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# Evaluating the Impact of ESG on Regional Development in Kazakhstan: Empirical Analysis

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**ABSTRACT**

Environmental, social, and governance (ESG) principles have become increasingly vital for fostering sustainable regional development in emerging economies in recent years. This study assesses the relationship between ESG factors and regional economic performance using a panel dataset covering 18 regions from 2005 to 2023. The research used panel data econometric methods, including fixed effects (FE) and random effects (RE) models, to control for regional heterogeneity and estimate the impact of key ESG indicators. The Hausman test is used to determine the appropriate model specification, while regression analysis quantifies the relationships between solid and air pollutant emissions, R&D expenditure, labor force size, and regional GDP. The empirical results indicate that solid pollutant emissions have a significant adverse effect on regional GDP (FE coefficient = –17.94, RE coefficient = –18.57), while R&D expenditure (FE = 0.33, RE = 0.30) and labour force size (FE = 8.55, RE = 7.37) contribute positively and significantly to GDP growth. Regions with high R&D investment demonstrate up to 15% higher GDP growth, whereas variations in pollutant emissions account for a 20% gap in economic output. These findings suggest that regional ESG strategies require targeted policy interventions to mitigate environmental damage while fostering innovation-driven economic growth. Future research should investigate long-term causal mechanisms, sector-specific ESG influences, and qualitative governance factors to enhance regional sustainability frameworks.

**KEYWORDS:** Economy, Economic Development, Economic Stability, Environmental Sustainability, Social Equity, Governance, Sustainable Growth, Kazakhstan

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## 1. INTRODUCTION

ESG has emerged as the building block of sectoral growth for all countries. This influences policy architecture, investment patterns, and regional development initiatives. It represents a suite of interlinked dimensions: environmental stewardship, social justice, and good governance. The integrated model maps onto the economic growth, inadequate availability of resources, and societal inequality nexus. During recent years, the relevance of ESG integration has enlarged practically in advanced economies, while in developing and emerging economies, structural and regional disparities greatly amplify the degree of challenges to sustainability. Considering all these conditions, Kazakhstan can be regarded as an interesting case study, thanks to its resource-oriented economy and geographical diversity with unequal regional development.

These are supported by the significant variations evident in practically all key economic, environmental, and social indicators across different Kazakhstan regions, further underlining the need for locally tailored ESG practices. For instance, the striking per capita disparities in emissions of solid and air pollutants across the regions reflect the highly heterogeneous environmental problems generated by industrial activities and regulatory regimes. Similarly, gaps in gross domestic expenditure on R&D, labour force participation, and regional GDP growth manifest uneven economic capabilities and diverging social dynamics. Although the country has taken measures toward modernizing its economic infrastructure and adherence to international sustainability goals, ESG principal integration at the state level remains an under-explored area of study.

It makes the absence of profound studies that connect ESG metrics with regional development in Kazakhstan a serious challenge for policymakers. The completeness of national commitments to the UN SDGs and several government programs regarding economic diversification and ecological sustainability have not yet been transformed into the qualitative elaboration of region-specific ESG assessments. This inequality is even more striking in the environmental sphere, as the industrial regions of Karaganda and Pavlodar constantly have higher levels of pollutant emissions than other less industrialized regions. Moreover, unequal financing of research and development activity across the regions denotes the potential for underutilizing opportunities provided by innovation for ecologically oriented economic growth. These depend upon a strong and prospective data-driven analysis of ESG dynamics, emphasizing the interaction between environmental factors, economic performance, and social development.

Hence, the given study tries to bridge such a gap through an empirical analysis of ESG-related trends across the Kazakhstani regions for 2005-2023, based on a panel dataset with all essential indicators such as emission, air pollution per capita, R&D expenditure, labour force participation, GDP, and state survivor benefits. The paper, therefore, seeks to identify, using advanced econometric techniques, the spatial and temporal pattern of ESG metrics, unravel the relationships between the environmental, social, and economic variables, and assess the impact of governance and R&D investment on regional sustainability. These latter will be specified in terms of the associations of levels of environmental degradation and solid pollutant emissions- with economic indicators of regional development such as regional GDP growth, and also how the social variables like labour force participation rates and state benefits intervene in these associations.

Integrating ESG principles into regional policy and strategy may help overcome some of Kazakhstan's unique challenges. A high reliance on extractive industries has brought about environmental degradation and regional inequalities that put the long-term sustainability of the country's development at risk. At the same time, regions with high levels of investment in R&D and higher innovative potential, like Astana and Almaty, have

specific opportunities to develop best practices in the context of sustainable government and a diversified economy. Through tapping into such a dataset and carrying out a profound analysis of those dynamics, this research complements not just the vast, rapidly growing body of material on ESG but also provides very real policy guidance for the policymakers in the pursuit of aligning Kazakhstan's regional development to international standards of sustainability.

The most critical aspect of this study is its connectivity between theoretical ESG frameworks and actual applications within developing economies. Most international research currently focuses on the macroeconomic implications of ESG adoption and the neglect of regional variability. Everything from agrarian economies, like those in the regions of Turkistan, up to the heavily industrialized zones of Karaganda, are so different that ESG integration into Kazakhstan needs to be separate. Thus, this study explores a differentiated approach to underlining local ESG strategies with consideration of regional disparities for the sake of national cohesion.

It is relevant not only for purely academic purposes but also because, through an evidence-based analysis of ESG trends in Kazakhstan, the following report covers its country's strategic priorities embodied in national development programs, which are targeted, among others, at such development priorities as economic diversification, reduction of regional inequalities, and the SDGs. The foreseen outputs will endow policymakers with the knowledge required to devise interventions that address the causes of environmental and social disparities, thereby helping achieve inclusive economic growth. It is also expected to contribute to the broader discussion on ESG integration in emerging markets through an approach that could be replicated in other resource-dependent economies with related challenges.

This research is one more step toward understanding and helping to find solutions to the complex dynamics of ESG in the regional development of Kazakhstan. It attempts to provide a holistic assessment of progress by Kazakhstan regarding environmental, social, and governance integration into the country's development trajectory based on an analysis of extensive data from almost two decades. On the other hand, such insight from this study would not benefit only at the regional policy level but would also contribute to the global discussion on sustainable development across emerging economies. It is underlined that data analysis and practical policy recommendations are stressed, so this research shows the vast role of ESG in Kazakhstan's sustainable, equable future.

## 2. LITERATURE REVIEW

Various ESG factors have recently received considerable academic and policy-focused scrutiny for their role in promoting global, national, and regional sustainable development. Environmental degradation, social justice, and governance effectiveness are linked on so many levels that there is an obvious need to consider an all-inclusive, multidisciplinary method to conceptualize and address inequities at the regional level. While it has been discussed at large for developed economies, limited work emphasizes how it relates to emerging economies, such as resource-dependent ones like Kazakhstan. This literature review synthesizes existing knowledge on the main ESG principles, focusing mainly on those studies that may be relevant for setting the context for Kazakhstan.

The tendencies of ESG, rooted in CSR and sustainable development paradigms, significantly shape the nature of the international dialogue concerning it. Eccles et al. (2014) report that, over time, emphasis on ESG factors would shift from optional corporate pursuit to a keystone approach, which will be imperative for the long-term viability of business and stakeholder confidence building. Indeed, this institutes the proliferation of ESG metrics and reporting frameworks across industries. As Clark et al. (2015) highlighted, implementing ESG principles transcends organizational confines,

impacting regional and national development frameworks by incorporating environmental sustainability, social welfare, and governance accountability within the policy formulation process.

Environmental sustainability represents one of the core components of ESG criteria and has received significant interest in literature that evaluates its impact on economic and social outcomes. According to Stern (2007), the financial effects of poor environmental performance are an outcome of ecological degradation highly relevant to countries whose economies rely on extractive industries. This is reflected in current findings, as Doda (2014) stresses that pollution and resource depletion disproportionately affect developing areas. Therefore, considering the contribution of industrial activity to regional inequalities in environmental outcomes in Kazakhstan, ensuring the effective implementation of environmental policy is highly relevant. The actual level of air quality and, most importantly, emissions control remains relatively low, especially in such industrial cities as Karaganda and Pavlodar.

Social equity, one of the central elements of ESG, is closely related to workforce participation, educational access, and social welfare systems. These findings align with comprehensive studies undertaken by Stiglitz et al. (2010), which assert that social inequalities undermine economic resilience and act as a barrier to achieving sustainable development goals. Integrating social equity into ESG mechanisms is highly instrumental in addressing regional disparities, particularly in emerging economies with diverse socio-economic profiles.

Governance is the third aspect of ESG, which forms the substance for sound environmental and social policy implementation. According to Acemoglu and Robinson (2012), credible institutions are a source of prosperous, inclusive, and sustainable development because their existence forms a basis for the equitative distribution of resources, policy, and stakeholder engagement. In this respect, particular attention has been paid to governance challenges in several studies on Kazakhstan, including that by Pomfret (2019), which has especially called for more decentralization and transparency regarding regional policy setting. This would align the governance frameworks towards ESG-related concerns and address regional disparities for comprehensive development.

The role of R&D in realizing ESG goals has been underlined repeatedly in scholarly discourse. Freeman and Soete (2009) believe that with technological progress, innovation is a primary driving force of economic growth and sustainable development. In the case of Kazakhstan, Bekmagambetova et al. (2021) underline inequality in the distribution of R&D expenditures between its regions; such a situation hinders the country's capability to use innovation for sustainable development. The findings are thus consistent with international studies, including by Griliches, 1998 that indicate the role of selective research and development policies for regional competitiveness and environmental protection.

Various methodological approaches have been tried within regional development, from econometric analysis to case study research. According to Sachs (2015), applying the system approach is necessary while analyzing the interlinkage of environmental, social, and governance variables. In this respect, such methodological insights have special relevance for the case of Kazakhstan, where regional disparities require an advanced and evidence-based approach towards ESG assessment. Kazakhstan's recent policy initiatives highlight its commitment to sustainable development. The government's "Strategy of the Republic of Kazakhstan on Achieving Carbon Neutrality by 2060" underscores efforts to reduce greenhouse gas emissions through comprehensive ESG policies. In addition, Reuters (2024a) reported that Kazakhstan is making progress in decarbonization, particularly as the country restructures its energy and resource policies in line with global energy transitions (Reuters, 2024a).

The social and governance aspects of ESG in Kazakhstan are also receiving growing attention. A survey conducted by PwC Kazakhstan (2024) on "ESG Awareness in Eurasia" revealed that many Kazakh companies have implemented mature ESG strategies, with a majority incorporating robust sustainability practices into their operations (PwC Kazakhstan, 2024). In parallel, Aggarwal (2024) highlighted in an interview that enhanced sustainability reporting is crucial for building stakeholder trust and ensuring transparency in ESG practices (Aggarwal, 2024). Innovation and green finance are recognized as key drivers of ESG outcomes in Kazakhstan. Davidenko et al. (2024) examined the eco-branding of an industrial region in Kazakhstan, demonstrating that ESG transformation can stimulate sustainable economic growth by promoting clean production and green technology (Davidenko et al., 2024).

Recent studies underscore the growing significance of integrating ESG principles across diverse sectors in Kazakhstan to foster sustainable development and enhance economic resilience. Maralov et al. (2024) examined ESG practices in the telecommunications industry, revealing that although current strategies offer valuable insights through their cross-sectional design and semi-structured interviews, notable weaknesses affect overall company performance. In parallel, Nurgaliyeva et al. (2024) introduced innovative modelling methods that incorporate ESG criteria into risk management frameworks tailored to Kazakhstan's green economy, highlighting quantitative and qualitative approaches for assessing ESG risks and their influence on sustainable growth. Complementing these sector-specific findings, Kuandykova et al. (2023) explored the application of ESG principles in organic agriculture as a strategy to attract investment and stimulate rural development, offering a case study approach that provides policy recommendations to improve both environmental quality and socio-economic outcomes in rural regions. Collectively, these studies illustrate that effective ESG integration—whether in telecommunications, risk management, or agriculture—contributes to improved operational performance and drives broader sustainable development in Kazakhstan.

The importance of good ESG reporting stems from its potential to draw investment and support regional economic performance. Aggarwal (2024) believes that comprehensive sustainability disclosures are essential since they encourage transparency, enable comparability, and build stakeholder trust (Aggarwal, 2024). This perspective is also supported by the standards established by the International Sustainability Standards Board (ISSB), such as IFRS S2 Climate-related Disclosures, which provide a framework for evaluating and disclosing climate-related risks (Reuters, 2024b). The changing dynamics of ESG in Kazakhstan reflect more exhaustive regional efforts in Central Asia. For instance, the Eurasian Development Bank (EDB) has promoted green finance in the region through investments in renewable energy schemes (Eurasian Development Bank, 2024). Similarly, the Astana International Financial Centre (AIFC) has a central role in attracting sustainable investments and developing a strong financial system that supports ESG-related activity (Astana International Financial Centre, 2024).

In this regard, Kazakhstan's adherence to the UN SDGs presents a meaningful framework that could adequately introduce ESG considerations while developing regional policy. The studies by Kolk (2016) also highlight that most of Kazakhstan's national development programs are related to the SDGs and require a proper localized approach to regional differences. The literature concerning ESG has grown, but significant research gaps remain, notably regarding emerging markets such as Kazakhstan. Current literature mainly focuses on country-level analyses, often to the detriment of regional dynamics and their implications for ESG integration. Therefore, Therefore, the current paper tries to bridge these gaps by undertaking a detailed analysis of

ESG-related variables across regions in Kazakhstan, using a panel dataset for nearly two decades. It also attempts to draw operational messages from what existing literature states and contributes to the more considerable debate on sustainable regional development in emerging economies.

## 3. RESEARCH METHODS

Panel data analysis is one of the most applied statistical approaches. It allows us to study a dataset's time series and cross-sectional dimensions and, therefore, is apt for assessing regional and time-series changes concerning ESG factors. The panel data analysis underpins the following research that sought to investigate the relationship between ESG indicators and regional economic performance in Kazakhstan during the years from 2005 to 2023, especially concerning further differences in environmental pollution, distribution of social welfare, investments in research and development, the size of the labour force, and GDP. The dataset will include yearly observations over 20 regions, thus allowing a comprehensive study of the intra-region and inter-region dynamics for almost two decades.

This analysis is underpinned by the definition that economic growth, proxied by GDP, emanates from various mixes of environmental, social, and governance variables. Generally speaking, the econometric model for this study can be summarized according to the formula (1):

$$GDP_{it} = \beta_o + \beta_2 Emissions_{it} + \beta_2 AirPollutants_{it} + \beta_3 StateBenefits_{it} + \beta_4 RDExpenditure_{it} + \beta_5 LabourForce_{it} + a_i + \epsilon_{it} \quad (1)$$

where:

$GDP_{it}$ – the gross domestic product of region *i* at time *t* (in million tenge);

$Emissions_{it}$ – total emissions of solid pollutants (in thousand tons);

$AirPollutants_{it}$ – air pollutant emissions per capita (in kilograms);

$StateBenefits_{it}$ – number of state survivor benefit recipients (serving as a proxy for social welfare);

$RDExpenditure_{it}$ – research and development expenditure (in million tenge);

$LaborForce_{it}$ – size of the labor force (in thousands);

$\alpha_i$ – a region-specific effect capturing unobserved heterogeneity;

$\epsilon_{it}$ – the idiosyncratic error term.

Including both the region-specific effect $\alpha$_i and the error term $\epsilon$ it ensures that the model captures variations arising from time-invariant and time-variant factors, providing a nuanced understanding of how ESG-related variables impact regional economic performance.

The primary objective of this analysis is to evaluate the relationships between ESG factors and GDP while controlling for region-specific and time-specific unobserved characteristics. To ensure robustness, the study employs fixed effects (FE) and random (RE) estimations. The FE model, which eliminates time-invariant regional effects, is specified as formula (2):

$$(GDP_{it} - GDP_i) = \beta_1 (Emissions_{it} - Emissions_i) + \beta_2 (AirPollutants_{it} - AirPollutants_{ii}) + \ldots + (\epsilon_{it} + \epsilon_i) \quad (2)$$

Therefore, the FE model only considers the estimated coefficient's within-region variation, cleansing the potential effect of ESG factors on economic growth from spurious effects due to persistent regional characteristics. In contrast, the RE model assumes that the region-specific effects are uncorrelated with the explanatory variables, allowing one to consider jointly within- and between-region variations. For each of these, the appropriateness is ascertained using the Hausman test, which tests for a correlation between region-specific effects and independent variables. A statistically significant test should thus favour the FE model, indicating violations in assumptions set by the RE model. The variables used in the analysis indicate a holistic approach toward capturing ESG dimensions. Environmental factors include per capita

emissions of solid and air contaminants, by which high pollution levels are expected to affect GDP via health-related costs and reduced labour productivity negatively. The social aspects shown are the number of state survivor benefit recipients, whereby these variable proxies for welfare distribution and social cohesion. Governance elements in this model include expenses related to research and development and reflect investment into innovation and sustained economic competitiveness. The magnitude of the labour force-control variable involves the inevitable effect on economic production.

Such a dataset configuration, with yearly observations across 20 regions for almost twenty years, provides a rich basis for analyzing temporal and spatial dynamics. In this model specification, the control for time-fixed effects captures national-level shocks and trends, such as changes in macroeconomic policy or exogenous economic shocks. In contrast, regional fixed effects capture time-invariant characteristics of each region, such as natural resource endowments or geographical advantages. Clustering the standard errors of regressions at the regional level usually controls for most of these econometric problems: heteroscedasticity and/or serial correlation. The standard errors of such a model are robust to various failures regarding the assumptions of the classical linear regression model. Besides, this analysis checks the robustness of these findings by using different model specifications and excluding outliers from strongly polluted or highly research and development-intensive areas.

The model's suggested relationships are grounded on theoretical underpinning and empirical findings. This study expects that higher per capita emissions of solid and air pollutants will lower the GDP in tandem with various theories of environmental economics that indicate the probable trade-offs between economic development and environmental deterioration. On the other hand, increased research and development outlay is believed to have positive spill-over effects on GDP due to technological innovation and productivity improvement. The number of state survivor benefits is a proxy for social welfare and is also supposed to correlate positively with the GDP of a state since social stability will ensure economic growth. The size of the labour force is a control variable, which has a presumed positive relationship with GDP since the regions possessing more substantial labour forces will most likely contribute to high economic output. The empirical analysis will be based on the intrinsic values of panel data, giving more detailed insight into the dynamic relationships between ESG variables and regional economic performance in Kazakhstan. With the contribution of advanced econometric methods and a rich dataset, this paper will enrich the current debate on sustainable development. It will be of great usefulness for policymakers in the balancing act between economic growth, environmental concerns, and social equity.

## 4. FINDINGS AND DISCUSSION

These results provide a wide-based analysis of the interactive effects of ESG and regional successes in Kazakhstan's economy. Panel data from 2005-2023 looks at regional disparities in economic growth, environmental sustainability, and social parameters. The estimates underline significant relations to GDP with variables such as solid pollutant emissions, air pollution per capita, state survivor benefits, R&D expenditure, and labour force size. Indeed, the regions with higher R&D investments and larger labour forces show better economic performances, while the regions burdened by higher pollutant emissions face stagnation.

Figure 1 shows GDP trends across all regions.

The data illustrates the GDP trends across all regions of Kazakhstan from 2005 to 2023, capturing the regional disparities in economic growth over time. Almaty city and Astana city show the most considerable upward trends, respectively, showing that these are the financial hubs of Kazakhstan with consistently growing GDPs after 2015.

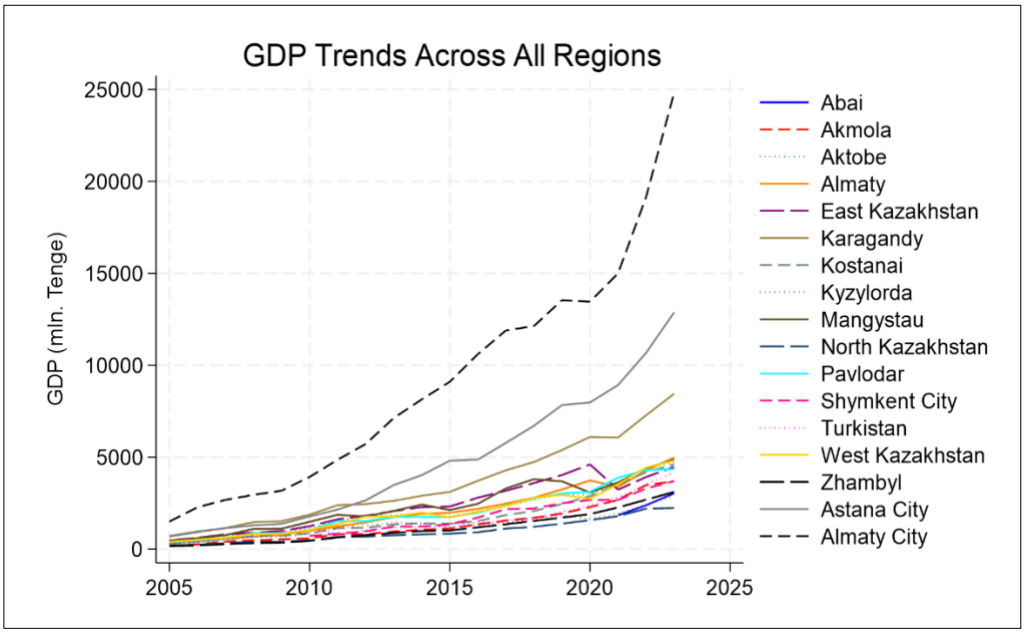


**FIGURE 1.** Respondents' familiarity with the concept of sustainable/conscious consumption

*Note*: compiled by authors

Other regions, such as Mangystau and Karaganda, have also been experiencing considerable upsurges, reflecting the implications of industrial and resource-based activities. On the other hand, Turkistan, Kyzylorda, and West Kazakhstan had relatively lower GDP growth rates, indicating a lower comparison rate with the other, more urbanized or industrialized regions in terms of economic development. The difference in this trend in economic development suggests structural differences and spontaneous agglomeration of economic activities in certain areas, entrenching the thought of special policy implementation for balanced and sustainable development.

Table 1 illustrates descriptive statistics of variables.

**Table 1**. Descriptive Statistics of Variables

| Variable | Mean | Std. Dev. | Min | 25% | 50% (Median) | 75% | Max | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|---|---|
| Emissions of solid pollutants | 34.11 | 52.68 | 1.10 | 4.35 | 13.00 | 35.50 | 251.30 | 2.41 | 8.13 |
| Emissions of air pollutants | 163.77 | 220.92 | 8.00 | 39.05 | 98.05 | 149.60 | 1062.00 | 2.46 | 8.36 |
| State survivor benefits | 17607.38 | 9949.08 | 6325.00 | 11015.50 | 14057.00 | 20505.00 | 55085.00 | 1.76 | 5.99 |
| R&D expenditure | 3799.95 | 7920.78 | 46.80 | 353.70 | 1050.50 | 3420.10 | 77204.10 | 4.56 | 31.21 |
| Labor force | 522.52 | 226.11 | 188.50 | 344.45 | 437.30 | 704.55 | 1132.70 | 0.89 | 2.80 |
| GDP | 2698.24 | 3024.52 | 168.60 | 955.60 | 1780.60 | 3227.60 | 24828.70 | 3.21 | 16.94 |

*Note*: compiled by author

Table 1 shows descriptive statistics of all the variables studied in this research. It was noticed that, on average, the mission of solid pollutants was 34.11 thousand tons and was highly variable Std. Deviation 52.68, and with a highly positively skewed distribution, Skewness=2.41, implies that most data are at the lower measurements, while only some areas attain high levels of up to 251.30 thousand tons of pollutant emissions. The air pollutant emission data represent the mean of 163.77 kg per capita with an SD of 220.92 and a maximum value of 1062 kg per capita. A positively skewed value of 2.46 and a kurtosis value of 8.36 also indicate the presence of outliers and a long tail in the distribution. State Survivor Benefits can be used here as a proxy for social aid. The average beneficiaries are 17,607 beneficiaries with considerable variation Std. Dev. = 9949. It ranges from 6,325 to 55,085 beneficiaries, showing significant differences among regions. The mean value of R&D Expenditure, as one of the drivers of innovation, stands at 3799.95 mln. tenge and its distribution is very leptokurtic, with exceptionally high investments in some regions (Skewness = 4.56) up to 77,204.10 mln. tenge. It follows that R&D funding is unequally distributed among different regions, reflecting regional inequalities of innovation potential.

The Labor Force variable demonstrates a more symmetrical distribution (Skewness = 0.89) with an average workforce size of 522.52 thousand. The standard deviation of 226.11 indicates moderate variation across regions. Finally, GDP showcases an average regional output of 2698.24 million tenge, with a high standard deviation (3024.52) and considerable skewness (3.21). Some regions show high GDP values: Maximum = 24,828.70 million tenge, indicating that economic activities are concentrated in narrow areas. The kurtosis value of 16.94 also denotes that the distribution contains many extreme outliers. These scattered statistics denote that regional differences are widely marked in aspects related to economic, social, and environmental variables. This calls for the implementation of region-specific policies and targeted intervention programs.

Table 2 compares fixed effects (FE) and random effects (RE) model statistics.

**Table 2**. Comparison of Fixed Effects (FE) and Random Effects (RE) Model Statistics

| **Model Statistics** | **Fixed Effects (FE)** | **Random Effects (RE)** |
|---|---|---|
| Number of observations | 312 | 312 |
| Number of groups | 18 | 18 |
| R-squared (Within) | 0.6949 | 0.6884 |
| R-squared (Between) | 0.7268 | 0.7756 |
| R-squared (Overall) | 0.6399 | 0.6725 |
| F/Wald Chi-squared | F (5, 289) = 131.64 | Wald chi2 (5) = 607.60 |
| P-value | 0.000 | 0.000 |
| Sigma_u (Variance due to u_i) | 1911.872 | 834.333 |
| Sigma_e (Residual Variance) | 1316.435 | 1316.435 |
| Rho (Variance due to u_i) | 0.6784 | 0.2866 |

*Note*: compiled by author

Table 2 compares the available statistics for both FE and RE models. In each model, the total observation is 312, divided into 18 groups. Therefore, the data possesses a regional panel dimension. From the P-value of 0.000, the significance of the models is quite high; thus, both models possess high explanatory power. The R-squared within values indicate that both models explain a large part of the variation across time and space, with the FE model performing slightly better than the RE model, as its R-squared is 0.6949 against 0.6884 for the RE model. However, the R-squared Between value for the RE model is much higher than the FE model, 0.7756 and 0.7268, respectively, meaning that the RE model

captures more variance between regions. The overall R-squared captures the combined explanatory power within and between variances. The values stand at 0.6725 for RE and 0.6399 for FE. This would suggest that RE might be better for analyzing impacts brought about by the time-invariant and time-variant predictors.

The FE model has a higher value of Sigma_u (1911.872) and Rho (0.6784), reflecting that a more significant fraction of the overall variance is due to unobserved regional characteristics in this model. In turn, the RE model has a lower value of Sigma_u (834.333) and Rho (0.2866). Therefore, it attributes less variance to unobserved factors, as is indeed presumed by this model. Overall, the FE model is more robust in analyzing the time-variant predictors within regions because it controls for unobserved heterogeneity. In contrast, the RE model allows both time-variant and time-invariant factors, assuming the unobserved effects are uncorrelated with predictors. This comparison provides good insight into the trade-off among these models concerning the study's aims.

Table 3 shows a comparative analysis of the coefficients.

**Table 3**. A comparative analysis of the coefficients

| Variable | FE Coefficient (SE) | RE Coefficient (SE) | P-value (FE) | P-value (RE) |
|---|---|---|---|---|
| Emissions of solid pollutants | -17.939 (5.663) | -18.567 (5.044) | 0.002 | 0.000 |
| Emissions of air pollutants | 1.523 (1.393) | 3.511 (1.222) | 0.275 | 0.004 |
| State survivor benefits | -0.229 (0.030) | -0.171 (0.025) | 0.000 | 0.000 |
| R&D expenditure | 0.329 (0.020) | 0.299 (0.019) | 0.000 | 0.000 |
| Labor force | 8.552 (1.427) | 7.368 (1.222) | 0.000 | 0.000 |
| Constant | 1320.714 (655.377) | 777.772 (507.181) | 0.045 | 0.125 |

*Note*: compiled by author

Table 3 provides evidence of the role the variables of emission, public benefits, research and development expenditure, and the size of the labouring force play in shaping regional economic outputs. Both models present a considerable negative relationship between the emissions of solid pollutants, expressed in thousand tons, and GDP, with coefficients of -17.939 for the fixed effects model and -18.567 for the random effects model. This may denote unfavourable economic consequences from higher emissions of solid pollutants since these can interfere with productivity and sustainability. The results also differ between the two models regarding air pollutants, whose emissions are expressed in kilograms per capita. While FE exhibited a positive effect insignificantly related at P = 0.275, RE unveiled a statistically significant positive effect at P = 0.004 with a coefficient value 3.511. The difference in findings constitutes yet another signal about the sensitivity of results to model specifications and may relate to variation across regional air quality regulations or economic frameworks.

In both models, it was seen that state survivor benefits were in steady and strong negative correspondence with GDP: The FE model estimated a higher effect than the RE model, -0.229 versus -0.171, indicating some inefficiency related to the spending of more public resources on survivor benefits, which could otherwise be invested in growth-oriented projects. In models FE and RE, the coefficients are 0.329*** and 0.299***, respectively, which shows that the impact of R&D expenditure is positive and very significant in influencing GDP. This indicates the importance of innovation and technological development in nurturing economic growth. Another key factor strongly influencing GDP positively is the labour force ('000), showing 8.552*** and 7.368*** in the FE and RE estimations, respectively. The strong relevance of this variable underlines the crucial role that human capital has in economic outcomes,

where larger labour forces directly raise productivity and overall output.

In the FE model, the constant term is significant at P = 0.045, indicating that unobserved region-specific factors influence GDP. In the RE model, however, the constant is insignificant, P = 0.125, probably due to an assumption about uncorrelated individual effects with the explanatory variables. Both models have good explanatory power as witnessed by an R-squared within (FE: 0.6949, RE: 0.6884), between FE: 0.7268, RE: 0.7756, and overall, FE: 0.6399, RE: 0.6725. Wald chi-squared = 607.60 (P = 0.000) can be seen in the RE model, while for FE, the F-statistic is computed at F (5, 289) = 131.64 (P = 0.000), which justifies the joint significance of all the predictors used. These models capture the different components of the variance variably. Specifically, the share of variance contributed by unobserved heterogeneity, i.e., Rho, is way higher in FE (0.6784) than in RE (0.2866), which shows significant variations due to region-specific effects in the former model.

FE and RE models revealed that emission, R&D expenditure, and labour force have their bearing effects on regional GDP with peculiar magnitude and coefficient effects. In contrast, by controlling for unobserved heterogeneity, FE model results are richer effects from within-region variations, while RE generalizes across regions. Therefore, there is a dire need for clear empirical evidence that policymakers do need to strike a balance in the wheel of environmental sustainability, optimization of the labour force, and R&D investments towards improving regional economic performance.

## 5. CONCLUSIONS

In summary, based on nearly two decades of panel data from Kazakhstan, this study examines the linkage between ESG factors and regional economic performance. The analysis highlights significant regional disparities in economic, ecological, and social outcomes, underscoring the need to integrate ESG principles into regional development strategies. Employing both fixed effects and random effects models, the results indicate that higher emissions of solid pollutants generally harm GDP, suggesting an economic cost associated with environmental degradation. However, the evidence is not unequivocal; for example, under the random effects model, per capita air-pollutant emissions were found to have a positive relationship with GDP. This ambiguous finding may reflect the dual role of industrial activity—contributing both to economic output and to environmental pollution—as well as differences in regional industrial structures and evolving policy frameworks. Thus, while there is a clear call for stricter environmental policies and the development of greener industries, the complex relationship between pollution and economic growth necessitates further investigation into the underlying mechanisms.

Striking correlations in the data involve the social variables, state survivor benefits, and labor force size. The continued negative correlation of state survivor benefits with GDP points to a misallocation in social welfare spending that requires policy changes to enhance social expenditure's effectiveness. Labour is an important determinant of economic output, further underlining the importance of human capital for regional development. Hence, policies fostering labour market participation and productivity are key from the perspective of inclusive economic growth. The robust positive effect of R&D expenditure on GDP, irrespective of model specifications, underlines innovation and technological change's role in attaining sustainable economic growth. While it signals, at the same time, very significant differences in regional R&D investment, such could well be put against the general innovative potential of the country. The catching-up policies boost diffused R&D spending and local innovation systems to reduce disparities in regional performances for better national competitiveness.

The FE and RE models are important methodologically speaking. While the FE model provides detail concerning changes within regions due to control for unobserved heterogeneity, the RE model provides broader

generalization since it encompasses both the time-variant and time-invariant factors. From the results of the Hausman test, the appropriateness of the FE model to capture region-specific effects was realized, which again supports the importance of localized policy interventions according to regional contexts. This, therefore, places ESG principles at the forefront of shaping the regional economic landscape in Kazakhstan. Conclusions reached herein, therefore, underline the need for evidence-based, region-specific policymaking- a delicate balance between economic growth and environmental conservation coupled with social equity. Kazakhstan should include ESG principles within regional development strategy tools, using some of the valuable outputs of this research as input and as an instrument of sound compatibility with sustainable and inclusive growth in improving diverse regional challenges. The research also allows making a case for dialogue on ESG integration within emerging economies while constituting a tool that countries dependent on natural resources can apply to handle the complex paths of sustainable development better.

## AUTHOR CONTRIBUTION

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