental Kuznets Curve where there is a rise in environmental stress at lower levels of income but an improvement as the economy develops. Human capital has a positive contribution to environmental quality, which reflects the importance of education and social development to strengthening sustainability. Estimates for the short run are more volatile and have no important meaning, other than greenfield investment. Some results of causality tests show two-way relationships between governance, investment, and environmental performance. Overall, the findings indicate how greenfield investment has the potential to become an engine for environmental improvement in Asia if backed by good governance, transparent policies, and human capital investment. The paper has important policy implications on how foreign investment policies can be operationalized in a manner that is consistent with the longer-term sustainability aspirations of the region.

Keywords: Green Investment, Institutional Quality, Environmental Performance, Asian Economies

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1. INTRODUCTION

Foreign direct investment has traditionally been seen as one of the key vehicles of economic growth and an important way in which frontier technology is transferred to host countries. Beyond contributing direct capital investment, foreign direct investment (FDI) is an influential engine of knowledge spillover, also when framing and redefining environmental effects. Although in the literature it usually has been the focus in terms that the propensity for foreign capital inflows is bad for the worst scenarios (via the movement of pollution-intensive industries to developing economies), recent literature suggests that foreign direct investment can be good for the environment too. By importing resource-efficient and more environmentally friendly technology or complying with international standards, multinational enterprises may help the receiving country in decarbonizing and in reducing carbon intensity (Demena and Van Bergeijk, 2019; Ali et al., 2023; Sadiq et al., 2025). A

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nice example is that US-owned factories in developing countries use less energy, and often less energy from clean sources than their local counterparts. This incorporation allows questioning the pollution havens hypothesis, in the sense that foreign affiliates would have a positive contribution, rather than a negative one, to the environmental performance of receiving countries. The superior results are often due to international enterprises having state-of-the-art technologies available, a global organization of knowledge, and environmental management practices on a larger scale. In addition, multinational companies are exposed to reputational and regulatory pressure in their home countries, which creates incentives for them to apply stricter environmental standards presented as requirements at the point of sale in spite of doing business abroad. Furthermore, the presence of such companies within the developing economies, thereby not only fosters spillover of knowledge but also results in diffusion of cleaner technologies and tightening up of adherence to the environmental regulations (Marc & Ali, 2017; Khan & Hassan, 2019; Demena & Kwaku, 2020; Ali et al., 2021; Rossi, 2023).

The shift to renewable economies throughout the world has been translated into a massive demand growth of financial instruments, designed to align actions to achieve the goal of imposing path dependency towards sustainable development. In its broadest sense, green finance, that is, the incorporation of environmental information in the decision-making process, has been one of the structural pillars of this transition. It offers the possibility of better preparing environmental and social risk management while still respecting the indispensable space to generate investments capable of generating economic earnings as well as real biological earnings. It links profitability and environmental implications to green finance, thereby facilitating companies and investors to invest in activities to contribute towards long-term sustainability goals and creating an incentive for reporting transparently and being accountable (Gorus & Groeneveld, 2018; Taghizadeh-Hesary and Yoshino, 2019; Bakht, 2020; Hussain & Khan, 2022). In this dynamic financial environment, greenfield investments are one such vital and relatively understudied institution to achieve sustainable growth. Unlike acquisitions and mergers, however, greenfield investments refer to the construction of absolutely new facilities - where investors can adopt more environmentally friendly technologies, modify production processes to be clean, and design structures more resource-efficiently from the ground up. Thus, such investments can serve as a source of a type of religiosity (with arguable contributions to environmental performance and parallel financial benefits to illicit beneficiaries) for the host countries (Doytch and Ashraf, 2015; Desiree, 2019; Zenios, 2024; Imran et al., 2024). In addition, the greenfield projects offer the promise of transfer of technology and employment to the host country, while gaining its sectoral experience in order to meet climate protection commitments under international regimes. While the literature on FDI and environmental quality is extensive, it is segmented between two hypotheses of the pollution haven hypothesis (FDI is inclined to establish polluting facilities in low-regulation countries) and cleaner technology (or cleaner practices). However, there is a dearth of empirical evidence on the role of investment in *ab initio* (green field) investments in the environmental performance of firms.

The present study tries to investigate and identify the dynamic relations among (GM, institutional quality, and environmental performance) in the Asian economies. By relying on the panel data econometrics, the paper has established new evidence on the interaction between foreign flows of new capital and governance regimes for the determination of sustainable development outcomes. The urgency of this question is evident as intervention in this area could help policymakers and practitioners offer evidence-based insights that will inform how to target and regulate greenfield investment that both contribute to improving the quality of institutions and reduce carbon emissions. Such results are particularly pertinent to the success of the transformation of the Asian economies into an environment of more sustainable economies with rapid industrialization and urbanization. Foreign direct investment, on the other hand, is one important predictor of growth in developing countries. In 2014 alone, that was the equivalent of nearly 681 billion US dollars in capital across developing economies alone and Asian markets accounted for a fair chunk of capital. Within the region, there are high increases in the FDI flows to East Asia and South Asia; the increase in FDI flows to South Asia was sixteen percent higher compared to last year (United Nations Conference on Trade and Development, 2015). A majority of these inflows have gone into the industrial sectors, in which importation of foreign technology and innovation of organizational practices and skillset has improved productivity, created more jobs, and enhanced human and capital capabilities (Zhang & Zhou, 2016). These knowledge spillovers are one example of how FDI can be an important agent of economic change in Asia.

Since the 1990s, developing regions in Asia have gained a reputation, quite deserved, of having achieved far higher rates of foreign direct investment in part precisely because their economic growth rates were brisk and their labor markets were sufficiently large and less. While it cannot be denied that FDI has resulted in growth and employment, it is even more controversial with regard to FDI and environmental impacts. Novel and emerging body of research suggested that foreign transnational corporations may sometimes transfer polluting industries to developing countries with weak environmental protection and thereby have an increased rate of air and water pollution and accelerated urbanization-based degradation (Shahbaz et al., 2015; Emodi, 2019; Imran et al., 2021). This brings into question the compatibility of foreign direct investment with the undisputed objective of sustainability, which strives to be prevalent in the long term.

More broadly defined as the destruction by anthropogenic processes of natural ecosystems, environmental degradation is an immediate outcome of industrial development with foreign capital. Hence, over-reliance on non-renewable energy resources, unsustainable urbanization, and overuse of natural resources have been identified as some of the channels through which capital inflows promote degradation of environmental quality. Moreover, recent theories of sustainability argue that the global challenges to ecological sustainability also come from less valid supply of governance and regulatory frameworks, transnational investment, and trade, which also aggravate environmental degradation (Grossman & Krueger,

1995; Copeland & Taylor, 2004; Kibritcioglu, 2023). Finally, a serious discussion on these two opposite hypotheses of pollution, pollution havens and pollution halos, is provided. According to the pollution haven hypothesis, the MNEs from developed countries tend to outsource pollution-intensive production to emerging economies with lax regulations to reduce the production cost, while externalizing the environmental constraints onto host countries (Pao and Tsai, 2011; Senturk, 2023). Moreover, this mechanism can even help explain why, in emerging markets, A) foreign direct investment inflows sometimes seem to be correlated to air quality deterioration, B) industrial emissions are rising, and C) ecological degradation is accelerating. In contrast, scholars of the pollution halo hypothesis hold that multinational firms can help improve environmental conditions in the host by means of technology transfers, adherence to national norms, and promotion of best management practices. Controlling accounts make the quality of institutions important: well-governed and well-enforcing governments may determine how foreign capital harms or eventually serves to protect the environment. In recent years, due to the large-scale increase of contemporary capital flows amongst countries, environmental issues are now too monumental both at a global scale and even at local levels. However, with metropolitan lifestyles and increasing industrial productivity and energy usage, such connections are at an increasingly deeper level of complexity. Natural resources and stocks affected by increasing human exploitation, fossil energy use, unsustainable land use, and actions have contributed to the growing environmental burden on Asian economies. This requires the salience of a deeper empirical study which adopts methodologies to attempt to imagine how greenfield investment can be beneficial rather than detrimental to environmental sustainability, and how the quality of institutional systems is important in mediating such sentiment.

2. LITERATURE REVIEW

This section is based on the literature about the relation between greenfield investment and institutional quality on environmental performance. The interplay between institutional quality, environmental sustainable transformation, economic development, and financial development is multidimensional, and new attention has been in empirical research over the past years. Many papers have targeted the double-edged sword nature of energy use, both renewable and non-renewable resources, with respect to the economy and the health of the environment. Musibau et al. (2021) employed the quantile-on-quantile regression analysis for nine advanced countries and discovered that the increase in nonrenewable energy consumption contributed to economic growth, while it increased deterioration. However, renewable was inversely correlated to economic growth due to early-stage inefficiency in the green energy systems. In accordance with others, Sohail et al. (2021), using nonlinear autoregressive distributed lag (ARDL) models, have found positive correlations between GDP, population, and renewable electric power with air pollution in South Asian economies, indicating that, again, demographic and economic growth are also having a cost on the environment.

Ren et al. (2021) applied the spatial Durbin model to estimate the spatial spillover effect between green investment and research and development (R&D) in China. For instance, while green investment has been linked to sustainable development, the study noted that capital and staff R&D investment are useless if not channeled in the right direction, with diminishing returns meaning a lot of money can be wasted for nothing. These nuanced results suggest the significance of the institutional options of sustainable environmental innovation. Likewise, Zahan and Chuanmin (2021) found that green investment and financial development significantly contributed to China's sustainable development, reinforcing the complementary role of fiscal mechanisms and technology.

The nexus between financial development and environmental sustainability has gained increasing scholarly attention. Zahoor et al. (2021), using a robust regression and unit root framework, found that financial development in China was positively associated with urbanization and clean energy initiatives. However, the value-added manufacturing sector had adverse environmental implications. Raza et al. (2021) offered cross-national insights from South and East Asia, suggesting that foreign direct investment (FDI) and GDP positively influence environmental performance, but urbanization and trade tend to exacerbate environmental stress.

The influence of green finance was further analyzed by Saeed et al. (2021), who demonstrated through quantile regression techniques that green finance had a negative short-term impact in the top ten economies due to implementation inefficiencies. Nonetheless, the long-term benefits of strategic green investments were evident in Muganyi et al.'s (2021) semi-parametric analysis in China, where trade openness and industrialization partially offset the negative influence of green fintech and GDP on environmental quality.

Huang et al. (2021) conducted two separate investigations into China's environmental and economic dynamics. In one study using entropy weight methods, they showed that FDI positively impacted environmental innovation, while increased GDP negatively affected ecological quality. In another study applying quantile regression and propensity score matching, they highlighted that population growth and environmental degradation indices were positively related, while energy consumption and green investment had mixed impacts depending on the income level and regional policy design.

Institutional factors have emerged as significant determinants of both economic and environmental outcomes. Kamal et al. (2021), analyzing data from 105 countries through dynamic ARDL and fully modified least squares methods, found that fiscal policy, financial development, and FDI positively affected economic performance. However, trade and urbanization had a negative effect, which reflects the need for using integrated governance systems that combine economic development with protection for the environment. Ahmed et al. In the year 2022 took Chinese firms were taken as an example. They

analyzed the socioeconomic factors using unrestricted negative binomial regression, and they proposed that sustainable innovation was positively correlated with the accountability of the government, while in the case of the firms, inflation, restrained patent institutes, and cultural distance were the barriers to innovation. These findings point to the importance of institutional mechanisms of support to environmental entrepreneurship. Similarly, from European Union data of Kwilinski et al. (2023), by using the fine Tobit model, they have shown that green investment and public governance were the primary and operative determinants of economic openness and environmental modernization. These results generally support that environmental sustainability is not simply a technical or economic issue, but is convincingly institutional.

Urbanization is a multifaceted buzzword, where there was economic progress at the expense of environmental devastation, or where it comes at a centralize to sustainable progress. Khan, Wenti Hospital, and Khoo, Chitkat University of Lampung; and Haoxuan Wang, orphanage for angels, have studied 6 Asian economies and understood that economic development positively correlates with GDP, population growth, and energy usage, and negatively correlates with government finance. Their results emphasize the relevance of the efficiency of public spending as well as the relevance of the fiscal misalignment concerning the achievement of the sustainability objectives.

Wang et al. (2021) used methods of entropy weight in China, and stated that urbanization was in some cases positively related to growth, and the effect of FDI and human capital index was, under certain conditions. Therefore, they suggest that there are, even without the possibility of environmental and economic payoffs from distributing resources and channeling foreign investment, cannot be taken for granted without containment by policy of the additional traffic and urbanization.

Zhang et al. (2021) were focused on difference-in-difference as a methodology approach to the evaluation of the impact of green credit policies in China. A second theme was also identified as FDI remains a central piece of development, but policymakers should consider the negative effect green credit policies may have on environmentally intensive industries because there is potential for a correlation between regulatory constraint and investment flow. Aggravating with their findings, Kong et al. (2021) found that industrial structure and layouts had a positive impact on GDP, and FDI had a certain negative externality on its environment under the prevailing policy regimes.

Setiawan et al. (2021), adopting a descriptive method, characterized Indonesia as being in the nascent stages of low-carbon development, underscoring the need for comprehensive planning, particularly in emerging economies. These findings are echoed in the work of Assamah and Yuan (2024), who used OLS analysis in Ghana and concluded that GDP growth and capital investment positively influenced development, while inflation and weak institutional integrity posed challenges.

Although a growing body of literature has examined the environmental implications of foreign direct investment (FDI), much of this research has remained polarized between the pollution haven and pollution halo hypotheses, often treating FDI as an aggregate rather than disaggregating its forms. Consequently, the specific role of greenfield investment—as distinct from mergers, acquisitions, or portfolio flows—remains relatively underexplored in empirical studies, particularly in Asian economies. Existing evidence suggests that FDI can either exacerbate ecological degradation or facilitate the transfer of cleaner technologies, depending on host-country conditions, yet few studies explicitly analyze how institutional quality mediates these outcomes. Furthermore, while research highlights the importance of governance, human capital, and green finance in shaping sustainability trajectories (e.g., Modibbo & Saidu, 2023; Kwilinski et al., 2023; Iqbal & Noor, 2023; Ahmed et al., 2022; Habibullah, 2020; Iqbal, 2018), there is limited empirical work that integrates these dimensions into a unified framework assessing greenfield investment and environmental performance. Finally, much of the current evidence is country-specific (e.g., China, Indonesia) or focused on developed regions, leaving a significant gap in comparative, multi-country analyses of Asia, where rapid industrialization and urbanization amplify both investment opportunities and environmental risks. This study addresses these gaps by investigating the dynamic interplay between greenfield investment, institutional quality, and environmental performance across 40 Asian countries, thereby providing policy-relevant insights into how governance can ensure that new investment inflows support sustainability rather than undermine it.

3. MODEL SPECIFICATION

The theoretical model linking greenfield investment and environmental performance is best explained by integrating concepts from the Environmental Kuznets Curve (EKC) hypothesis, institutional theory, and human capital theory. The dependent variable of the study, Environmental Performance Index (EPI), is an aggregate measure of environmental quality of Asian countries, and the explanatory variables are greenfield investment (GFI), GDP growth (GDPG and GDPG2), governance (GI), and human capital index (HDI), which capture environmental, economic, institutional, and social dimensions. The continuous increase in GDP per head (per capita GDP, or sometimes real per capita GDP) and its smoothness is fit into a two-factor model as originally proposed by Grossman and Krueger (1995) and called the EKC (—strands the economics convergence hypothesis). The EKC states that environmental degradation rises with economic development until an income threshold is reached, after which it reverses as industrialization and per capita income rise, thus improving the quality of the environment through adopting cleaner technologies and investing in environmental sustainability. In order to test for this inverted U-shaped relationship between GDP growth and environmental performance, GDP growth and its squared term are included in the model.

Institutional theory supports the inclusion of the governance index as an explanatory and interacting variable. North (1990) argues that effective governance structures reduce transaction costs, enforce regulations, and shape economic behavior,

thereby influencing environmental outcomes. Strong governance ensures that foreign direct investments, such as greenfield projects, adhere to environmental standards and contribute positively to sustainable development.

Human capital theory (Becker, 1964) justifies the role of the human capital index in the model. Education and skill development not only enhance productivity but also increase societal awareness of environmental issues, encouraging demand for sustainable practices and technologies. A higher level of human capital fosters innovation and the adoption of environmentally friendly processes, which in turn improves environmental performance.

Greenfield investment, as measured in millions of dollars, is included in the model because foreign direct investment has a dual potential: it can either exacerbate environmental degradation if directed toward polluting industries or contribute to improved performance if channeled into cleaner sectors. The pollution haven hypothesis suggests that foreign investors might relocate polluting industries to developing economies with weaker environmental standards (Cole, 2004). However, the pollution halo hypothesis posits that multinational enterprises may bring advanced technologies and better environmental practices, thereby enhancing environmental quality (Zarsky, 1999). The inclusion of governance as a moderating factor provides a theoretical mechanism to determine whether greenfield investment acts as a haven for pollution or as a halo of sustainable development in the Asian context.

Table 1: Definitions and Measurement of Variables

Variable	Description	Source
Dependent Variable		
EPI	Environmental Performance Index	WDI
Explanatory Variables		
GFI	Greenfield Investment (Millions of dollars)	UNCTAD
GI	Governance Index	WGI
HCI	Human capital index, based on years of schooling and returns to education	UNDP
GDP	GDP per capita growth (annual %)	WDI
GDPG ²	Square of GDP per capita growth (annual %)	

The current study looks at the impact of greenfield investment, the governance index, the human capital index, GDP per capita growth, and the square of GDP per capita growth on the environmental performance of selected Asian countries from East Asia, South-west Asia, West Asia, and South Asia from 2000 to 2024. We have used the environmental performance index (EPI) as a proxy to evaluate the total environmental performance of countries to examine environmental degradation.

Data for different variables were obtained from a variety of sources. Greenfield investment data (millions of dollars) from UNCTAD, governance index data from the World Governance Index, human capital index data (based on years of schooling and returns to education) from Penn World, and gross domestic product per capita growth (annual percent) and square of gross domestic product per capita growth (annual percent) from World Development Indicators. Sample of selected countries are: China, Korea, Democratic People's Republic of Korea, Republic of Hong Kong China, Mongolia, Taiwan Province of China, Macao, China, Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste, Viet Nam, Afghanistan, Bangladesh, Bhutan, India, Iran, the Islamic Republic of, Maldives Nepal, Pakistan, Sri Lanka, Bahrain, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, State of Palestine, The Syrian Arab Republic, Turkey, United Arab Emirates, Yemen.

4. RESULTS AND DISCUSSION

The long-run outcomes from the autoregressive distributed lag (ARDL) model in Table 2 examine the influence of multiple economic and institutional variables on the Environmental Performance Index across Asian countries. The Environmental Performance Index is used here as a comprehensive measure of environmental quality, reflecting the extent to which countries are able to maintain ecosystems and environmental health in the face of economic and institutional pressures. Beginning with greenfield investment, its estimated coefficient is positive, indicating that foreign direct investment in the form of new projects is associated with improvements in environmental performance. However, the accompanying probability value is high ($p = 0.8478$), suggesting that this relationship is not statistically significant in the long run. This finding may align with the mixed literature on the environmental impact of foreign direct investment, where its effects are conditional on the regulatory environment and sectoral focus (Doytch & Uctum, 2011).

The relation of economic progress has a very different correlation. Possible interpretation of the regression equation indicates that the terms for squared consumption have nonzero and highly significant coefficients, the coefficient for the mean term of growth of gross domestic product is negative and significant as well. This results in an inverted-U-shaped relationship, which matches the Environmental Kuznets Curve hypothesis. As per this theory, with economic development,

environmental degradation has increased in the initial stage, but reversed after a threshold of income when resources are available for programmed learning about the environment and technological changes (Grossman and Krueger, 1995; Shahbaz et al., 2013). In this context, it implies that the Asian economies are more environmentally stressed in the initial stages of the industrialization process, but this will likely be reversed as development is achieved.

Human development index is positively and significantly correlated with the environmental quality. This means countries that pay more attention to health, education, and standard of living perform better on environmental issues. This could be attributed to increased availability of more environmentally conscious neonics, better institutional quality, and enforcement capacity in relatively institutionalized human capital environments (Majeed and Luni, 2019). The environmental performance is also seemingly positively and statistically significantly impacted by the governance index. Good governance can result in favorable environmental outcomes in terms of establishing rules (see Dasgupta et al. 2006), increasing information and people's involvement in the environmental decision-making process, and in steady and responsive institutional frameworks, environmental policies regarding resource appropriation, pollutant discharge, or environmental protection are more likely to be implemented. Finally, there is a significant (positive) intercept (constant term), but it is not statistically significant. This suggests that the differences in the basic level of environmental performance are too massive to be accounted for by using economic and institutional parameters modeled.

Table 2: Long Run Outcomes

Dependent Variable: EPI				
Model selection method: Akaike info criterion (AIC)				
Selected Model: ARDL (1, 1, 1, 1, 1, 1)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
GFI	0.1291	0.9008	2.4322	0.8478
GDPG	1.9537	0.5203	-8.6892	0.0000
GDPG2	0.5745	0.8752	8.8192	0.0000
HDI	0.7443	0.107	5.7745	0.0000
GI	0.2898	0.5984	4.4033	0.0000
C	7.7865	5.638	2.0613	0.4833

The long-run estimation results, which are presented in Table 3, estimate the relationship between environmental performance and a set of economic, institutional, and social variables, as well as interaction terms, have been included to account for the moderating effect of governance. The dependent variable of the model is the Environmental Performance Index (EPI), which measures the quality conditions of environmental development and sustainability of countries in Asian. From the results, it is estimated that there is a significant motive of governance to environmental performance; sole the coefficient of governance are positive and statistically significant, where better governance has significant positive impact environmental quality, thereby substantiological to findings of Dasgupta and et al. (2006) and Majeed and Luni (2019) on importance of governance to effective implementation of environmental policies. Moreover, we also document that government and greenfield investment interaction is also positive and statistically significant. This finding, therefore, implies that a stronger effect of FDI on the environment is more likely to materialize in the presence of stronger governance structures, reproducing previous evidence underlining the importance of institutional quality when moderating the effect of capital flows on the environment (Doytch and Uctum, 2011).

The exponentiation growth of Gross Domestic Product is still positive and significant, which provides the environmental Kuznets curve hypothesis. It means that while the earlier stages of the economic growth would witness environmental degradation, above a threshold, there is a tendency for the environment to improve as economic growth continues (Grossman and Krueger, 1995; Shahbaz et al., 2013). Furthermore, the importance of the interaction term encompassing the governance and economic growth suggests that good governance amplifies the environmental gains of introducing high stages of economic growth and further boosts the driving force behind the institutional channels through which EKC emerges.

On the other hand, the interaction term of governance and the human development index is found not to be significant, but is positive. While this model captures an overall positive correlation of human development and environmental improvement (Majeed & Luni, 2019), the issue of the moderating function of governance on this relationship is more varied, serving potentially driven by trade-off factors relating to sector or region, but beyond the model's representation. Interestingly, the main effect of greenfield investment is not statistically significant in this specification. This outcome suggests that investment alone may not substantially impact environmental performance unless moderated by effective governance mechanisms. Such findings align with the literature emphasizing the conditional effects of foreign capital inflows on environmental outcomes, especially in developing regions (Doytch & Uctum, 2011). Overall, the inclusion of

interaction terms in this model provides nuanced insight into how governance functions as an enabling or amplifying factor in the green growth-environment nexus. The evidence supports the proposition that institutional quality is not only directly beneficial for environmental quality but also essential in transforming other growth-related variables, such as investment and human development, into positive environmental outcomes.

Table 3: Long Run Outcomes

Greenfield Investment, Institutional Quality, and Environmental Performance Model (With Interaction Terms)

Dependent Variable: EPI				
Model selection method: Akaike info criterion (AIC)				
Selected Model: ARDL (1, 1, 1, 1, 1, 1)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
GFI	0.8424	0.7423	6.8209	0.741
GDPG	-2.9611	0.4636	-0.1303	0.8504
GDPG2	0.7077	0.4931	4.3484	0.0000
HDI	0.4451	0.6441	3.3319	0.8055
GI	0.556	0.9423	90.049	0.0000
GI*GFI	0.6185	0.9387	8.185	0.0000
GI*GDPG	0.1794	0.319	3.6034	0.0000
GI*HDI	0.7336	0.6988	4.8553	0.1117
C	0.1736	0.5674	1.7	0.3694

Table 4: Short Run Outcomes

Dependent Variable: D(EPI)					
Model selection method: Akaike info criterion (AIC)					
Selected Model: ARDL (1, 1, 1, 1, 1, 1)					
Variables	Coefficient	Std. Error	t-Statistic	Prob.*	
COINTEQ01	1.1276	0.4214	-5.6752	0.927	
D(GFI)	6.9912	4.3214	5.7707	0.8545	
D(GDPG)	0.4853	0.5627	1.2303	0.1396	
D(GDPG2)	0.3447	0.7877	13.452	0.0000	
D(HDI)	0.3755	0.5237	-2.1271	0.1479	
D(GI)	0.4607	0.1031	0.5612	0.7766	
C	-2.6508	0.6974	2.5411	0.3048	

The short-run estimation results in Table 4 provide additional insights into the dynamic adjustments affecting the Environmental Performance Index (EPI) in Asian countries. These results are based on the ARDL (1,1,1,1,1,1) specification selected using the Akaike information criterion, where first differences of the explanatory variables are used to capture short-term deviations from equilibrium, while the error correction term (COINTEQ01) reflects the speed at which the system returns to its long-run equilibrium after a shock.

Interestingly, the coefficient of the error correction term (ECM) is positive and statistically insignificant, which is unexpected in an ARDL framework. Normally, we expect a negative and significant coefficient for the error correction term, indicating a convergence toward long-run equilibrium (Pesaran et al., 2001). In this case, the positive sign and high p-value (0.927) suggest that the model does not exhibit stable adjustment dynamics in the short run. This could mean that the model was mis-specified, or there were structural breaks or missing variables that were interfering with the short-run adjustment.

A large positive coefficient on the short-run regressions of greenfield investment provides good evidence that greenfield investment over the short run can be positively correlated with changes in environmental performance. However, the p-value is a high number (0.8545), and this suggests that this relationship is not statistically significant. Similar results are obtained for governance and human development index variables, which have positive signs as expected, but are statistically not significant in the short run. These findings are in line with prior studies (e.g., Majeed and Luni, 2019) that have generally found that the institutional and social determinants of environmental performance are more influential in the long term as opposed to exercising acute effects.

The coefficient for the squared growth term in GDP still remains significant ($p < 0.001$) as well, and positively, making the EKC still a valid theory, even in the short run (Grossman et al., 1995). This suggests that while starting from lower levels of growth, growth might be poor for the quality of the environment, economies nevertheless move towards a position in which growth would produce a better environmental quality. This finding also highlights the non-linear character of economic-environment interactions, echoing results from Shahbaz et al. (2013) and Dasgupta et al. (2006), where the trajectory of environmental outcomes is strongly influenced by the maturity of economic development.

On the other hand, current GDP growth and the human capital index have no statistically significant short-term impact on EPI. This again aligns with theoretical perspectives that emphasize the gradual nature of institutional, educational, and technological transformations required for environmental improvement (Doytch & Uctum, 2011). The constant term is also statistically insignificant, reinforcing the possibility that short-term fluctuations may be better explained by external shocks or time-variant country-specific factors not captured in the model.

The short-run outcomes presented in Table 5 reflect the dynamic interactions between greenfield investment, institutional quality, and environmental performance across Asian countries, estimated via an ARDL (1,1,1,1,1) model selected by the Akaike information criterion. In this model, the dependent variable is the first-differenced Environmental Performance Index (Δ EPI), and the key focus lies in understanding how the short-term fluctuations in greenfield investment, governance, human development, and economic growth, both directly and through interaction terms, affect environmental outcomes.

One of the most striking observations in this model is the coefficient of the error correction term (COINTEQ01), which is negative, as theoretically expected, but not statistically significant ($p = 0.4233$). While a negative sign typically indicates convergence toward the long-run equilibrium, the lack of statistical significance suggests that short-run deviations are not robustly corrected, pointing to weak short-term adjustments in the relationship between environmental performance and its drivers (Pesaran et al., 2001).

Table 5: Short Run Outcomes

Estimates of Greenfield Investment, Institutional Quality, and Environmental Performance Model (With Interaction Terms)

Dependent Variable: D(EPI)				
Model selection method: Akaike info criterion (AIC)				
Selected Model: ARDL (1, 1, 1, 1, 1)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
COINTEQ01	-2.4592	0.6106	-5.9085	0.4233
D(GFI)	0.7018	0.125	74.074	0.0000
D(GDPG)	-1.5186	0.437	-3.8453	0.6815
D(GDPG2)	-2.6921	0.6414	-0.741	0.5508
D(HDI)	-2.8064	5.1447	-3.6746	0.9096
D(GI)	5.3558	4.6959	0.5776	0.7495
D(GFI*GI)	0.1331	0.3873	0.0707	0.9102
D(GDPG*GI)	2.4978	0.2089	-2.0863	0.3805
D(GI*HDI)	-0.5083	1.0266	-2.8545	0.4185
C	0.537	0.7953	7.1047	0.5532

Among the independent variables, first-differenced greenfield investment (Δ GFI) emerges as the only statistically significant variable in the short run ($p < 0.001$), with a positive and substantial coefficient of 0.7018. This suggests that increases in greenfield investment are immediately associated with improvements in environmental quality. This result is consistent with existing literature that emphasizes the potential of greenfield investments to introduce cleaner technologies and environmentally friendly infrastructure, particularly in developing economies (Doytch & Uctum, 2011).

On the other hand, short-run changes in GDP growth (Δ GDPG), its squared term (Δ GDPG²), human development index (Δ HDI), and governance (Δ GI) all yield statistically insignificant effects. This implies that, in the short run, fluctuations in these variables do not have a measurable impact on environmental performance. It is plausible that their effects are either lagged or cumulative, manifesting more clearly in the long run, which aligns with previous findings by Dasgupta et al. (2006) and Shahbaz et al. (2013) on the non-linear and slow-moving nature of institutional and economic transformations affecting environmental quality.

The interaction terms— D(GFI*GI), D(GDPG*GI), and D(GI*HDI)- were introduced to explore whether governance amplifies or mitigates the effects of investment, economic growth, and human development on environmental outcomes. However, none of these interaction terms are statistically significant in the short run. Despite some of them having theoretically meaningful directions (e.g., the positive sign on Δ (GFIGI)), their large standard errors and p-values above conventional thresholds suggest that the moderating role of governance is not immediately observable. These results echo the findings of Majeed and Luni (2019), who noted that governance quality typically strengthens environmental performance over time but may not yield instantaneous effects, especially in less institutionally mature environments.

Furthermore, the constant term is also insignificant, reinforcing that short-term changes in environmental quality cannot be explained by unobserved fixed effects or shocks within this model specification. The insignificant short-run effects of key socio-economic variables also suggest a need for deeper examination of structural breaks, possible non-linearities, or heterogeneity across countries that may be dampening these relationships.

The results from the Dumitrescu-Hurlin panel causality tests presented in Table 6 reveal important directional linkages among governance, greenfield investment, and environmental performance within Asian countries. Firstly, the rejection of the null hypothesis that governance does not cause greenfield investment ($p = 0.015$) suggests that institutional quality

exerts a statistically significant causal influence on greenfield investment inflows. This is consonant with the argument that improved governance structures can help with the creation of investor and institutional confidence that will gather more sustainable investment flows or investment directed to environmental priorities (Majeed and Luni, 2019).

By contrast, the causal link in the opposite direction, from investment (in greenfields) to governance, was close to significant ($p = .0829$), suggesting that there is little strong evidence that such investment impacts the existing governance arrangements, or can improve governance arrangements, in these extraction environments. This asymmetry justifies our view that governance is a more fundamental determinant of investment flows than it is an endogenous proxy for investment flows (Doytch and Uctum, 2011).

A second alternative indicator of environmental performance-the environmental performance index-which also captures the impact on the ecological environment due to these exchanges, is also purportedly relevant to bi-directional causality with GCCI. The test shows that environmental performance affects the greenfield investment ($p=0.0448$), but rather greenfield investment has a significant effect on the environmental performance ($p=0.0000$). Two-way causality, what they propose is that there can be a feedback loop between the environmental quality of a country and how much green investment is attracted by that quality, and vice versa.

In addition, governance is shown to affect environmental performance significantly ($p = 0.029$), which adds to the role of institutional quality and the institutional quality of environmental regulation as important determinants of environmental performance. This is empirically valid because, regarding previous works, it has been indicated that the governance quality is a mediator variable between economic input to environmental output (Shahbaz et al., 2013). Also, the reverse relationship of environmental performance to governance state is crucial ($p = 0.0195$), and the result indicates that changing environmental performance (either a process of degradation or an improvement) will, in turn, put pressure on the governments and institutions to adjust policies and/or improve supervision.

The results, overall, support the interconnectedness of interaction between political factors and investment, and environmental quality. These connections are thus voiced across the theoretical predictions of the environmental governance and institutional quality literature in that there is no one-way causality; rather, divisive causality is often "upwards" and downward in a continuous dynamic development environment (Pesaran, Yu, & Wu, 2001).

Table 6: Pairwise Dumitrescu- Hurlin Panel Causality Tests

Null Hypothesis	W-Stat.	Zbar-Stat.	Prob.
GI $\rightarrow$ GFI	4.3897	9.3665	0.015
GFI $\rightarrow$ GI	1.0936	0.2984	0.0829
EPI $\rightarrow$ GFI	2.1434	9.6516	0.0448
GFI $\rightarrow$ EPI	41.316	60.37	0.0000
GI $\rightarrow$ EPI	7.2078	2.2118	0.029
GI $\rightarrow$ EPI	5.6378	3.4387	0.0195

5. CONCLUSIONS

This research has looked at the inter-relationship between greenfield investment, institutional quality, human capital, economic growth, and ecological sustainability for 40 countries in Asia from 2000 to 2024. The results stemming from the panel ARDL approach supplemented by the causality tests provide some interesting evidence of others for the effects of new FDI flows, governance systems, and socio-economic factors on environmental outcomes in the region. This study found that in long-run estimates, while greenfield investment has a positive association with environmental performance, this association is heterogeneous in importance across the quality of governance. Indeed, this moderating effect correlates very well with government effectiveness, making greenfield investment an investment demand for cleaner technologies and sustainable practices. If their institutional structures were right, mobilization of foreign investment to take cognizance of the environment would be most conducive for the pollution halo view of investment. On the one hand, when governance was fragile, however, the independent influence of greenfield monetary exercise was weakly positive, which provided insight into the conditional nature of the environmental worth of greenfield monetary workout. A Kuznets Curve was developed - a negative link to the environment in the earlier part of growth, but a positive link in the more advanced phases - the quadratic growth term is capable in the long and short-term equation, and the Nonlinearity of the Income and Environment strain Curves. Human capital also has a constant positive impact of process changes on the course of educational progress and increases the standard of living is linked to a strong sense of the climate or better capacity of institutions to impose and facilitate. He found that governance itself was an important determinant of environmental performance, both directly and through its interaction with investment and growth, confirming the importance of institutional quality for attaining environmental benefits. Short-run results were much more varied, with most variables not achieving the statistical significance threshold, with the exception of greenfield investment, where a strong immediate positive effect was observed on environmental performance. However, the error correction terms in some specifications indicated weak or unstable adjustment dynamics, pointing to structural breaks and short-term volatility that may affect environmental outcomes in

rapidly industrializing economies. The causality analysis further confirmed the reciprocal nature of these relationships. Governance was found to drive greenfield investment inflows, while environmental performance itself influenced and was influenced by new investment. These bidirectional linkages highlight the feedback loops between institutional quality, capital inflows, and environmental outcomes. Overall, the results suggest that greenfield investment can contribute positively to environmental performance in Asia, but its success is contingent upon institutional quality and governance. Strengthening regulatory frameworks, enhancing transparency, and investing in human capital are essential for ensuring that foreign investment not only fuels economic growth but also supports long-term environmental sustainability across the region.

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