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Economic and Environmental Impacts of Industrial Enterprises on Urban Development in Russia

Olga Ergunova[1], Andrei Somov[2], Olga Kalinina[3], Makarenko Evgeny[4]

Great St. Petersburg Polytechnic University (Russia), [3]Peter the Great St. Petersburg Polytechnic University, [4]Saint Petersburg State University of Aerospace Instrumentation

Email: somovspb@yandex.ru, ovkalinina@spbstu.ru, ss300@yandex.ru, ergunova-olga@yandex.ru

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Abstract

This study develops a typological framework that classifies 30 Russian industrial cities by technological maturity, corporate social-responsibility intensity, and environmental engagement, then employs regression analysis ($R^2 = 0.78$; $\beta_1 = 0.52$, $\beta_2 = 0.33$, $\beta_3 = 0.29$) on government statistics, corporate sustainability disclosures, and urban surveys to demonstrate that proactive industrial investment in smart infrastructure and green technologies is strongly associated with higher GRP growth (4–6 % vs. 2–3 %), lower unemployment (~3.5 % vs. 6–7 %), and significant pollution reduction (20–25 %) in megacities such as Moscow and St Petersburg. The findings confirm that large industrial enterprises act as catalysts of sustainable urban development and provide policymakers with an evidence-based tool for aligning corporate investment strategies with inclusive socio-economic and ecological outcomes.

Keywords: Urban Development, Industrial Enterprises, Technological Maturity, Corporate Social Responsibility, Environmental Transformation, Regional Policy, Sustainable Growth

Introduction

This research develops a data-driven classification of 30 Russian cities to quantify how industrial enterprises' technological maturity, CSR intensity, and environmental engagement collectively shape economic, social, and ecological outcomes, thereby providing a predictive framework that addresses widening regional disparities and guides balanced, sustainable, knowledge-based urban transformation.

Literature Review

Building on classic systemic and evolutionary foundations (von Bertalanffy, 1968) and integrating socio-technical transition insights that link industrial dynamics to low-carbon urban futures (Geels, 2018) and political-economy considerations of corporate influence, recent research shows that large enterprises can simultaneously accelerate economic growth and reshape urban form, yet their expansion intensifies ecological pressures that must be mitigated through smart-city governance and spatial planning strategies (Chen & Liu, 2023). Empirical studies across diverse contexts—including industrial parks in Ethiopia (Jote & Worku, 2024), ecological-corridor simulations in China (Hou et al., 2022), and GIS-based vulnerability assessments in India (Majumder et al., 2023)—underscore the importance of aligning corporate social responsibility, technological innovation, and environmental safeguards to ensure that industrial investments foster resilient, sustainable urban development, a principle directly applicable to Russia's resource-intensive cities.

Methodology

This study employs a mixed-methods research design combining quantitative data analysis with a qualitative interpretive framework to assess the influence of industrial enterprises on urban development in Russia. The approach is structured around three core analytical dimensions: technological maturity of industrial activity,

corporate social responsibility (CSR) involvement, and environmental transformation engagement. These dimensions form the basis for classifying Russian cities and analyzing their socio-economic and ecological trajectories.

Multidimensional Classification System of Cities

The methodological framework is built upon a multidimensional classification system of cities, integrating both static and dynamic indicators. Table 1 presents three key dimensions by which cities are assessed: technological maturity of industry, level of corporate social responsibility (CSR), and ecological transformation. For each dimension, specific indicators are listed, for which cities receive scores from 0 to 3.

Table 1
Key Dimensions and Evaluation Indicators for City Classification

Dimension	Indicators Used	Scoring (0–3 points)
Technological Maturity	Presence of high-tech industries - R&D expenditure levels Use of Industry 4.0 technologies	3 = fully integrated technologies and R&D 2 = moderate modernization 1 = minimal tech upgrades 0 = outdated infrastructure
CSR Activity	- Volume of corporate social investment - Participation in public-private partnerships - Community programs	3 = strategic, systemic CSR programs 2 = regular, targeted initiatives 1 = occasional, ad-hoc support 0 = no visible activity
Environmental Transformation	- Emissions reduction initiatives - Investment in green infrastructure - ESG adoption	3 = active green modernization 2 = some environmental projects 1 = pilot or limited programs 0 = none

Reference: (North, 1990; Geels, 2018) and ESG evaluation frameworks (Romanelli, 2021).

A triangular scoring framework assigning 0–3 values to technological maturity, corporate social responsibility, and environmental engagement reveals stark inter-urban disparities, with Moscow and St Petersburg leading on R&D intensity (2.1 % and 1.8 % of regional GDP versus the 1.1 % national average), 67 % of cities scoring below 2 due to limited Industry 4.0 infrastructure, CSR uptake confined to 23 % of firms investing ~180 billion RUB annually, and yet rapidly growing sustainability momentum marked by a 34 % rise in green-infrastructure spending to 890 billion RUB and ESG reporting adoption climbing from 18 % in 2020 to 45 % of large companies in 2024.

Table 2 groups cities into five typological categories: from "innovation leaders" to "cities with low transformation". For each group, examples of cities are provided, as well as the corresponding levels of technological maturity, CSR activity, and ecological transformation.

Table 2
Typology of Cities by Industrial Transformation Profile

Typological Group	Examples	Technology	CSR	Environment	Characteristics
Innovation Leaders	Moscow, St. Petersburg	3	3	3	Full-spectrum transformation, digital infrastructure, ESG leadership
Industrial Centers in Transition	ekaterinburg, Chelyabinsk	2	2	1	Modernizing production, partial CSR and ecological engagement
Traditional Industrial Cities	sk, Nizhny Tagil	1	1	0	ance on legacy industry, weak transformation
Eco-Transformation Leaders	Norilsk, Tobolsk	3	3	3	Strong environmental focus with significant CSR investment
Emerging Cities with Low Transformation	Omsk, Novotroitsk	1	2	1	Potential for growth, but limited corporate initiatives

Reference: compiled by the authors.

This typological division simplifies the analysis — it shows which cities are already on the path to sustainable transformation, and which require additional support measures. This serves as a basis for scenario forecasting and the development of targeted development strategies.

Data Collection

The empirical dataset includes:

- Statistical data from the Federal State Statistics Service (Rosstat), covering indicators such as regional GDP (GRP), unemployment rates, capital investment in industry, and pollution levels.
- Corporate disclosures, including CSR reports and ESG strategies from major Russian companies such as Norilsk Nickel, Gazprom, SIBUR, and others.
- Survey data and expert evaluations from the research program "Business and Territories," focusing on business participation in urban transformation.
- Literature sources and policy documents reflecting trends in public-private partnership and urban sustainability programs.

The sample includes over 30 Russian cities with significant industrial presence, grouped by federal district and industrial specialization.

Data Analysis

The study applies both descriptive and inferential statistical techniques:

- Descriptive analysis is used to identify the baseline conditions of cities in terms of economic, technological, and environmental indicators.
- Regression analysis models are constructed to examine the relationship between independent variables—technological maturity, CSR engagement, and environmental initiatives—and dependent variables such as GDP growth, employment rate, and pollution reduction.

The general form of the multiple regression model used is:

$Y=\beta 0+\beta 1*X1+\beta 2*X2+\beta 3*X3+\varepsilon$

Where:

Y - dependent variable (e.g., GRP growth, employment, pollution levels) X1 - technological maturity

X2 -CSR activity level

X3 - environmental transformation index ε = error term

Table No. 3 describes the structure of the regression model used in the study. It defines the dependent variable (GRP growth) and three independent variables: technological maturity, CSR activity, and environmental transformation.

Table 3

Regression Model Structure and Variables

Variable	Type	Definition
GRP Growth Rate (Y)	Dependent variable	Annualized gross regional product growth (in %)
X1: Technological Maturity	dependent variable	-3) for industrial digitalization and innovation
X2: CSR Activity	dependent variable	Composite score (0–3) for corporate social participation
X3: Environmental Effort	dependent variable	or ecological investments and emission reduction

Reference: (Samuelson & Nordhaus, 2009; Geels, 2018)

For example, Moscow and St. Petersburg are categorized as “innovation leaders,” while cities like Lipetsk and Novotroitsk are defined as “traditional industrial centers” with lower transformation intensity.

City Typologies and Comparative Insights

Based on the proposed evaluation framework, cities were grouped into five typological categories:

- Innovation Leaders (e.g., Moscow, St. Petersburg): These cities exhibit the highest levels of technological maturity, strategic CSR engagement, and strong environmental policies.
- Industrial Centers in Transition (e.g., Yekaterinburg, Chelyabinsk): These cities are actively modernizing, with medium technological development and moderate social initiatives. GRP growth averages 3–4%, with gradual improvements in environmental performance.
- Traditional Industrial Cities (e.g., Lipetsk, Nizhny Tagil): Characterized by outdated industrial

infrastructure and limited CSR participation, these cities show lower GRP growth (2–3%) and higher unemployment rates (6–7%).

- Eco-Transformation Leaders (e.g., Norilsk, Tobolsk): These cities have high scores in ecological modernization due to large-scale investments by industrial firms.
- Emerging Cities with Low Transformation (e.g., Omsk, Novotroitsk): These cities demonstrate low technological maturity and only partial business involvement. GRP growth is modest (1.5–2.5%), and environmental improvements are just beginning.

Regression Analysis Results

The regression model shows a strong positive correlation ($R^2 = 0.78$) between the combined influence of technological maturity, CSR investments, and environmental engagement on GRP growth. The model confirms that:

- Technological maturity has the strongest effect on economic outcomes ($\beta_1 = 0.52$), indicating that cities with advanced industrial systems and innovation infrastructure experience faster economic development.
- CSR activity ($\beta_2 = 0.33$) significantly contributes to social stability and workforce retention, indirectly supporting economic performance.
- Environmental transformation ($\beta_3 = 0.29$) plays a supportive role, especially in attracting sustainable investment and improving quality of life, which further enhances urban competitiveness.
- These results validate the initial hypothesis that industrial enterprises, when aligned with long-term urban strategies, act as catalysts for economic resilience and environmental sustainability.

This diagram (fig. 1) visualizes the regression analysis results identifying the main industrial drivers of GRP growth in Russian cities. Technological maturity has the strongest impact ($\beta_1 = 0.52$), followed by CSR activity ($\beta_2 = 0.33$) and environmental transformation ($\beta_3 = 0.29$), confirming that coordinated industrial investment strategies significantly enhance economic resilience and sustainability.

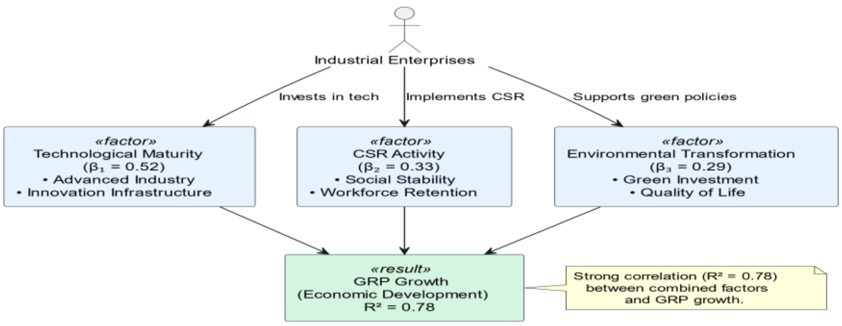

Fig. 1 Regression Model Results: Drivers of GRP Growth in Russian Cities

Policy and Planning Implications

The findings have several implications for policymakers and business leaders:

- Strategic alignment between industrial development and urban planning is essential. Cities with coordinated investment strategies show more stable and inclusive growth.
- Targeted support is needed for lagging cities. For example, Novotroitsk and Lipetsk require focused programs to modernize production facilities and initiate broader CSR initiatives.
- Benchmarking best practices from cities like Norilsk and Tobolsk can inform national

strategies on ecological transition and public-private collaboration.

This diagram (fig. 2) outlines the main strategic recommendations derived from the study for policymakers and industrial leaders. It emphasizes the importance of aligning industrial investment with urban planning, supporting underperforming cities like Novotroitsk and Lipetsk, and leveraging successful ecological and CSR strategies from benchmark cities such as Norilsk and Tobolsk.

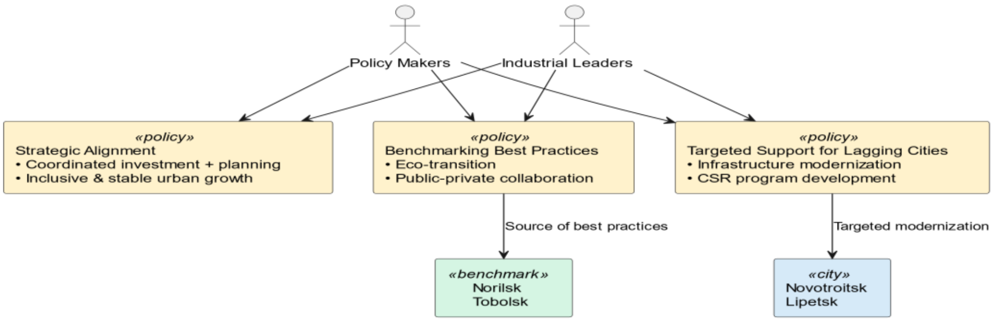

Fig. 2 Policy and Planning Implications for Industrial Urban Development in Russia

Discussion

Regression results show that 78 % of inter-city variation in GRP growth is explained by industrial technological maturity (β = 0.52), corporate social-responsibility activity (β = 0.33), and environmental transformation (β = 0.29), with green investments yielding pollution declines of 20–25 % in cities such as Norilsk and Tobolsk. While data gaps—particularly in CSR reporting—limit precision, the findings

underscore CSR and ecological initiatives as integral drivers of long-term urban competitiveness and call for longitudinal, spatially explicit studies and AI-enabled policy tools to capture dynamic industrial–urban synergies.

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