INTRODUCTION

The economic development of a region is determined by its internal resources and opportunities for interaction with other territories. In addition to cooperative and trade relations, the channels of interregional influences include population migration, technology and innovation transfer, diffusion of knowledge and information, and institutional and social relations. The patterns of direct and indirect interregional relations help the region receive impulses from processes that originate and develop in a neighboring territory [1]. The result of this influence is not necessarily positive. For example, the location of new production facilities and implementation of large infrastructural projects can enhance the competitive position of one territory and have an adverse effect on the attractiveness and prospects of economic growth of the neighboring regions. On the other hand, the expansion of demand in a geographically proximate growing economy can have a positive effect on the economy of a given region, and advanced technological solutions and innovations adapted to a similar institutional environment can be used in other regions, which is an additional incentive for their development [2].

The intensity of interactions between neighboring regions is determined by the degree of integration of the country’s economic space, which depends on the general economic activity in the country, maturity and reliability of communication systems, and interregional physical and institutional barriers that constrain the mobility of production factors and output [3].

Relations between even the most geographically proximate regions of Russia are hampered by large distances between the centers of economic activity, which are separated by unpopulated or low-populated areas. Interregional relations are also impeded by the low-quality outdated transport infrastructure. This is why there are doubts that, in Russia, the economic activity of neighboring territories can be considered a development factor for a given region, when this activity has nothing to do with specialization-based cooperation. This skepticism is strengthened by numerous examples of keen competition between neighboring regions for the location and implementation of national and international projects.

This paper estimates the effects of Russian regions on one another. For this purpose, we propose to carry out an empirical test of the theoretical model of spatial technology diffusion originally proposed by E. Lopez-Bazo, E. Vaya, and M. Artis in [4] and developed by E. Vaya, E. Lopez-Bazo, R. Moreno, and J. Surinach in [5].

Economic growth is channeled between regions by various mechanisms and factors. However, not all effects can be traced explicitly. Therefore, it makes sense to estimate the cross-effects of regions through their investment activity, which accumulates all the contradictory influences. The indicator of regional investment activity is the capital stock shown by per capita fixed assets. An increase in investment activity in a region results in the growth of demand for workforce and goods that may be produced outside the region. Therefore, capital investments not only boost production within the region but also affect other territories.

The underlying model in the above works is the Solow–Swan model of economic growth for an individual regional economy:

\[ y_i = A_i k_i^{\alpha} \]  

where \( y_i \) is the income per capita in the region \( i \) and is a function of the capital stock per capita \( k_i \) and the
level of technologies $A$. The function $y_i$ has a diminishing return on the capital stock per capita if $\alpha < 1$.

Provided that other territories have no effect on the region, the level of technologies in this region $i$ depends on the capital stock:

$$A_i = \Delta k_i^\delta,$$

where $\Delta$ is an exogenous variable kept constant for simplicity; $\delta$ is the parameter describing the effect of the capital stock per capita in the region on the level of technologies.

The influence of other territories is incorporated into the model on the basis of the assumption that the level of technologies in region $i$ is also affected by the capital stock per capita in the neighboring regions $k_{pi}$:

$$A_i = \Delta k_i^\delta k_{pi}^\gamma,$$

where $pi$ is the set of neighbors of region $i$, $k_{pi}$ is the capital stock per capita of the neighboring regions, and $\gamma$ is the return on capital investments made by the neighbors of region $i$. This value determines the effect of $k_{pi}$ on the level of technologies in region $i$ and, hence, the production output in this region. It would be realistic to assume that $\gamma$ is positive. This means that a 1% growth of $k_{pi}$ would induce an increase in the level of technologies in region $i$ by $\gamma$ percent. It is assumed that the region can capitalize on the neighbors’ investments due to the spatial diffusion of technological innovations.

The substitution of formula (3) in (1) gives an expression for the output per capita in region $i$:

$$y_i = \Delta k_i^\delta k_{pi}^\gamma,$$

where the value $\tau$, equals to ($\alpha + \delta$), shows the total return of the capital stock per capita in the region $i$.

Thus, all other factors being equal, if the region’s capital stock per capita in the neighboring regions grows by 1%, provided that the value $k_i$ is unchanged, then the output in the given region will grow by $\gamma$ percent. The reason is that the neighbors’ investments make the capital in this region more productive. If the capital stock increases in region $i$ and neighboring regions simultaneously, the spillover effect will increase the total return on fixed investments in region $i$ to $(\tau + \gamma)$.

The growth rate of $k_i$ is

$$\frac{k_i^\delta}{k_i} = s\Delta k_i^{-(1-\gamma)}k_{pi}^\gamma (d + n),$$

where $s$ is the rate of capital accumulation (can be considered constant for simplicity’s sake), $d$ is the rate of capital retirement (depreciation rate), and $n$ is the rate of population growth.

Thus, $(d + n)$ is an effective depreciation rate; it shows the increment of capital that not only covers the capital replacement costs but also provides capital for additional workers.

The rate of growth of capital in region $i$ is a decreasing function of the capital stock per capita in the region if $\tau < 1$ and an increasing function of the capital stock per capita in the neighboring regions ($k_{pi}$) if $\gamma > 0$. In this case, the higher $k_{pi}$, the greater the capital investments in the region. The external effects for this region will increase the return on its own fixed investments, pushing up incentives for capital accumulation.

In an equilibrium state, the region makes investments only to retain a simple reproduction of capital; i.e., the increase in the capital stock per capita and the rate of economic growth are zero. Then, $k_i$—the capital–labor ratio in region $i$—can be expressed through the capital–labor ratios in the neighboring regions as follows:

$$k_i^* = \left(\frac{s\Delta}{(n + d)}\right)^{\frac{1}{1-\tau}}.$$

Substituting expression (6) into the production function gives the equilibrium characteristics for region $i$ in terms of productivity:

$$y_i^* = \Delta \left(\frac{s}{(n + d)}\right)^{\tau} (k_{pi})^{\frac{\gamma}{1-\tau}}.$$

Thus, the equilibrium for region $i$ is determined not only by the region-specific parameters—the effective depreciation rate $(d + n)$, propensity to save $s$, and parameter $\Delta$—but also by the return on capital investments $\gamma$ and the capital stock per capita in the neighboring regions $k_{pi}$. In the assumption that $\tau < 1$ and $\gamma > 0$, the higher the capital–labor ratios in the neighboring regions, the higher the capital–labor ratio and income per capita in the equilibrium state of region $i$. The same result is achieved by increasing the return on capital investments in the neighboring regions.

If we assume that the equilibrium capital–labor ratios in the region and its neighbors are the same ($k_i^* = k_{pi}^* = k^*$), then the expressions for the equilibrium capital–labor ratio and income per capita have the form

$$k^* = \left(\frac{s\Delta}{(n + d)}\right)^{\frac{1}{1-(\tau + \gamma)}},$$

$$y^* = \Delta \left(\frac{s}{(n + d)}\right)^{\tau + \gamma} (k_{pi})^{\frac{\gamma}{1-(\tau + \gamma)}}.$$

Note that the last assumption is rather strong. In the more realistic assumption that the external effects generated by the neighboring territories diminish with