ШКУРОПАТ Г.В.
д-р екон. наук, проф.
науковий професор
Інститут проблем Європи, Росії та Євразії Карлнтонського
университету, (3304, Richcraft Hall, Carleton University,
1125 Colonel by Drive, Ottawa, ON K1S 5B6)
м. Оттава, Канада;
головний науковий співробітник Всеросійської академії зовнішньої торгівлі Міністерства
экономічного розвитку Російської Федерації,
вул. Вавілова, 7, м. Москва, Росія, 117312,
провідний дослідник Російської академії народного господарства та державної служби при
Президентові Російської Федерації, Москва, Росія
Проспект Вернадського, 84/2, Москва, Росія,, 119571
E-mail: ashkuropat@idmag.com
ORCID: 0000-0002-0258-333X

СТЕПАНОВ В.М.
д-р екон. наук, проф.
головний наук. співроб.
Інститут проблем ринку та економіко-екологічних досліджень НАНУ
Французький бульвар, 29, м. Одеса, Україна, 65044
E-mail: Stepanov.ipr@gmail.com
ORCID: 0000-0001-5432-115

МЕТОДОЛОГІЧНІ ПІДХОДИ ДО ВКЛЮЧЕННЯ ЧИННИКІВ "ЗЕЛЕНОЇ ЕКОНОМІКИ" В СЕРЕДНЬОСТРОКОВІ МОДЕЛІ ПРОГНОЗУВАННЯ РЕГІОНАЛЬНОГО РОЗВИТКУ

Актуальність питання визначається важливістю координації національної та регіональної соціально-економічної політики, підвищенням необхідності її екологізації та підвищенням обгрунтованості виборних інструментів публічної політики на використання методики багаторегіональних моделей для аналізу впливу державної політики та прогнозування сталого соціально-економічного розвитку країни в середньостроковій перспективі.

Мета та завдання. Метою дослідження є підвищення наукової обґрунтованості методології середньострокових прогнозів головних параметрів соціально-економічного розвитку країни в розрізі окремих регіонів на основі координації цілей та пріоритетів державної політики. Завданнями є, на основі огляду світової літератури, розробка методологічних підходів до середньострокових прогнозів оцінок територіальних значень головних груп економічних, соціальних і екологічних показників розвитку, які базується на сучасних методиках для вимірювання впливу політики на поліпшення життєвого рівня, зеленого зростання, загальної конкурентоспроможності економіки в її просторовому контексті.

Результати дослідження базуються на огляді методології застосування сучасних мульти-регіональних моделей з метою розробки та аналізу впливу взаємозалежної економічної, соціальної та екологічної політики, аналізі взаємодії національних і регіональних чинників сталого економічного зростання, впливу політики на зменшення регіональної диференціації та підвищення національної конкурентоспроможності.

Висновки. Сучасні багато-регіональні моделі, які застосовуються для середньострокового цільового прогнозування, пройшли етапи розвитку, як і теорії регіональної економіки та інструменти математичного моделювання соціально-економічних систем. Такі моделі найбільш широко застосовуються сьогодні в практиці регіональної політики Європейського Союзу. Методологія розробки багаторегіональних моделей повинна бути гнучкою, а моделі – розвиваючимося комплексами модулів, що дозволяє врахувати взаємодоповнення різних методів і проводити поетапну деталізацію блоків для опису взаємодії національних і регіональних чинників сталого економічного зростання, в тому числі з урахуванням зелених інвестиційних показників. Для оцінки екологічних параметрів використовуються ряд специфічних модельних інструментів (спеціальні інженерні моделі моделювання, моделі, що базуються на ГІС-моделях). Наше дослідження пропонує включити основні показники зеленого зростання в національні та регіональні блоки мульти-регіональних моделей, починаючи від найпростіших їх варіантів, таких як малі економетричні моделі часткової рівноваги, які, на основі спеціально проведеного аналізу, включають найбільш значущі економічні чинники стійкого зростання та набори

экзогенних параметрів, що встановлюються за узгодженою громадською політикою. Особливе місце приділяється аналізу ефективності інструментів, які сприяють зростанню зеленої економіки.

__Ключові слова:__ Сталий соціально-економічний розвиток, мульти-регіональні моделі, регіональна політика, економічне зростання, основи регіонального благополуччя.

SHKUROPAT, A.V.
Dr.Sc. (Economics), Professor,
Research Professor (International Economics),
Institute of European, Russian and Eurasian Studies,
Carleton University, 3304, RichcraftHall,
1125 Colonel by Drive,Ottawa, Canada ON K1S 5B6
Main Researcher
Russian Foreign Trade Academy, Ministry of Economic Development
7, Vavilova street, Moscow, Russia, 117312,
Leading Researcher,
Russian Presidential Academy of National Economy & Public Administration
Prospect Vernadskogo, 84/2, Moscow, Russia, 119571
E-mail: ashkuropat@idmag.com
ORCID: 0000-0002-0258-333X

STEPANOV, V.M.
Dr.Sc. (Economics), Prof.
Institute of Market Problems and Economic&Ecological Research,
National Academy of Sciences of Ukraine
Frantsuzskiy Boulevard, 29, Odessa, Ukraine
E-mail: Stepanov.ipr@gmail.com
ORCID: 0000-0001-5432-115

METHODOLOGICAL APPROACHES FOR INCLUSION OF FACTORS OF A "GREEN ECONOMY" INTO MEDIUM TERM FORECASTING MODELS FOR REGIONAL DEVELOPMENT

__Topicality.__ This is based on the importance of coordinating national and regional socio-economic policy with a recognition of the need for "green" growth and an assessment of government policy measures based on the application of multi-regional modeling methodology to analyze the effects of public policy in a regional context, and on medium-term forecasting of a country's sustainable socio-economic development.

__Aim and tasks.__ The aim of the study is to improve the scientific validity of methodology for medium-term forecasting of the main parameters of a country's socio-economic development in terms of individual regions by aligning the objectives and priorities of public policy. The objective is to develop, based on a review of international literature, methodological approaches for obtaining coherent medium-term forecast estimates of major groups of territorial economic, social and environmental indicators, based on modern methodologies for measuring the targeted effects of improving living standards, "green" growth, and overall competitiveness of the national economy in its spatial dimension.

__Research results.__ The results of the research are based on a review of international literature and the justification for methodology to apply modern multi-regional models for the assessment of the effects of interconnected economic, social and environmental policies in the analysis of interactions between national and regional factors of sustainable economic growth, regional disparities, and strengthening of national competitiveness.

__Conclusion.__ Modern multi-regional models for medium-term forecasting have passed several stages of development, and have incorporated into them theories of the regional economy and the mathematical tools for socio-economic systems modeling. The most effective current policy application is in the practice of recent EU regional policy. Methodology for application of complex multi-regional models has to be flexible, with the application of complementary modeling tools, and providing for further development of model modules to describe the mutual interaction of national and regional factors of sustainable economic growth, including indicators for "green" investment. A number of specific modeling tools (special engineering simulation models, GIS-based models) are usedto assess environmental parameters of spatial development. Our research proposes to incorporate the main indicators of "green" growth into national and regional blocks of multi-regional models, starting with the simplest options such as small econometric models of partial equilibrium, into which - based on a specially conducted analysis - the most significant factors of sustainable economic

growth and exogenous parameters of public policy are included. A special place is given to testing the effectiveness of "green" economy measures.

Keywords: *Sustainable socio-economic development, multi-regional models, regional policy, economic growth, green investment, framework for regional well-being.*

Problem statement and its connection with important scientific and practical tasks. The development of an annual medium-term forecast of socio-economic development, on the basis of which an annual and medium-term national Budget is prepared, is usual public policy practice. The related issueofpreparing a regional structure for the main national forecast, on the basis ofdifferentpolicy scenarios is, however, not a minor task. A practical requirementis to justify a formalized methodology to harmonize the main parameters of the national forecast of socio-economic development with forecasts of the country's regional development. Different countries have different regional models of governance, but the task of building a regional dimension for national forecast indicators is faced by all countries. In recent years the "greening" of the economy and the introduction of "green" growth indicators into a country's strategic management system has also become an important public policy objective.Environmental parameters, however, differ significantly at the level of individual regions,but are important for regional well-being and regional policy-making.

To assess sustainable development policies in spatial terms, in international practice multi-regional modelsare used as a tool to assess the effects of public policy before implementation as well asfor medium- and long-term forecasting.

Historically, the firstmost famous practical models of the national economy and their regional disaggregation for economic policy analysis and medium-term forecasting were developed in the United States. They have, however, in the last twenty years received the most practical application in policy-making for socio-economic development of multi-regional systems in the European Union. International experience in using multi-regional models to address the challenges of managing different areas of socio-economic development and new practical methodologies for assessing regional development indicators for countries in the post-Soviet space isalso important to reap greater benefits from wider participation in international cooperation.

Analysis of recent publications on the problem. The analysis of international experience inpredicting the socio-economic development of regions is undertaken and methods of disaggregation of projected macroeconomic indicators to the regional level are considered. This is the area, first of all, of the application of multi-regional economic and mathematical models. Such models usually consist of two levels of national and regional sub-models. The links between these sub-models or modules are taken into account on the basis of the relationship of disaggregationin both the "top-down" directionand the "bottom-up" direction, or by simultaneously taking into account both the top-down or distributive approach and the bottom-up or aggregative approach in the process of developing and implementing modeling complexes.

Multi-regional models of countries with advanced market economies have passed through the evolutionary stages of their development since the 1960s, in accordance with the stages of development of the science of regional economy, as well as the development of methodology for building the respective types of economic and mathematical models (Leontief's input-output tables, macro-economic models, models of general economic equilibrium, and development of practical procedures of stochastic methods forecasting).

In the last two decades, new theoretical ideas of the developing interdisciplinary science of the regional economy have been implemented in economic and mathematical models for prediction of regional economic growth. First of all, this is reflected in regional models with micro-foundations, based on approaches of new economic geography, increasing returns (fields of firms), and the economy of the city.

A special role is played inrespect of endogenous development, in which the concepts of industrial areas, innovation environment, and production clusters are developed, and which is aimed at a better understanding of a more detailed model of sustainable regional growth by better interpreting the factors that determine it, including the need for "green" socio-economic development. In such a theoretical framework, sustainable regional economic growth is presented as an interconnected process based on specific environmental, local synergy and governance factors. These elements in the last decade haveused an interpretation of the concepts of social capital,natural capital, relational capital or,in a slightly different context,knowledge assets.

Modern models are based on new approaches in the regional policies of developed countries, which take into account spatial parameters and their potential effects on socio-economic development indicators,

and first of all on economic growth. Traditional market and institutional approaches that did not take spatial parameters into account were replaced by new approaches based on local specificity. Thus, the new generation of models reflects current approaches to regional policy that are being implemented in OECD countries.

Modern regional policy is intended to ensure that local specificities and assets of specific territories are taken into account. It is developed in a transparent and inclusive manner by local territorial actors, supported by external institutional and economic actors.Such regional policy is based on the "bottom-up" approach.Refs [1] and [2]. It is expected that the process of entrepreneurial innovation will force local economic agents to take part in determining the future development trajectories, and the synergy of interactions between innovations in the "bottom-up" direction and "top-down" management support should improvethe chances of regions to transit to a "smart" specialization mode and increase the productivity of factors ofproduction [3], [4]. In order to be able to assess the impact of the new regional policy, it is important to include measures of such policies in regional models. An increasing interdependence of regions makes this requirement even more important.

New factors and theoretical assumptions lead to the need to develop new models for the purpose of regional economic forecasting, allowing innovations to be reflected in their structure. In the last decade, a new generation of such models has been developed for regional economic growth forecasting. Examples include *The Geographic and Regional Model (GMR)*[5] and *Macroeconomic, Industry,* Social and *Territorial Model (MASST) [6],* developed in the EU.

Also, the new theoretical and regulatory provisions were included in the previous generationof models, which were further developed, such as the successful adaptation of the famous US *Regional Economic Model, Inc.(REMI)*[7]and *Regional Integrated Model(RHOMOLO)*[8]. Both models are used to predict regional economic growth as a result of EU regional policy measures implementation.

Some key examples of the latest generation of multi-regional models are shown in

Table 1.

Examples of latest generation models

Model	Authors and Publications	Main Methods	Comments
REMI-IRPET	Paniccia, R., and Gori G. 2015. «A Structural Multisectoral Model with New Economic Geography Linkages for Tuscany» Papers in Regional Science	Structural Input-Output General Equilibrium Model	With elements of new economic geography
Geographical and Regional Model (GMR)	Varga, A. 2015. «Place-based, Spatially Blind or Both? Challenges in Estimating the Impacts of Modern Development Policies: The Case of the GMR Policy Impact Modeling Approach» International Regional Science Review. doi:10.1177/0160017615571587.	Comprehensive General Equilibrium Model	For Medium-Term Forecasting and Policy measures assessment that encourage innova-tion and smart special-ization in the regions.
RHOMOLO	Brandsma, A., Kancs, d'A., Monfort, P., and Rillaers, A. (2015). "RHOMOLO: A dynamic spatial general equilibrium model for assessing the impact of cohesion policy," Papers in Regional Science, 94, 197-221.	Dynamic Spatial General Equilibrium Model	For forecasting andEU cohesion policy assessment.
RHOMOLO-v2	Mercenier J., Álvarez-Martínez M.T., López-Cobo M., Brandsma A. and others. RHOMOLO-v2 Model Description: A spatial computable general equilibrium model for EU regions and sectors, EU Commission Technical Report, Luxembourg:	Dynamic Spatial General Equilibrium Model with new elements	Large scale model: there are more than 1 million. equations due to the detailed disaggregation. Implemented in GAMS.

Model	Authors and Publications	Main Methods	Comments
	Publications Office of the European Union, 2016.		
Multi-regional spatial vector autoregression model for Spain MultiREG-SpVAR	Ramajo J., Marquez M.A., Hewings G. J. D., Regional growth and spatial spillovers: Evidence from anSpVAR for the Spanish regions. 2013.	Stochastic dynamic econometric vector autoregression model	To access scenarios of growth points.
Macroeconomic, Sectoral, Social and Territorial Model MASST	Capello, R., A. Caragliu, and U. Fratesi. 2015. «Modeling Regional Growth between Competitiveness and Austerity Measures: The MASST3 Model»// International Regional Science Review.	Complex of macro-economic models of partial equilibrium	For regional economic growth forecasting. Since the early 2000s, several versions of this model have been developed.

*Source:*Compiled by the authors based on References [1] – [12] and other sources.

The presentreview has shown that in developed countries there is a tendency today to use increasingly complex integrated models that, on the one hand, are based on continuation of an initial tradition of inter-industry, inter-regional analysis, complemented by other elements of economic and mathematic methods, including theoretical concepts of new economic geography, such as an adaptation of the complex long-livedUS*REMI* project to its EU version- *REMI-IRPET*project [7].The second approach, traditionally developed on the basis ofan adaptation of macroeconomic modelingapproaches to regional analysis,has today grown into the actively used tools of Dynamic Stochastic General Equilibrium models, such as *RHOMOLO,QUEST3*[13].Both approaches require a very time-consuming process of model implementation based on fairly ambitious requirements for statistics.

In thepost-Soviet Union countries, which in the 1980s were famous for applied works on multi-regional modeling, there is currently some loss of the former competencies in building interregional inter-industry models. There is also a clear lag behind OECD countriesin the extent to which other types of multi-regional models are being used in regional development (based on Stochastic General Equilibrium and large scale structural econometric models). Multi-regional models developed in the 70s and 80s of the 20th century in the main scientific centers of the USSR were initially different from similar models developed in market economy countries. The Soviet school was developing input-output models under different basic assumptions. These included exogenously set prices for input-output models and a massive use of linear programming methods, including for optimization of resource allocation. The Soviet school of economic and mathematical modeling followed the adaptation of Leontief'sinput-output methodologyunder conditions of a centralized system for national economic planning.This tradition stilllives in today's approaches to multi-regional modeling in the main schools on the comprehensive modeling of socio-economic systems[14]-[16].

In the newly independent post-Soviet states, in the early 1990s there has been a reduced demand for models for national forecasts, yet comprehensive scientific studies on multi-regional models under new economic conditions and new geographical realities continued to be conducted in the key centres specializing in building integrated models for assessing national economic policies.

Research on regional modeling has also been undertaken by scientists from the specialized departments of universities and academic institutions in all post-Soviet countries, but mostly for theoretical purposes rather than for government medium-term forecasting. At the same time, the analysis of regional systems for medium-term forecasting is focused more on the production side.

In the early 1990s, the foundations were laid for adapting previously developed economic and mathematical models to new economic conditions, and new models based on market economy principles were developed. Computable General Equilibrium models for additional countrieswere alsodeveloped. During this period, new research schools have been actively developing, including private consulting companies specializing in the development of integrated software systems for purposes of national economic and regional forecasting[17].

The present analysis of international literature has highlighted the lack of environmental indicators in multi-regional countrymodels in accordance with the latest OECD methodologieson the impacts of "green" growth for the economy. Although some models incorporate environmental parameters, in most cases multi-regional models traditionally continue to describe the basic relationships of economic theory with a minimum introduction of social, demographic, ecological and spatial parameters. The latter are found in

econometric types of models with partial economic equilibrium, which are most suitable for assessing the effects of public policy and forecasting for a medium-term period.

Allocation of previously unsolved parts of the general problem. Despite accumulation of some experiencein the application of the new generation of empirical models by the post-Soviet countries,such tools are not yet in place for coordinated multi-regional policy application by government.This applies totaking into account important theoretical achievements (in the theory of the regional economy and new approaches to the interactions of economic, social and environmental processes), as well as to developing new elements of economic and mathematical modeling of market processes. The availability of the necessary consistent statistical information for model-building, especially at the regional level, is also an issue. The post-Soviet countries lag behind in the application ofDynamic Stochastic General Equilibrium models, widely used in OECD countries, in which macro-economic models are complemented by descriptions of the behavior of economic agents at the micro level[18].

For modeling purposes in non-EU post-Soviet countries, social accounting matrices are usually not available, and these are an integral part of Computable General Equilibrium Model (CGEM) methodology, especially for the regional level. There is also no single approach for all countries to determine the performance of the "green" economy. Therefore, multi-regional national models will have their own characteristics, including those incorporatedinto the models as "green" economy parameters and their relationship with policy instruments to stimulate "green" investment.

In connection with regional policy assessment for the non-EU post-Soviet countries, the usual methodological issues include:

- the lack of justification of the main factors of regional development for different types of regions, reflecting essential components of the socio-economic situation of the regions;
- a lack of methodologies for assessing standards of living in the regions and the relationship with the main economic and environmental parameters that allow the choice of differentiated measures of public policy;
- alack of methodologiesforscientifically-based quantitative assessment of the effectiveness of economic policies at national and regional levels;
- a lack of methods for coherence of national parameters of social development in the territorial context; and
- the lack of reliable statistics for balanced regional social and environmental indicators,including on indicators of the"green"economy.

Thus, it is extremely relevant to develop methodologies for taking into account the inter-action of the principalsocial, environmental and economic indicators for further development of model complexes for medium-term forecasting of a country's socio-economic development in the territorial context, which will contribute to the quality of decision-making on government regulation of regional development, taking into account the implementation of national goals and strategic objectivesat the regional level.

Formulation of research objectives (problem statement). The aim of the present study is to improve the validity of methodology for medium-term forecasting of the main parameters of a country's socio-economic development in terms of individual regions by aligning the objectives and priorities of public policy.

The objective is to develop the methodological approaches for obtaining coherent medium-term forecast estimates of major groups of indicators of territorial economic, social and environmental development, based on modern methodologies for measuring the targeted effects of improving living standards, "green" growth, and overall competitiveness of the national economy in its spatial dimension.

This will require a detailed review of the main types of multiregional models, to understand international experience and its application in public policy development. Special attention needs to be given to theanalysis of the strengths and limitations of different mathematical methods used to develop the complexes of multi-regional modelsand determine the main blocks of models and their links.Based on international experience, this would identify and introduce into model architecture thenewest indicators and public policy measures, taking into account social and environmental parameters that are increasingly being used to supportregional development.

An outline of the main results and their justification. The present research summarizes international experience in the development and practical application of multi-regional models, and identifies the main features of different types of models, including differences for the stages of their development in line with advances in regional economy theory and the applications of relevant mathematical modeling

methodologies. The practicality and complexity of model development is assessed for different types of models. As a result, an approach for development of a multiregional model complex is introduced for the medium-term forecasting of national socio-economic development in a regional context.

In terms of the use of different economic and mathematical methods that have evolved in the tradition of leading schools of economic theory, the main types of relevant models are: Input-Outputmodels, Computable General Equilibrium Models (CGEM), Partial Equilibrium Macroeconomic Models, and Structural Econometric Models. Since each type of model is based on specific economic and mathematical methodology and has its own strengths and limitations, model complexes have been developed to overcome some methodological limitations, incorporating combinations of different methods - for example, the combination of Leontief's production functions with macroeconomic blocks of models.

Some US models used in the early 1980s have been modified in following decades and have served as prototypes for replication by other countries in the application to medium-term forecasting and public policy analysis.In analyzing the direction forfurther conceptual development, it is important to classify themodels in conjunction with the periods of development in regional economic science and the theoretical framework which has laid the basis for model formalization.

*Theoretical framework for the developmen to regional models for analysis of economic policy and medium-term forecasting.*The study analyzes types of multi-regional models, the conceptual basis of regional economic theory for incorporation into the model structure, and the use of such models for medium-term forecasting and assessment of government policy measures. New methodological approaches are suggested, among which is incorporation into the model of new social and environmental parameters, including "green" economy indicators.

In the last two decades there has beena revival of interest in the economic community in regional forecasting models.It should be noted that in the early stages regional models were built to analyze the structure of the economy, and the effects of economic policy. As the role of regional policy in OECD countries has increased, models have reflected new approaches by incorporating variables that take into account factors that explain regional development, as well as measures to facilitate the economic growth of particular regions. More recent modelsalso take into account new approaches to assessing social well-being and environmental policies [19].

The most modern models pay attention to factors that determine differences in economic growth rates of individual regions from the average rate of economic growth in the country. It is important to consider models that are based on the theories of economic dynamics, economic growth and considerations of "green" economy factors for a country's socio-economic development in the regional context.

The present study substantiates the conceptual framework for a methodological approach to medium-term forecasting of the territorial dimension of acountry's socio-economic development indicators. The main elements of such a framework are the followinge:

• As a methodological tool for forecasting, the dynamic econometric type of a partial equilibrium modelis proposed as a major means for describing links in a multiregional model complex, where regional growth is driven by the interaction of major factors of national, external and regional influence;

• Multiple examples show that socio-economic development of the regions in post-Soviet countries is largely dependent on the general situation in the national economy and economic policy at the national level. Economic trends analysis for the Russian Federation shows that regional dynamics in the last 20 years have largely followed national trends, although they do not repeat them in exactly the same way;

• When the spatial structure of the economy is characterized by a conservative pattern over the last 20 years (which is the case for the Russian Federation), in such a situation the main changes can be achieved by aproactive investment policy;

• Thus, one of the main assumptions for model development is that regional growth is driven mostly by investment policy, according to which the regional dynamics of the main indicators of socio-economic development are determined by the dynamics of regional investment activities. Inter-regional structural shifts are also mainly the result of investment activities. Investment in fixed capital is the most important exogenous factor shaping regional dynamics, but investment is a limited resource at the national level, the bulk of which (extra-budgetary investments) is distributed between regions on a more or less competitive basis;

• The structure of the model complex should be flexible and open for continuous adjustment, allowing for improvements and incorporation of new variables and functions;

• At the first stage, the main focus should be on analysis of regional investment potential and more detailed description of regional disaggregationof such macro-indicators as *Investment in Fixed Capital;*

• At the initial stage the relationship between national and regional model levels will be modeled in the "top-down" direction, i.e. macroeconomic forecast parameters will be introduced into the model as exogenous variables;

• It is assumed that the main dynamics are set by macroeconomic factors of national action, among them: institutional characteristics (e.g. legislation and efficiency of public administration); organizational factors (e.g. the quality of services such as educational and health systems, transport system development, communications system, and security); the country's overall level of economic development; the basic structure of the economy; the country's position in the global division of labour (the potential of the economy to attract FDI to the country); the overall state of the financial system; and the efficiency of public spending (public financial management);

• Other keyfactors explaining regional economic growth are: changes in the economic structure of the region (e.g. sectoral employment, which depends on the availability of industries with high or low value added); inter-sectoral productivity (explaining why a particular type of economic activity achieves greater productivity in some regions than in others); demographic dynamics (the role of the accumulation of local human capital); technological relationships with other regions (the dissemination of knowledge between regions and the mechanisms for theiraccumulation);and natural capital;

• The country's macro-region's development indicators, together with the macroeconomic conditions of the country's development, can act as baseline conditions and restrictions at the regional level, which should betaken into account when producing forecasts for the development of individual regions;

• In order to balance and harmonize the parameters of the model complex (for balancing forecast values for national and regional levels) it is proposed to use an iterative two-way approach: on one hand a method for disaggregation of predicted macro indicators usinga top-to-bottom method, and on the other hand, the aggregation of regional forecasts (the "bottom-up" method). In the developmentof a territorial dimension for national forecasts, it is important to have an interactive alignment of national and regional interests andthe exchange of information between different levels and participants in interconnected economic activities;

• Formalization of the parameters for production blocks for regions it is proposed to determine on the basis oftheir typology in accordance with the potential foreconomicspecialization, and if possible taking into account the development ofthe knowledge economy. It is important to include ecological parameters of production into the model,as well as productivity ofproduction factors, innovation development and stimulationincentives, and indicators for"green" investments.

Among the main resulting regional indicators are the following:
• Gross Regional Product (GRP);
• investment in fixed capital;
• regional productivity of labour;
• productivity in the manufacturing and market services sectors;
• inter-regional differentiation of average per capita GRP (in PPP); and
• the separate as well as combined share of the types of economic activity in the"manufacturing" and "market services" sectors (transport and communications, trade, financial services, real estate transactions, etc.) in the structure of GRP.

Exogenous parameters at the regional levelinclude:
• a region's population;
• territorial settlement structure;
• public investment in major national projects and programs, etc.

Overall economic forecasts are complemented by a number of indicators developed in the autonomous model blocks, including the investment bloc, which reflect in more detail information about national and regional development plans on infrastructure and major spatial development projects.

The relationships and factors of "green" development are manifested directly at the territorial level. On the one hand, it is necessary to protect state parks, nature and fauna, and on the other hand, the ecologicalization of all areas of human life should be promoted without excessive losses for economic growth. It is proposed to take into account "green" growth in four areas (in line with OECD methodology): the transition to a low-carbon, resource-efficient economy; conservation and management of natural resources; improving the environmental quality of life; implementation of the government's "green" growth

policy and the effects of new economic opportunities in this regard. Following OECD recommendations, it is proposed to use the following key indicators:

- carbon and resource efficiency;
- multi-factor productivity that takes into account the role of environment and natural resources for production;
- Natural Resources Index changes for land use and soil cover; and
- impact of air pollution on the population.

The model should also introduce parameters to assess the limits of "green" development for different types of regions.

Conclusions and perspectives of further research. Based on an analysis of existing approaches, taking into account the latest achievements in the regional economy (e.g. spatial parameters, government incentives for stimulation of endogenous growth, new economic specialization of regions), as well as an analysis of the relationship between environmental, social and economic indicators of the regional model modules, the major requirements for the main blocks and indicators of multi-regional models were identified.

In multi-regional models, usually the neo-Keynesian analogues of aggregated demand models are used to describe national blocks, and regional blocks are characterized by descriptions of production processes and specific factors of sustainable endogenous economic growth. Also, the models contain in one or another degree of detail social blocks and spatial factors that take into account parameters of the "green" economy: living standards, increasing the efficiency of the use of natural resources, and general environmentalization of socio-economic development. The literature proposes taking into account the factors of "green" development incorporated into the blocks of multi-regional CGE models. But since these require data on social accounts for the purpose of calibrating the model, and a social accounts matrix for the regional level is often absent, the present study proposes to use the approach of building econometric partial equilibrium multi-regional models to focus on taking into account the most significant factors in regional development and on the interaction of regional and national factors of economic growth.

Based on the analysis undertaken, the requirements for statistics for the construction of models, and the need to produce forecasts quickly, the main conceptual approaches for methodology of the medium-term forecasting model for the territorial dimension of the macroeconomic forecast were formulated. Use of adynamic macroeconometric model of partial equilibrium with individual micro-elements at the regional level is proposed. This type of model allows the inclusion of factors affecting sustainable regional economic growth based on new advances in the science of regional economy.

The present study, using the example of Russian Federation data, tested a general methodological approach to building a regional dimension of the national forecast based on the development of a multi-regional model. Blocks and inter-dependencies were implemented to assess investment policy and measures to stimulate regional development, depending on the development potential of specialties based on prioritizing the implementation of Russia's Spatial Development Strategy, taking into account the achievement of national development goals and their regionalization.

The procedures for disaggregation of macroeconomic indicators from "top-to-bottom", as well as aggregation and balancing of the results from "bottom-up", should be developed for the regional dimension of a sustainable forecast ofacountry's socio-economic development, depending on the availability of statistical information. To simplify the balancing process, it is possible to use the intermediate level of macro-regional indicators (for the purposes of aggregation and disaggregation of the relevant socio-economic indicators).

In developing the model, the principle of flexibility and openness should be established to improve its structure and include new details, new variables and equations as well as develop and verify basic functional dependencies.

Priority should be given to analyzing the investment potentia lof regional development, to a better description of the process of disaggregation of the *investment in the fixed capital,* as well as to justification of the possible share of investments directed to "green" growth.

Methodologically new are the proposals to include in the models the interrelations of economic, social and environmental parameters of regional development, and to take into account the specific features of certain types of regions. The model wouldtake into account the interactions of national and regional economies and different areas of public policy - economic, social, environmental, coordinated for different sectors of the economy at national, regional and microlevels.

Further study of the EU's experience in developing new types of multi-regional economic models is suggested, especially where efficiency of public policy measures within the framework of unified national strategic concepts is concerned.

The proposed methodological approach implies the possibility of continuous improvement of the model complex, refinement and introduction of new blocks of indicators and dependencies, and new exogenous parameters. Thus, as conceptual approaches are refined and the statistical base developed at the regional level, more detailed research will be needed in the future to take into account the multi-level interaction of indicators and public policy measures for achieving the OECD's "green" growth targets [20].

Determining the parameters of "green" growth for the country's system of coherent public policy measures requires the coordination of various ministries and government departments: ministries of Economy, Finance, Industry, Agriculture and Environment, as well as other agencies, depending on the specifics of the public administration system in individual countries. As the system of "green" growth indicators originally formulated by the OECD in 2011 is constantly advancing, further work is needed to develop the methodological approaches to adjust or include new regional level model blocks (for more interconnections between economic, social and environmental parameters). For further advancement, there will be a need to take into accountnew areas,such as linking the efficiency of production with resources consumed, and pollution generated in the environment.

To implement the substantive environmental blocks of the model in practice, useof the System of Ecological-Economic Accounting, recently approved by the UN, is needed. In accordance with the OECD Guidance for the countries ofthe Eastern Partnership, (which includes a number of post-Soviet countries, including Ukraine) (OECD, 2016), there is no defined system of indicators within the designated four previously mentioned areas. Thus, it is proposed to define for each country such "green" growth indicators, in line with the characteristics and priorities for socio-economic development of individual countries.

Implementation of the methodology presented above for building multi-regional models for regional medium-term forecasting, taking into account social and environmental parameters, will help to ensure that new indicators of regional well-being, including "green" growth indicators.and appropriate government policy measures, have been used to achieve strategic goals of socio-economic development and beneficialinternational cooperation.

ЛІТЕРАТУРА

1. Барка Ф. Порядок денний реформованої політики згуртованості: місцевий підхід до вирішення викликів та очікувань Європейського Союзу. Незалежний звіт, підготовлений на замовлення Європейського комісара з питань регіональної політики Данути Хабнер. Брюссель. – 2009.

2. Барка Ф., Макканн П. та Родргігес-Поз А. Дослідження управління регіональним розвитком: підходи управління на місцях та нейтральні підходи / Ф. Барка // Журнал регіональної науки. – 2012 - №52. – С. 134–52.

3. Коффано М., Форай Д. «Ключова роль підприємницьких ініціатив у створенні та впровадженні розумної спеціалізації / М. Коффано // Scienze Regionali - Італійський журнал регіон. – 2014. - №13. – С. 33-50.

4. Камагні Р., Капелло Р. Регіональні інноваційні структури та реформа регіональної політики ЄС: до розумної інноваційної політики. – 2013. - Зростання та зміни № 44 (2). – С. 55–89.

5. Варга А. Місцеві підходи, просторово сліпі або обидва? Виклики щодо оцінки наслідків сучасної політики розвитку: моделювання впливу ГМР підходів // Міжнародний регіональний науковий огляд – [Електронний ресурс]. – Режим доступу: http://dx.doi.org/10.1177 / 0160017615571587.

6. Капелло Р., Карагліу А., Фратезі У. Моделювання регіонального зростання між конкурентоспроможністю та заходами жорсткої економії: модель MASST3 // Міжнародний регіональний науковий огляд. – [Електронний ресурс]. – Режим доступу: http://dx.doi.org/10.1177 / 0160017614543850.

7. Панічча Р., Горі Г. Структурна багатосекторальна модель з новими економічними зв'язками географії для Тоскани. Доповіді з регіональної науки.

8. Брандсма А., Канч Д., Монфорт П., Ріллерс А. RHOMOLO: Динамічна просторова модель загальної рівноваги для оцінки впливу політики згуртованості. Документи в регіональній науці. - №94. С. 197 – 222. – [Електронний ресурс]. – Режим доступу: http://dx.doi.org/10.1111/ pirs.12162

9. Мерсеньєр Ж., Алварез-Мартінез М. Т., Лопез-Кобо М. Врандсма А. та ін. Опис моделі RHOMOLO-v2: Просторова обчислювана модель загальної рівноваги для регіонів та секторів ЄС, Технічний звіт. Люксембург: Управління публікацій Європейського Союзу, 2016.

10. Капелло Р., Фратезі У. Моделювання регіонального зростання: вдосконалена MASST модель // Просторовий економічний аналіз. - 2012. - №7:3. - С. 293-318.

11. Рамаджо Дж., Маркес М. А., Хьюінгс Дж. Д. Просторово-часовий аналіз регіональних систем: багаторегіональна просторова векторна авторегресивна модель для Іспанії» // Міжнародний регіональний науковий огляд. – [Електронний ресурс]. – Режим доступу: http://dx.doi.org/10.1177 / 0160017615571586.

12. Capello R., Fratesi U., Моделювання регіонального зростання: вдосконалена MASST модель // Просторовий економічний аналіз. – 2012 - № 7. С. 293-318.

13. Ратто М., Роєгер В., Вельд Дж. Орієнтовна відкрита модель DSGE єврозони з фіскальною та валютною політикою. Економічне моделювання. – 2009. -- №22 – С. 22-33.

14. Оптимізація територіальних систем / за ред. С. А. Суспіцина. Новосибірськ: ІЕОПП СО РАН, 2010. - 632 с.

15. Широв А.А. Багаторівневі структурні дослідження як інструмент обґрунтування економічної політики. [Електронний ресурс]. – Режим доступу: http://www.dslib.net/econom-teoria/mnogourovnevye-strukturnye-issledovanija-kak-instrument-obosnovanija-jekonomicheskoj.html (дата доступу 29.05.2019).

16. Узяков М.Н. Сапова Н. Н. Херсонський А. А. Інструментарій макроструктурного регіонального прогнозування: методичні підходи та результати розрахунків // Проблеми прогнозування. – 2010. - №2. - С. 3-21.

17. Шкуропат А. В. Економічні тенденції та роль макроекономічної політики: методологічний аналіз. Таджикистан в перехідному періоді: чи може макроекономічна політика боротися з бідністю, російська версія / за ред. А. Шкуропат. Рига: Tiesu namu agentura, 2014. ISBN 978-9934-508-15-8

18. Адамс Ф., Діксон Дж., Гісекке Дж., Хоррідж М. MMRF: Мультирегіональна модель прогнозування. Динамічна мультирегіональна модель економіки Австралії, Центр політичних досліджень, Університет Монаш. - 2010.

19. Сассі О., Крассус Р., Хуркад Дж., Гітз В., Вайсман Х., Гуйварч С. IMACLIM-R: основи моделювання для імітації шляхів сталого розвитку // Глобальні екологічні проблеми. т. 10 - 2010. - № 1/2 – С. 5–24.

20. OECD, показники зеленого зростання 2014: (російська версія), OECD Publishing, Париж. - [Електронний ресурс]. – Режим доступу: URL: http://dx.doi.org/10.1787/9789264256767-ru.

REFERENCES

1.   Barca, F. 2009. «An Agenda for a Reformed Cohesion Policy: A Place-based Approach to Meeting European Union Challenges and Expectations» Independent Report, prepared at the request of the European Commissioner for Regional Policy, Danuta Hubner. Brussels.

2.   Barca, F., P. McCann, and A. Rodr`ıguez-Pose. 2012. «The Case for Regional Development Intervention: Place-based versus Place-neutral Approaches» Journal of Regional Science 52:134–52.

3.   Coffano, M., and D. Foray. 2014. «The Centrality of Entrepreneurial Discovery in Building and Implementing a Smart Specialisation» Scienze Regionali - The Italian Journal of Regional Science 13:33–50.

4.   Camagni, R. and R. Capello. 2013. «Regional Innovation Patterns and the EU Regional Policy Reform: Toward Smart Innovation Policies» Growth and Change 44 (2):355–89.

5.   Varga, A. 2015. «Place-based, Spatially Blind or Both? Challenges in Estimating the Impacts of Modern Development Policies: The Case of the GMR Policy Impact Modeling Approach»// International Regional Science Review. doi:10.1177/0160017615571587.

6.   Capello, R., A. Caragliu, and U. Fratesi. 2015. «Modeling Regional Growth between Competitiveness and Austerity Measures: The MASST3 Model» // International Regional Science Review.doi:10.1177/0160017614543850.

7.   Paniccia, R., and G. Gori. 2015. «A Structural Multisectoral Model with New Economic Geography Linkages for Tuscany» Papers in Regional Science. Accessed January 28, 2015.

8.   Brandsma, A., D. Kancs, P. Monfort, and A. Rillaers. 2015. «RHOMOLO: A Dynamic Spatial General Equilibrium Model for Assessing the Impact of Cohesion Policy» Papers in Regional Science 94:S197–S222. doi:10.1111/pirs.12162.

9.   Mercenier J.,Álvarez-Martínez M.T.,López-Cobo M.,Brandsma A. and others. RHOMOLO-v2 Model Description: A spatial computable general equilibrium model for EU regions and sectors, Technical Report. Luxembourg: Publications Office of the European Union, 2016.

10.   Varga A., Sebestyén T., Szabó N., Szerb A., Economic Impact assessment of Entrepreneurship policies with the GMR Europe Model. Work Report, EC, 2018.

11.   Ramajo, J., M. A. Marquez, and G. J. D. Hewings. 2015. «Spatio-temporal Analysis of Regional Systems: A Multiregional Spatial Vector Autoregressive Model for Spain»// International Regional Science Review. doi:10.1177/0160017615571586.

12.   Capello R., Fratesi U., Modelling Regional Growth: An Advanced MASST Model. (2012) // Spatial Economic Analysis. 7:3, 293-318.

13.   Ratto, M., W. Roeger, and J. in't Veld. 2009. «QUEST III: An Estimated Open-economy DSGE Model of the Euro Area with Fiscal and Monetary Policy» Economic Modelling 26:222–33.

14.   Optimization of territorial systems/ edited by Dr. Suspitsyn S.A. / IEOPP SO RAS, Novosibirsk, 2010. – 632 p.

15.   Shirov A.A. Multi-level structural research as a tool to justify economic policy. URL: http://www.dslib.net/econom-teoria/mnogourovnevye-strukturnye-issledovanija-kak-instrument-obosnovanija-jekonomicheskoj.html (date of access 29.05.2019).

16.   M.N. Uzyakov, N.N. Sapova, A.A. Khersonsky. Macrostructural regional forecasting toolkit: methodical approaches and results of calculations.// "Forecasting Problems", M.: INP, RAS, 2010, №2, pp. 3-21.

17.   Shkuropat A.V. Economic Trends and the Role of Macroeconomic Policy: Methodology Analysis// Tajikistan in Transition: Can good Macroeconomic Policy combat Poverty, Russian version, Generaleditionof AnnaV. Shkuropat, Riga: Tiesu namu agentura, 2014., ISBN 978-9934-508-15-8

18.   Philip Adams, Janine Dixon, James Giesecke & Mark Horridge, MMRF: Monash Multi-Regional Forecasting Model A Dynamic Multi-Regional Model of the Australian Economy, Centre of Policy Studies, Monash University, 2010.

19.   Sassi, O., Crassous, R., Hourcade, J-C., Gitz, V., Waisman, H. and Guivarch, C. (2010) 'IMACLIM-R: a modelling framework to simulate sustainable development pathways', Int. J. Global Environmental Issues, Vol. 10, Nos. 1/2, pp.5–24.

20.   OECD (2016), Green Growth Indicators 2014: (Russian version), OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264256767-ru