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Title:	**Administrative Capacity and Political Economy of $PM_{2.5}$ Regulation in Asia: Translating Pigouvian Theory into Environmental Governance**
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Administrative Capacity and Political Economy of $PM_{2.5}$ Regulation in Asia: Translating Pigouvian Theory into Environmental Governance

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Abstract

This paper develops an integrated framework to explain why air quality regulation succeeds in some Asian economies but falters in others. Drawing on the principles of Pigouvian welfare economics, it conceptualizes administrative capacity as the operational mechanism that converts environmental regulation into welfare outcomes for a country. The study introduces the analytical model of the Pigouvian-Administrative Capacity Linkage Model, which records how regulatory, fiscal, and institutional dimensions mediate corrective policy effectiveness. The Environment-Growth Diagnostic Framework, adapted from the idea of Hausmann, Rodrik, and Velasco, identifies structural constrictions to $PM_{2.5}$ regulation through low social returns, weak appropriability, and limited finances. In view of this causality, data for three categories of Asian countries is selected to endorse the strong relationship between regulatory quality and $PM_{2.5}$ reduction, ratifying the notion that for environmental and welfare outcomes, the integration of policy way forwards with institutional capacity is extremely important, such that both go in tandem. The paper's primary theoretical contribution is the reinforcement of administrative capacity as an endogenic variable within the Pigouvian welfare theory, linking the environmental, economic, and institutional governance relationship in a unified framework applicable to the developing Asian economies. The empirical analysis further illustrates that there is a negative relationship between regulatory quality and mortality rates attributable to ambient and household air pollution, showing that governance effectiveness and proper administration directly impacts human welfare gains. The findings conclude that administrative capacity is the driver of Pigouvian correction, offering a governance-based pathway toward achieving SDG 11.6 on clean and sustainable cities in Asia.

Keywords: administrative capacity, environmental governance,

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environment–growth diagnostic framework, Pigouvian welfare economics, regulatory quality, $PM_{2.5}$, Sustainable Development Goal 11.6, Asia.

Introduction

Since the mid-20th century, Asian economies have undergone a massive transformation across different sectors. Simultaneously, Asian societies have witnessed the greatest urban expansion in human history. This has uplifted millions out of poverty and created economic opportunities. However, it has also posed the threat of various negative externalities such as that of unprecedented environmental stress, particularly in the form of deteriorating air quality. Fine particulate matter ($PM_{2.5}$), one of the most harmful components of urban air pollution, has emerged as a public health crisis and caused economic congestion across different regions. WHO data shows that almost all of the global populations (99%) breathe air that exceeds WHO Global Air Quality Guidelines (World Health Organization, 2022), including the recommended 24-hour mean limit for $PM_{2.5}$ which is 15 micrograms per cubic meter ($\mu g/m^3$) and contains high levels of pollutants, with low- and middle-income countries suffering from the highest exposures (World Health Organization, 2022). As per the US Environmental Protection Agency, there has been a persistent gap between policy planning and environmental outcomes, underscoring the effective role of administrative and institutional capacity in environmental regulations.

Air pollution causes negative environmental externality (Zhu et al., 2024), putting long-term growth in jeopardy through increasing healthcare costs, labor market inefficiencies, and urban livability constraints, delaying the yield of the environment-economic nexus. Hence, targeting and monitoring the $PM_{2.5}$ emissions has become central to Sustainable Development Goals, introduced as per the UNDP agenda of 2030, declaring environmental regulation and administrative capacity as critical strategy variables. In many Asian countries, mitigation plans on controlling air pollution have been adopted including economic and technological strategies.

The effective tools to ensure air quality include the emission standards, clean air programs, improved fuel quality, renewable energy transitions, industrial retrofitting, and vehicle emission controls. Still, the $PM_{2.5}$ emissions are increasing at an unprecedented rate and incurring an

enormous cost on human health, especially the vulnerable groups of the population. The situation gets even worse when the temperature falls. The irony is that this situation is getting worse even when international and regional attention is focused on air quality management. This scenario eventually highlights the need of national and subnational administrative and regulatory capacities to prevent the point source and non-point source pollution through proper enforcement and compliance of the standards (Harris, 2020).

Administrative capacity comprises the institutional, technical, and organizational competences required to effectually design, implement, and enforce environmental policies (Trnka, 2020). In the context of air quality management, the conceptual framework includes monitoring networks, enforcement mechanisms, inter-governmental coordination, technical expertise, and fiscal resources essential to transform regulatory frameworks into quantifiable pollution reductions.

Policy slippage and fragmented compliance, as well as the unavailability of the measurable benefits of environmental goals, are caused by weak regulatory institutions, disjointed governance structures, and uneven, missing budgetary alignment (Petrie, 2021). Altogether, several Asian economies retain the competitive edge in green technologies and environmental commodities, presenting the indication that market forces may supplement governmental action (Chen & Li, 2024). However, there is currently no concrete evidence available based on which it can be concluded as to how and what kind of economic competition genuinely improves air quality in situations where administrative and regulatory capacities remain limited. This generates the research question of the current study: Do countries with stronger regulatory institutions enjoy the environmental benefits of green competitiveness and reduced $PM_{2.5}$ emissions across Asia?

The linkage between administrative capacity and PM2.5 regulation is not only important for air quality management but also for achieving sustainable, welfare-oriented development under SDG 11.6 which focuses on reducing the environmental impact of cities through improved air quality. Despite high economic development and growth, weak regulatory enforcement, limited monitoring capacity, and poor coordination of institutions can lower environmental outcomes in Asia. The importance of governance and administrative capacity in relation to pollution has been understudied, especially in developing Asian economies, while most of the

existing studies have concentrated on technological and macro-economic factors affecting pollution. This paper attempts to fill this gap by combining Pigouvian welfare economics and administrative capacity theory to investigate the interactive mechanism between regulatory quality and comparative advantage in environmental goods (CAEG) and its effects on $PM_{2.5}$ reduction. Based on the evidence of enforcement capacity and not just the stringency of regulations, the study presents the Pigouvian Administrative Capacity Linkage Model as a policy-relevant framework to enhance air quality governance in various settings in Asia.

The current research brings together three theoretically distinct strands in the literature on environmental governance and welfare economics. Firstly, the research develops Pigouvian welfare economics theory from the classic version, formalizing administrative capacity as the indispensable transmission vehicle between corrective policy design and welfare outcomes. The classic Pigouvian welfare economics theory presumes a well-organized government that can design and enforce the relevant corrective instruments; this research relaxes this assumption and formally integrates institutional capacity as the endogenous variable into the Pigouvian welfare economics theory, resulting in the development of the Pigouvian-Administrative Capacity Linkage Model. It is a theoretical development that has not been formalized before in environmental economics literature. Secondly, the research applies the Growth Diagnostics Framework developed by Hausmann et al. (2008) to diagnose macroeconomic binding constraints to the domain of environmental governance, resulting in the development of the Environment-Growth Diagnostic Framework. Such a cross-domain adaptation of the framework is unique because it has never been done before in any study conducted to diagnose why $PM_{2.5}$ regulation has failed in developing Asian countries. Finally, the research integrates the literature on institutional economics (Evans, 1995; North, 1990; Ostrom, 1990) with the Pigouvian welfare economics theory.

This study aims to critically scrutinize the interrelationship of $PM_{2.5}$ exposure, environmental competitiveness, regulatory quality, and administrative capacity across ten Asian economies, categorized into three different income level groups, developing a comparison and highlighting the crucial role of government administration in maintaining air quality. It suggests that environmental economists develop a policy framework based

on the best international practices to achieve SDG 11.6 and improve air quality systems.

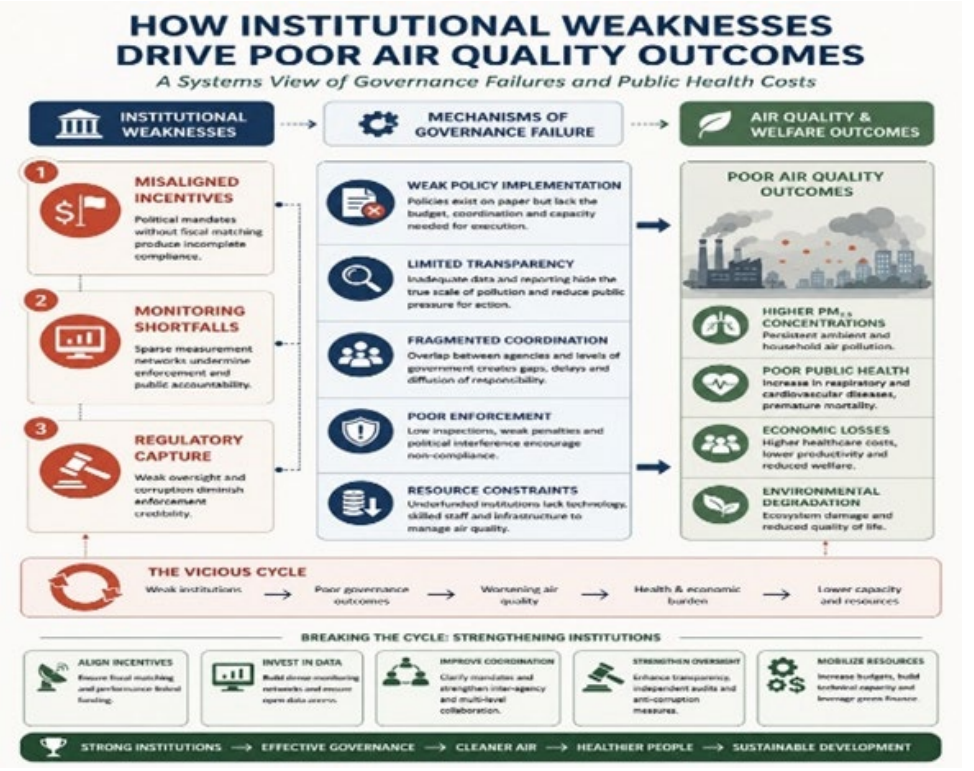
Literature Review

Institutional Weakness and Air Quality Outcomes

The literature highlights the major causes of bad air quality in the region, and one of them is the weak institutional and administrative culture, especially the missing loop at the subnational level, as shown in Figure 1. It highlights how the nexus fails to translate national air quality policies into locally reduced $PM_{2.5}$ emissions outcomes. The implementation gaps are further widened by weak monitoring, fiscal misalignment, and fragmented enforcement, even in the presence of strong regulatory frameworks (Bolorinos et al., 2018).

Figure 1

Author's idea on Governance Failure & Public Health Cost



The institutional economics and governance literature have long explored the interaction between state capacity and the environment. Evans (1995) found that the combination of insulated, bureaucratic structures and dense networks within the society, what he calls embedded autonomy, is essential for the effectiveness of the developmental state, which also entails environmental regulation. Further, Acemoglu and Robinson (2012) suggested that inclusive institutions ensure long-run economic and environmental resilience, whereas extractive institutional setups sustain regulatory capture, enforcement failures, and so on.

Regional Governance Patterns

A cross-country analysis further validates the importance of governance capability and institutional quality in enhancing environmental performance. With an efficient M&E system, Wu (2017) found that higher reported $PM_{2.5}$ levels can occasionally be correlated with stronger institutional quality. This suggests that transparency and timely reporting records time to time data, suggesting the policy way forward.

Regulatory Frameworks and Governance Structures

The changing trends of air quality are directly affected by the low level of legal compliance, weak enforcement mechanisms, and lack of policy tools. Literature compares the performance of market-based instruments (MBIs), hybrid approaches, and command-and-control regulation to identify the root causes of issues in the governments lacking in protecting the air quality. (Ogunmola & Kumar, 2025).

Methods of Command and Control

South Korea ensures the integration of traditional measures and sufficient capacity. It recorded quantifiable reductions in urban PM_2 concentrations by using the harmonized system of regulations and increasing the local inspection capacity (World Bank, 2025). Research underlines the need for a strong enforcement capability to grow in tandem with regulatory ambition.

Market-Based Instrument

MBIs, akin to pollution taxes and emission trading programs exercised through strong regulatory enforcement mechanisms, results in cost-effective pollution controlling outcomes.

Hybrid Models

China employs all-inclusive strategies integrating public campaigns, administrative orders, and budgetary transfers, still the results vary throughout depending on the strength of the institutions. According to Wong and Karplus (2017), success depends heavily on the central government's ability to track local performance, obtain cost information, and coordinate fiscal obligations.

A strong monitoring infrastructure with dependable data systems and verification procedures is a prerequisite for regulatory decisions to match instruments with the current administrative capabilities. In contrast, hybrid models that combine technical, legal, and financial tools typically function best under institutional frameworks that are well-coordinated (Sabarwal et al., 2024).

The new institutional economics tradition further investigates the theoretical link between state ability and Pigouvian correction. North (1990) noted that the transaction costs of compliance, which are the costs of enforcing the regulations, are directly shaped by institutions, or the formal rules and informal norms regulating economic activities, and hence whether corrective instruments function as intended. Ostrom (1990) presented this logic to show that effective monitoring and sanctioning systems are essential for the collective management of common-pool resources, like clean air. Such findings indicate that the Pigouvian approach is context-specific and thus should not be analyzed as an independent one, hence affirming the basic thesis of the current study that institutional capacity is not an ancillary factor, rather it is the main mechanism through which the welfare impact of regulation is realized.

Theoretical Framework: The Pigouvian Welfare Economics Perspective

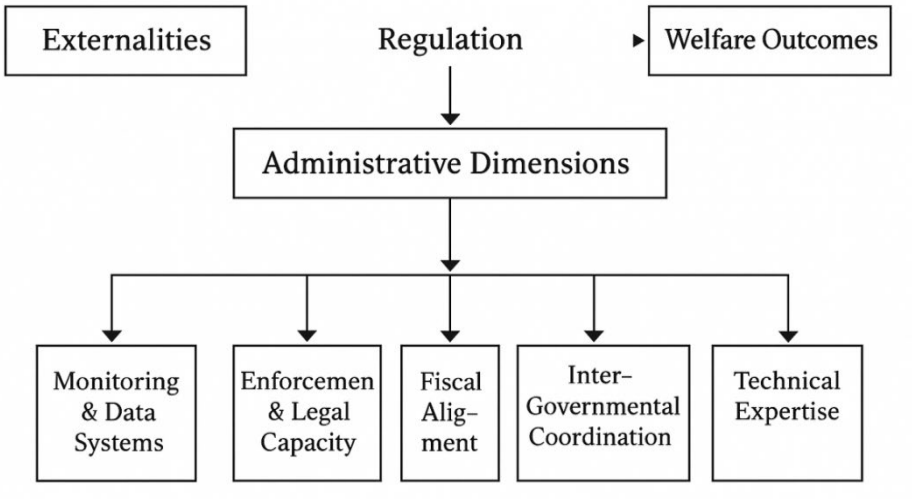
Foundations of Pigouvian Welfare Theory

The notion of externalities, costs, or benefits resulting from economic activity is not reflected in market prices until it was established in Arthur Cecil Pigou's The Economics of Welfare (Pigou, 1920), which serves as the philosophical foundation for contemporary environmental legislation. Pigou maintained that because private agents acting in their own best interests incur social costs that they are not responsible for, these externalities constitute a basic instance of market failure. This suggests

corrective state action through fiscal or regulatory tools often referred to as Pigouvian taxes or Pigouvian subsidies to enhance social welfare and restore efficiency. By balancing private incentives with social welfare, these tools internalize externalities and ensure that the marginal social cost (MSC) and the marginal social benefit (MSB) remain equal. The equilibrium that results is an ideal distribution of resources when environmental harm is present (Johnson, 1960).

Figure 2

Conceptualization of Pigouvian Welfare – Administrative Capacity Linkage Model



Pigouvian Framework and Administrative Capacity

The Pigouvian paradigm considers the state responsible as a corrective performer that bridges the gap between private rationality and social optimality; with the aim of public welfare. This notion fails in developing countries, as it assumes that their governments have the administrative and technical capacity to design, implement, and enforce corrective instruments efficiently. Modern environmental governance experts have extended Pigou's logic from policy design to policy execution, endorsing the assumption of Pigouvian correction depending on the state's administrative capacity, as well as its ability to monitor, enforce, coordinate, and finance regulatory actions.

This causality can be studied in Asian countries' planning and policy formulation to control $PM_{2.5}$ pollution. Many economies have adopted the green-growth policies aligned with Pigouvian principles but due to the lack of institutional apparatus they fail to reap the benefits from the reforms (Adjei & Afriyie, 2025). Weak data systems, fragmented jurisdictional mandates, and limited fiscal autonomy weaken the state's ability to internalize environmental costs. Thus**,** administrative capacity is a key determinant of welfare outcomes, but not the exogenous factor.

Application to $PM_{2.5}$ Regulation in Asia

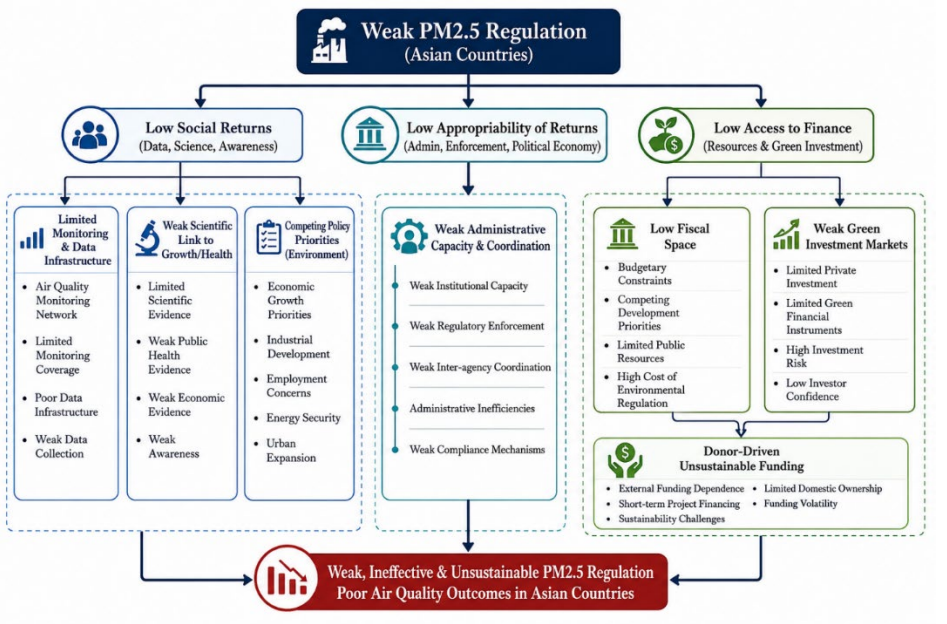
Literature suggests that Pigouvian principles fail despite proper formal policy adoption in countries which have missing infrastructure including weak administrative capacity, causing welfare losses of health and social mobility (Al Alim et al., 2025). $PM_{2.5}$ pollution in Asia is an evident and interesting case study of this proposition. It represents a textbook Pigouvian externality, yet corrective measures, including emission charges, the tradable permits fail due to administrative inefficiencies. Political constraints, weak enforcement, and poor coordination disrupt the mechanisms that intend to fix market failures, bringing in secondary market failures (Phetmany et al., 2025). This shows that the effectiveness of the Pigouvian instruments requires an all-around infrastructure for policy execution, as well as a 360 degree mechanism to monitor the emissions, recording the sources and trends and targeting the interventions.

Environment–Growth Diagnostic Framework

Building on the Hausmann et al. (2008) Growth Diagnostics approach, the Environment–Growth Diagnostic Framework identifies the root cause of weak PM2.5 regulation in Asian countries. The framework traces three primary constraints including low social returns, low appropriability of returns, and low access to finance (Altenburg & Strohmaier, 2025). Low social returns arise from gaps in environmental data infrastructure, limited scientific integration into policy, and competing developmental priorities between economic growth and environmental sustainability. Low appropriability depicts the incapacity of institutions to capture and enforce the benefits of regulation due to weak administrative coordination, poor enforcement, and political or industrial resistance (Sytch & Kallapur, 2025).

Figure 3

Environment–Growth Diagnostic Framework



The framework, through comparative governance analysis, reveals that the significant variation across Asian countries directly depends on their level of administrative capacities. Countries with strong administrative and regulatory capacities, such as Japan, Singapore, and Malaysia, have managed to render environmental awareness and scientific evidence into enforceable regulation, supported by strong fiscal systems and credible green investment markets (Salleh et al., 2025) and vice versa.

Conceptual Framework

Linking Theory to Empirical Context

This study extends the Pigouvian Welfare Economics framework and defines administrative capacity as the key mechanism through which environmental regulation affects welfare. The effectiveness of Pigouvian policies relies on governance quality, monitoring, enforcement, and institutional coordination. This is especially true in Asia where many countries have implemented environmental policies but struggle with low scores in implementation because of inadequate administrative capacity to ensure air quality and public health improvements.

Figure 4

Linking Pigouvian Welfare to Empirical Context

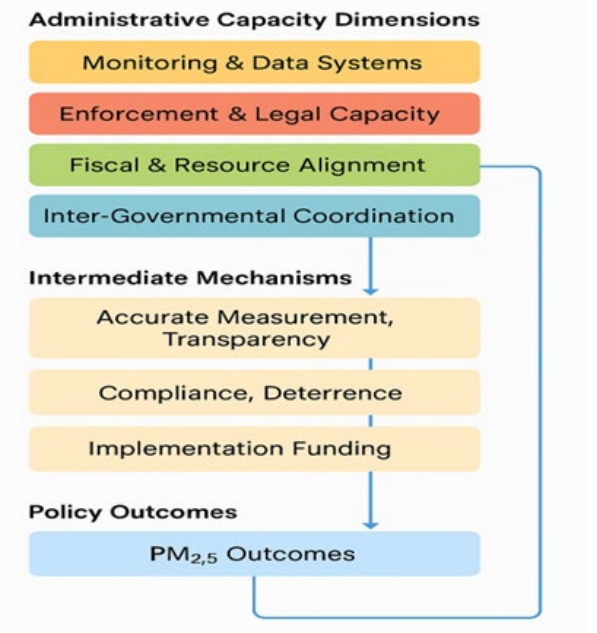
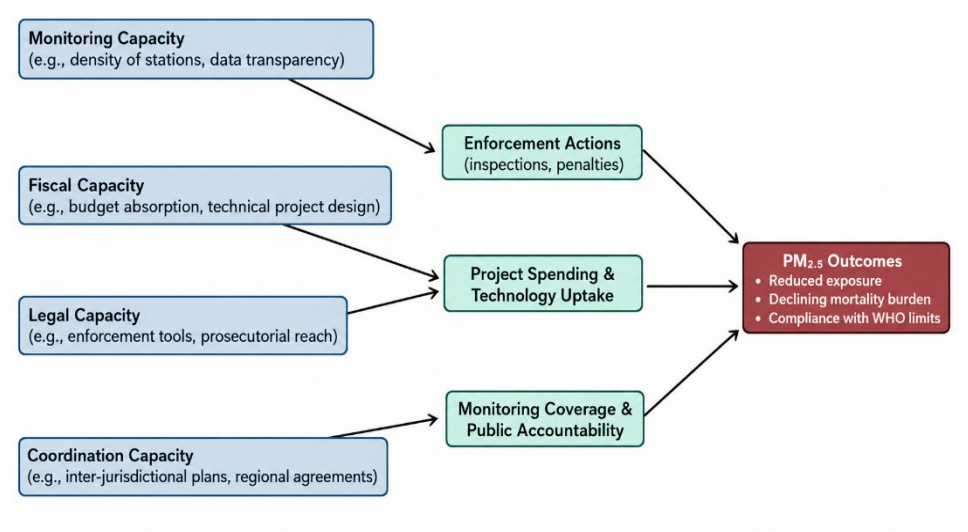


Figure 5

Interdependent Dimensions - Grounded in Pigouvian Logic



Core Constructs and Relationships

The proposed framework further suggests that administrative capacity settles the causality between environmental regulation and $PM_{2.5}$ outcomes through the following five interdependent dimensions, each grounded in Pigouvian logic.

Table 1

Core Constructs and Pigouvian Relationships Linking Administrative Capacity to $PM_{2.5}$ Regulation Outcomes

Administrative Dimension	Pigouvian Link	Relevance for $PM_{2.5}$ Regulation
Monitoring & Data Systems	Information about welfare maximization	Accurate air-quality data closes information gaps and enables targeted interventions (Sawant & Dalve, 2025).
Enforcement & Legal Capacity (Chan, 2024)	Mechanisms to internalize externalities	Effective enforcement ensures polluters bear true social costs.
Fiscal & Resource Alignment	Public finance for welfare optimization	Fiscal instruments fund monitoring, enforcement and clean technologies (Özker, 2023).
Inter-Governmental Coordination	Spatial jurisdiction of welfare policy	Coordination between central and local levels addresses cross-boundary pollution.
Technical & Human Capacity	Feasibility and transaction cost minimization	Skilled personnel and institutional expertise lower implementation costs and enhance policy effectiveness (Song et al., 2021).

Methodology

This study makes a comparative case analysis, with the aid of descriptive quantitative evidence and typological clustering, to explore the link between administrative capacity and $PM_{2.5}$ regulation across ten Asian economies. Epistemological support arises from the fact that the research question focuses on causal mechanisms (how institutional dimensions mediate the

translation of Pigouvian corrective instruments to welfare outcomes), which are best addressed by the process-tracing and cross-case comparison approach, in addition to variable-based statistical inferences (Mahoney & Thelen, 2010).

Country Selection Criteria

The ten countries analyzed were carefully chosen to reflect three criteria: (i) geographical and economic diversity across Asia, including variation in the level of institutional development; (ii) availability of comparable data on $PM_{2.5}$ concentrations (WHO/SDG 11.6.2 indicator), governance indicators (World Bank Worldwide Governance Indicators, WGI), and health outcomes (WHO Global Health Observatory); and (iii) representativeness of the three governance typologies identified in the theoretical framework. The purposive sampling is in line with the theory-building comparative case research (Yin, 2018).

The three levels of administrative capacity are based on the thresholds used in the governance measurement literature. On the basis of Kaufmann et al. (2010), countries that have mean scores of more than +0.5 on the standardized index (with a range of −2.5 to +2.5) on the Regulatory Quality indicator of the World Bank Worldwide Governance Indicators (WGI) are categorized as having economies with a strong administrative capacity. The countries in the range of −0.5 to +0.5 are in the transitional governance economy phase, indicating that institutional development is uneven and partial. Countries with scores below −0.5 for a time of three years or more are deemed to have economies with a weak administrative capacity, weak fiscal alignment, and fragmented enforcement. This is in line with a cross-national typology of governance in environmental policy used in the comparative environmental policy literature (Damania et al., 2019; Li & de Oliveira, 2021).

Data Description and Variable Specification: Administrative Capacity, $PM_{2.5}$ Concentrations, & SDG 11.6.2

There are four main variables employed in this study. Regulatory Quality (Estimate) from World Bank WGI measures the government's capacity to formulate and implement sound policies and regulations and is the operational proxy for administrative and institutional capacity. The CAEG Index (Comparative Advantage in Environmental Goods) is derived from World Bank Country Climate and Development Reports and UN trade

databases and is an indicator of green trade competitiveness because of governance quality. Both Mortality Rate Attributable to Household Air Pollution (MRAP) (WHO Global Health Observatory) and Mortality Rate Attributable to Ambient Air Pollution (MRAP) (World Bank CCDRs) are used as proxy for the health impacts of exposure to $PM_{2.5}$. The study spans the years 1999-2023, allowing for the longitudinal analyses of governance environment associations throughout the study period.

Table 2

Dependent Variable and Details

Indicator	Description
Air pollution: concentrations of fine particulate matter ($PM_{2.5}$),- SDG 11.6.2 (WHO Global Observatory)	• SDG Target 11.6 – "Clean cities: Reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management" • Indicator 11.6.2: "Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted) SDG Indicator 11.6.2 Concentrations of fine particulate matter (PM2.5)"

The analysis further utilizes data extracted from the World Bank's Country Climate and Development Report (CCDR*)* (World Bank, 2023) for selected Asian economies. The variables employed are listed in the table below.

Table 3

Independent Variables and Details

Variable	Theoretical Construct	Data Source
Regulatory Quality (Estimate)	Proxy for Administrative and Institutional Capacity: reflects government effectiveness in formulating and enforcing policies	World Bank – Worldwide Governance Indicators (WGI)
Comparative Advantage in Environmental	Indicator of Green Competitiveness and Innovation: measures trade	World Bank – Country Climate and Development

Variable	Theoretical Construct	Data Source
Goods (Index)	competitiveness in environmental and clean-tech products	Reports (CCDR); UN
Mortality Rate Attributable to Household Air Pollution (per 100,000)	Proxy for Household-Level Environmental Health Outcomes – reflects exposure to indoor pollution and access to clean energy	World Bank – CCDR; WHO Global Health Observatory
Mortality Rate Attributable to Ambient Air Pollution (per 100,000)	Proxy for Ambient Air-Quality and Public Health Outcomes ($PM_{2.5}$ exposure)	World Bank – CCDR; WHO Global Health Observatory

From 2013 to 2019, the countries including Japan, Singapore, and Malaysia with strong administrative capacities consistently showed lower trends of $PM_{2.5}$ emissions, while aiming at the WHO standards. It suggests that their mature monitoring frameworks, stringent compliance with emission standards, and uninterrupted funding are the main reasons for good air quality. The second group of countries, including China, Thailand, and Vietnam, which are in the transitional phase of developing systems and technologies for clean air, display gradual improvements in achieving the WHO standards of clean air.

In contrast, the third category of the countries—countries with weak administrative capacities and the implementation gaps mainly the South Asian countries have shown consistently high trends of $PM_{2.5}$ concentrations, underlining the fragmented policy uptake and implementation adeptness. Though these states boast policy laws attuned to international specifications, they suffer from chronic enforcement shortages, bureaucratic breakdown of intergovernmental coordination, and sparse budgetary allocations to monitoring and abatement. Where administrative structures are strong, SDG 11.6.2 indicators tend to improve via sustained control over pollution; where the administrative capacity is low, $PM_{2.5}$ concentrations continue to stay high even with regulatory intention. Therefore, realizing SDG 11.6 (Clean Cities) in Asia relies less on the spread of new policies and more on enhancing the administrative and

fiscal machinery that makes their enforcement and continuity possible.

Figure 6

PM 2.5 Emissions Trends across Ten Asian Countries (2013 -19) – WHO

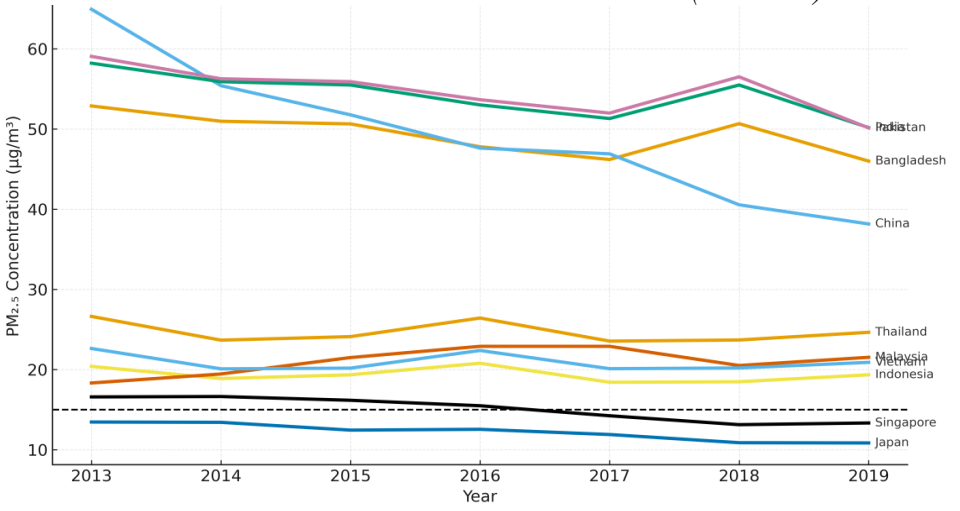
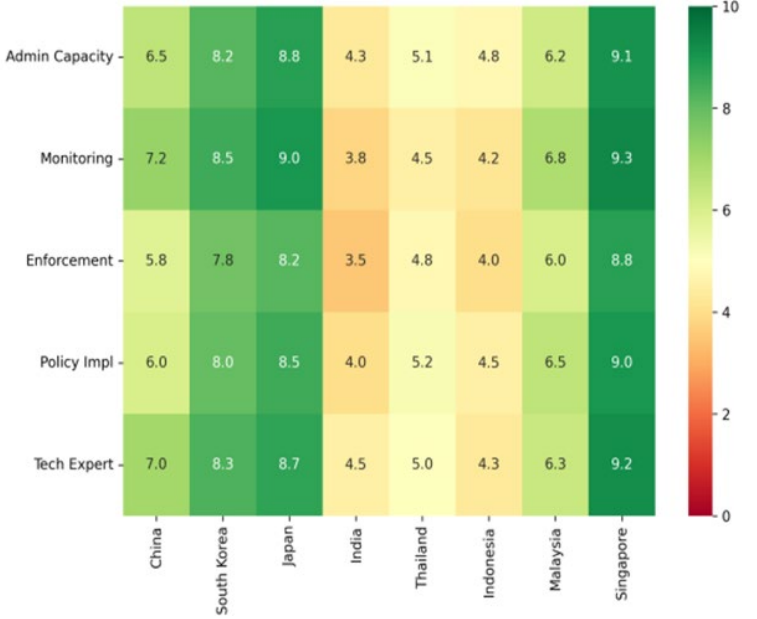


Figure 7

Regulatory Quality – WHO

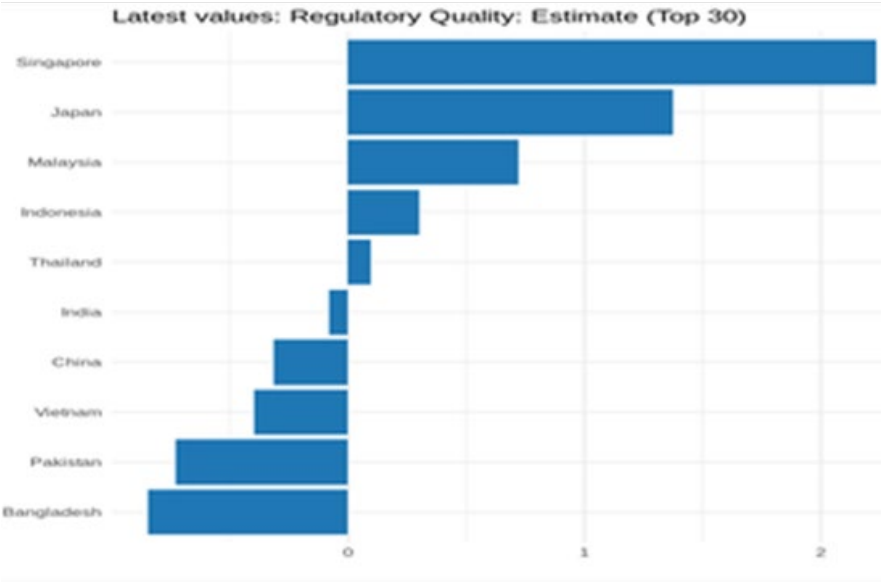


The analysis used the above-mentioned data set for the years 1999-2023

of the ten selected Asian economies grouped into three categories bases on their administrative and governance capacities. The selected variables together demonstrate the full causal pathway linking administrative capacity to environmental and health outcomes in Asian countries.

Figure 8

Governance Effectiveness Indicators – WHO & WB



Estimation Technique

The analysis is performed in three phases. The typological clustering exercise categorizes each country according to the regulatory quality score of the WGI, which is based on the criteria used in the governance literature (Kaufmann et al., 2010). Secondly, cross-case descriptive comparison is used to look at changes in $PM_{2.5}$ concentrations (2013–2019, SDG 11.6.2) across the three typologies, with figures annotated to provide information on the sources of data and the year of collection, as required by the reporting standards. Third, bivariate correlation analysis is used to determine the direction and strength of the relationship between Regulatory Quality and the outcome variables (concentrations of $PM_{2.5}$; CAEG Index; mortality rates). The $r = 0.956$ correlation value between governance effectiveness and the improvement of $PM_{2.5}$ is reported and is considered associational evidence. It is explicitly stated that this study can't provide econometric

proof of causality and thus also causal statements are qualified; as a result, conclusions regarding causality may be considered tentative it is presented as explicating associations consistent with the theory under discussion, not as proof of causality. This restriction is mentioned and the future direction of the quasi-experimental and longitudinal econometric analysis are noted.

Justification for Qualitative Orientation

The objectives of the study are to develop a framework and conduct a policy-oriented institutional analysis suitable for the use of the qualitative comparative method. Small-N comparative analysis is appropriate for uncovering the necessary and sufficient conditions for outcomes, not for the estimation of average treatment effects (Geddes, 2003). This study is a theoretical and typological contribution because it develops a replicable analytical model (the Pigouvian–Administrative Capacity Linkage Model), which can be applied to future research, subject to the availability of appropriate data, by using a panel econometric model, regression discontinuity model, or difference-in-differences model.

From Governance to Green Outcomes: How Regulatory Quality Shapes $PM_{2.5}$ Regulation and Welfare

The Regulatory Quality metric is a proxy to administrative capacity and measures the extent to which institutions can develop environmental regulatory policies and put them into practice. Good regulation leads to a coordinated implementation of policy, green innovations, the adoption of environmental goods, and comparative advantage in green goods (Usman et al., 2024). The governance heat map also reveals that countries with better institutions (e.g. Singapore, Japan, South Korea) have lower levels of $PM_{2.5}$ concentration, resulting from effective monitoring and enforcement of regulations. Whereas, the weaker the capacity of administrative systems, the higher the level of $PM_{2.5}$ concentration and the higher the economic and health costs.

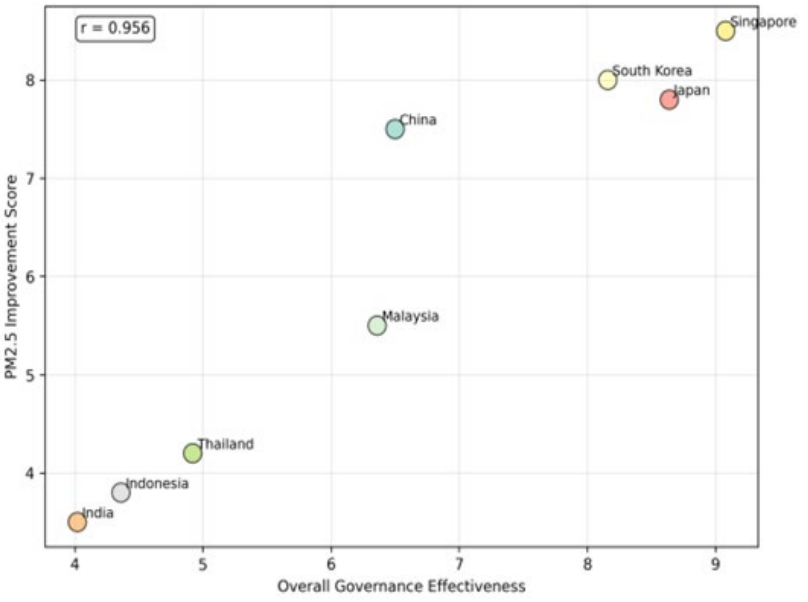
Regulatory Quality and Environmental Performance

Figure 9 gives the average government effectiveness scores of WGI for ten Asian countries, which are strongly correlated with the changes in population-weighted $PM_{2.5}$ concentrations across these countries (2013–2019), with a Pearson correlation of 0.956. The results show that policy success in improving environmental outcomes is more related to administrative effectiveness, such as policy coherence, inter-agency

coordination, and credible enforcement, as compared to the presence of regulations, leading to a close linkage between administrative effectiveness and environmental outcomes.

Figure 5

Governance vs PM 2.5 Advancement - WB



Operationalizing Administrative Capacity: Data and Analytical Design

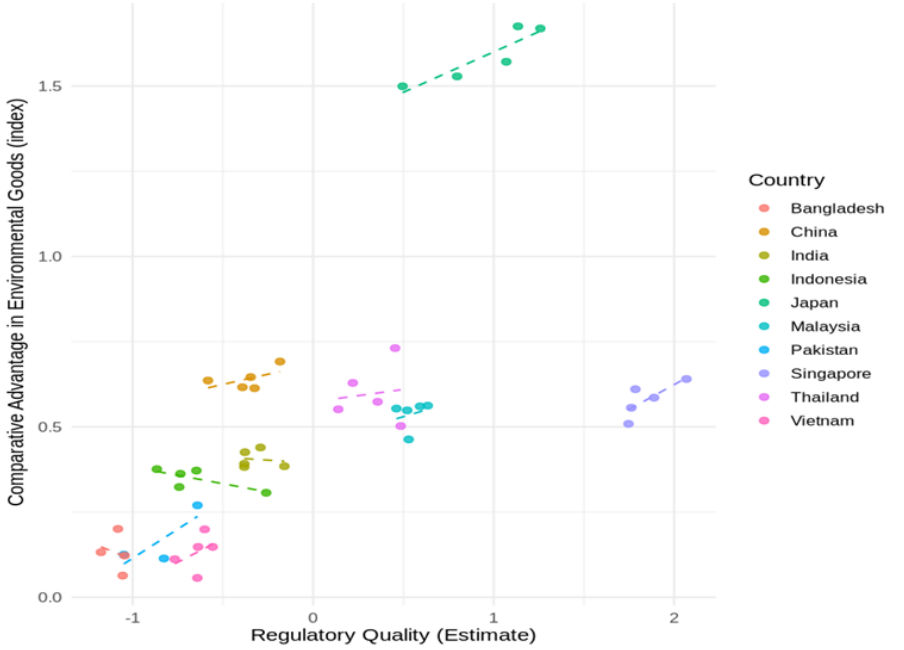
The scatter plot shows the relationship between the average score for Regulatory Quality on WGI for each country (1999–2023), as well as the average score for Comparative Advantage in Environmental Goods (CAEG) Index (2008–2023). The CAEG Index is a revealed comparative advantage indicator, with a value above 1 showing comparative advantage in the exports of environmental goods. The unit of analysis is the country (n = 10).

The scatter plot shows a strong positive relationship between CAEG and Regulatory Quality, indicating that countries with good governance models tend to have leverage in higher environmental and clean-technology exports, building a confident status in green markets and reducing their carbon footprints, thus advancing towards environmental sustainability. This endorses the narrative that administrative and regulatory capacities

build foundations for the production and export of green innovation and sustainable trade performance (Mahajan & Majumdar, 2022).

Figure 10

Regulatory Quality vs CAEG - WB & WHO



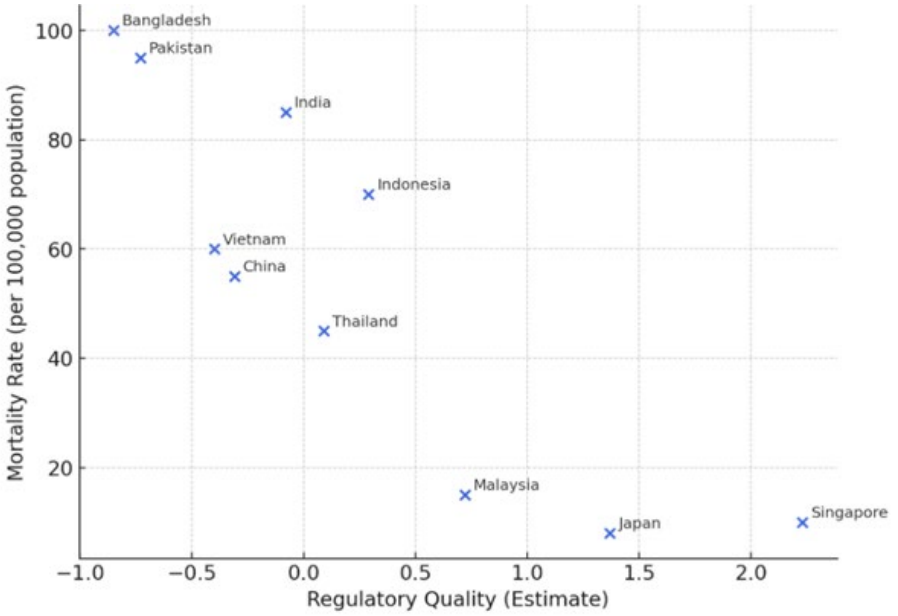
On the other hand, highly regulated economies like Japan, Singapore, and Malaysia appear on the upper-right quadrant, representing institutional maturity and strategic alignment of industrial policy with environmental objectives. Their consistently increasing trends are evidence that good governance mechanisms are proportionate to the continued improvements in green trade competitiveness. In contrast, moderate-capacity nations like China, Thailand, and Vietnam are yet in the transitional role in which incremental progress in regulatory quality is linked with slow gains in environmental goods trade, reflecting the consistent strengthening of governance and innovation linkages.

Lastly, in the lower-left corner, India, Pakistan, Bangladesh, and Indonesia represent weak-capacity economies which have fragmented regulatory competence and weaker comparative advantage as compared to the developed economies. The declining trend of these economies specifies

ongoing institutional and enforcement challenges that hinder the expected diffusion and integration of environmental technology into green value chains. This empirical evidence confirms the central hypothesis of the study that administrative capacity, coupled by regulatory quality, is an important determinant of environmental competitiveness and the environmentally ensured sustainable transformation in Asian economies.

Figure 11

Regulatory Quality vs Mortality from Household Air Pollution (PM 2.5) – WHO



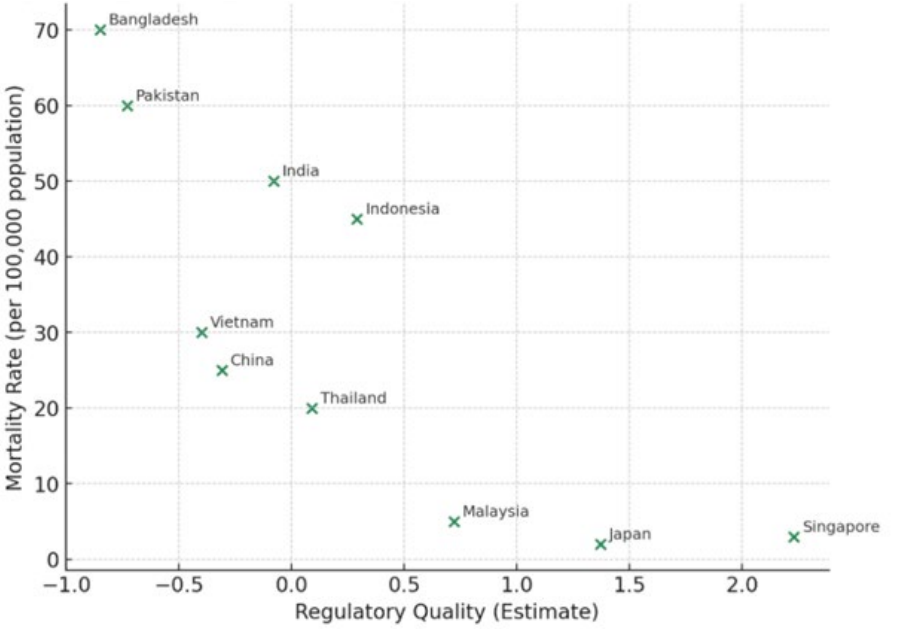
Linking Administrative Capacity to Environmental and Health Outcomes

The results show a significant negative relationship between Regulatory Quality and $PM_{2.5}$ attributable mortality, indicating that a higher regulatory capacity is correlated with better environmental policies through public health benefits. The blue dashed lines in Figures 11 and 12 represent negative Pearson correlation between average WGI Regulatory Quality scores and mortality attributable to household and ambient air pollution in Asian countries (2016–2019) respectively, suggesting that higher scores of the WGI Regulatory Quality component are always correlated with lower

burdens of death because of household and ambient air pollution. Effective monitoring, policy coordination, enforcement, and support for clean energy transitions create these outcomes in high-capacity countries, while in countries with weak governance systems, lack of coordination and implementation capacity indicates pollution exposure and health risks remain high. Overall, the findings of this study are consistent with the Pigouvian–Administrative Capacity Linkage Model and suggest that regulatory quality is one of the main factors shaping environmental sustainability, lower exposure to $PM_{2.5}$, and enhanced human welfare in Asia.

Figure 12

Regulatory Quality vs Mortality from Ambient Air Pollution (PM 2.5) – WHO



Results

The quantitative analysis across Asian economies of different income levels provides supporting evidence and also verifies that administrative and institutional capacity is still the determinant factor of $PM_{2.5}$ mitigation success. Comparative analysis of ten of the above Asian nations identified an evident gradient, that the countries with well-organized regulatory

frameworks, fiscal prudence, and well-developed monitoring systems show the most sustained air quality outcomes.

The study employs both the qualitative and quantitative empirical approaches which are eventually integrated into a coherent integrated framework. The qualitative phase, which focuses on the cross-case comparative analysis organized around the three typologies of governance, builds the contextual mechanisms whereby the administrative capacity impacts the outcomes of $PM_{2}.5$ in each country group. The quantitative part (descriptive statistics, trend analysis, and bivariate correlations) gives numerical illustrations of these patterns and tests to illustrate the consistency of the patterns. The evidence provided is quantitative and correlations (e.g. $r = 0.956$ for the relationship between governance effectiveness and $PM_{2.5}$ improvement) reflect high association and are not causal proof. Causal statements in this study should be interpreted not as the sort of statements that can be coerced with econometric identification procedures such as instrumental variables and panel fixed-effects, rather as statements that are theoretically grounded in associational relationships consistent with the Pigouvian–Administrative Capacity Linkage Model. This distinction is preserved throughout the analysis and the study's limitations regarding this distinction are pointed out.

Evidence shows that countries with a higher administrative capacity have better air quality results due to effective enforcement, monitoring, and institutional coordination. Countries with high-capacity economies such as Malaysia, Singapore, and Japan have been able to achieve pollution reduction by establishing effective regulations, regular emission monitoring, and a unified control mechanism. Administrative measures, such as the 2013 Air Pollution Action Plan in China, can achieve quick results in reducing $PM_{2.5}$, as seen in transitional economies like China, Vietnam and Thailand. Countries like India, Pakistan, Bangladesh, and Indonesia, on the other hand, have been known as capacity constrained countries, which still suffer from implementation issues, even under the most ambitious policies. This indicates that regulatory success relies on effective institutional capacity, financial resources, and monitoring capability. The benefits of transparent data systems, robust institutions, fiscal alignment, and adaptive governance are emphasized by best international practices, such as Japan's integrated monitoring systems, Singapore's polluter pays approach, the European Union's cross-sectoral

compliance model, South Korea's AI-based monitoring, and China's carbon trading pilots, all of which demonstrate how these elements can lead to environmentally sustainable air quality and public health outcome.

Discussion

The following discussion is based on the descriptive and correlational evidence presented in the previous sections to show patterns consistent with the propositions of the current study. The analysis is not intended to make econometric causal inferences regarding the relationship between administrative capacity and $PM_{2.5}$ outcomes. Instead, it reads the observed associations (high positive correlation between regulatory quality and environmental goods competitiveness and high negative correlation between regulatory quality and pollution-attributable mortality) as empirical signals that are consistent with the Pigouvian–Administrative Capacity Linkage Model. The term 'effect' or 'impact' in the following discussion refers to an associational relationship that has been confirmed by cross-country descriptive data but has yet to be validated by econometric research.

To achieve sustainable $PM_{2.5}$ reductions and meet SDG 11.6, Asian governments must work on the capacity-first environmental reforms**,** treating air quality management as an institutional challenge rather than solving it only on the dimension of technicality. The evidence across countries highlights that ecological environmental outcomes depend on the robustness of regulatory, fiscal, and data systems. Accordingly, the following policy directions suggest the strategic policy formulation for South and Southeast Asia.

Policy: Way Forward

- *Improve Monitoring and Data Infrastructure:* Enhance the monitoring network of integrated air quality station, satellite monitoring, and low-cost sensor and make air quality data readily available for public access in real time (He et al., 2024).
- *Coordinate Fiscal and Regulatory Responsibilities:* Align fiscal incentives with regulatory performance through dedicated air quality funds, mandatory air quality audits, and incentivizing local governments to effectively reduce $PM_{2.5}$ levels (Ike, 2025).
- *Technical and Human Capital:* Enhance enforcement capacity by

training environmental professionals in emissions modelling, regulatory compliance, and environmental economics (Dechezleprêtre & Popp, 2017).

- *Strengthen Coordination and Accountability:* Foster collaboration among the environment, energy, transport, industry and health sectors, with coordination and monitoring mechanisms at regional level in accordance with the Chinese model of regional coordination.
- *Encourage Transparency and Independent Oversight:* Build regulatory credibility by making information on emissions available to the public, having citizens participate and with independent audits, as in Singapore and Japan (Matlala, 2024).
- *Enhance Cross-Border Cooperation:* Foster regional air quality management through regional monitoring, exchange of data, and joint capacity building programmes under cooperation agreements like ASEAN and SAARC.
- *Adapt Policies to Local Realities:* Develop pollution targets according to the regional characteristics of $PM_{2.5}$, industrial structure, and climatic conditions, instead of taking national standards as a reference. Improve the integration of public health into air quality policy by incorporating health outcomes (e.g. health costs, morbidity and mortality) as a measure of welfare gains (Olsson et al., 2009).
- *Implement Clean Technology and Green Transition:* Implement emission trading, pollution pricing, and green fiscal measures to incentivize cleaner production and long-term decrease in $PM_{2.5}$.

Synthesis: From Ambition to Administrative Execution

Air quality policies need to be based on robust fiscal, institutional, and technological measures. The experience of the developed Asian economies shows that strong governance, monitoring, and enforcement policies have tangible health and welfare benefits. Indeed, many transitional and low-capacity economies still suffer from implementation issues stemming from weak governance, weak institutions, inadequate financing, and poor coordination of policy. This requires good governance, investment in technical and human capacity, and best international practice for sustainable improvements in air quality. The policy recommendations outlined here are not speculative; rather, they are based on the empirical patterns revealed in

this study, as exemplified by China's significant reduction in $PM_{2.5}$ levels in provinces that have greater administrative capacities.

Limitations and Future Research

The study offers cross-country support for the administrative capacity argument in the context of improving the regulation of $PM_{2.5}$. However, the results are subject to caution because of a few methodological weaknesses. It is important to note that the statistical analyses used are qualitative-comparative methods, descriptive trends, and bivariate correlation and that the associations reported (e.g., the strong correlation between governance effectiveness and $PM_{2.5}$ improvement) should not be interpreted as causal. Furthermore, the study has not been adjusted for relevant confounding variables, such as economic factors (GDP per capita), industrial composition, urbanization, energy mix, population density, and geographical and climatic factors, all of which could also have a significant impact on air quality outcomes. However, the empirical results are also limited since they lack robustness and sensitivity tests. Moreover, the cross-sectional sample is too small (ten countries) and since the results only cover one governance indicator (WGI Regulatory Quality), this can also be affected by outliers like Singapore and Japan. Future studies should focus on applying panel econometric techniques using proper control variables, other governance measures, and robustness checks to further differentiate the specific impact of administrative capacity on the outcomes of $PM_{2.5}$.

Conclusion

This research affirms that the task of regulating $PM_{2.5}$ in Asia is more of an administrative capacity weakness rather than a mere environmental objective, connecting policy design to implementation and enforcement. By placing environmental regulation under the Pigouvian welfare lens, the paper contributes through the fresh vision of how institutional strength serves as the implementation basis for the mechanism of corrective governance, turning theoretical welfare efficiency into evident environmental and health returns. The Pigouvian–Administrative Capacity Linkage Model formulated in this paper outlines how monitoring, enforcement, fiscal coherence, coordination, and technical expertise collectively define the performance of regulatory interventions. The Environment–Growth Diagnostic Framework further reveals that that inefficient data infrastructure disperses fiscal mandates, while low

appropriability of regulatory returns is the root cause of environmental hazards and incurs an additional cost of health. These binding constraints inhibit low- and middle-income Asian economies to achieve sustained air quality improvements, as per the WHO guidelines.

The empirical analysis of the selected ten differently income grouped Asian nations confirms the theoretical claims: countries with high regulatory quality can substantially cut in $PM_{2.5}$ levels and manage a quantifiable reduction in deaths due to good ambient and indoor air pollution. This further confirms that a highly equipped government with all the necessary tools is indeed a type of public health infrastructure that needs to be adequately funded also the retention of institutional memory and maturity is essential to translate into welfare benefits. In contrast, administrative fragmentation perpetuates policy slippage, fiscal underinvestment, and ongoing human exposure to pollution and health hazards.

The research finally suggests that sustainable environmental change requires capacity building reforms first: open data infrastructure, performance-centric fiscal systems, and interdisciplinary coordination. Institutionalizing and operationalizing these administrative pillars is the only way through which Asian countries can thrive beyond reactive control of pollution to preventive environmental management achieving the twin objectives of clean air and equitable, welfare-focused growth, which is the mandate of Sustainable Development Goal 11.6.

Author Contribution

Aimen Mansoor: conceptualization, data curation, formal analysis; methodology, visualization, writing – original draft, writing – review & editing. **Wajahat Naeem:** investigation, resources, software, validation, project administration, supervision.

Conflict of Interest

The authors of the manuscript have no financial or non-financial conflict of interest in the subject matter or materials discussed in this manuscript.

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