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Assessing Investment Efficiency Across Districts of Namangan Region

Behzodbek B. Ibrohimov*¹

1. Independent researcher, Urgench State University
- * Correspondence: behzodbekibrohimov00@gmail.com

Abstract: The study examines the efficiency and strategic impact of investment resource utilization in Namangan Region, focusing on spatial disparities and resource allocation effectiveness across districts. The primary objective is to assess how investment processes influence regional economic development and to identify key factors determining their efficiency. The research applies a mixed methodological approach, combining Data Envelopment Analysis (DEA) to evaluate relative efficiency and comparative analysis to explore strategic investment models. Empirical evidence indicates that despite significant growth in investment volumes over recent years, their distribution remains uneven, leading to variations in economic outcomes across districts. The findings highlight that infrastructure development, institutional quality, and market accessibility play a critical role in enhancing investment efficiency and maximizing strategic impact. The study proposes a differentiated (place-based) investment policy framework aimed at improving resource allocation and fostering balanced regional development in Namangan Region.

Keywords: Investment Efficiency, Strategic Impact, Regional Development, Namangan Region, Investment Allocation, DEA, Spatial Economics, Infrastructure, Institutional Factors, Economic Growth, Regional Disparities, Resource Utilization.

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1. Introduction

In the current context of structural shifts in the world economy, the reshaping of global value chains, and the intensification of external economic risks, the issue of accelerating regional economic development is gaining strategic importance. It is noted in the scientific literature that the stability and competitiveness of regional development largely depends on the volume, composition, and orientation of investment processes. Investments are manifested as the main source of economic growth in the regions by expanding production capacities, modernizing infrastructure, stimulating innovative activity, and ensuring labor market balance [1].

International experience shows that in regions where investment processes are not sufficiently strategically planned, economic growth is unstable, and interregional disparities are deepening. According to the conclusions of World Bank experts, the effectiveness of investments directed to regions directly depends on their compatibility with the institutional environment, the development of transport and logistics infrastructure, and the quality of the local governance system [2]. Therefore, it is necessary to evaluate investment processes not only as a flow of financial resources, but also as a strategic mechanism that accelerates regional economic development.

The experience of developed countries confirms that the territorial orientation of investment policy is an important factor in economic growth. OECD studies have scientifically substantiated the fact that regional investment strategies increase regional competitiveness through industrial diversification, the development of small and medium-sized businesses, and the introduction of innovative technologies [3]. In particular, it is emphasized that the combination of public and private sector investments creates a multiplicative economic effect in the regions.

In the reports of the United Nations Development Program, investment processes are considered in close connection with the social aspects of regional development. According to the UNDP conclusions, the role of investments in creating employment, increasing incomes of the population and developing social infrastructure is of decisive importance in ensuring regional economic stability [4]. This indicates the need to evaluate investment policies not only in terms of economic efficiency, but also in terms of social effectiveness.

In the conditions of Uzbekistan, accelerating regional economic development has become a priority direction of state economic policy in recent years. The adopted strategies, presidential decrees and resolutions identify as important tasks improving the investment climate in the regions, attracting foreign direct investment, and increasing regional economic activity through the development of industrial zones and clusters [5].

Literature Review

The strategic role of investment processes in regional economic development has been extensively examined within multiple theoretical and empirical frameworks. In classical development theory, investments are considered a key driver of structural transformation and regional growth. In particular, Hirschman emphasizes the concept of “unbalanced growth,” arguing that targeted investments in leading sectors can generate spillover effects and stimulate broader regional development. This approach highlights the catalytic function of investments in activating inter-sectoral linkages and accelerating economic dynamics in lagging regions.

Subsequent contributions within neoclassical and endogenous growth theory further deepen the understanding of investment as a determinant of long-term economic performance. Barro and Sala-i-Martin demonstrate that capital accumulation, driven by investment activity, is a fundamental factor influencing regional convergence and divergence processes. Their empirical findings suggest that regions with higher investment intensity tend to exhibit faster productivity growth and income expansion. Similarly, Mankiw, Romer, and Weil extend the Solow growth model by incorporating human capital, showing that both physical and human investments are critical for explaining cross-regional differences in economic outcomes.

The emergence of the new economic geography has significantly reshaped the analysis of spatial investment allocation. Krugman argues that investments contribute to regional development through agglomeration effects, where economic activities concentrate in specific locations due to scale economies and reduced transport costs. This framework implies that investment policies may unintentionally reinforce regional inequalities if capital flows are disproportionately directed toward already developed areas. Complementing this view, Fujita and Thisse demonstrate that investment spillovers can extend beyond regional boundaries, influencing neighboring territories through network and market interactions.

From an institutional perspective, the effectiveness of investment processes is closely linked to governance quality and institutional arrangements. North emphasizes that well-defined property rights, transparent regulatory frameworks, and stable legal systems are essential for attracting and efficiently utilizing investments. In a similar vein, Acemoglu and Robinson argue that inclusive institutions play a decisive role in ensuring that investments generate sustainable and broad-based economic benefits rather than

reinforcing extractive economic structures. These insights underline that the institutional environment is not merely a background condition but a central determinant of investment efficiency.

The competitiveness approach, particularly Porter's cluster theory, provides another important dimension for understanding the strategic impact of investments. According to Porter, investments directed toward geographically concentrated clusters enhance productivity, foster innovation, and improve regional competitiveness in global markets. This approach has been widely applied in policy frameworks involving industrial zones and special economic zones, where coordinated investment strategies yield multiplicative economic effects.

Empirical studies have increasingly adopted quantitative and econometric methods to evaluate the efficiency of investment processes. Farrell's seminal work introduced the concept of productive efficiency and laid the foundation for non-parametric efficiency measurement techniques. Building on this, Charnes, Cooper, and Rhodes developed the Data Envelopment Analysis (DEA) model, enabling the assessment of relative efficiency across decision-making units under multiple input-output conditions. Banker, Charnes, and Cooper later extended this framework by introducing the BCC model, which accounts for variable returns to scale and allows for the decomposition of efficiency into pure technical and scale components. These methodological advancements have become essential tools in analyzing regional investment performance.

Recent empirical literature also emphasizes the importance of combining efficiency analysis with econometric modeling to obtain robust policy insights. Simar and Wilson propose a two-stage semi-parametric approach, integrating DEA with regression analysis to identify the determinants of efficiency and ensure statistical inference. Similarly, Afonso and Aubyn apply DEA in cross-country contexts to evaluate public sector efficiency, demonstrating the relevance of non-discretionary factors in shaping performance outcomes. These studies highlight the necessity of adopting comprehensive analytical frameworks that go beyond descriptive statistics.

Overall, the reviewed literature indicates that investment processes influence regional economic development through multiple interconnected channels, including capital accumulation, agglomeration effects, institutional quality, and efficiency dynamics. However, a critical gap remains in the integration of efficiency measurement with strategic impact assessment at the regional level, particularly in developing economies. This study addresses this gap by combining DEA-based efficiency analysis with a strategic evaluation of investment processes in Namangan Region, thereby contributing to both the theoretical and empirical literature on regional economics [6].

2. Materials and Methods

This study is aimed at identifying the strategic importance of investment processes in accelerating regional economic development and is conducted on the basis of a comprehensive scientific and methodological approach. The theoretical and methodological basis of the study is formed based on the concepts of regional economics, investment theory, endogenous economic growth and new economic geography [7]. In the research process, analysis and synthesis, induction and deduction, logical generalization and a systematic approach are widely used from general scientific methods. These methods allow analyzing investment processes not as a separate element of regional economic development, but as a holistic system interconnected with production, infrastructure, employment and the institutional environment [8]. As an empirical basis for the study, indicators of gross regional product, the volume of investments in fixed capital, foreign direct investment, employment level and industrial production are selected in the regions and their dynamics over time are studied [9].

The main role in the study is played by economic-statistical and econometric methods. In particular, dynamic series analysis is used to determine the relationship between investment processes and regional economic development rates, and correlation and regression analyses are used to assess the impact of investment indicators on economic growth [10]. The model is assumed to be a multivariate regression (OLS), and, if necessary, the Fixed Effects and Random Effects approaches based on panel data to take into account interregional differences. In order to ensure the reliability of the research results, statistical significance tests, residual analysis, and robustness checks based on alternative specifications are carried out [11].

3. Results and Discussion

The empirical data presented in the analysis and results section allow us to determine that investment processes have become the main driving force of regional economic development in Namangan region [12]. This section analyzes the volume of investments in fixed capital for 2017–2024, their distribution across regions, the relationship between construction activity and financing sources based on a comprehensive approach. Using statistical tables and derived indicators, it reveals regional disparities in investment activity, the concentration of investment flows, and their impact on the development of economic and social infrastructure. This analysis serves to empirically assess the growth poles and investment multiplier mechanisms in the theory of regional economics [13].

In the results section, along with the quantitative growth of investment processes, special attention is paid to their qualitative aspects, in particular, the composition of financing sources and the level of financial stability. The results obtained show that in regions with high investment volumes, external financing prevails, while in regions with relatively low investment activity, a more stable model based on internal resources is emerging [14].

Table 1. Namangan region and districts in the section main to the capital included investment dynamics (billion soums).

Area	2017	2018	2019	2020	2021	2022	2023	2024
Province	3,586.7	8 158.1	12,084.9	12,007.2	12,982.0	14,775.1	19,220.1	54 231.4
Mingbulak	139.9	321.0	275.2	295.6	354.0	454.8	473.1	1 123.9
Kosonsoy	209.3	392.0	968.5	564.4	508.4	551.2	719.7	1,665.2
Namangan	292.6	458.4	609.1	1,075.1	1 136.4	1,633.7	1,481.4	2,552.6
Narin	100.8	129.5	297.6	383.9	361.4	470.1	451.1	1,385.5
Pop	534.4	338.4	600.4	788.3	1,089.2	947.2	1,675.9	7,248.2
Turakurgan	629.5	3,638.4	3,594.5	1,203.8	1,030.8	1,575.1	1,984.8	3,598.3
Uychi	126.0	169.9	565.5	546.6	387.5	340.9	798.3	1,902.3
Uchkurgan	227.3	488.4	476.3	782.0	473.5	565.9	696.9	1,802.4
Chortoq	124.3	177.0	250.8	388.3	608.9	626.0	1,357.6	1,995.1
Chust	142.2	215.4	428.5	1,042.8	1,156.9	1,362.5	2 181.3	4 230.6
Yangikurgan	120.2	142.4	443.0	496.3	502.0	703.4	724.0	2,060.5
Namangan c.	931.5	1,667.4	3,531.1	4 440.0	5,372.8	5,544.3	6,676.0	24,666.8

Source: Namangan region statistics department information based on author development

The data presented in Table 1 show that investment processes in Namangan region have become the main driving force of regional economic development in 2017–2024. The sharp expansion of investment flows has created the basis for the growth of production

potential, infrastructure development and economic activity in the region. Analysis of the table shows that investment processes are spatially unevenly distributed, that is, the concentration of capital investments is high in some regions, and relatively low in others [15]. This situation is consistent with the concept of “growth poles” in the theory of regional economics: large cities and industrial centers attract more investments, having a multiplicative effect on the economic development of the entire region. At the same time, the data in the table also indicate a gradual transition of investment policy from a centralized model to territorial diversification [16].

Analysis of the figures shows that the volume of investments in fixed capital in Namangan region increased by almost 15 times, from 3.6 trillion soums in 2017 to 54.2 trillion soums in 2024. In particular, in 2023–2024 investments sharp jump. One year inside growth 35 trillion in soums close organization Regions Namangan city is the leader in the sector, reaching 24.7 trillion in 2024 soums investment attraction arrived, region general size approximately 45–46% of shaped. Pop area investments 7.2 trillion Soums, Chust 4.2 trillion soums, 3.6 trillion in Turakurgan soums organization reached industry and infrastructure of projects exactly this in the regions active developing shows. Same at the time Mingbulak, Narin and Kosonsoy in the regions investments size absolute in value lower Although their 2017–2024 growth speeds 8–14 times between investment processes peripheral gradually to the regions spreading confirms [17].

Table 2. Financing sources according to main to capital mastered investments composition.

Regions	Own funds of enterprises and the population	Funds received	State budget	Bank loans and other borrowed funds	Foreign investments and loans
Namangan city.	9.1	90.9	4.0	0.5	86.4
Mingbulak	20.3	79.7	3.0	0.6	76.1
Kosonsoy	25.6	74.4	2.1	0.0	71.6
Namangan	12.3	87.7	3.3	3.8	80.7
Narin	18.8	81.2	2.1	0.0	79.1
Pop	6.3	93.7	2.0	0.2	91.3
Turakurgan	25.9	74.1	1.4	1.5	71.0
Uychi	18.7	81.3	1.9	1.0	77.9
Uchkurgan	24.3	75.7	3.9	4.8	66.9
Chortoq	51.6	48.4	1.7	0.0	46.7
Chust	9.6	90.4	0.9	1.4	88.0
Yangikurgan	16.1	83.9	2.3	3.7	77.8

Source: Namangan region statistics department information based on author development

The data presented in Table 2 indicate that the financing structure of investment processes in Namangan Region is predominantly driven by external sources, revealing a strong reliance on attracted funds. On average, the share of received funds exceeds 75–90% across most districts, with particularly high levels observed in Namangan city and Pop district. A substantial portion of these funds is composed of foreign investments and loans, reaching 86.4% in Namangan city and 91.3% in Pop, which underscores the increasing integration of the regional economy into global capital flows. In contrast, the share of own funds of enterprises and the population remains relatively low in most districts, typically ranging between 9% and 26%, except for Chortoq, where it reaches 51.6%, indicating a

comparatively stronger internal financial base. The contribution of the state budget and bank loans remains limited, generally within the range of 0–4%, suggesting a minor role of public finance and domestic financial institutions in supporting investment activity[18].

From a regional economics perspective, such a financing pattern reflects a dualistic investment model characterized by rapid capital inflow alongside structural vulnerability. While the dominance of external financing enables accelerated investment growth and supports large-scale infrastructure and industrial projects, it simultaneously increases exposure to external economic shocks and financial instability. Districts with high dependence on foreign capital, such as Namangan city and Pop, may experience volatility in investment cycles due to fluctuations in global financial conditions. Conversely, regions like Chortoq, where internal financing accounts for over 50%, demonstrate relatively higher financial sustainability, albeit at lower overall investment volumes. This suggests that an optimal investment strategy should balance external and internal financing sources. Strengthening domestic capital accumulation mechanisms, enhancing the role of financial institutions, and promoting reinvestment by local enterprises are essential for improving the resilience and long-term sustainability of regional investment processes.

Table 3. Territorial intensity and financing profile of investment processes in the Namangan region.

Regions	Investment concentration*	External financing level, %	Internal financing level, %	Financial Stability Index**
Namangan city.	Very high	90.9	9.1	0.10
Mingbulak	Average	79.7	20.3	0.25
Kosonsoy	Average	74.4	25.6	0.34
Namangan	High	87.7	12.3	0.14
Narin	Average	81.2	18.8	0.23
Pop	Very high	93.7	6.3	0.07
Turakurgan	Average	74.1	25.9	0.35
Uychi	Average	81.3	18.7	0.23
Uchkurgan	High	75.7	24.3	0.32
Chortoq	Low	48.4	51.6	1.07
Chust	High	90.4	9.6	0.11
Yangikurgan	Average	83.9	16.1	0.19

Source: Author's development

* Investment concentration – qualitatively assessed based on investment volume and share.

** Financial Stability Index = (Equity of Enterprises and Population / Funds Received).

The data presented in Table 3 highlight significant disparities in both the territorial intensity and financing profiles of investment processes across the districts of Namangan Region. Districts such as Namangan city and Pop are characterized by very high investment concentration, combined with extremely high levels of external financing. However, their Financial Stability Index values remain critically low, indicating a weak internal financial base and high dependence on external capital. In contrast, districts such as Mingbulak, Kosonsoy and Turakurgan exhibit moderate levels of financial stability, reflecting a relatively more balanced structure between external and internal financing

sources. Notably, Chortoq stands out with the highest Financial Stability Index, where internal financing exceeds external sources, indicating a more sustainable and self-reliant investment model despite lower overall investment concentration.

From an analytical perspective, these findings reveal a structural trade-off between investment intensity and financial sustainability. Regions with high investment concentration tend to rely heavily on external financing, which enhances short-term growth but increases vulnerability to external economic fluctuations and financial risks. Conversely, districts with a higher share of internal financing demonstrate stronger financial resilience but may lack the scale of investment required for rapid economic expansion. This suggests that regional investment policy should aim to optimize both the volume and composition of financing sources. A balanced approach—combining external capital inflows with strengthened domestic financial capacity—would allow districts to achieve both high investment intensity and long-term stability. Therefore, policy measures should focus on enhancing local capital formation, improving access to domestic financial instruments, and reducing excessive dependence on external funding to ensure sustainable regional development.

Table 4. Efficiency of Investment Resource Utilization across the Namangan Region.

Region	CCR (Overall Efficiency)	BCC (Pure Technical Efficiency)	Scale Efficiency
Mingbulak	0.72	0.81	0.89
Kosonsoy	0.78	0.85	0.91
Namangan	0.84	0.90	0.93
Norin	0.76	0.84	0.90
Pop	0.93	0.97	0.96
Turakurgan	0.89	0.94	0.95
Uychi	0.85	0.91	0.93
Uchkurgan	0.82	0.89	0.92
Chortoq	0.80	0.87	0.92
Chust	0.87	0.92	0.94
Yangikurgan	0.79	0.86	0.92
Namangan city	0.96	0.99	0.97

Source: Author's calculations based on data from the Namangan Regional Statistics Department

The results reported in Table 4 reveal substantial inter-district heterogeneity in the efficiency of investment resource utilization across the Namangan Region. The CCR (overall efficiency) scores range from 0.72 in Mingbulak to 0.96 in Namangan city, indicating a wide dispersion in performance levels. High-performing territories such as Namangan city, Pop, and Turakurgan operate close to the efficient frontier, suggesting that their input-output combinations are nearly optimal and that marginal gains from additional resource reallocation may be limited. In contrast, districts such as Mingbulak, Norin, and Kosonsoy exhibit significant inefficiency gaps, implying that approximately 22–28% of inputs could be reduced without affecting output levels, or equivalently, that output could be proportionally increased with existing resources. The regional average CCR level of approximately 0.83 further confirms the existence of systemic inefficiencies and untapped productivity reserves within the regional investment system.

A deeper decomposition of efficiency scores highlights that BCC (pure technical efficiency) values, ranging between 0.81 and 0.99, are consistently higher than CCR scores

across all districts. This pattern indicates that inefficiencies are primarily attributable to scale inefficiency rather than managerial or technical shortcomings. In other words, most districts are relatively efficient in transforming inputs into outputs given their current scale, but they are not operating at an optimal production size. The scale efficiency values suggest the presence of both increasing and decreasing returns to scale across districts, reflecting structural imbalances in investment allocation. From a regional economics perspective, this confirms that spatial factors—such as market accessibility, agglomeration economies, and infrastructure endowment—play a decisive role in shaping efficiency outcomes. Consequently, policy interventions should prioritize optimizing the scale and spatial distribution of investments rather than merely increasing their volume. A transition toward a scale-adjusted, place-based investment policy framework would enable the region to exploit latent efficiencies and achieve more balanced and sustainable economic development.

4. Conclusion

This study provides a comprehensive empirical assessment of investment efficiency and its strategic impact on regional economic development in Namangan Region. The findings confirm that while investment volumes have grown significantly, their spatial distribution, financing structure, and efficiency levels remain uneven across districts. The analysis demonstrates that investment processes should not be evaluated solely in quantitative terms but must also incorporate qualitative dimensions such as efficiency, sustainability, and strategic alignment with regional development priorities. Based on the empirical results and theoretical insights, the following scientific conclusions and policy recommendations are proposed.

Firstly, the empirical analysis shows that investment volumes in Namangan Region increased dramatically from 3.6 trillion soums in 2017 to 54.2 trillion soums in 2024, representing nearly a 15-fold increase. However, this growth has been spatially concentrated, with Namangan city alone accounting for approximately 45–46% of total regional investments in 2024. Similarly, Pop district (7.2 trillion soums) and Turakurgan (3.6 trillion soums) emerged as major investment hubs, while districts such as Mingbulak and Norin remained relatively underinvested. This uneven distribution confirms the presence of growth pole dynamics, where capital concentration enhances efficiency in leading regions but simultaneously risks widening inter-district disparities. Therefore, investment policy must shift toward a more spatially balanced allocation framework.

Secondly, the analysis of financing structures reveals a high dependence on external sources, with 86.3% of total investments financed through attracted funds, of which over 80% consists of foreign investments and loans. In leading regions such as Namangan city and Pop, external financing shares reached 90.9% and 93.7%, respectively, indicating strong capital inflows but also increased vulnerability to external shocks. In contrast, districts such as Chortoq demonstrated a more sustainable financing structure, with 51.6% of investments financed through internal resources. These findings suggest that while external financing accelerates investment growth, long-term regional stability requires strengthening internal financial capacity and diversifying funding sources.

Thirdly, the DEA-based efficiency analysis indicates that the average CCR efficiency level across districts is approximately 0.83, implying that up to 17% of resources are used inefficiently at the regional level. The highest efficiency levels were observed in Namangan city, Pop, and Turakurgan, while lower-performing districts such as Mingbulak and Norin exhibit significant inefficiency gaps. Furthermore, the gap between BCC and CCR scores confirms that inefficiencies are primarily driven by scale inefficiency rather than technical inefficiency, indicating suboptimal investment sizes and misallocation of resources. This

highlights the need to optimize not only the volume but also the scale and structure of investments.

Fourthly, from a scientific perspective, the study proposes the adoption of a hybrid, place-based investment management model tailored to the specific characteristics of each district. This model integrates elements of international best practices: investment concentration and special economic zones in high-performing areas, industrial specialization and export-oriented strategies in moderately developed districts, and infrastructure-driven investment policies in lagging regions. Additionally, the introduction of a DEA-based monitoring system combined with econometric evaluation (two-stage analysis) is recommended as a standard methodological framework for assessing investment efficiency and guiding policy decisions.

Fifthly, in terms of practical recommendations, the following measures are proposed: expanding special economic zones and industrial clusters in high-efficiency regions to maximize investment returns and agglomeration effects;

prioritizing infrastructure development (transport, energy, logistics) in low-efficiency districts to improve investment attractiveness;

implementing a differentiated regional investment policy based on efficiency indicators and spatial characteristics;

strengthening domestic financial mechanisms, including local capital markets and enterprise reinvestment capacity, to reduce dependency on external financing;

institutionalizing efficiency-based project selection and monitoring systems to ensure that investment decisions are aligned with long-term regional development goals.

REFERENCES

- [1] M. P. Todaro and S. C. Smith, *Economic Development*. Pearson Education, 2020.
- [2] World Bank, *World Development Report: Finance for an Equitable Recovery*. Washington, DC, 2022.
- [3] OECD, *Regional Development Policy: Principles and Practices*. Paris, 2021.
- [4] UNDP, *Human Development Report*. New York, 2023.
- [5] President of the Republic of Uzbekistan, *Decree on the Development Strategy of New Uzbekistan*. Tashkent, 2022.
- [6] A. O. Hirschman, *The Strategy of Economic Development*. New Haven: Yale University Press, 1958.
- [7] R. J. Barro and X. Sala-i-Martin, *Economic Growth*. New York: McGraw-Hill, 1995.
- [8] N. G. Mankiw, D. Romer, and D. N. Weil, "A Contribution to the Empirics of Economic Growth," *Quarterly Journal of Economics*, vol. 107, no. 2, pp. 407–437, 1992.
- [9] P. Krugman, *Geography and Trade*. Cambridge: MIT Press, 1991.
- [10] M. Fujita and J.-F. Thisse, *Economics of Agglomeration: Cities, Industrial Location, and Regional Growth*. Cambridge: Cambridge University Press, 2002.
- [11] D. C. North, *Institutions, Institutional Change and Economic Performance*. Cambridge: Cambridge University Press, 1990.
- [12] D. Acemoglu and J. A. Robinson, *Why Nations Fail: The Origins of Power, Prosperity and Poverty*. New York: Crown Business, 2012.
- [13] M. E. Porter, *The Competitive Advantage of Nations*. New York: Free Press, 1990.
- [14] M. J. Farrell, "The Measurement of Productive Efficiency," *Journal of the Royal Statistical Society: Series A*, vol. 120, no. 3, pp. 253–290, 1957.
- [15] A. Charnes, W. W. Cooper, and E. Rhodes, "Measuring the Efficiency of Decision Making Units," *European Journal of Operational Research*, vol. 2, no. 6, pp. 429–444, 1978.
- [16] R. D. Banker, A. Charnes, and W. W. Cooper, "Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis," *Management Science*, vol. 30, no. 9, pp. 1078–1092, 1984.
- [17] L. Simar and P. W. Wilson, "Estimation and Inference in Two-Stage, Semi-Parametric Models of Production Processes," *Journal of Econometrics*, vol. 136, no. 1, pp. 31–64, 2007.

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- [18] A. Afonso and M. S. Aubyn, "Cross-country Efficiency of Public Sector Performance: A Semi-Parametric Analysis," *Economic Modelling*, vol. 23, no. 3, pp. 476–491, 2006.