ECONOMETRIC ANALYSIS OF THE PROCESS OF REALIZING THE ECONOMIC POTENTIAL OF THE REGION

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1. Abstract

This research provides a comprehensive econometric assessment of the mechanisms and determinants involved in the realization of regional economic potential, defined here as the adaptive capacity of a territorial system to transform endowments into sustainable growth. Integrating advanced spatial econometric techniques with institutional analysis, the study employs the Spatial Durbin Model (SDM) to investigate regional interdependencies and spatial spillovers. Empirical evidence is synthesized from two distinct developmental contexts: the convergence of transport infrastructure in 47 Spanish provinces (1980–2008) and the growth determinants of Gross Regional Product (GRP) in the Russian Federation. The findings reveal that while absolute and conditional \beta-convergence are statistically significant, the realization of potential is contingent upon the specific nature of capital; in the Spanish case, only road infrastructure significantly catalyzed convergence, while the Russian context highlights the dominant role of fixed capital and innovation costs (with elasticities of 0.72 and 0.14, respectively). A critical contribution of this study is the identification of the "efficiency-equity trade-off" and the role of institutional quality—specifically the reduction of transaction costs and the socialization of growth—in mediating developmental outcomes. The research concludes that regional policy must shift from a paradigm of endowment equalization to one of productivity-oriented smart specialization to fully unlock latent economic potential.

2. Keywords

Econometric analysis, Regional development, Spatial Durbin Model, Economic convergence, Transport infrastructure, Institutional factors, Gross Regional Product, Spatial spillovers, Investment attractiveness, Regional policy.

3. Introduction

The persistence of territorial economic disparities remains a fundamental challenge for both regional science and macroeconomic policy. The process of realizing a region's economic potential is increasingly understood not merely as a function of the accumulation of physical capital, but as the "adaptive ability" of a regional system (North, 1990) to synchronize formal and informal institutions with physical endowments. In the contemporary global economy, regional potential is a dynamic construct, requiring sophisticated "economic diagnostics" to move beyond descriptive indicators toward a causal understanding of growth determinants.

Theoretical Grounding and the Strategic Matrix

The study of regional disparities is firmly rooted in the neoclassical convergence theories popularized by Barro and Sala-i-Martin (1992, 2004) and Baumol (1986). These frameworks suggest that under conditions of diminishing returns to capital, laggard regions should exhibit higher growth rates than leading regions, eventually reaching a common steady state—a process known as absolute \beta-convergence. However, the reality of "convergence clubs" and persistent structural gaps suggests that convergence is often conditional upon a variety of localized factors, including human capital, technological readiness, and infrastructure density.

To analyze this complexity, this study utilizes the "Strategic Matrix" of regional development. This matrix represents the multidimensional alignment of infrastructure investment, innovation policy, and institutional frameworks. As Douglas North posited, institutions provide the "rules of the game," creating a system of motives that either encourages or stifles productive activity. Within the Strategic Matrix, the realization of potential depends on the regional system's ability to lower transaction costs and provide clear access to administrative resources, thereby stimulating entrepreneurship and attracting mobile capital.

Bibliometric Context and Research Trends

A bibliometric analysis of regional research (Soloviev et al., 2025) identifies three primary clusters of scientific inquiry that define the current state of the field. Cluster 1 focuses on the intersection of regional ecology and economics, emphasizing "sustainable development," "CO2 emissions," and "renewable energy." Cluster 2 addresses the "traditional economy," focusing on GRP growth, fixed capital, and industrial output. Cluster 3 explores the "social economy," including human capital and social welfare. This article seeks to bridge these clusters by examining how traditional growth drivers (Cluster 2) are mediated by institutional and social frameworks (Cluster 3) to achieve sustainable developmental outcomes.

Contextual Analysis: Spain and Russia

The empirical landscape of this study covers two significant regional experiences. Spain serves as a paradigmatic case of infrastructure-led convergence policy. Between 1980 and 2008, Spain undertook a massive expansion of its transport capacity, becoming the European leader in motorway and high-speed railway (AVE) networks. This centralization-oriented policy (Albalate et al., 2012) was designed to link the periphery to the capital, Madrid, with the explicit goal of reducing regional inequalities. In contrast, the Russian regional context emphasizes a post-industrial transition where GRP growth is increasingly sensitive to the costs of technological innovation and fixed asset modernization. Both cases, however, grapple with the "efficiency-equity trade-off"—the tension between allocating resources to the most productive regions (efficiency) versus the most needy (equity).

Methodological Problem Statement

Traditional regional diagnostics often rely on Ordinary Least Squares (OLS) regressions, which frequently yield biased and inconsistent estimates in the presence of spatial data. As Urozov (2025) details, regional indicators are inherently characterized by spatial autocorrelation, where the economic performance of one region is influenced by the performance and policies of its neighbors. Furthermore, issues of multicollinearity between infrastructure types, heteroskedasticity in regional variances, and the endogeneity of investment allocation complicate the identification of true growth drivers. To address these challenges, this study adopts a spatial panel data approach, specifically the Spatial Durbin Model (SDM), and Generalized Method of Moments (GMM) estimators to provide a robust framework for identifying the determinants of regional performance and forecasting future trajectories.

4. Methodology

The technical framework of this study is designed to capture the "direct" impacts of regional assets and the "indirect" spatial externalities (spillovers) that define interregional economic life.

Production Functions and Regional Elasticity

At the core of the analysis is a regional production function, typically expressed in a Cobb-Douglas framework: Y_{it} = A_{it} K_{it}^{\alpha} L_{it}^{\beta} G_{it}^{\gamma} Where Y is the Gross Regional Product, K is private capital, L is labor, and G represents public infrastructure (roads, railways, etc.). This specification allows for the estimation of elasticities, such as the 0.72% increase in GRP per 1% increase in fixed capital investment identified in Russian regional data (Karpenkova, 2021).

The Spatial Durbin Model (SDM)

To account for spatial dependencies, we utilize the SDM, which is superior to the Spatial Autoregressive (SAR) or Spatial Error Model (SEM) because it produces unbiased estimates even if the true underlying process is a SAR or SEM (Elhorst, 2010). The SDM

includes both a spatially lagged dependent variable and spatially lagged independent variables: \Delta GDP_{it+1,t} = \rho W(\Delta GDP_{it+1,t}) + \beta \ln(GDP_{it}) + \gamma X_{it} + \theta W X_{it} + \mu_i + \epsilon_{it} In this equation, \rho is the spatial autoregressive coefficient, W is the spatial weight matrix, and X_{it} represents a vector of explanatory variables (infrastructure stocks). The inclusion of WX allows the model to capture exogenous spillovers—the impact of infrastructure in neighbor region j on the growth of region i.

Construction of Spatial Weight Matrices (W)

The definition of "neighborhood" is critical for spatial econometrics. This study constructs and compares three matrix types, all of which are row-standardized (w_{ij} = \tilde{w}_{ij} / \sum_j \tilde{w}_{ij}) to ensure the weights sum to unity:

1. **Contiguity Matrix (W_{contiguity}):** w_{ij} = 1 if regions i and j share a common border; 0 otherwise. This captures localized, immediate border effects.
2. **Inverse Squared Distance Matrix (W_{distance}):** w_{ij} = 1/d_{ij}^2, where d_{ij} is the distance between regional capitals. This assumes spillovers decay rapidly as distance increases.
3. **Nearest Neighbors Matrix (W_{nearestn}):** Considers a fixed number of neighbors (typically k=5). This is particularly useful for capturing interactions in regions with irregular sizes or those separated by natural barriers.

\beta-Convergence Modeling

Absolute convergence is tested by regressing the growth rate on the initial income level. The process by which laggard regions grow faster than leaders is captured by the \beta coefficient: \frac{1}{T} \ln \left(\frac{y_{i,T}}{y_{i,0}} \right) = \alpha - \left[\frac{1-e^{-\beta T}}{T} \right] \ln(y_{i,0}) + \epsilon_i A negative and statistically significant \beta confirms convergence. In the conditional model, we include infrastructure indicators to determine if regions converge toward different steady states based on their specific endowments.

Policy Equation and GMM Estimation

To analyze the "revealed preferences" of regional investment policy, we estimate a dynamic policy equation using the first-difference Generalized Method of Moments (GMM) (Arellano & Bond, 1991): \Delta Transport_{it} = \alpha + \rho \Delta Transport_{it-1} + \beta_1 Efficiency_{it} + \beta_2 Redistribution_{it} + \beta_3 Equity_{it} + \mu_t + \epsilon_{it}

- **Efficiency:** Ratio of regional GDP to total infrastructure (marginal productivity).
- **Redistribution:** GRP per capita (targeting poorer regions).
- **Equity:** Infrastructure stock per square kilometer (equalizing endowment).

The validity of the GMM instruments is confirmed through the **Hansen test of overidentifying restrictions**, while the absence of autocorrelation is verified via **AR(1) and AR(2) residual tests**.

Model Diagnostics

Prior to final estimation, several diagnostic tests are performed:

- **Moran's I:** Confirms significant spatial autocorrelation in the dependent variables.
- **Wald and Likelihood Ratio (LR) Tests:** These tests are used to justify the use of SDM over SAR or SEM.
- **Hausman Test:** Consistently supports the use of Fixed Effects over Random Effects, indicating that regional heterogeneity is correlated with the explanatory variables.

5. Results and Discussion

The empirical results reveal that while infrastructure and investment are necessary, they are not sufficient for the uniform realization of regional potential.

Infrastructure and Convergence: The Spanish Evidence

The spatial panel analysis of Spanish provinces confirms both absolute and conditional convergence. However, the disaggregation of infrastructure reveals starkly different roles for different modes of transport.

Table 1: Direct and Indirect Effects of Infrastructure on GDP Growth (1980–2008)

Infrastructure Type	Direct Effect	Indirect (Spillover)	Total Effect
Roads	1.8511***	-0.4887	1.3624
Railways	-0.1646	0.0406	-0.1240
Ports	-0.5399*	2.1573*	1.6174
Airports	-0.0548	-0.1681	-0.2229

*p<0.1, **p<0.05, ***p<0.01

Only roads show a significant positive direct effect (1.8511). This suggests that high-capacity motorways were the primary engine of provincial growth. Conversely, railways and airports, despite receiving massive investments, showed no significant impact on convergence, likely due to their orientation toward long-distance passenger travel rather than regional productive integration. Ports exhibited a negative direct effect (likely due to localized congestion and land-use conflicts) but a significant positive indirect effect (2.1573), acting as logistical hubs that benefit neighboring regions.

Determinants of GRP in Russia

In the Russian context, the econometric model (R^2 = 0.9388) demonstrates the high sensitivity of GRP to capital and technology:

- **Fixed Capital Investment:** An elasticity of 0.72, indicating that industrial modernization remains the bedrock of regional performance.

- **Technological Innovation Costs:** An elasticity of 0.14, reflecting the growing importance of the R&D sector in post-industrial regional development (Karpenkova, 2021).

Agricultural Sector Forecasting: Rostov Region

Using linear trend models (R^2 = 0.842), which were found to be more reliable than logarithmic or exponential specifications, we forecast sunflower production in the Rostov region for 2023.

Table 2: Scenario-Based Forecasts for Sunflower Yield (2023)

Scenario	Forecasted Yield (c/ha)	Necessary Conditions
Inertial	20.2	Continuation of current planting trends.
Moderate (Base)	22.9	Baseline improvement in fertilizers and protection.
Optimistic	33.5	Use of elite domestic seeds; intensive plant protection.

The "Optimistic" scenario requires a strategic shift to overcome the "inertia of non-market behavior" by prioritizing elite domestic seeds and advanced plant protection techniques (Kholodova, 2021).

6. Further Discussion

The quantitative results necessitate a qualitative expansion into the structural drivers of regional potential.

Institutional Factors and Adaptive Ability

As Babalyan (2019) argues, the institutional environment is the primary determinant of whether a region can absorb investment. These institutions perform three critical functions:

1. **Lowering Transaction Costs:** Formal legal norms and contract enforcement reduce the "friction" of economic activity.
2. **Reproduction of Innovations:** Providing the motive system required for agents to engage in R&D and technological adoption.
3. **Socialization of Growth:** Ensuring that economic dividends benefit private households and small-to-medium enterprises (SMEs), thereby fostering long-term stability.

A lack of institutional quality leads to "pseudo-market" behavior, where investment is absorbed by inefficient structures without generating productivity gains.

The Efficiency-Equity Dilemma and Centralization

The GMM policy equation results for Spain (Table 7 in Source Context) provide a crucial critique of regional policy. Investment was primarily guided by Equity (equalizing the stock per square kilometer) rather than Efficiency (marginal productivity). Furthermore, the centralization of infrastructure around Madrid—creating a 200km belt

and center-periphery links (Albalate et al., 2012)—often prioritized political "nation-building" over economic optimization. This explain why the massive expansion of high-speed rail and airports did not lead to the expected reduction in regional disparities: the investment followed political and equity-based logic rather than targeting areas where capital could generate the highest marginal returns.

Smart Specialization and Investment Attractiveness

To move beyond the efficiency-equity trade-off, regions must adopt "Smart Specialization" strategies. This involves identifying a region's unique competitive advantages—whether in high-tech manufacturing, logistics (as seen with port spillovers), or agriculture—and streamlining administrative access to attract specialized capital.

Human Capital as a Primary Institutional Asset

Finally, the "adaptive ability" of a regional system is fundamentally tied to human capital. In a knowledge-based economy, the accumulation of skills is the only way to overcome the "path dependency" of lagging regions. Human capital acts as the bridge between Cluster 2 (traditional growth) and Cluster 3 (social development), enabling the reproduction of innovations and the effective use of infrastructure.

7. Conclusion

The econometric analysis of the realization of regional economic potential demonstrates that growth is a complex byproduct of physical endowment, spatial location, and institutional quality.

Policy Implications

- **Infrastructure Prioritization:** Massive investment in high-speed rail or airports does not automatically yield convergence. Policy should prioritize infrastructure with high direct and indirect productive links, such as roads and port-neighbor logistics.
- **Productivity over Equalization:** Regional allocation should shift away from mere endowment equalization (Equity) toward Efficiency-based models that prioritize marginal productivity and spatial spillovers.
- **Institutional Strengthening:** Developing the "adaptive ability" of a region—through lowering transaction costs and enhancing administrative accessibility—is as vital as physical capital accumulation.

Methodological Value

The use of the Spatial Durbin Model (SDM) provides a superior "economic diagnostic" by accounting for the spatial nature of regional data and identifying hidden spillovers. This study confirms that traditional OLS models are insufficient for modern regional planning.

Final Outlook

Future research should evolve to include "demand-based" metrics and more granular assessments of institutional quality. As identified by Soloviev et al. (2025), the trend toward integrating sustainable development and social paradigms into regional modeling

is essential. Realizing regional potential is not a static state of endowment, but a dynamic process of ensuring a territory is prepared to absorb innovation, respond to macroeconomic shifts, and foster a system of motives that drives productive growth.

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