Barometr Regionalny
Rok 2024 Tom 20 nr 1

Model of a Regional Value-Creation System under the Impact of Structural Funds for Evaluation Purposes

Elżbieta Wojnicka-Sycz
Fahrenheit Universities: University of Gdańsk and Gdańsk University of Technology, Poland

Submitted: November 2, 2023
Accepted: January 2, 2024

Abstract

Institutions managing European Funds are obliged by the European Commission to evaluate them. In the article, a micro-macroeconomic model of the regional value-creation system with the impact of structural funds is proposed. Besides the traditional variables of supply and demand in the economy, the model also embraces variables reflecting natural environment protection as well as research and development and innovation. The model may be used as a theoretical framework for evaluation with the usage of quantitative and qualitative methods. The model is based on a systems approach that emphasizes interdependencies and causal loops rather than unidirectional causal relationships. An application of the model for the evaluation of the impact of European Funds on Polish counties is presented, showing the positive impact of the funds of the 2014-2020 programming period on an income proxy and knowledge-based entrepreneurship.

Keywords: evaluation, micro-macroeconomic models, European structural funds, regional system, Poland

DOI: 10.56583/br.2313

Introduction

Since joining the European Union in 2004, Poland has been one of the main recipients of the European Union funds related to the cohesion policy, the so-called Structural Funds (SFs). For the years 2021–2027, it will be EUR 76 billion, or about EUR 2,000 per capita. Hence, the proper usage of these funds in Poland is particularly important. The authorities in charge of the Structural Funds programs are required to implement the European evaluation standards at both the regional and national levels (Baslé 2006).

The primary objective of the evaluation is to gather data that may be utilized to enhance public European action (Baslé 2006). The evaluation involves collecting evidence to assess individual implementations and to analyze them for any unintended consequences. It also results in the decision to adjust or stop the programs using EU funds (Chłoń-Domińczak et al. 2022).[1]

Resource dependence theory (RDT) explains the need for evaluations imposed by the European Commission (EC) on member states. According to RDT, actors engage in wealth-maximizing strategies within an interorganizational context to ensure the long-term survival of their organizations. Interorganizational coordination is the only way to create common wealth. Moreover, only effective distribution of common wealth will guarantee political support to ensure the survival of

1. See also: "Better Regulation Guidelines." Commission Staff Working Document, Brussels, 3.11.2021, SWD (2021) 305 final, available at https://commission.europa.eu/document/download/d0bbd77f-bee5-4ee5-b5c4-6110c7605476_en?filename=swd2021_305_en.pdf&prefLang=pl.

E-mail addresses and ORCID digital identifiers of the authors
Elżbieta Wojnicka-Sycz • e-mail: elzbieta.wojnicka-sycz@ug.edu.pl • ORCID: 0000-0002-0016-5580

an organization. Poor implementation of EU policies constitutes a threat to the commission. To minimize this threat, the EC creates mechanisms to control the domestic usage of European Funds. As an organization, the European Commission wants other actors to implement commonly agreed programs, but it faces the problem of moral hazard. In order for the principal to deal with the moral hazard of asymmetric information about the agent, it is important to enlarge the informational basis. Hence, the EC invests its resources in monitoring and evaluating activities (Bauer 2006).

The process of evaluating the European Structural Funds results in reports on outcomes, processes, or quality, as well as information regarding the effectiveness, efficiency, and impact of the funds. Such monitoring provides information for ongoing outputs and results. A less frequently conducted evaluation consists of assessing policy characteristics according to a specific objective or perspective. Evaluation is usually carried out by entities external to the authorities responsible for the policy (Ostašius and Laukaitis 2015). Evaluation takes the forms of ex-ante, mid-term and ex-post assessments. Ex-ante evaluation assesses whether the indicated priorities will bring the effects assumed in the EU and the national policies of member states (Barca 2006). Mid-term assessments include a critical analysis of the data collected through monitoring activities and allow for corrective actions to the program (Bachtler and Michie 1997). Ex-post evaluation checks whether the assumed indicators have been achieved.

Many objections to the excessive bureaucracy of the EU procedures and excessive evaluations, as well as an unclear division of the funds, have been raised for years (Barca 2006; Dellmuth 2011). However, since it is impossible to manage something that cannot be measured, monitoring and evaluation are the basis for responsible public management. The understanding of the causes of good or bad performance can be ensured through evaluation (Gancarczyk, Ujwary-Gil, and González López 2021). Only when decision-makers are aware of how assessment might affect their actions will the evaluation be effective (Barca 2006).

Since the beginning of the 21st century, the EU strategy has emphasized research and development and innovation (R&D&I), as well as green and inclusive growth (Bongardt and Torres 2010). Hence, EU funds have supported transitions to higher innovation, employment (Bondonio and Greenbaum 2014), or pollution reduction (Włodarski and Martyniuk-Pęczek 2017). Entrepreneurship development is a path both to higher innovation and lower unemployment (Crudu 2019). Corporate innovation is crucial for regional and local development, and it is affected by regional and local conditions (Reidolf and Graffenberger 2019). Accordingly, the SFs supporting corporate innovation also affect the economic cohesion of European countries and regions, which can be measured by the impact on incomes in less developed EU countries, such as Poland.

The structural funds are part of the financial ecosystem of companies in Poland, as they can use these funds to support their innovation, technology transfer and employee training. Grants for start-ups are also present.[2] The differences in the absorption of SFs between local economies also reflect the strength of local financial ecosystems — i.e., the financial services present there and their interconnections with organizations in other sectors eligible to apply for funding (Gancarczyk and Rodil-Marzábal 2022).

Regional socio-economic development is usually well-documented in evaluation reports, although these are often not impact evaluations or program effectiveness studies (Baslé 2006). The evaluation of the impact of the Structural Funds at the micro level is often based on standard cost-benefit and other techniques. Assessing the macroeconomic impact of public spending has been an area of research since the development of quantitative macro models in the 1930s. Since assessing the impact of SFs is difficult due to their structural transformational objective, the models have had to consider measures on the supply side in addition to those on the demand side. It is necessary to examine the impact of SFs taking into account economy-wide feedbacks and interactions, along with spillovers and externalities. This requires formal national or regional economic models (Bradley 2006).

Econometric modeling is used in the Structural Funds evaluations in the form of HERMIN-type multivariate macroeconomic models (Mogiła 2019), but this type of research is expensive and

2. See: European Funds in Poland. Information published by Ministry of Development Funds and Regional Policy on October 15, 2015, available at https://www.funduszeeuropejskie.gov.pl/en/site/learn-more-about-european-funds/discover-how-the-funds-work/european-funds-in-poland/, accessed 2023-04-29.

usually requires a separate contract. However, most of the evaluations are comprehensive procurements in which the contractor is expected to conduct a quantitative study using a survey of the beneficiaries and a control sample, as well as in-depth interviews with the beneficiaries and officials, an analysis of project documentation, and statistical and econometric analyses (Spanache 2018).[3] Evaluation based on micro-level data uses methods such as propensity score matching (Mróz et al. 2023), conditional difference-in-difference models (Bondonio and Greenbaum 2014), and logit regressions (Wojnicka-Sycz and Sycz 2016). One multi-equation evaluation model other than HERMIN is, for example, the regional econometric labor market model for Lombardy (Baussola 2007).

Di Caro and Fratesi (2022) use a two-stage method to estimate the impact of the cohesion policy over the 1990–2015 period for regions in the old EU-15 and the 2000–2015 period for regions in the 10 new member states. They use an autoregressive distributed lag panel model and a dynamic mean group model to estimate the impact of cohesion policy on regional economic performance, which allows them to identify region-specific coefficients of the policy's impact. They find that a 1% increase in EU cohesion policy spending was associated with a significant positive variation in regional GDP of around 0.07% in the old EU-15 regions, while it was around 0.05% in the new member states. In the second stage, they use logit regression to analyze the impact of different regional factors on the effectiveness of the policy. They find that the level of SF expenditure matters for policy effectiveness with decreasing returns. Furthermore, the quality of regional institutions and human capital are the drivers of higher cohesion policy effectiveness.

Another model describing the regional system, which can also be used for evaluation as it includes an SF component, is the regional multi-equation model for MASST (Macroeconomic, Sectoral, Social, Territorial) growth forecasting. The advanced version of MASST consists of a regional and a national component. The national component reflects macroeconomic and international economic variables. The regional component takes into account the territorial capital stock (sectoral employment and cross-sectoral productivity components, demography, spatial interdependence, growth spillovers, and agglomeration economics), employment growth, population growth, and migration flows (Capello and Fratesi 2012). To forecast the regional structure of economic employment, Masouman and Harvie (2018) use an embedded model that integrates an input-output (IO) framework with regional econometric modeling. The IO analysis reflects the cross-sectoral structure of the economy, while the regional econometric modeling captures dynamic technological change and price effects.

The Spanish experience shows that the future EU cohesion policy should focus on coordination failures that undermine the transformation towards a high-skill-high productivity growth equilibrium (Faiña, Lopez-Rodriguez, and Montes-Solla 2020), which can be achieved through better cooperation in regional innovation systems between different actors of the sextuple helix (firms, science, bridging institutions, administration, societies, and environment). The problems related to evaluation stem from the complexity of policies, as well as the lack of consideration of cause-and-effect loops rather than linear cause-and-effect relationships. The impact of these relationships is often overemphasized, and there are many other interdependent factors (Spanache 2018) that need to be taken into account (Baslé 2006). Huber (2006) states that in order to improve evaluation methods, it is important to use creative trial and error as well as benchmarking.

This paper proposes a model of the regional value creation system under the influence of the Structural Funds for evaluation purposes. The model reflects the challenges of the paradigm of sustainable innovative development based on the integration of social and economic spheres and environmental and spatial dimensions. It also addresses the challenges of the evaluation process of the impact of European Funds on the regional economy and proposes a framework of complex systemic linkages that could be explored during the evaluation using both quantitative and qualitative methods. An exemplary application of the model for the evaluation of the impact of the SFs of the 2014–2020 programming period at the level of Polish counties has been presented.

3. See also: "Ocena wpływu Programu Operacyjnego Innowacyjna Gospodarka na zwiększenie innowacyjności przedsiębiorstw" [Assessment of the impact of the Innovative Economy Operational Program on increasing the innovativeness of enterprises]. Report by Tomasz Klimczak et al. (WYG PSDB Sp. z o. o.), Departament Konkurencyjności i Innowacyjności. Ministerstwo Infrastruktury i Rozwoju, Warszawa, 2015, available at https://www.poir.gov.pl/media/11383/Raport_Koncowy_inowacyjnosc_POIG_grudzien_2014.zip.

1 The proposition of a micro-macroeconomic model of the regional system

The micro-macroeconomic model of the regional value creation system is the proposed theoretical framework for evaluating the impact of the Structural Funds (Figure 1). From an economic point of view, a region is a defined area with its own economy, formed on the basis of available internal and external economic resources and factors influencing its development, such as capital, labor, technologies, information, etc. (Ginevičius and Podvezko 2009). This concept is the theoretical basis for relationships that can be estimated through econometric modeling and qualitative research. The model is based on a systems approach, which means that dependencies are interdependencies and not cause-and-effect relationships. Cause-and-effect relationships can only occur in time, such as earlier changes in the factors included in the model and later outcomes. Baslé (2006) raised the objection that the traditional causal logic diagram of interventions does not take into account complex relationships. However, it can be stated that co-financing projects from the Structural Funds, as an exogenous factor, can be a determinant that changes the parameters reflecting the economic processes included in the proposed model.

The model of the regional value creation system is based on the bottom-up approach. It reflects the philosophy of value creation in organizations according to Porter's Diamond (1990) — i.e., competitiveness resulting from the environment (clusters), the model of the territorial growth pole (Wojnicka-Sycz 2013), and the macroeconomic theory of J.M. Keynes (1936), based on the calculation of Gross Domestic Product (GDP) and multiplier effects. It also takes into account the evidence from spatial economics on the importance of agglomerations and externalities for economic growth (de Groot, Poot, and Smit 2008), the key importance of innovation and productivity for economic growth — neoclassical and new growth theory as represented by Solow (1988), Romer (1990), and Freeman (1994) — theories of regional development (the importance of sectoral and territorial growth poles), theories based on innovation and knowledge diffusion, and the concept of eco-development (Capello and Nijkamp 2009; Hirschman 1958; Perroux 1950). This model also considers the importance of political, economic, social, technological, environmental and legal conditions originating from the domains included in the PESTEL analysis (Çitilci and Akbalık 2020). Therefore, this model takes into account the indications of theories that deal with the micro and meso levels: region/territory and industries, as well as macro and international dimensions, such as the theory of European integration and international economics.

The following supply-side subsystems were distinguished in the model: 1. the subsystem for production factors and development conditions; 2. the subsystem for processing and delivering goods and services (supply); 3. the subsystem of effects, which reflects the demand side of the economy and is influenced by national and international conditions. The regional value creation system operates within value-added cycles. Between individual subsystems there are flows and feedbacks (i.e., interdependencies).

The effectiveness of the regional system of value creation is reflected in such result variables as GDP growth, employment, the state of public finances, social, spatial and economic regional cohesion (the coefficient of the variation between territories in terms of labor market variables, the incomes of communes and citizens, transport infrastructure, etc.), and sustainable development, which will manifest itself, for example, in increased life expectancy in a region.

The Structural Funds measured by the total value of projects supported by them, that is, together with additional national funds (Bradley 2006), affect the development factors and conditions used by the regional subsystem for processing and delivering goods and services from the regional, national and international environment. The Structural Funds also affect the organization of the processing and delivering subsystem that produces effects for the environment — i.e., value added, which in turn determines the demand and distribution of income, as well as value creation in the next cycle. It also affects outcome variables such as unemployment, coherence/diversity, life expectancy, and the state of the natural environment. The structure of support from the Structural Funds will determine the strength of their impact on individual elements of the system, and thus their effects will be different.

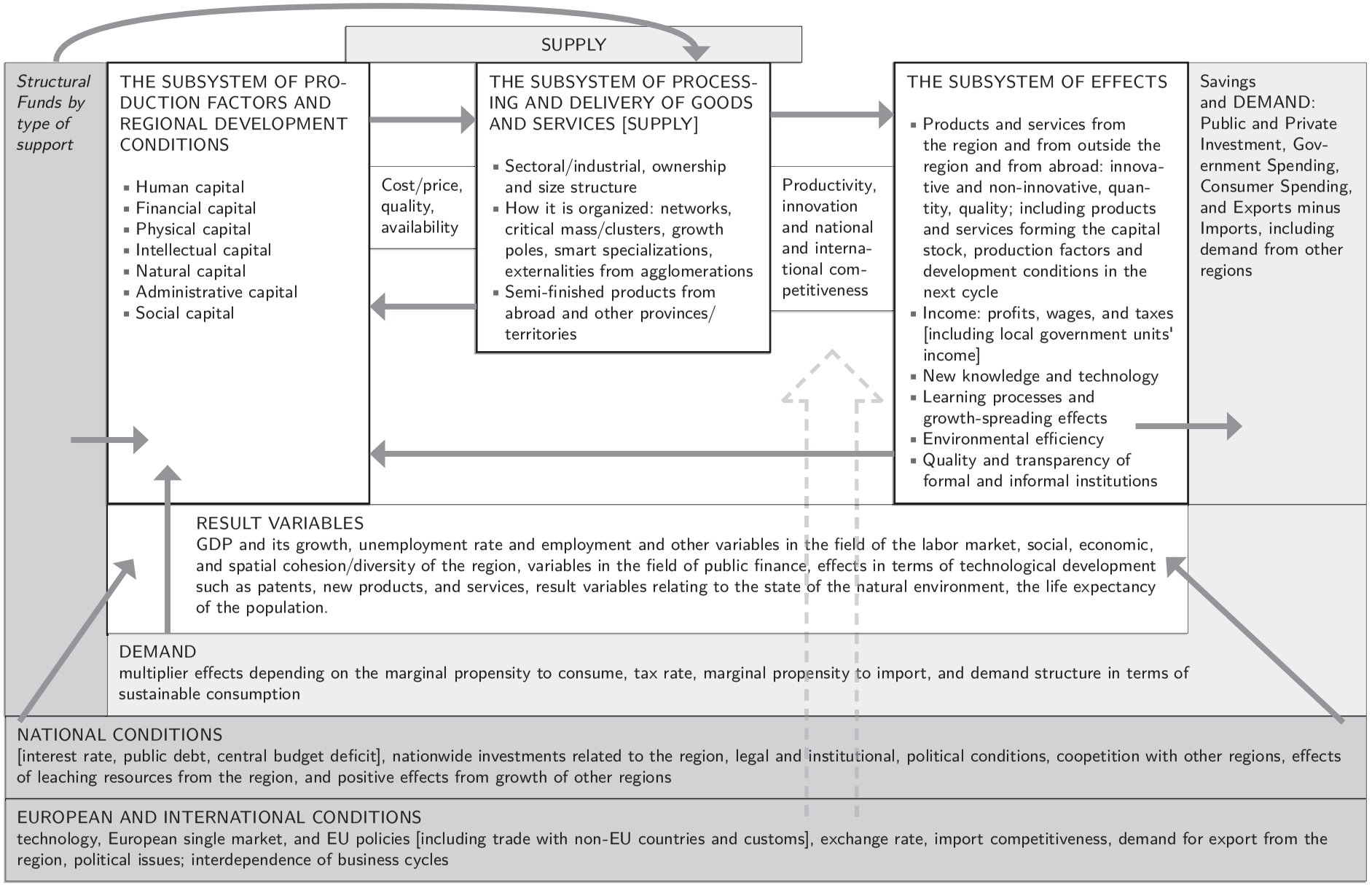

Figure 1. Model of the regional value-creation system with the influence of the Structural Funds

This model shows the process of value creation in a regional system with feedback. The Structural Funds influence the factors of regional development, such as production factors and other conditions that determine the creation of value added through transformative processes carried out in the production and service sectors under given regional, national, European and international conditions.

In the resource part of the regional value creation system it is possible to distinguish capitals reflecting groups of development factors indicated in the macro-, meso- and microeconomic geographical, social and management theories (Wojnicka-Sycz 2013). They determine qualitative development, measured, for example, by life expectancy, and quantitative income growth, measured by GDP. Economic growth, in turn, affects, for example, the situation on the labor market and the creation of better infrastructure, which is conducive to qualitative development. The proposed development capitals are human, financial, physical, intellectual, social, natural, and administrative.

Human capital includes skilled and unskilled labor, the labor market, the education system, domestic and foreign migration, education in the field of sustainable development, and public health. Financial capital consists of financial institutions, financial resources of people and companies, and foreign funds: foreign investments, funds from exports and the Structural Funds that can be used by regional actors. Physical capital includes transportation and communication infrastructure, environmental protection devices, machinery and technology, as well as housing and general construction. Intellectual capital refers to technology, knowledge infrastructure, pro-innovation infrastructure, diffusion of knowledge, creative entrepreneurship, R&D activity, cooperation in the innovation process, innovation systems, and technological awareness. Natural capital reflects the state of the natural environment, natural resources, geographical location, demographic structure, and population growth. Administrative capital refers to the quality and transparency of the work of public institutions as well as administrative cooperation. Social capital consists of resources such as the willingness to cooperate, cooperation networks, and social organizations.

From the point of view of the processing and delivering subsystem, what is important is the availability and prices of production factors, as well as their quality, which increases the innovativeness of enterprises. Equally important are the external effects generated in a region by territorial and industrial growth centers. External benefits may result from the agglomeration of people and economic entities in a territorial growth pole, which may be a metropolitan area, and the diffusion of growth from this area to the rest of the region. External effects can also be negative, the most common one being pollution (Petrakos 1992). The Structural Funds can help to internalize these costs, for example by expanding the use of renewable energy and energy-saving methods or technologies that reduce air pollution.

The external determinants of the resource subsystem of a given region include national or European policies or external migration into the region. The negative effects of leakage from the region should also be considered. They can sometimes be a side effect of strengthening the region's transportation links (de Blasio, Poy, and Ciani 2020; Persyn et al. 2023). The sensitivity of the region to changes in the global economy will depend, among other things, on the level of international linkages of regional actors.

The Structural Funds affect individual elements of the resource part of the economy, and their impact on various outcome variables will depend on the structure of the support. They will also have a direct impact on the processing and delivering subsystem represented by a specific regional industrial structure. These funds often stimulate the development of high technology industries or areas strongly related to science, such as regional smart specializations. SFs also aim to restructure agriculture and fisheries or to support small and medium-sized enterprise sectors, thereby ensuring competition. They thus support the structural transformation of the regional processing and supply subsystem. Their aim should be to increase the productivity, innovation, and international competitiveness of regional actors, which in turn will determine economic growth and improve the quality of life. In addition, the indirect impact of the funds on the processing and delivering subsystem will result from their impact on the quality of the resource side of the economy through activities such as training. The processing and delivering subsystem will also depend on the prices and quality of semi-finished products from abroad and from other regions of the country.

The Structural Funds also support networking in the form of industrial clusters (Žižka and Pelloneová 2019) or intersectoral connections between business, science, administration and society that stimulate knowledge diffusion. The structure of the subsystem for processing and delivering goods and services based on clusters and smart specialization should promote higher productivity and regional GDP growth, and, based on the assumption of innovation, satisfy new or hitherto unsatisfied needs of the residents, thus improving the quality of life. At the same time, innovation allows us to overcome the barrier of lack of resources, because it means an additional resource of knowledge and technology. It also makes it possible to shift the production possibilities frontier of the economy outwards, even with a limited amount of land, natural resources or labor. Innovations also shift the aggregate supply curve to the right (Goodwin, Harris, and Nelson 2019). Technology and knowledge, along with the innovations that result from them, develop this potential and constitute factors of production that tend to grow as they are shared and thus increase thanks to their diffusion in the innovation system. Innovations also make it possible to achieve the same level of production with less input from classical factors of production. A large part of the Structural Funds is allocated to the development of innovation potential through research infrastructure, research and innovation grants or technology transfer embodied in machines and equipment.

The regional processing and supply subsystem consists of both domestic and foreign companies. They purchase semi-finished products and raw materials, partly from other regions and partly from abroad, and receive income from sales to external entities. In addition, they may acquire financial capital and workers from abroad. The international interdependence of business cycles and the impact of national macroeconomic policies will take place through the macroeconomic environment. In addition, the subsystem for processing and delivering goods and services is influenced by the legal and political environment as well as demographic, socio-cultural and technological trends in the country and the world. These trends determine both the resource and demand sides of the model. For example, the demand for a particular type of product or service may be driven by fashion or demographics.

In the analysis of the subsystem for processing and delivering goods and services in a voivodship 5 sectors can be distinguished, such as industry, construction, market services, non-market services, and agriculture and fisheries. The level of their internationalization can be assessed through the prism of the intensity of foreign investments or export-import relations, which also influences the sensitivity of the region to international shocks. The analysis of the changes in the GDP of the region in comparison with the national trends will also make it possible to capture the region's sensitivity to disturbances in the previous period, which can be extrapolated to future crisis risks.

The economic effect resulting from the processing of production factors by regional enterprises is the value added generated by the sale of the products and services provided by them. The products distributed in the regional system may come from the country and from abroad. At the same time, they can be used for the development of regional resource potential for the next cycle of value creation. The activity of regional agents will also result in income: the profits of capital owners and enterprises, including those from outside the region, employees' salaries, and taxes, such as the income of local government units and the central budget. There will also be new knowledge and technology along with growth spillovers from their diffusion. An additional effect of SFs will be the internalization of external costs by regional agents due to the implementation of environmentally friendly technologies.

These effects are also transferred to the extra-regional system in the form of profits, wages of migrants and extra-regional suppliers, the diffusion of new knowledge in the form of innovative products, or taxes paid to the central budget.

At the same time, these effects determine demand and capital accumulation as well as demand itself: its size and structure determine the directions of business investment as well as prices and demand for resources and other development factors in the region. This demand will also be the demand from outside the regional system, and its size and structure will depend on international and national conditions.

Macroeconomic conditions depend on taxes, public debt, interest rates, exchange rates, cost inflation or deflation, the growth rate of major trading partners and the EU as a whole, etc.

The socio-cultural trends that determine the direction of regional/local development include the aging population, McDonaldization, the healthy food trend, the promotion of the circular economy, responsible innovation, the trend towards a better work-life balance, and anti-consumerism. Regional development is also affected by political and regulatory factors. These include issues such as changes in legislation that stimulate the development of specific industries, for example those related to ecology, labor law, the threat of international conflict, etc. The environmental conditions relate to sustainable consumption patterns, circular economy, eco-innovation, etc. As for the external technological determinants for regional and local actors, these are digital innovations and the dematerialization of consumption, for example through the purchase of virtual products, including those affecting the relative competitiveness of regional industries, etc.

Demand is also corporate and public investment in the next value-added cycle, which is determined, among other things, by the interest rate as well as the level of savings available in the regional system. Demand is also consumption, which results from the utility of consumption of certain goods by a society with given preferences and budget constraints. Demand is also external demand for regional goods and services. The analysis should also consider the multiplier effects of investment, conditioned by the marginal propensity to consume, the tax rate, and the marginal propensity to import. This demand will determine the structure and intensity of value added in the next cycle, the necessary factors of production, and other general and specific conditions. As for the positive effects in terms of value creation in the regional system, they include economic growth, an increase in employment, and a good state of public finances. With well-functioning channels of diffusion of knowledge and growth, these effects should lead to a higher economic, social and spatial cohesion of a region. It should be noted, however, that the relationship between economic growth and cohesion is not linear. To some extent, inequalities can stimulate economic growth in the region as a whole by concentrating economic activity and increasing competition and by reaching a critical mass for development. Beyond a certain level, however, inequalities become an obstacle and are associated with pathologies, so their elimination will accelerate economic growth (Barro 1999).

In addition, more effective value creation should also shift the economy of a region towards value creation based more on innovation and R&D. Thus, in the next period, the effects of the R&D and innovation process, such as patents obtained or new products, are expected to increase. Innovations will reflect better resources and transformative capacity of the regional system. Among the positive effects of a well-functioning regional system for value creation will also be a cleaner natural environment, with less energy consumption and less environmental pollution.

2 Application of the model

The data on the Structural Funds in Poland in a given territorial unit, specified by means of axes, measures and sub-measures of operational programs and categories of assistance (such as research, development and innovation, road infrastructure, etc.) was sourced from reports prepared by the institution managing operational programs on the basis of IT systems collecting data on individual projects. For the 2014–2020 Structural Funds programming period, this was the SL 2014 system.

When modeling the impact of the funds on individual variables, any of the relationships indicated in the regional value-creating model could be used, assuming a time lag of supply effects in relation to the implementation of projects supported by the Structural Funds, but with a faster emergence of income effects on the side of entities from the subsystems of production and processing factors associated with the implementation of the projects in question. The model could be used to complement the existing multi-equation models, for example by taking into account the importance of innovation for development, a multifaceted approach to development factors, or the inclusion of environmental issues and an economy based on business and innovation ecosystems, exemplified by clusters and smart specialization. At the same time, it would require the work of a larger team of researchers to develop a multi-equation model based on the proposed model. Thus, due to its theoretical nature, it can also provide a rationale for single-equation models aimed at testing the importance of Structural Funds of a given type for specific effects (e.g., on innovation) or the influence of total funds on income or GDP with control variables reflecting factor and processing subsystems.

Data on variables reflecting the various elements of the model can be obtained from central statistical offices, Eurostat, or other available sources. In the case of statistical data, the level of detail will depend on the level of the analysis—most data will concern states and provinces rather than counties. The individual variables included in development capitals can be considered separately or in the form of synthetic indices. For example, to reflect intellectual capital at the level of provinces, one can use data from the Regional Innovation Scoreboard[4] referring to the resource part, such as outlays on R&D&I, employment in knowledge-intensive services, employment in innovative enterprises, and cooperation in innovation processes. At the level of counties these can be notifications of inventions at the Patent Office of the Republic of Poland or the share of the creative sector in new entities.

The subsystem for processing and delivering goods and services can be reflected through the structure of enterprises, such as the number of entities registered per persons of working age (entrepreneurship), the number of entities employing more than 49 people compared to the number of residents, the number of active clusters or the rate of employment in industries related to regional smart specializations or their LQ (location quotient), regional imports in high-tech products, and the percentage of innovative enterprises. In terms of the impact on the environment, one can analyze the share of high-tech exports, the share of innovations located in foreign markets, sales of innovative products, the level of environmental pollution, local government tax revenues, and wage dynamics in relation to the national average. In the case of panel models, national conditions changing from year to year can be included, such as the exchange rate, interest rate, etc. Inflation should be considered by expressing the variables in constant prices analyzed in the model.

In addition, the model can be used as a basis for seeking new data, for example, in webscraping or surveys, in which one can ask about the impact of, for example, the Structural Funds on the introduction of environmentally friendly technologies by companies or the increase in employees' skills or wages. In survey questionnaires, such issues would be addressed separately, that is, by asking questions about the use of new environmental technologies and, at the same time, about the implementation (or its lack) of projects supported by the EU. Then, with the help of logit regressions, it is possible to check whether there were greater chances of implementing new technologies in the case of receiving support (Wojnicka-Sycz et al. 2020).

In the case of econometric modeling using panel models for the level of provinces in a country or subregions/counties in these provinces, it will be necessary to estimate the value of projects from the Structural Funds in each year. In order to do this, it is necessary to divide the amounts attributable to projects lasting more than a year by the number of years so as to estimate the annual allocations. Such estimates will be particularly useful for mid-term evaluations when a shorter data series is available. The problem, however, is the smaller number of available statistical data for units of increasingly lower territorial levels.

Below, an application of the model for assessing the impact of the 2014–2020 structural funds in Poland is discussed, based on data for counties. The value of projects co-financed from the Structural Funds has been calculated based on the place of project implementation indicated for a given county. Thus, national or provincial projects are not taken into account. The data on the Structural Funds in Poland was sourced from reports prepared by the institution managing operational programs based on IT systems collecting data on individual projects.[5] The analysis is based on the report of November 30, 2021.

The econometric methods used to assess the impact of the Structural Funds are spatial linear regressions based on cross-sectional data for counties. Such analyses, especially in the case of ex-post evaluation, allow for a comparison of the situation in territorial units before and after the

4. See: Regional innovation scoreboard, Directorate-General for Research and Innovation, available at https://research-and-innovation.ec.europa.eu/statistics/performance-indicators/regional-innovation-scoreboard_en, accessed 2023-12-10.

5. See: Stan wdrażania Funduszy Europejskich w Polsce w latach 2014–2020: lista umów z miejscami realizacji [Status of implementation of European Funds in Poland in 2014–2020: list of contracts with places of implementation]. Information published by Ministry of Funds and Regional Policy, available at https://www.funduszeeuropejskie.gov.pl/, accessed 2023-12-10.

financing as a function of the level of absorption of the Structural Funds. Spatial dependence means that an observation in a given territory may depend on another observation elsewhere. The spatial error model (SEM) assumes a spatially lagged random error. The spatial lag model (SLM) includes a spatially lagged explained variable (Kossowski 2010). Such modeling also makes it possible to assess the impact of the Structural Funds on neighboring areas by estimating spatial regressions using a spatially lagged variable reflecting the Structural Funds (SLX model).

Cross-sectional spatial models for counties were estimated in Gretl using robust standard errors. The models were then tested for spatial dependence and the validity of the use of spatial regression in the GeoDa package. Robust LM tests for spatial dependence indicated the validity of the spatial lag models. The first order queen-type contiguity matrix was used. In addition, SLX models were estimated with a lagged independent variable reflecting the value of projects co-financed from the Structural Funds. To avoid the problem of endogeneity, all control variables reflect the situation in 2014, that is, before the inflow of the Structural Funds associated with the 2014–2020 programming period. As a dependent variable, I used the absolute increase in the value of the variable in 2021 compared to 2014. Two sets of models were estimated. The first one reflects the impact of the value of all projects co-financed from the Structural Funds on the increase in communes' income from personal income tax (PIT) and rural tax per capita. This was calculated after subtracting the additional county share of cities with county rights from communes' and cities' PIT revenues in order to make it comparable with the share of taxes from communes. In addition, the data is for up to 2021, so it does not concern the changes introduced by the reform of the tax system in Poland in 2022. As farmers do not pay PIT, rural tax revenue has also been included. This indicator reflects the share of the income of employees, pensioners, and entrepreneurs in the form of individual business activity. In fact, it is a good indicator of GDP at the local level (Ciołek 2017). The second group of models examines whether the projects co-financed from the Smart Growth Operational Program, aimed at stimulating research, development and innovation (R&D&I), had an impact on the increase in the value of the indicator of knowledge-based entities registered per 1,000 residents. These are units operating in the following sections of the Polish Classification of Economic Activities (PKD): J — information and communication; K — financial and insurance activities; L — real estate activities; M — professional, scientific and technical activities; N — administrative and support service activities. This is one of the scarce variables that may resemble R&D&I activity at the level of counties.

The first group of models assesses the impact of SFs on the subsystem of effects of the regional value creation model — i.e., income, which later determines demand and GDP. The control variables in these models reflect the initial state of the element of the subsystem of production factors: physical capital (the gross value of fixed assets per resident of productive age, with the Polish average being 100, and the 3-year average of the number of new dwellings per 1,000 residents) and the initial state of the processing subsystem (the number of registered companies per 10,000 residents and the number of employees per 1,000 people of productive age). The variable reflecting the value of projects co-financed from the Structural Funds covers the impact of the funds on both the production factor subsystem and the processing subsystem throughout the period 2014–2020. The second set of models examines the impact of the projects co-financed from the Smart Growth Operational Program on the processing subsystem in terms of the increase in the number of knowledge-based firms per 1,000 residents. The control variables reflect the initial state of financial capital (foreign capital in PLN million), physical capital (the gross value of fixed assets per resident of productive age and the 3-year average of the number of new dwellings per 1,000 residents, as well as municipal and county paved roads per 100 km2), and the initial state of the processing subsystem in the form of the number of enterprises registered in sections J-N of the Polish Classification of Economic Activities (PKD) per 1,000 residents.

The spatial lag model is characterized by the highest coefficient of determination and the lowest Akaike criterion in the case of the two independent variables. The 1% increase in the value of projects co-financed from SFs per capita in Polish counties in 2014–2021 coexisted with the 0.037% increase in the growth of real municipal tax revenues from PIT and rural tax (table 1). Thus, doubling the value of projects co-financed from SFs per capita would lead to an increase of 3.7% in the

Table 1. Model of the regional value-creation system with the influence of the Structural Funds

	Dependent variable: Logarithm of absolute increase in communes' incomes from PIT and rural tax per capita in 2014–2021 in 2014 prices		
Independent variables	**Linear regression[a]**	**SLX**	**SLM**
Constant	1.124 (0.48)**	1.159 (0.39)***	−0.480 (0.38)
Logarithm of value of projects co-financed from the Structural Funds in PLN per capita 2014–2021	0.031 (0.01)***	0.033 (0.01)***	0.037 (0.01)***
Spatial lag[b] of logarithm of value of projects co-financed from the Structural Funds in PLN per capita 2014–2021	–	−0.011 (0.02)	–
Logarithm of employed per 1,000 residents of productive age in 2014	0.131 (0.05)***	0.133 (0.04)***	0.132 (0.03)***
Logarithm of registered entities per 10,000 residents in 2014	0.487 (0.05)***	0.493 (0.05)***	0.352 (0.04)***
Logarithm of 3-year average of new dwellings per 1,000 residents in 2014	0.130 (0.02)***	0.130 (0.02)***	0.103 (0.02)***
Logarithm of gross value of fixed assets per resident of productive age, with the 100 Polish average in 2014	0.036 (0.02)**	0.035 (0.02)**	0.026 (0.02)*
Rho (lag of dependent variable)	–	–	0.440 (0.05)***
R-squared	0.600	0.600	0.690
Akaike criterion	−254.3	−262.0	−343.2
N	380	380	380

Source: Own calculation based on SL2014 and data published by Statistics Poland.
Note: Standard errors are given in brackets; logarithm denotes natural logarithm.
[a] Linear regression with robust standard errors.
[b] Spatial lag — in neighboring counties.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

proxy for the growth of income in counties. This is not high, but it reflects the overall share of the Structural Funds in Polish GDP, which in the years 2014–2020 ranged from 1.15% in 2017 to 2.6% in 2020. It was also below 2% in 2016 and 2018, while in 2014, 2015 and 2019 it was around 2.3% (*Wpływ polityki...* 2022). However, these figures for 2014–2016 include projects co-financed from SFs from the 2007–2013 programming period. Moreover, these indicators include the SFs linked to national and voivodship projects in the 2014–2020 programming period. Therefore, the impact of SFs at the county level in the years 2014–2020 of the 2014–2020 programming period on the increase in income growth is higher than the value of these SFs in GDP. It is also consistent with the estimated impact of SFs on GDP growth in the years 2015–2020. In the years 2015–2017, it was slightly negative (−0.2% to −0.9% of GDP) due to the low number of completed projects. This weakened the increase in demand directly caused by the funds, which require a constant inflow of financial resources. The impact of SFs in the years 2018–2020 was also positive due to the activation of the supply side changes by the projects co-financed from these funds, and it amounted to 0.2%–0.3% of GDP (*Wpływ polityki...* 2022). In 2018–2019,[6] it accounted for around 4% of GDP growth, which is similar to the results of the spatial lag model estimates. However, the estimated spatial lag model also showed the clustering of income growth in counties in Poland, as the bigger increase in municipal PIT and rural tax revenues per capita in neighboring counties caused a stronger increase in the indicator in a given county. The initial state of the processing sub-system of the regional value creation model, measured by the number of registered enterprises per resident

6. In 2020, GDP growth was negative and SFs reduced the rate of the decline.

of working age, was also very important for the increase in income. The Structural Funds projects implemented in neighboring counties were not important for the increase in the income proxy in a given county. These projects were implemented in each county and their lowest value as a sum of the years 2014–2021 was PLN 1,542 per capita, with a median of PLN 7,222 and a 99th centile of PLN 101,112. The real increase in the PIT and rural tax revenues of the communes per capita ranged from PLN 171 per capita, with a median of PLN 318, to a 99th centile of PLN 708.

The projects co-financed from the Smart Growth Operational Program (SGOP) were not implemented in 6 counties, and they varied greatly between counties. The 5th centile was PLN 15.5 per capita, the median was PLN 713 per capita, and the 99th centile was PLN 25,919 per capita. The increase in the value of the indicator of the number of knowledge-based companies per 1 thousand residents in 2014–2020 was 2.3 at the 1st centile, 4.4 at the median, and 21.8 at the 99th centile. The highest value of R^2 (0.83–0.84) and the lowest value of the Akaike criterion were found in the spatial models. The estimated models (table 2) showed that the increase in the value of the projects co-financed from OP SG by PLN 1,000 per capita caused an increase of 0.17 in the growth of the indicator of the number of companies registered in J-N sections, so, again, it was not large. However, in the case of knowledge-based entrepreneurship, SG OP co-financed projects in neighboring counties were also crucial. They increased the indicator of the increase in knowledge-based entrepreneurship even more. This reflects the strong concentration of these projects in metropolitan areas, which are the strongest knowledge-based growth poles and in which the SG OP projects

Table 2. Results of estimating the impact of OP SG co-financed projects on knowledge-based entrepreneurship

	Dependent variable: increase in the value of the indicator of J-N PKD sections' registered entities per 1,000 residents		
Independent variables	**Linear regression[a]**	**SLX**	**SLM**
Constant	0.557 (0.34)	0.614 (0.192)***	−0.482 (0.037)**
Logarithm of value of projects co-financed from SG OP in PLN per capita 2014-2021	0.00017 $(3.1 \cdot 10^{-5})$***	0.00017 $(2.3 \cdot 10^{-5})$***	0.00018 $(2.18 \cdot 10^{-5})$***
Spatial lag[a] of logarithm of value of projects co-financed from SG OP in PLN per capita 2014–2021	–	0.00046 $(4.8 \cdot 10^{-5})$***	–
Logarithm of foreign capital in million PLN in 2014	0.00014 $(1.6 \cdot 10^{-5})$***	0.00015 $(1.98 \cdot 10^{-5})$***	0.00014 $(1.9 \cdot 10^{-5})$***
Logarithm of registered entities of J-N Sections per 1,000. residents in 2014	0.164 (0.031)***	0.149 (0.01)***	0.1172 (0.01)***
Commune and county paved roads per 100 km^2 in 2014	0.004 (0.001)***	0.003 (0.001)***	0.0035 (0.001)***
3-year average of new dwellings per 1,000 residents in 2014	0.456 (0.065)***	0.3(0.051)***	0.321 (0.047)***
Gross value of fixed assets per resident of productive age in 2014	$-7.3 \cdot 10^{-6}$ $(3.7 \cdot 10^{-6})$**	$-4.95 \cdot 10^{-6}$ $(3.2 \cdot 10^{-6})$***	$-4.89 \cdot 10^{-6}$ $(3.03 \cdot 10^{-6})$
Rho (lag of dependent variable)	–	–	0.42***
R-squared	0.79	0.84	0.85
Akaike criterion	1,454.4	1,372.2	1,353
N	377	377	377

Source: Own calculation based on SL2014 and data published by Statistics Poland.

Note: Standard errors are given in brackets; logarithm denotes natural logarithm.

[a] Linear regression with robust standard errors.

[b] Spatial lag — in neighboring counties.

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

were mainly implemented.[7] However, enterprises are often established in places where people live, which in the case of metropolises are often neighboring counties (Martyniuk-Pęczek, Martyniuk, and Parteka 2020). The spatial lag model also showed a clustering of increases in the indicator of knowledge-based entrepreneurship. A bigger increase in the value of this indicator in neighboring counties meant a bigger increase in knowledge-based entrepreneurship in a given county. In addition, the initial state of the processing subsystem of the regional value creation model was also important in terms of knowledge-based entrepreneurship intensity. Also important for the growth of knowledge-based entrepreneurship was financial capital in the form of foreign capital invested in a given county, as well as initial physical capital in the form of municipal and county paved roads per 100 km^2 and the 3-year average of new dwellings per 1 thousand residents in 2014.

Conclusion

The developed regional value creation system model offers a scheme for analyzing the impact of the Structural Funds on various outcome variables, including R&D&I and environmental performance in addition to standard macroeconomic variables. The model thus describes the impact of the Structural Funds on regional systems taking into account the paradigm of innovation-based sustainable development, which reflects the main goals of the European Union's long-term strategy. It can be used as a theoretical background for analyses using econometric modeling, as well as for adjusting the existing macroeconomic models. It assumes systemic interdependencies and causal loops since the elements of the regional system are interrelated and an exogenous injection of funds will directly or indirectly affect various elements of the system. However, the relationships described in the model can also be used in non-quantitative research methods, such as document analysis or interviews with beneficiaries.

The application of the model showed a weak but positive overall impact of the SF co-financed projects on the increase in income and knowledge-based entrepreneurship in Polish counties in the period 2014–2021.

Future research could attempt to operationalize the regional value creation system model in the form of a multivariate micro-macroeconomic model, considering the challenges of the innovation-based sustainable development paradigm. This could include other data sources, such as information from websites reflecting changes in consumption patterns or attitudes, which may be relevant from the perspective of the circular economy promoted by EU policy during the 2021–2027 programming period.

References

Bachtler, J., and R. Michie. 1997. "The Interim Evaluation of EU Regional Development Programmes: Experiences from Objective 2 Regions." *Regional Studies* 31 (9):849–858. doi: 10.1080/00343409750129968.

Barca, F. 2006. "European Union Evaluation between Myth and Reality: Reflections on the Italian Experience." *Regional Studies* 40 (2):273–276. doi: 10.1080/00343400600600710.

Barro, R.J. 1999. "Inequality, Growth, and Investment." *NBER Working Papers* (7038).

Baslé, M. 2006. "Strengths and Weaknesses of European Union Policy Evaluation Methods: Ex-Post Evaluation of Objective 2, 1994–99." *Regional Studies* 40 (2):225–235. doi: 10.1080/00343400600600595.

Bauer, M.W. 2006. "Co-Managing Programme Implementation: Conceptualizing the European Commission's Role in Policy Execution." *Journal of European Public Policy* 13 (5):717–735. doi: 10.1080/13501760600808592.

Baussola, M. 2007. "Modelling a Regional Economic System: the Case of Lombardy." *Regional Studies* 41 (1):19–38. doi: 10.1080/00343400600929036.

7. The highest value of SG OP co-financed projects per capita was observed in Cracow, Wrocław, Warsaw, Poznań, Gdańsk, Łódź, Bydgoszcz, Lublin, the Rzeszowski County, Białystok, Gliwice, and the following counties: Krakowski, Poznański, Warszawski Zachodni, Dębicki, Rzeszów, Dąbrowa Górnicza, and Oświęcimski (from PLN 48,600 to 6,500 per capita)—i.e., in metropolitan areas.

Bondonio, D., and R.T. Greenbaum. 2014. "Revitalizing Regional Economies through Enterprise Support Policies: an Impact Evaluation of Multiple Instruments." *European Urban and Regional Studies* 21 (1):79–103. doi: 10.1177/0969776411432986.

Bongardt, A., and F. Torres. 2010. "Europe 2020—A Promising Strategy? (The Competitiveness Rationale, Sustainable Growth and the Need for Enhanced Economic Coordination)." *Intereconomics* 45 (3):136–170. doi: 10.1007/s10272-010-0332-9.

Bradley, J. 2006. "Evaluating the Impact of European Union Cohesion Policy in Less-Developed Countries and Regions." *Regional Studies* 40 (2):189–200. doi: 10.1080/00343400600600512.

Capello, R., and U. Fratesi. 2012. "Modelling Regional Growth: an Advanced MASST Model." *Spatial Economic Analysis* 7 (3):293–318. doi: 10.1080/17421772.2012.694143.

Capello, R., and P. Nijkamp, eds. 2009. *Handbook of Regional Growth and Development Theories*. Cheltenham, UK; Northampton, MA: Edward Elgar.

Chłoń-Domińczak, A., A. Jędrzejowski, J. Perek-Białas, and J. Pokorski, eds. 2022. *Public Intelligence. Wykorzystanie danych administracyjnych do monitorowania i ewaluacji polityk publicznych*. Warszawa: Polska Agencja Rozwoju Przedsiębiorczości.

Ciołek, D. 2017. "Oszacowanie wartości produktu krajowego brutto w polskich powiatach." *Gospodarka Narodowa* 289 (3):55–87. doi: 10.33119/gn/100738.

Çitilci, T., and M. Akbalik. 2020. "The Importance of PESTEL Analysis for Environmental Scanning Process." In *Handbook of Research on Decision-Making Techniques in Financial Marketing*, edited by H. Dinçer and S. Yüksel, 336–357. Hershey, PA, USA: IGI Global.

Crudu, R. 2019. "The Role of Innovative Entrepreneurship in the Economic Development of EU Member Countries." *Journal of Entrepreneurship, Management and Innovation* 15 (1):35–60. doi: 10.7341/20191512.

de Blasio, G., S. Poy, and E. Ciani. 2020. "Transportation Infrastructure and Local Growth: Historical Evidence from the South of Italy." CEPR, last modified 2020-07-11, accessed 2023-04-24, https://cepr.org/voxeu/columns/transportation-infrastructure-and-local-growth-historical-evidence-south-italy.

de Groot, H.L.F., J. Poot, and M.J. Smit. 2008. "Agglomeration Externalities, Innovation and Regional Growth: Theoretical Perspectives and Meta-Analysis." *University of Waikato Working Paper in Economics* (01/08):1–33.

Dellmuth, L.M. 2011. "The Cash Divide: the Allocation of European Union Regional Grants." *Journal of European Public Policy* 18 (7):1016–1033. doi: 10.1080/13501763.2011.599972.

Di Caro, P., and U. Fratesi. 2022. "One Policy, Different Effects: Estimating the Region-Specific Impacts of EU Cohesion Policy." *Journal of Regional Science* 62 (1):307–330. doi: 10.1111/jors.12566.

Doszyń, M. 2009. "Testowanie egzogeniczności zmiennych w modelach ekonometrycznych." *Studia i Prace Wydziału Nauk Ekonomicznych i Zarządzania* (15):33–40.

Faiña, A., J. Lopez-Rodriguez, and P. Montes-Solla. 2020. "European Union Regional Policy and Development in Spain: Capital Widening and Productivity Stagnation over 1989–2010." *Regional Studies* 54 (1):106–119. doi: 10.1080/00343404.2018.1542127.

Freeman, C. 1994. "Innovation and Growth." In *The Handbook of Industrial Innovation*, edited by M. Dodgson and R. Rothwell, 78–93. Aldershot, England; Brookfield, Vt., USA: Edward Elgar.

Gancarczyk, M., and Ó. Rodil-Marzábal. 2022. "Fintech Framing Financial Ecologies: Conceptual and Policy-Related Implications." *Journal of Entrepreneurship, Management and Innovation* 18 (4):7–44. doi: 10.7341/20221841.

Gancarczyk, M., A. Ujwary-Gil, and M. González López, eds. 2021. *Partnerships for Regional Innovation and Development. Implementing Smart Specialization in Europe, Routledge Studies in Business Organizations and Networks*. New York, NY: Routledge.

Ginevičius, R., and V. Podvezko. 2009. "Evaluating the Changes in Economic and Social Development of Lithuanian Counties by Multiple Criteria Methods." *Technological and Economic Development of Economy* 15 (3):418–436. doi: 10.3846/1392-8619.2009.15.418-436.

Goodwin, N.R., J.M. Harris, and J.A. Nelson. 2019. *Macroeconomics in Context*. 3rd ed. New York: Routledge.

Hirschman, A.O. 1958. The Strategy of Economic Development, Yale Studies in Economics. New Haven: Yale University Press.

Huber, W. 2006. "Evaluation of European Union Cohesion Policy: Window-Dressing, Formal Exercise or Coordinated Learning Process?" *Regional Studies* 40 (2):277–280. doi: 10.1080/00343400600600751.

Keynes, J.M. 1936. *The General Theory of Employment, Interest and Money*. London: Macmillan.

Kossowski, T. 2010. "Teoretyczne aspekty modelowania przestrzennego w badaniach regionalnych." *Praktyczne aspekty badań regionalnych. Varia* 3:9–26.

Martyniuk-Pęczek, J., O. Martyniuk, and T. Parteka. 2020. *Entrepreneurship Nests in a Polish Edge City*. Translated by A. Bielecka. Gdańsk: GUT Publishing House.

Masouman, A., and C. Harvie. 2018. "Regional Economic Modelling through an Embedded Econometric-Inter-Industry Framework." *Regional Studies* 52 (9):1237–1249. doi: 10.1080/00343404.2017.1363389.

Mogiła, Z. 2019. "Rozwój modeli HERMIN w Polsce w kontekście badań ewaluacyjnych." In *Wykorzystanie modelowania ekonometrycznego w ewaluacji wpływu polityk publicznych i programów*, edited by J. Pokorski, J. Szut, T. Wyszyńska, Z. Mogiła and J. Zaleski, 37–64. Warszawa: Polska Agencja Rozwoju Przedsiębiorczości.

Mróz, A., Ł. Komorowski, M. Wolański, M. Stawicki, P. Kozłowska, and M. Stanny. 2023. "The Impact of Territorial Capital on Cohesion Policy in Rural Polish Areas." *Regional Studies* 57 (3):497–510. doi: 10.1080/00343404.2022.2091774.

Ostašius, E., and A. Laukaitis. 2015. "Reference Model for E-Government Monitoring, Evaluation and Benchmarking." *Engineering Economics* 26 (3):255–263. doi: 10.5755/j01.ee.26.3.8128.

Perroux, F. 1950. "The Domination Effect and Modern Economic Theory." Social Research 17 (2):188-206.

Persyn, D., J. Barbero, J. Díaz-Lanchas, P. Lecca, G. Mandras, and S. Salotti. 2023. "The Ripple Effects of Large-Scale Transport Infrastructure Investment." *Journal of Regional Science* 63 (4):755–792. doi: 10.1111/jors.12639.

Petrakos, G.C. 1992. "Urban Concentration and Agglomeration Economies: Re-Examining the Relationship." *Urban Studies* 29 (8):1219–1229. doi: 10.1080/00420989220081231.

Reidolf, M., and M. Graffenberger. 2019. "How Local Resources Shape Innovation and Path Development in Rural Regions. Insights from Rural Estonia." *Journal of Entrepreneurship, Management and Innovation* 15 (3):131–162. doi: 10.7341/20191535.

Romer, P.M. 1990. "Endogenous Technological-Change." *Journal of Political Economy* 98 (5): S71–S102. doi: 10.1086/261725.

Solow, R.M. 1988. "Growth Theory and After." *American Economic Review* 78 (3):307–317.

Spanache, I. 2018. "Implications of EU Evaluation Practices: from a Positivist Approach to a Realist One in Evaluating 2007–2013 Cohesion Policy." *Europolity* 12 (1):107–136.

Włodarski, M., and J. Martyniuk-Pęczek. 2017. "Relevance of the EU Structural Funds' Allocation to the Needs of Combating Air Pollution in Poland. Analysis of the Operational Programmes of Regions Threatened With Critical Air Pollution from Distributed Energy Sources." *IOP Conference Series: Materials Science and Engineering* 245 (8):1–14. doi: 10.1088/1757-899X/245/8/082060.

Wojnicka-Sycz, E. 2013. *Model terytorialnego bieguna wzrostu jako systemu czynników rozwojowych*. Gdańsk: Wydawnictwo Uniwersytetu Gdańskiego.

Wojnicka-Sycz, E., and P. Sycz. 2016. "Public Innovation Policy and Other Determinants of Innovativeness in Poland." *The Innovation Journal: The Public Sector Innovation Journal* 21 (3):article 2 (pages 1–23).

Wojnicka-Sycz, E., P. Sycz, P. Walentynowicz, and J. Waśniewski. 2020. "Internal Determinants of Firms' Innovativeness." *Operations Research and Decisions* (4):83–97. doi: 10.5277/ord180406.

Wpływ polityki spójności na rozwój społeczno-gospodarczy Polski i regionów w latach 2004–2020. 2022. Warszawa: Ministerstwo Funduszy i Polityki Regionalnej.

Žižka, M., and N. Pelloneová. 2019. "Do Clusters with Public Support Perform Better? Case Study of Czech Cluster Organizations." *Revista Administratie Si Management Public* (33):20–33.