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The Impact of Carbon Pricing on Economic Attractiveness and Environmental Performance: A Structural Equation Modelling Approach Across Asia-Pacific

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Abstract
This study examines the multidimensional effects of carbon pricing on environmental quality and economic attractiveness in Asia-Pacific countries, applying Partial Least Squares Structural Equation Modeling (PLS-SEM). Economic attractiveness is proxied by foreign direct investment (FDI) indicators, while environmental quality is assessed through the Environmental Performance Index (EPI) and related metrics. The model incorporates four latent constructs: carbon pricing, environmental performance, fiscal capacity, and FDI. Results indicate that carbon pricing exerts a statistically significant and positive impact on both environmental quality and government revenue, reinforcing its role as a policy instrument with dual ecological and fiscal benefits. Notably, carbon pricing also demonstrates a direct positive influence on FDI, suggesting that credible and transparent environmental policies may enhance a country's investment appeal. However, indirect effects via environmental performance and fiscal capacity are not statistically significant. By integrating environmental, fiscal, and investment dimensions, this study contributes a novel empirical framework to the literature on sustainable development policy in emerging economies. The findings offer actionable insights for policymakers aiming to design carbon pricing strategies that support both environmental goals and economic competitiveness. Overall, the model demonstrates that carbon pricing simultaneously strengthens environmental quality, fiscal capacity, and investment attractiveness, offering empirical evidence that such policies function as an integrated lever for both sustainability and economic competitiveness.

1. Introduction

The increasing urgency of climate change has catalyzed a global shift toward carbon pricing mechanisms as tools to mitigate greenhouse gas emissions. As of 2024, more than 75 carbon pricing instruments, including carbon taxes and emissions trading systems (ETS) are operational worldwide, covering approximately 24% of global greenhouse gas (GHG) emissions and generating over USD 104 billion in revenue [1]. This growing momentum reflects not only environmental imperatives but also the recognition that climate-related fiscal tools can be leveraged for economic and developmental transformation.

Nowhere is this trend more dynamic and more contested than in the Asia-Pacific region, home to several of the world's largest carbon emitters and fastest-growing economies. Countries such as China and South Korea have implemented nationwide ETS programs, with China operating the largest carbon market in the world. Singapore introduced Southeast Asia's first carbon tax in 2019, signaling a shift in regional climate policy leadership. Meanwhile, countries like Singapore, Indonesia, and Malaysia are at various stages of carbon pricing readiness, ranging from pilot projects to national consultations, while others such as Bangladesh, Nepal, and Laos have yet to formalize any pricing strategy [2] .

This heterogeneity is not only a policy divergence it reflects varying levels of institutional capacity, fiscal autonomy, and environmental performance. According to the 2024 Environmental Performance

Index (EPI), scores across the region vary dramatically: Singapore ranks highest in Southeast Asia with a score above 50, while countries such as India, Bangladesh, and Myanmar fall near the bottom globally, with EPI scores below 30. These indicators, which include air quality, climate mitigation, and ecosystem vitality, reflect one of the key dimensions analyzed in this study is about Environmental Performance [3].

In parallel, carbon pricing also interacts with a second important dimension, economic attractiveness. In this study, economic attractiveness is understood as a country's capacity to attract foreign direct investment (FDI), which reflects global investor confidence, institutional credibility, and market openness. FDI is thus used as a proxy to represent how carbon pricing affects economic competitiveness from an international capital perspective particularly under increasing ESG investment criteria [4].

Yet despite these developments, a critical question remains, does carbon pricing attract or deter investment in emerging economies? On one hand, stringent carbon policies may increase production costs and deter high-emitting industries, a notion supported by the Pollution Haven Hypothesis. On the other hand, such policies may signal long-term stability and innovation potential, thereby attracting "green" FDI aligned with sustainability principles, consistent with the Porter Hypothesis [5].

Moreover, most empirical studies focus on single pathways e.g., carbon pricing's effect on emissions, or FDI's sensitivity to regulatory burden without modeling the multi-directional, structural relationships between environmental regulation, fiscal capacity, and investment attractiveness. This is especially problematic for countries in the Asia-Pacific region, where economic development and environmental governance are tightly intertwined [6].

To address this gap, this study adopts a Structural Equation Modeling–Partial Least Squares (PLS-SEM) framework to assess the multi-layered impact of carbon pricing on environmental performance and economic attractiveness, mediated by fiscal variables. By focusing on the Asia-Pacific a region of high emissions, active policy experimentation, and significant investment dependency this study contributes both to academic literature and policymaking by offering an integrated, empirically tested model of how carbon pricing influences environmental and investment outcomes in emerging economies.

2. Literature Review

The relationship between environmental policy, fiscal performance, and foreign direct investment (FDI) has become increasingly significant in the context of global climate change and sustainable economic development. Carbon pricing, in particular, has been recognized as a key mechanism for reducing greenhouse gas (GHG) emissions, while also potentially influencing government revenue and the investment climate. This literature review synthesizes existing studies across four key thematic areas: carbon pricing mechanisms, environmental performance, fiscal capacity, and foreign direct investment. Additionally, it provides a rationale for employing the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach in the present study.

2.1. Overview of Previous Empirical Studies

A growing body of literature has attempted to examine the environmental, fiscal, and economic implications of carbon pricing policies. Aldy & Pizer (2015) found that carbon taxes implemented across OECD countries had statistically significant effects on reducing GHG emissions without compromising economic growth [7]. Metcalf & Stock (2020) confirmed similar patterns in Sweden and British Columbia, both early adopters of carbon pricing mechanisms [8].

In the context of developing economies, Wang et al. (2021) demonstrated that China's national ETS pilot significantly reduced emission intensities among regulated firms, especially in the power and industrial sectors [9]. Imamoglu & Topcu (2023) analyzed 15 Asia-Pacific countries and found a weak but positive correlation between environmental performance and FDI inflows [3].

On the fiscal front, OECD (2022) reported that countries with carbon pricing instruments tend to exhibit more resilient and diversified revenue structures [10]. However, Benedek et al. (2017) cautioned that without appropriate revenue recycling mechanisms, carbon taxes may face public resistance and diminish in effectiveness [11].

Despite this progress, relatively few studies have explored the full structural linkages between carbon pricing, environmental performance, fiscal capacity, and foreign direct investment. Even fewer have done so using PLS-SEM, which is particularly suitable for modeling indirect and mediating effects in complex policy environments.

Most existing research has focused on:

1) Single-country case studies (e.g., Sweden, Canada, China)
2) Isolated bivariate relationships (e.g., Carbon Tax → Emissions; FDI → GDP)
3) Linear regressions or CB-SEM with strict assumptions

This study fills that gap by offering a multi-country PLS-SEM model focused on the Asia-Pacific region a high-emission, high-growth zone with diverse carbon policy maturity [12, [13].

2.2. Carbon Pricing Mechanisms and Policy Design

Carbon pricing is rooted in the Pigouvian tradition of internalizing negative externalities through economic instruments. The two most widely implemented carbon pricing mechanisms are carbon taxes and emissions trading systems (ETS), which have been adopted in over 70 jurisdictions globally [1]. Empirical studies suggest that carbon pricing can effectively reduce emissions if properly designed and implemented. For example, Metcalf and Stock (2020) find that carbon taxes in Nordic countries have significantly reduced CO2 emissions without negatively impacting economic growth [8]. Similarly, Wang et al. (2021) analyze China's ETS and find improvements in emission intensity among covered entities [9].

Various indicators have been employed in the literature to represent the strength and effectiveness of carbon pricing. These include the scope of sectoral coverage, the level of carbon prices (USD/tCO2), and policy implementation status (implemented, planned, or absent). These indicators are commonly used as proxies for a country's commitment to decarbonization and regulatory capacity.

2.3. Environmental Performance Metric

Environmental performance is often assessed through composite indices and thematic indicators. The Environmental Performance Index (EPI), developed by Yale and Columbia Universities, is one of the most frequently used tools to evaluate country-level environmental outcomes. It incorporates multiple dimensions such as air quality, climate change mitigation, and ecosystem vitality [14].

Previous studies have shown that Environmental Performance can serve as both an outcome and a determinant of policy and investment behavior. Kellenberg (2009) and Doytch and Uctum (2016) provide evidence that countries with stronger environmental performance tend to attract more sustainable and higher-quality FDI. Indicators commonly used to measure environmental performance include PM2.5 concentration, GHG emissions per capita, the share of renewable energy, and biodiversity indices [15], [16].

2.4. Fiscal Capacity and Reveneu Mobilization

The fiscal implications of environmental policy are increasingly relevant in developing and emerging economies. Carbon pricing instruments, especially carbon taxes, generate significant public revenue, which can be reinvested in infrastructure, clean energy, or used for broader fiscal consolidation. OECD (2022) reports that carbon tax revenues have strengthened fiscal capacity in several European and East Asian countries [10].

Fiscal capacity is often measured using indicators such as tax revenue as a percentage of GDP, total government revenue, and budgetary reliance on environmental taxes. Rodrik et al. (2004) emphasizes the role of fiscal institutions in enhancing state capacity, which can influence economic competitiveness and investor confidence. In the context of this study, fiscal strength is hypothesized as a mediating variable linking environmental policy to investment outcomes [17].

2.5. Foreign Direct Investment (FDI) and Sustainable Considerations

FDI is a crucial driver of economic development, particularly in capital-scarce countries. However, its relationship with environmental regulation is complex. The Pollution Haven Hypothesis posits that stringent environmental policies deter investment in pollution-intensive industries [18], whereas the Porter Hypothesis suggests that such regulations can stimulate innovation and attract investment in cleaner technologies [19].

Empirical studies reveal mixed evidence. While Golub et al. (2022) find that ESG-compliant investors prefer environmentally progressive jurisdictions, others caution that excessive regulatory burdens may reduce FDI flows. FDI performance is typically measured through annual inflows, FDI per capita, and FDI as a percentage of GDP, all of which are indicators used in macroeconomic modeling [4].

In this study, economic attractiveness is operationalized through Foreign Direct Investment (FDI) indicators, which serve as measurable proxies for a country's appeal to international capital. FDI reflects investor perceptions of political stability, institutional quality, regulatory environment, and long-term growth potential. In the context of green transition, FDI is increasingly shaped by sustainability criteria, with investors prioritizing jurisdictions that offer policy clarity, ESG alignment, and climate resilience. Therefore, FDI inflow, FDI per capita, and FDI as a percentage of GDP collectively capture the economic dimension of a country's positioning in the global investment landscape [4].

2.6. Methodological Considerations: The Case for PLS-SEM

Given the complexity of the interrelationships among carbon policy, environmental outcomes, fiscal strength, and investment flows, Partial Least Squares Structural Equation Modeling (PLS-SEM) is deemed appropriate for this study. PLS-SEM is particularly suited for exploratory models, small-to-medium sample sizes, and non-normal data distributions [13].

Unlike covariance-based SEM (CB-SEM), which focuses on theory testing, PLS-SEM emphasizes prediction and variance explanation. It is also flexible in handling both reflective and formative measurement models. The structural model in PLS-SEM can be expressed as:

$$\eta=\beta\eta+\Gamma\xi+\zeta$$

Where, η: endogenous latent variable vector; ξ: exogenous latent variable vector; β:path coefficient matrix among endogenous constructs; Γ: path coefficient matrix from exogenous to endogenous constructs; ζ: error term.

PLS-SEM enables the estimation of both direct and indirect effects, making it well-suited to test mediation hypotheses involving environmental performance and fiscal capacity. Its application in cross-country sustainability and policy research has been increasingly recognized in recent years [20].

3. Research Method / Methodology

3.1. Research Design

This study adopts a quantitative research approach using a descriptive and explanatory design. The primary objective is to analyze the structural relationships between carbon pricing mechanisms (specifically in the energy and industrial sectors), environmental performance, fiscal capacity (government revenue), and foreign direct investment (FDI) attractiveness in Asia-Pacific countries. By employing Partial Least Squares Structural Equation Modeling (PLS-SEM), this research seeks to explore both direct and mediated effects across complex policy variables.

To enhance methodological transparency, the following flowchart illustrates Fig. 1, the sequential stages of data processing, model estimation, and statistical testing conducted in this research.

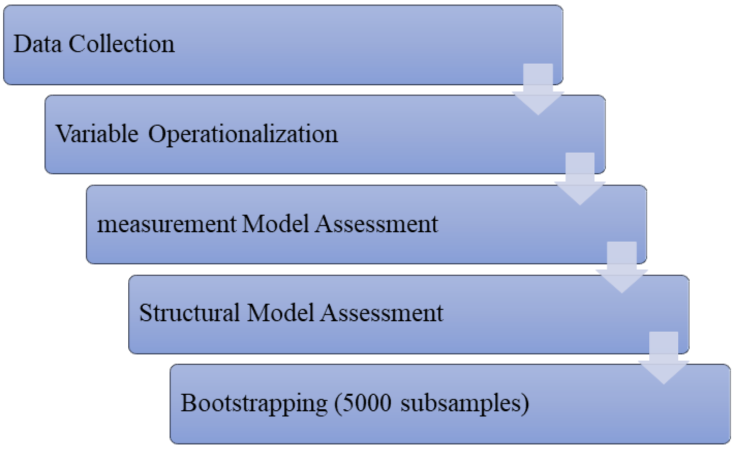

Fig 1. Flowchart of Methodology

This flowchart outlines the complete sequence of analytical steps performed in this study, providing a structured overview of how the PLS-SEM calculations were carried out.

3.2. Population and Sampling

The population of the study comprises 20 Asia-Pacific countries with varying levels of carbon pricing implementation as of 2024. These countries were selected based on their relevance to carbon pricing developments and data availability across key variables.

The sampling method is purposive, involving 20 countries categorized into three groups according to their carbon pricing implementation:

1) Fully Implemented (Ordinal Score: 2): Countries with formal carbon taxes or Emissions Trading Systems (ETS) applied to both energy and industrial sectors (e.g., Singapore, China, Korea, Japan).
2) Partial/Planning Stage (Ordinal Score: 1): Countries with ongoing policy development or implementation in only one sector (e.g., Indonesia, Malaysia, Vietnam).
3) Not Implemented (Ordinal Score: 0): Countries with no official carbon pricing schemes or legislative progress (e.g., Pakistan, Laos, Bangladesh).

3.3. Operationalization of Variables

This study comprises four latent variables and one exogenous variable, measured through a combination of ordinal and numerical data as shown in Table 1.

Table 1. Operationalization of Variables

Latent Variable	Measurement Indicators	Data Type	Source
Carbon Pricing (CP)	Ordinal scores (0–2) for Energy and Industrial Sectors	Ordinal (composite)	Ordinal Data
Environmental Performance (EP)	Environmental Performance Index (EPI); Air Quality; Climate Change indicators	Numerical	Yale EPI 2024
Government Revenue (GR)	Tax revenue as % of GDP; Total public revenue	Numerical	World Bank (WDI)
Foreign Direct Investment (FDI)	FDI inflow (USD); FDI per capita; FDI as % of GDP	Numerical	UNCTAD, World Bank

Carbon Pricing is treated as a formative construct composed of two ordinal indicators: carbon policy in the energy and industrial sectors. The remaining variables are reflective latent constructs.

3.4. Research Hypotheses

Based on theoretical and empirical literature, the following hypotheses are formulated as shown on Table 2.

Table 2. The Hypotheses

Code	**Hypothesized Path**	**Expected Direction**	**Rationale**
H1	Carbon Pricing → Environmental Performance	Positive (+)	Carbon pricing is expected to reduce emissions and improve EPI scores.
H2	Carbon Pricing → Government Revenue	Positive (+)	Carbon taxes or ETS permit auctions generate fiscal revenue.
H3	Environmental Performance → FDI	Positive (+)	Green investors are attracted to countries with better Environmental Performance.
H4	Government Revenue → FDI	Positive (+)	Higher government revenue supports infrastructure and investment climate.
H5	Carbon Pricing → FDI	Negative (–)	Higher costs from carbon pricing may deter emission-intensive FDI.
H6a	CP → EP → FDI (Mediation via Environmental Performance)	Positive (+)	Improved environmental reputation attracts sustainable investments.
H6b	CP → GR → FDI (Mediation via Government Revenue)	Positive (+)	Revenue from carbon pricing can enhance state capacity and investor trust.

3.5. Data Collection and Sources

Data were collected from secondary sources including:

1) Carbon Pricing: Official government publications, national climate strategies, World Bank Carbon Pricing Dashboard.
2) Environmental Performance: 2024 Environmental Performance Index (Yale University).
3) Fiscal Indicators: World Bank Development Indicators (tax revenue, government revenue).
4) FDI Statistics: UNCTAD World Investment Report, World Bank FDI dataset.

The data span the most recent available year 2023, ensuring consistency in cross-sectional analysis.

3.6. Analytical Technique: PLS-SEM

This study employs Partial Least Squares Structural Equation Modeling (PLS-SEM) using SmartPLS 4.0 [21], justified by:

1) Small sample size (n = 20 countries)
2) Exploratory nature of the model

3) Non-normal data distributions (ordinal indicators for carbon pricing)
4) Emphasis on path prediction and variance explanation

The model estimation follows the two-step approach:

1) Measurement Model Assessment
    a. Reflective constructs are evaluated using internal consistency (Cronbach's alpha, Composite Reliability), indicator reliability (outer loadings), and validity (Average Variance Extracted, Discriminant Validity via HTMT).
    b. Formative construct (Carbon Pricing) is assessed through multicollinearity (VIF) and the significance of outer weights.
2) Goodness of Fit (GoF) Index

This study applies the Goodness of Fit (GoF) index as proposed by Tenenhaus et al. (2008) to evaluate the global fit of the PLS-SEM model [22].

$$GoF = \sqrt{Average\ AVE \times Average\ R^2}$$

The GoF integrates measurement model quality and structural model explanatory power into a single performance index.

3) Structural Model Assessment
    a. Direct effects: Path coefficients, significance via bootstrapping (5000 subsamples), R^2 for endogenous constructs.
    b. Indirect effects: Mediation analysis (Variance Accounted For - VAF).
    c. Model Fit: SRMR and NFI statistics used for global model fit.

3.7. Structural Model Specification

The structural model is specified as follows Table 3.

Table 3. Model Specification

Path	**Direct Relationship**	**Mediated Path**	**Endogenous Variable**
CP → EP	Yes	–	EP
CP → GR	Yes	–	GR
EP → FDI	Yes	–	FDI
GR → FDI	Yes	–	FDI
CP → FDI	Yes	–	FDI
CP → EP → FDI	No	Mediation through Environmental Performance	FDI
CP → GR → FDI	No	Mediation through Government Revenue	FDI

Note: "CP" = Carbon Pricing, "EP" = Environmental Performance, "GR" = Government Revenue, "FDI" = Foreign Direct Investment.

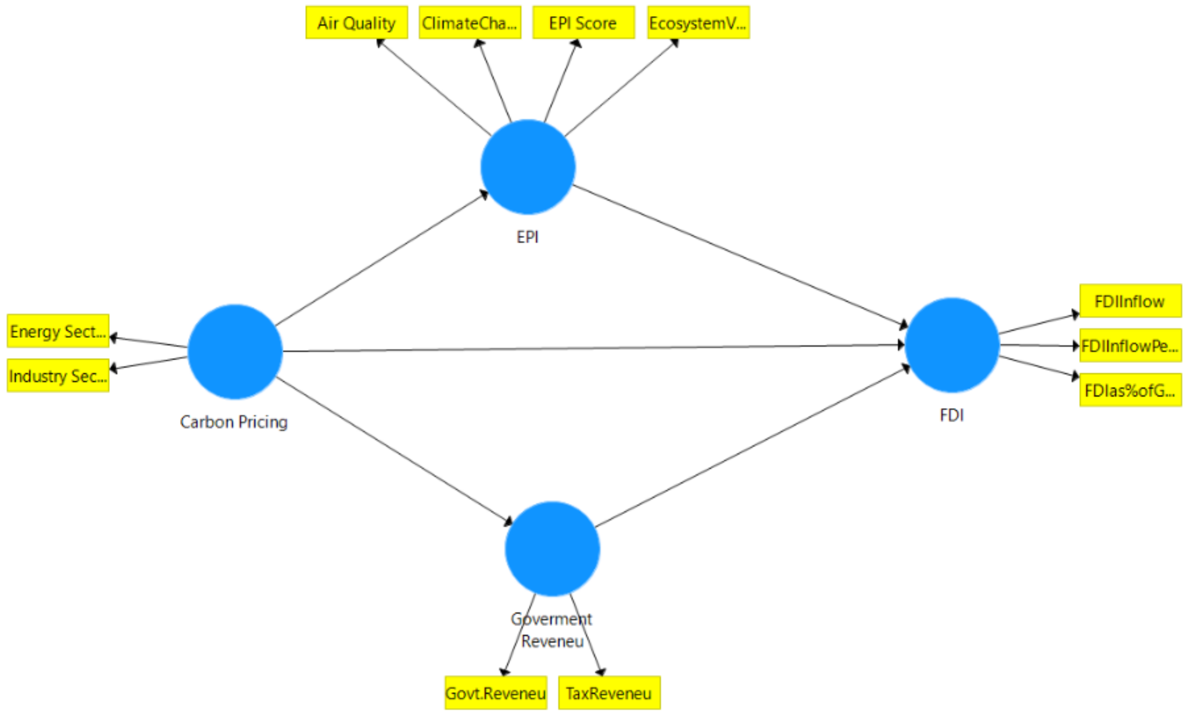

Fig 2. Hypotheses Path

3.8. Justification for Ordinal Data Use

Carbon pricing implementation across sectors is represented through an ordinal coding scheme:

1) 0 = No policy
2) 1 = Policy in discussion/draft phase
3) 2 = Fully implemented

This approach reflects the policy maturity of each country in each sector, aligned with prior studies using policy readiness scores (e.g., World Bank, IMF climate readiness indices) [1], [23].

3.9. Country Sample Description

This study includes 20 countries from the Asia-Pacific region, classified based on the implementation status of carbon pricing in the energy and industrial sectors. Each sectoral policy is scored ordinally (0 = none, 1 = planning, 2 = implemented) [24]. The Table 4 show the country classification.

Table 4. Country Description

Country	Energy Sector Score	Industry Sector Score	Carbon Pricing Status
Singapore	2	2	Fully implemented
Japan	2	2	Fully implemented
South Korea	2	2	Fully implemented (ETS)
China	2	2	Fully implemented (ETS)
India	2	2	Fully implemented (Cess)
Israel	2	2	Fully implemented (2023)
Kazakhstan	2	2	Fully implemented (ETS)
Uzbekistan	2	2	Fully implemented (ETS)
Türkiye	2	2	Fully implemented (hybrid)
Taiwan	2	2	Fully implemented (2023 Act)
Indonesia	2	1	Partial (Energy only)
Malaysia	1	1	In planning
Vietnam	1	1	In planning (roadmap stage)
Thailand	1	1	In discussion
Philippines	1	1	Early-stage consultation
Pakistan	0	0	No implementation
Bangladesh	0	0	No implementation
Nepal	0	0	NDC mention only
Sri Lanka	0	0	No roadmap
Laos	0	0	No active policy

These countries were selected to reflect diversity in carbon pricing maturity, allowing the model to assess whether sectoral carbon policy intensity affects environmental and investment outcomes.

4. Results and Discussions

4.1. Descriptive Statistics

This section presents the descriptive statistics of the variables used in the structural equation modeling (SEM) to evaluate the impact of carbon pricing on economic attractiveness and Environmental Performance across Asia-Pacific countries (Table 5). The variables include indicators for Environmental Performance, fiscal capacity, and foreign direct investment, along with a composite measure of carbon pricing implementation. To ensure comparability across different measurement units and scales, all variables were standardized using z-score transformation (mean = 0, standard deviation = 1) prior to model estimation. Table 5 summarizes the standardized mean, median, minimum, maximum, standard deviation, skewness, and excess kurtosis for each variable across 20 observations.

The standardization ensures that the variables originally measured in different units such as percentage of GDP, air quality index, or revenue levels are on a comparable scale. This step is particularly crucial for Partial Least Squares Structural Equation Modeling (PLS-SEM), which is sensitive to unstandardized variable ranges.

Although the Composite Carbon Pricing variable shows a standard deviation of zero in the standardized table, the original data reflect substantial cross-country differences. This variable was constructed by averaging ordinal scores (ranging from 0 to 2) for the implementation status of carbon pricing policies in the energy and industrial sectors. For example, countries like Singapore, South Korea, and Japan received a full score (2.0), while others such as Pakistan, Bangladesh, and Laos scored 0 due to lack of any pricing mechanism. The standardization process reduced these values to a mean of zero and thereby masked the original variance in the descriptive statistics.

Table 5. Descriptive Statistics of Variables

Variable	Mean	Median	Min	Max	Std. Dev	Excess Kurtosis	Skewness	N
Air Quality	0	0.044	-1.003	0.706	0.337	3.353	-0.876	20
Climate Change	0	0.035	-0.62	0.459	0.245	0.819	-0.341	20
Composite Carbon Pricing	0	0	0	0	0	-1.347	0.663	20
EPI Score	0	-0.017	-0.137	0.217	0.107	-0.635	0.682	20
Ecosystem Vitality	0	0.006	-0.231	0.33	0.12	1.655	0.64	20
FDI Inflow	0	-0.2	-0.509	2.739	0.696	12.365	3.381	20
FDI Inflow Per Capita	0	0.04	-0.684	0.16	0.188	8.319	-2.684	20
FDI as % of GDP	0	0.023	-0.793	0.265	0.217	8.59	-2.527	20
Government Revenue	0	0.047	-0.778	0.762	0.503	-1.431	0.025	20
Tax Revenue	0	0.054	-0.697	0.712	0.46	-1.431	-0.025	20

Note: All variables were standardized (z-score transformation) prior to analysis. The zero standard deviation observed in the Composite Carbon Pricing variable reflects this transformation and not a lack of variation in the original policy data.

Several variables show notable skewness and kurtosis. FDI Inflow exhibits high positive skewness (3.381) and excess kurtosis (12.365), indicating the presence of countries with disproportionately large investment inflows relative to others. Conversely, FDI Per Capita and FDI as % of GDP display negative skewness with similarly high kurtosis, suggesting outliers on the lower end of the distribution. These characteristics reflect the unequal distribution of investment attractiveness in the region, with a few countries, such as Singapore and China, capturing most of the FDI.

Environmental indicators such as Air Quality and Climate Change are negatively skewed, pointing to countries with particularly low environmental performance compared to the average. Meanwhile, Government Revenue and Tax Revenue distributions are more symmetric, though their relatively high dispersion highlights fiscal heterogeneity across Asia-Pacific economies.

These descriptive patterns provide important context for interpreting the relationships observed in the structural model, especially the varying impacts of carbon pricing on fiscal and investment-related outcomes.

4.2. Measurement Model Evaluation (Outer Model)

4.2.1. Initial Evaluation: Convergent Validity and Multicollinearity

This section evaluates the reliability and validity of the measurement model by assessing convergent validity and multicollinearity among indicators. These assessments provide initial insight into whether the indicators adequately measure their corresponding latent constructs and whether any redundancies or statistical issues exist that require model refinement.

1) Convergent Validity

Convergent validity refers to the degree to which multiple indicators of a construct are correlated and effectively represent the same underlying concept. The standard criterion for convergent validity is a loading factor (outer loading) greater than 0.7 [12], [13], indicating a high level of indicator reliability.

Table 6. Presents the Loading Values of Each Indicator

	Carbon Pricing	**EPI**	**FDI**	**Gov Rev**
Air Quality		0.942		
ClimateChange		0.969		
Carbon Pricing	1.000			
EPI Score		0.994		
EcosystemVitality		0.993		
FDI Inflow			0.718	
FDI Inflow Per Capita			0.982	
FDI as % of GDP			0.976	
Government Revenue				0.864
Tax Reveneu				0.888

All indicators meet the threshold of 0.7, confirming satisfactory convergent validity. Particularly high loadings are observed in EPI Score (0.994), Ecosystem Vitality (0.993), and Climate Change (0.969), suggesting that these indicators strongly reflect their respective constructs. These findings support the construct validity of the environmental and fiscal latent variables in the initial model specification.

2) Multicollinearity (Variance Inflation Factor)

While convergent validity is confirmed, a critical issue emerges in the form of multicollinearity. The Variance Inflation Factor (VIF) is used to assess the degree of redundancy among indicators. According to Hair et al. (2022), VIF values above 5 (or conservatively, 3.3) indicate potential multicollinearity problems, which may distort path coefficients and reduce model robustness [13].

Table 7. Variance Inflation Factor

Indicator	**VIF**
Air Quality	9.718
Climate Change	25.993
Composite Carbon Pricing	1.000
EPI Score	56.548
Ecosystem Vitality	42.414
FDI Inflow	1.546
FDI Inflow Per Capita	45.271
FDI as % of GDP	43.472
Government Revenue	1.404
Tax Revenue	1.404

The VIF analysis reveals alarmingly high multicollinearity in several constructs. EPI Score (56.548), Ecosystem Vitality (42.414), and FDI Per Capita (45.271) exhibit particularly severe collinearity issues. This suggests substantial overlap in the information captured by these indicators, which can lead to instability in model estimation and interpretation.

Consequently, a model respecification is necessary, involving the removal or reduction of redundant indicators to improve model parsimony and statistical reliability. In subsequent sections, we will revise the measurement model to address these issues and re-evaluate the adjusted model structure.

4.2.2. Revised Measurement Model
After excluding highly collinear indicators, a refined measurement model was estimated. The updated model consists of six indicators distributed across four constructs, as presented in Table 8.

Table 8. Outer Loadings and VIF (Revised Model)

Indicator	**Construct**	**Loading**	**VIF**
Air Quality	Environmental Performance	0.942	3.424
Climate Change	Environmental Performance	0.969	3.424
Composite Carbon Pricing	Carbon Pricing	1.000	1.000
FDI Inflow	Economic Attractiveness	0.718	1.000
Government Revenue	Government Revenue	0.864	1.404
Tax Revenue	Government Revenue	0.888	1.404

The revised model meets the thresholds for both convergent validity and multicollinearity. All outer loadings remain above 0.7, confirming adequate indicator reliability. Moreover, all VIF values are now comfortably below the conservative cutoff of 5, eliminating any concerns regarding multicollinearity.

This revised measurement model provides a statistically sound foundation for proceeding with the structural model estimation, which will examine the hypothesized relationships between latent constructs.

4.3. Measurement Model Validity and Model Fit

This section presents the validation and reliability testing of the revised measurement model, followed by an assessment of the inner model's overall performance and goodness of fit.

4.3.1. Convergent Validity (AVE)
Convergent validity was assessed through the Average Variance Extracted (AVE), which indicates the amount of variance captured by a construct in relation to the variance due to measurement error. According to Fornell and Larcker (1981), an AVE value of 0.50 or higher reflects sufficient convergent validity [25].

As shown in Table 9, all constructs in the revised model exhibit AVE values significantly above the threshold, thereby confirming adequate convergent validity.

Table 9. AVE Values of Constructs

Construct	**AVE**
Carbon Pricing	1.000
EPI	0.958
FDI	1.000
Government Revenue	0.869

These results suggest that the indicators reliably measure their respective latent variables and capture a substantial portion of the underlying construct variance.

4.3.2. Discriminant Validity: Cross Loading Analysis
Discriminant validity assesses the degree to which a construct is empirically distinct from other constructs within the model. In PLS-SEM, discriminant validity is commonly evaluated using the cross-loading criterion, which posits that each indicator should load more strongly on its associated latent construct than on any other [13].

Table 10 presents the cross-loadings of all indicators across the four latent variables: Carbon Pricing, Environmental Performance (EPI), Foreign Direct Investment (FDI), and Government Revenue.

Table 10. Cross Loadings of Indicators

Indicator	Carbon Pricing	Environmental Performance (EPI)	FDI	Government Revenue
Air Quality	0.559	**0.968**	0.265	0.589
Climate Change	0.479	**0.950**	0.147	0.374
Composite Carbon Pricing	**1.000**	0.545	0.423	0.618
FDI Inflow	0.423	0.221	**1.000**	0.158
Government Revenue	0.511	0.434	0.218	**0.872**
Tax Revenue	0.571	0.466	0.062	**0.881**

The results demonstrate that each indicator loads most highly on its intended construct compared to all other constructs. For instance, *Air Quality* and *Climate Change* exhibit stronger loadings on the Environmental Performance construct (0.968 and 0.950, respectively) than on any alternative constructs. Similarly, *Composite Carbon Pricing* loads exclusively on Carbon Pricing (1.000), while *FDI Inflow* shows a strong and unique association with the FDI construct (1.000).

Government Revenue and *Tax Revenue* also display higher loadings on the Government Revenue construct than on others, supporting their discriminant capacity.

These findings provide strong evidence of discriminant validity according to the cross-loading criterion, suggesting that the constructs in the revised model are empirically distinct and conceptually valid.

4.3.3. Construct Reliability

Construct reliability was assessed using the Composite Reliability (CR) coefficient, which measures the internal consistency of a construct by considering the actual outer loadings of its indicators. Unlike Cronbach's Alpha, composite reliability does not assume equal loading weights, making it more appropriate for PLS-SEM analysis [13].

A CR value of 0.70 or higher is generally considered acceptable, while values above 0.80 indicate high reliability. The results are presented in Table 11.

Table 11. Composite Reliability of Constructs

Construct	Composite Reliability
Carbon Pricing	1.000
Environmental Performance (EPI)	0.958
Foreign Direct Investment (FDI)	1.000
Government Revenue	0.869

All constructs in the revised model exceed the minimum threshold of 0.70, confirming that the items reliably measure their respective latent variables. Notably, the constructs Carbon Pricing and FDI exhibit perfect composite reliability (1.000), while EPI and Government Revenue also demonstrate strong internal consistency, with CR values of 0.958 and 0.869 respectively.

These results support the reliability and robustness of the measurement model, justifying its use in the subsequent structural model evaluation.

4.3.4. Evaluation of the Inner Model (Path Coefficients)

The inner model evaluation aims to examine the hypothesized causal relationships between latent constructs by analyzing path coefficients generated through the PLS algorithm. These coefficients represent the strength and direction of the influence from one latent variable to another.

Figure 3 summarizes the path coefficients among the constructs included in the revised model.

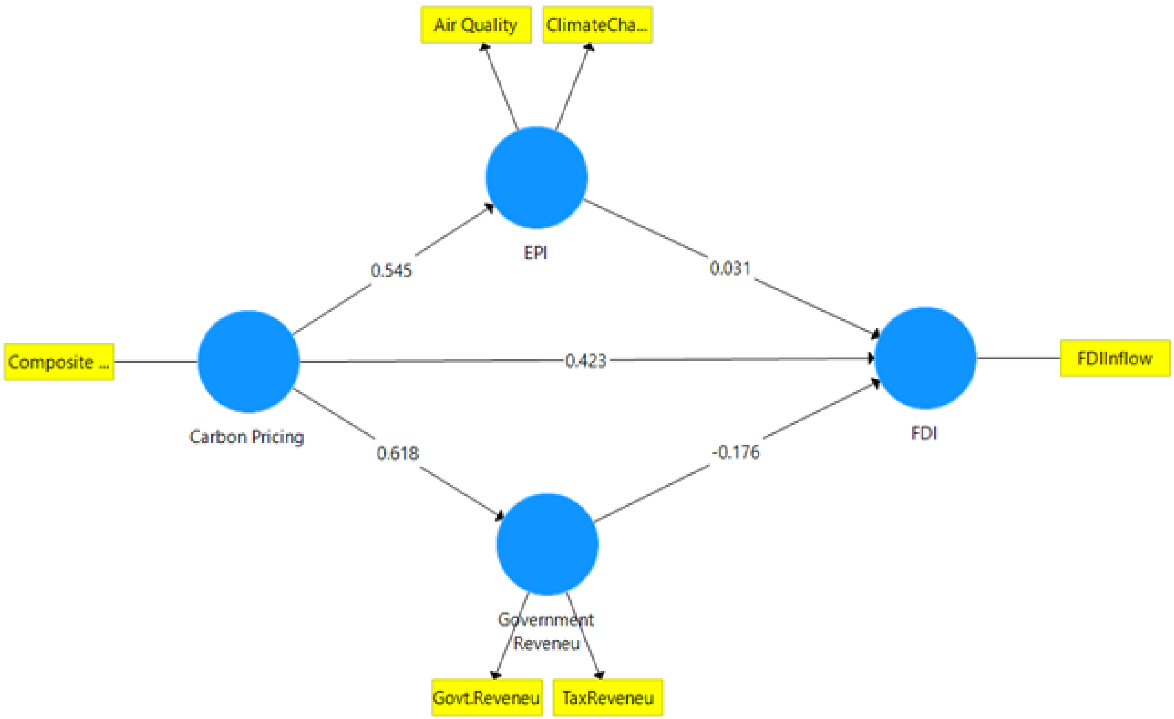

Fig 3. Path Coefficients of the Inner Model

The analysis reveals that Carbon Pricing has a substantial positive effect on all three outcome constructs:

1) A moderate effect on Environmental Performance (β = 0.545),
2) A positive influence on Foreign Direct Investment (FDI) (β = 0.423), and
3) A strong association with Government Revenue (β = 0.618).

These findings imply that the implementation of carbon pricing may simultaneously support environmental performance, fiscal strength, and economic attractiveness.

In contrast, Environmental Performance demonstrates a minimal positive influence on FDI (β = 0.031), suggesting that while environmental improvements are valuable, they may not significantly drive foreign investment in isolation.

Interestingly, Government Revenue exhibits a negative relationship with FDI (β = –0.176), indicating that increased public revenue might be associated with factors that discourage investment inflows, such as higher taxation or regulatory burdens.

These path relationships provide preliminary insights into the model's explanatory power. However, statistical significance and effect size will be further validated in the next step using bootstrapping analysis, presented in Section 4.4.

4.3.5. Overall Model Fit: Goodness of Fit (GoF)

To assess the overall quality of the structural model, the Goodness of Fit (GoF) index was calculated. The GoF is a global fit measure proposed by Tenenhaus et al. (2008) that combines the quality of the measurement and structural models by integrating the Average Variance Extracted (AVE) and the R^2 values of the endogenous constructs [22]. The simplify the presentation of the Goodness of Fit (GoF) components, the AVE and R^2 values used in the calculation are summarized in the following table:

Table 12. Component Goodness of Fit

Construct	AVE	R^2
Carbon Pricing	1.0000	-
Environmental Performance (EPI)	0.958	0.297
Foreign Direct Investment (FDI)	1.0000	0.197
Government Reveneu	0.869	0.382

Based on the values above, the average AVE is 0.95675 and the average R^2 is 0.292. Therefore, the Goodness of Fit (GoF) is calculated as:

$$GoF = \sqrt{0.95675 \times 0.292} = 0.529$$

According to the GoF classification by Wetzels et al. (2009), a GoF value above 0.36 is considered large, indicating a strong overall model fit. Therefore, the structural model in this study demonstrates an acceptable level of predictive power and model quality [26].

4.4. Hypothesis Testing Result

To evaluate the significance of the proposed relationships in the structural model, a bootstrapping technique with 5,000 subsamples was employed. The analysis focuses on the path coefficients, t-statistics, and p-values, which serve as the basis for hypothesis testing.

The null hypothesis (H_0) in each case posits that there is no significant relationship between the predictor and outcome variable. A hypothesis is considered statistically significant if the p-value is less than 0.05, allowing for the rejection of the null hypothesis at the 5% significance level.

Table 13. Hypothesis Testing Results

Hypothesis	Path Coefficient (β)	T Statistic	P Value	Decision
H_{01}: Carbon Pricing → Environmental Performance	0.545	3.653	0	Reject H_0
H_{02}: Carbon Pricing → FDI	0.423	4.515	0	Reject H_0
H_{03}: Carbon Pricing → Government Revenue	0.618	5.815	0	Reject H_0
H_{04}: Environmental Performance → FDI	0.031	0.074	0.941	Fail to reject H_0
H_{05}: Government Revenue → FDI	–0.176	0.606	0.545	Fail to reject H_0

The results indicate that the null hypotheses H_{01}, H_{02}, and H_{03} can be rejected at the 5% significance level, implying that Carbon Pricing exerts a statistically significant positive influence on Environmental Performance (β = 0.545, p < 0.001), Foreign Direct Investment (β = 0.423, p < 0.001), and Government Revenue (β = 0.618, p < 0.001).

In contrast, H_{04} and H_{05} fail to be rejected, suggesting that there is insufficient statistical evidence to confirm a relationship between Environmental Performance and FDI (β = 0.031, p = 0.941), and between Government Revenue and FDI (β = – 0.176, p = 0.545). These results imply that the respective relationships are not statistically significant within the context of the model.

4.4.1. Direct Effect Analysis

To provide a deeper understanding of the inner structural model, this section examines the direct effects among the latent constructs. The direct effects refer to the immediate, unmediated relationships between exogenous and endogenous variables. These standardized path coefficients (β) were estimated using the PLS algorithm and are presented in Table 14.

Table 14. Direct Effect Between Constructs

	Carbon Pricing	EPI	FDI	Government Revenue
Carbon Pricing		0.545	0.514	0.618
EPI			0.031	
FDI				
Government Revenue			-0.176	

The findings demonstrate that Carbon Pricing exerts statistically significant and substantively meaningful direct effects on three outcome variables. The path coefficient from Carbon Pricing to Environmental Performance (β = 0.545) indicates a moderate-to-strong positive relationship, suggesting that market-based environmental instruments (e.g., carbon taxes or emissions trading schemes) are associated with measurable improvements in ecological performance within the Asia-Pacific context.

Similarly, the direct effect of Carbon Pricing on Foreign Direct Investment (FDI) (β = 0.514) supports the proposition that regulatory mechanisms oriented toward environmental sustainability do not inherently deter foreign capital flows. Instead, they may serve as signals of institutional quality, policy credibility, and long-term stability, which are increasingly valued by investors.

The most pronounced direct relationship is observed between Carbon Pricing and Government Revenue (β = 0.618), which may reflect the fiscal mobilization potential of carbon pricing instruments, especially when implemented through taxation frameworks that are integrated into broader public finance systems.

In contrast, the direct effect of Environmental Performance on FDI is negligible (β = 0.031), and the negative direct path from Government Revenue to FDI (β = –0.176) lacks statistical significance. These outcomes suggest that neither environmental indicators nor fiscal variables when considered in isolation constitute primary determinants of foreign investment behavior. It is plausible that their influence is mediated through other variables or operates under conditional (moderated) effects not captured directly in this model.

Overall, the structural relationships presented reinforce the centrality of Carbon Pricing as a policy instrument with multidimensional impacts across environmental, economic, and fiscal domains. These results also imply the need for further analysis of indirect and interaction effects, which are addressed in subsequent sections.

4.4.2. Indirect Effect Analysis (Mediation Test)

To complement the direct path analysis, this section presents the indirect effects derived from the structural model estimation. Indirect effects describe the transmission of influence from an exogenous variable to an endogenous variable through a mediating construct. Such effects offer additional insight into how certain relationships may unfold through intermediate mechanisms. The results are summarized in Table 15.

Table 15. Indirect Effect Between Constructs

From → To	Indirect Effect (β)
Carbon Pricing → FDI	–0.091

The structural model reveals a single indirect relationship in which Carbon Pricing influences Foreign Direct Investment (FDI) through one or more intermediate constructs. The estimated indirect effect is –0.091, indicating that part of the impact of Carbon Pricing on FDI occurs via mediating variables included in the model (e.g., Environmental Performance or Government Revenue).

Although the magnitude of this effect is relatively modest, it highlights the potential presence of mediating mechanisms in the interaction between environmental policy instruments and investment outcomes. This suggests that the effectiveness of carbon pricing in shaping investment dynamics may not be solely direct, but can also be understood within a broader structural context involving environmental and fiscal dimensions.

In sum, the indirect effect complements the direct relationships identified earlier and contributes to a more comprehensive understanding of how carbon pricing policies interact with other national attributes to influence foreign investment. This warrants further exploration in future research, particularly by incorporating additional mediating or moderating variables.

4.4.3. Structural Model Summary

Carbon Pricing has a direct positive effect on Environmental Performance (EPI) and Government Revenue, with the structural equations as follows:

$$\eta_1 = 0.545\xi_1$$

$$\eta_2 = 0.618\xi_1$$

Foreign Direct Investment (FDI) is directly influenced by Carbon Pricing, Environmental Performance (EPI), and Government Revenue, represented by the following structural equation:

$$\eta_3 = 0.514\xi_1 + 0.031\eta_1 - 0.176\eta_2$$

Carbon Pricing significantly and positively impacts both Environmental Performance and Government Revenue. Foreign Direct Investment is influenced directly by Carbon Pricing and also indirectly through Environmental Performance and Government Revenue. These results highlight Carbon Pricing's central role in shaping environmental, fiscal, and investment outcomes.

4.5. Discussion

This study provides compelling evidence that carbon pricing exerts multifaceted impacts on Environmental Performance, government revenues, and foreign direct investment across Asia-Pacific countries. The findings reinforce the role of carbon pricing not only as an environmental instrument but also as an effective fiscal tool that can mobilize substantial public resources to support sustainable development objectives.

The positive association between carbon pricing and government revenue suggests a promising mechanism to generate stable fiscal income aligned with environmental goals. Such revenue streams can be instrumental in financing climate adaptation, green infrastructure, and low-carbon technologies, thereby advancing the transition toward a sustainable economy.

Perhaps most notably, the analysis reveals a statistically significant and positive direct effect of carbon pricing on foreign direct investment (FDI). While the Pollution Haven Hypothesis argues that environmental regulations raise production costs and deter foreign capital, the findings of this study support the Porter Hypothesis, which posits that well-designed regulatory frameworks can stimulate innovation and improve long-term investment attractiveness.

This result can be explained by a shift in investor preferences, particularly in the Asia-Pacific context, where policy credibility, transparency, and long-term regulatory consistency increasingly influence cross-border capital flows. In an era where ESG (Environmental, Social, and Governance) standards shape global investment behavior, carbon pricing may serve as a signal of institutional maturity and environmental stewardship, rather than as a cost burden. Countries that adopt predictable and transparent pricing mechanisms are often seen as more stable and forward-looking, thereby enhancing their economic attractiveness to global investors.

Recent empirical studies such as Lu & Yang (2021) and Bertram et al. (2018) lend support to this view, showing that carbon pricing can positively influence investment flows in countries that implement it as part of coherent sustainability strategies. For example, South Korea's national ETS is frequently cited as an institutional model that combines market-based efficiency with policy certainty, helping to draw climate-related foreign investment. Therefore, the positive effect observed in this study is not inconsistent with prior theory, but rather reflects a nuanced evolution in how environmental regulation is perceived in emerging economies [27], [28].

Conversely, the study finds that neither Environmental Performance nor government revenue exerts a significant direct influence on FDI. The weak relationship between Environmental Performance and FDI may suggest that while ecological performance is desirable, it is not yet a primary driver of foreign investment decisions in developing countries. Similarly, the negative but insignificant path from government revenue to FDI implies that increased fiscal capacity alone is not sufficient to attract investment and may even be viewed skeptically if associated with higher tax burdens.

These findings imply that investors may value regulatory clarity and policy orientation more than fiscal or environmental outcomes per se. This underscores the importance of carbon pricing not only as a technical instrument but as a broader governance tool that shapes investor expectations. In this context, the positive influence of carbon pricing on FDI seems to emerge not through indirect fiscal or environmental pathways, but as a direct reputational and institutional signal.

Overall, these results highlight the necessity of integrated policy frameworks that align environmental objectives with fiscal strategies and investment promotion. Complementary measures such as revenue recycling, green investment incentives, and regulatory transparency can enhance the effectiveness of carbon pricing schemes, ensuring they contribute not only to ecological preservation but also to long-term economic competitiveness.

5. Conclusion

5.1. Conclusion

This study provides empirical evidence that carbon pricing is not merely an environmental regulation, but a strategic lever that simultaneously enhances environmental quality, strengthens fiscal capacity, and attracts foreign direct investment in the Asia-Pacific region. Through a PLS-SEM framework, the findings confirm the direct, positive impact of carbon pricing on both government revenue and FDI, positioning it as a dual-purpose instrument for sustainability and economic resilience.

However, the indirect roles of environmental performance and fiscal capacity as mediators appear limited, suggesting that the effectiveness of carbon pricing lies not solely in its outcomes but in its signal to investors: policy credibility, regulatory clarity, and long-term commitment to sustainability.

In essence, carbon pricing is more than a cost it is a commitment. In the eyes of global investors increasingly attuned to ESG metrics, it signals governance maturity and forward-looking ambition. For emerging economies seeking to transition toward green growth, carbon pricing is not just a fiscal or ecological tool it is the currency of future competitiveness.

5.2. Recommendations

Based on the findings, the following policy recommendations are proposed:

1) Design carbon pricing schemes as strategic economic signals

   Policymakers should recognize carbon pricing not solely as an environmental mandate, but as a signal of institutional credibility and market readiness. Embedding carbon taxes or emissions trading systems within transparent and consistent regulatory frameworks can boost investor confidence and attract ESG-aligned capital.

2) Ensure fiscal revenues are recycled toward green innovation

   Governments should channel revenues generated from carbon pricing into public investments that support decarbonization such as renewable energy, climate-resilient infrastructure, and low-carbon technologies. Transparent revenue recycling mechanisms can enhance both public acceptance and economic returns.

3) Minimize regulatory uncertainty to maintain investment attractiveness

The positive impact of carbon pricing on FDI underscores the importance of regulatory stability. Sudden policy reversals or inconsistent implementation may erode the credibility that carbon pricing builds. Long-term roadmaps and legally binding climate commitments are key to maintaining investor trust.

4) Tailor carbon pricing to national context, but benchmark against regional standards

While policy design must be context-specific, aligning pricing instruments with regional best practices can prevent regulatory arbitrage and promote cross-border climate cooperation. Establishing a regional knowledge platform on carbon pricing can enhance policy learning and coherence.

5) Integrate carbon pricing into broader sustainability governance

Carbon pricing should not operate in isolation. It must be embedded within a coherent framework that includes environmental regulations, investment incentives, and institutional reforms. Only through integrated governance can carbon pricing achieve its full potential as a tool for future competitiveness.

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