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Solution of one Global Problem by Approach of the Parametric Control Theory

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Abstract: Purpose of this paper is to show the potential of parametric control theory approach for the optimal solution of global problems (in the case of the food problem) and to substantiate the benefits of joint action to solve them on the basis of the developed global multi-country computable general equilibrium model (hereinafter - Model).
The main results of the paper:
Model verification (testing the possibility of its practical application) of the constructed and calibrated Model was successfully carried out by methods of parametric control theory: using sustainability assessments and assessments of sustainability indicators of smooth mappings, which are defined by the Model; as well as through conducting of series of counterfactual and forecast scenarios.
Based on the Model a number of parametric control problems were solved in finding the optimal values of the instruments of public policy, which provide economic growth, reducing the gap in economic development between rich and poor regions, as well as increasing the production of agricultural products in the regions.
Value consists in the developed Model and in showing approaches of parametric control theory on providing guidance to address global problems and to substantiate the benefits of joint action within the framework of their decision.

Keywords: Global problem, Parametric control theory, Computable general equilibrium (CGE) model, Model verification.

1. INTRODUCTION

The formed world economy (after independence of former colonies, collapse of the Soviet Union, emergence of new states and economic unions) for many years keeps the imbalances in the economic development of individual countries and regions of the planet. These imbalances formulate global and regional problems (including individual countries problems), without their solution further humanity progressive advance along the path of economic progress is impossible. The most urgent problems are the "North-South" problem - the gap in economic and social development between rich and poor countries and the associated food problem, which lies in inability of poor countries to support them completely with even vital food.

Different mathematical models are widely used to assess the scenarios of food products output in various regions of the world for different periods of time. For example, the econometric model which has been proposed in [1] is used for short-term assessment of grain yield in different parts of the US. The paper [2] contains a description of the International Food Security Assessment model, which is designed to assess food consumption, food access, and food gaps (previously called food needs) in low-income countries through 2025. Let us

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give as example the basic characteristics of the most ambitious IMPACT model [3]. It is partial equilibrium, multi-commodity, multi-country model which generates projections of global food supply, demand, trade, and prices. IMPACT covers over 46 crops and livestock commodities and it includes 115 countries/regions where each country is linked to the rest of the world through international trade and 281 food producing units. The forecast data until 2050 for the three scenarios (Baseline, Yield Increase, Energy Shock) are presented in the mentioned paper. It should be noted, that the above and other discussed models in the available literature are mainly used to obtain projections, and they have not been used for evaluation of optimal agreed measures of economic policies of different regions to address the food problem in these regions. However, it is generally recognized that for solution of these global problems it is required to have all humanity coordinated efforts and, in particular, efforts of all countries concerned states. This interest in coordinated efforts can be improved if based on the Model tested for the possibility of its practical application (that is, tested for transferring the computational experiments results into the subject area of macroeconomic analysis and the choice of the values of economic policy tools), will:

1) Reasonable optimal steps will be offered (steps which will be defined by economic policy instruments) which should be taken in order to solve these global challenges;

2) The justified assumptions that coordinated actions of all states (or at least states of the countries within regional economic union) will give a greater effect for each country than optimal uncoordinated action of this country.

In this paper, based on the macroeconomic Model developed and tested on the possibility of its practical application, the possibilities of the parametric control theory [4] approach were demonstrated to solve a number of formulated problems of parametric control; and the benefits of joint action to address them are justified. The considered parametric control problems are aimed to evaluate the optimal values of economic instruments that provide economic growth, the convergence of macroeconomic indicators and the growth of regions' agricultural output. Note that the main difference between the parametric control theory and other well-known macroeconomic theories is in using only such mathematical models that have been tested for the possibility of their practical application through a series of original and classical methods. At the same time model verification is carried out not only for its basic calculation, but for optimal scenarios resulting from solving these parametric control problems.

2. THE MODEL

2.1. General features of the Model

In this paper, a static computable general equilibrium model Globe 1 [5] is developed to describe the dynamics of functioning of interacting economies of 9 Regions: five countries (Kazakhstan, Russia, Belarus, Armenia, Kyrgyzstan) forming the Eurasian Economic Union (EAEU); European Union (EU, as one country); USA; China and the Rest of the World (as one country).

The economy of each Region of the Model includes the following 16 industries:

1 – Agriculture, forestry and fisheries;
2 – Production of crude oil and gas;
3 – Metal-working production and machine-building;
4 – Metallurgical industry;
5 – Education, Health, and Public Administration;
6 – Production and transmission of electricity, gas, and hot water;
7 – Production of Food, beverages, and tobacco;
8 – Professional, scientific and technical activities;
9 – Other industries;

10 – Other services;
11 – Mining (except for oil and gas production);
12 – Construction;
13 – Production of textiles, apparel, and leather and related products;
14 – Financial services;
15 - Chemical and petrochemical production;
16 – Transport.

In addition to the specified producers, present in each Region of the Model, there are such consumer agents as the Households and the State. In the output of products, the Industries utilize two production factors which are owned by the Households in their Region: the Labor and the Capital. In the Model there is also yet another special agent (a.k.a. Region) the Globe, importing transport services from the rest of the Regions and providing these services to other Regions for the import of goods.

The Industries, the Households, and the Government (within the framework of productions consumption) in each Region (except the Globe) are composed of a large number of representative price-taker agents, annually solving the appropriate optimization problems.

The Model, as compared to the base case of the Globe 1, was developed as follows. The static Globe 1 model was developed to become a dynamic model by describing the following variables by using dynamic equations: technological factors of production functions for the GVA of all the Industries in the Regions, and the supply of Factors by the Households in the Regions.

2.2. Conceptual description of the economy and the mathematical Model

It is assumed that Producer agents, Household agents and Government agents are assumed to be perfect rationality agents. Here we list their basic functions.

Producer agent in its activities annually:

- produces one, corresponding to the name of the Industry, type of production (subject to the condition of minimizing the costs);
- produces GVA - gross value added (based on the use of factors as the labor and the capital of the households);
- exports a part of produces production (subject to the condition of maximizing the profits);
- imports intermediate productions from other Regions and consumes intermediate production;
- pays net tax payments to their Government.

Producer agents solve following two pairs of the nested optimization problems:

- minimization costs for the purchase of the intermediate productions and GVA costs for a given production output;
- minimization costs for the purchase of the production factors at the given output of the final production;
- profit maximization from sales within the Region and beyond, at the given production output;
- profit maximization from exports to various Regions at the given level of production exports.

Household Agent in its activities annually:

- gains income from the producers in their Region on the basis of demand for the belonging to them factors;
- consumes the productions from all the Regions (according to the solution of the problem of maximizing their utility functions under the budget constraints);
- perform savings in the form of investment products based on their income and consumption;

- pays net tax payments to their Government.

Government of each Region (except for Globe) in its activities annually:

- determines the effective tax rates and receives income in the form of net tax revenue (including revenue from customs duties);
- consumes the final productions (government spending);
- performs savings in the form of investment products based on its income and expenses.

Industry, Household, and Government Agents each year jointly solve the following optimization problems:

- determination of the optimal share of imports in the consumption of each type of production subject to minimum of costs of domestic and imported components of this production;
- determination of the optimal regional structure of each type of imported production subject to minimum of costs of this type of imported production.

The conceptual description of the Model economy contains the statements of the above optimization problems with the corresponding first order conditions, other equations describing the functions of the agents, balance ratios for prices and quantities (indicators, measured in the prices of the producer), the internal balances in the accounts of the government and the external balances of trade accounts.

In the Model is used the system of endogenous prices for all the 16 types of productions of each Region, including the buyer's and seller's prices, the prices of the exporter and importer, and etc. The calculated values of the prices ensure the performance of the annual balance sheet ratios, providing for:

- the equilibrium in factor (labor and capital) markets;
- the equilibrium in the markets for each type of production;
- bilateral current account balances for each pair of the Regions;
- the equilibrium of savings (Households, Governments) and their investments in the Regions’ industries.

The mathematical Model (which has been built on the basis of its conceptual description) was obtained as the result of combining into a single set of equations describing: the first order conditions of all the agents’ optimization tasks and other rules of the agents’ activity, including the equations describing the dynamics of technological factors of production functions and the factors supply. The balance and the auxiliary equations are also included to the mathematical Model.

2.3. Source database, calibration, and calculation of the Model

The core of the database of the Model is the set of concordant Social Accounting Matrices (SAM) of the Regions for each year under review (2004-2021), which are demonstrating how the productions flows (in monetary terms) and financial flows are distributed among the Producers, Households, Governments, importers and exporters. The mentioned SAM sets for 2004, 2007, and 2011 were extracted with a special converter from the [6]. Note that in the database there are no data for the remaining years of the considered historical 2004-2014 period. Therefore, for 2005, 2006, 2008-2010, and 2012-2014 the desired sets of SAM were calculated using the developed algorithm (Algorithm 1) on the basis of the available statistical sources, containing input-output tables (see, e.g., [7], indicators of mutual trade [8], using the basic ratios calculated using the known SAM of the nearest last year (2004, 2007, or 2011). For the forecast period (2015-2021), algorithm 2 was used, which allows to calculate the mentioned SAM sets on the basis of the following look-ahead indicators of the Regions provided by the [9]: GDP, Total Investment, Imports of Goods, Imports of Services; Exports of Goods, Exports of Services, Total Government Revenues, and Total Government Expenditures. At the same time were used the basic ratios, calculated using the obtained SAMs for 2014.

In addition to the obtained SAM sets, the source database of the Model includes the values of replacement coefficients of various factors in the production function of Producers; replacement coefficients of various types of productions in the output functions of Producers, utility functions of Households and aggregation functions describing the consumption by the agents as well as the initial values of the dynamic equations of the corresponding model. These replacement coefficients were obtained from the GTAP 9 database for 2004, 2007, and 2011 and then extrapolated for the remaining years of calculation period of the Model (2004-2021).

The calibration is carried out at each start-up of the model. At this stage, on the basis of the formed database using special expressions, computation is performed of all the values of the exogenous variables in the Model for the time from 2004 to 2021.

The solution of the calibrated equation set of the Model (Model Calculation) is performed with the help of the software which was implemented in the integrated design environment of the GAMS [10] with the use of the built-in solver PATH [11]. The results of calculation of the considered baseline scenario of the calibrated Model precisely reproduce the statistical and forecast data used in the building of SAMs for the baseline database of the Model.

3. VERIFICATION (TESTING THE POSSIBILITY FOR PRACTICAL APPLICATION) OF THE MODEL

Verification of the calibrated model was performed by three methods, the first two of which were proposed by the authors within the framework of the development of the Parametric Control Theory.

3.1. Assessing the stability of smooth mappings defined by the Model

The availability of the stability properties of mapping $f : A \to B$, transferring the values of exogenous parameters $p \in A$ into the solutions (the values of endogenous variables) suggests preserving the qualitative properties of such mapping at small (in some sense) changes of the mapping. To assess the stability of smooth mapping of the specified type, based on the numerical evaluation of the fulfillment of its conditions, the authors proposed the corresponding set of numerical algorithms for the cases of immersion, submersion, and submersion with a fold [12]. In the experiments, basic mappings of types with $\dim A = 5$ and $\dim B = 9$ were considered, whereas the arguments of *f* were taken the value-added tax rates of the five EAEU countries (Kazakhstan, Russia, Belarus, Armenia, and Kyrgyzstan) for 2015. As the output variables of *f* were taken of values GDP in all the 9 Regions of the Model for 2021. A five-dimensional *A* box (with the center at the point $p = (p_1, \ldots, p_5)$, corresponding to the baseline values of the specified tax rates) boundaries are distanced from the values p_i to the value of $0.5 p_i$. It should be noted that the time to calculate the implemented mappings stability algorithms will increase approximately exponentially with increasing the dimension of *A* box ($\dim A$). This limits the use of this approach, so to obtain a reasonable calculation time the set (of the most important factors used in the solution on the basis of the model of specific problems for macroeconomic analysis and parametric control) was selected.

The results of the specified numerical experiments demonstrated the absence of singular points of the *f* mapping in *A* box and the stability of this immersion.

3.2. Estimation of stability indicators of smooth mappings defined by the Model

The $\beta_f(p,\alpha)$ stability indicator of (defined by the Model) mapping $f : A \to B$ at the $p \in A$ point and for the selected positive α number is the diameter of the image (when *f* mapping) of the ball with its radius α and with its center at the point *p* (in relative terms). If for all the $p \in A$ points the numerical assessment of the $\beta_f(p) = \lim_{\alpha \to 0} \beta_f(p, \alpha)$ value is uniformly close to zero, then the *f* mapping, defined by the tested model is assessed on the *A* set as continuously dependent on exogenous values.

In the experiments with the Model, as *A* set, a ball was considered centered at *p* point corresponding to the baseline values of all the tax rates in all the Regions in 2004, whereas endogenous variables B_t set – GDP, exports, and imports of all the Regions of the Model for the fixed computational year *t* (from 2004 to 2021).

As an example, table 1 shows the calculated values of the Model stability indicators (in percent) for the base point *p* and $\alpha = 0.01$.

Table 1. Values of stability indicators for the basic calculation of the Model

Year	2004	2005	2006	2007	2008-2021
$\beta_f(p, 0.01)$	0.4536	0.0813	0.0097	0.0060	0.0000

All the specified in Table 1 assessments of stability indicators do not exceed 0.4536, which characterizes the stability of the Model (in terms of the considered stability indicators) for calculations up to 2021 as sufficiently high. In particular, the acquired for the year 2004 value of the $\beta_f(p, 0.01)$ indicator means that the image of a sphere centered at the point p (corresponding to the basic values of all the 2004 tax rates) and having the radius of 0.01 (in relative terms) in the calculation of the Model is transformed into a set with the diameter of 0.4536 (in relative terms) for the output variables values (GDP, exports, and imports of all the Regions in 2021). Various options of the calculated values of the limit indicators $\beta_f(p)$ were close enough to zero at $\alpha = 0.0001$, which evaluates the tested mapping as a continuous one in *A* box.

3.3. Implementation of counterfactual and forecast scenarios

According to the well-known macroeconomic theory, the reduction of taxes levied on producers and consumers, as well as the increased state demand for consumer products will increase the country's output and GDP. As part of its testing, based on the Model counterfactual and forecast scenarios were calculated to assess the implementation of the provision of the theory. In particular, the scenario was performed featuring a 10% decrease in the effective tax rates of value added tax, tax on the producers' income and 10% increase in government consumption in each EAEU country. The results of the calculation of this scenario demonstrated an changes in GVA in each sector in the relevant country (ranging from -3.85% to 6.16%) and increases in GDP in each Region ranging from 0.0279% in 2009 for global economy to 0.7715% in 2012 for EAEU, compared with the observed data.

The above results of the three test methods make it possible to draw the conclusion of a successful verification of the tested Model.

4. SOLUTIONS TO PARAMETRIC CONTROL PROBLEMS ON THE BASIS OF THE MODEL

As part of the proposal of optimal measures to reduce the gap in economic development among the Regions, as well as of the action to increase agricultural output, a series of parametric control problems were solved on the basis of the Model. In those problems, the values of all the uncontrolled exogenous variables of the Model match the baseline forecast of the variables. Hereinafter indices correspond to the Region number ($i = 1, \ldots, 9$ – the Regions of the Model): 1 – Kazakhstan, 2 – Russia, 3 – Belarus, 4 – Armenia, 5 – Kyrgyzstan, 6 – European Union, 7 – USA, 8 – China, 9 – the Rest of the World; 10 – Eurasian Economic Union, and 11 – World Economy.

Statement of the P_i problem ($i = 1, \ldots, 11$)**:**

To identify on the basis of Model the values of the control parameters $u(t)$ (effective tax rates for producers revenues, sales and customs duty taxes differentiated by production and industry sector: shares of public spending for consumption) that provide the maximum value of the K_i criterion (2) - (4) *with constraints on control instruments of $u(t) \in U(t)$ type and with restrictions* (1) *for some of the endogenous variables.*

Here, for $t = 2015, \ldots, 2021$; $U(t)$ – is a box with the center at the point of base values $u(t)$ and boundaries spaced at ± 10% of the baseline values. For P_i, ($i = 1, \ldots, 9$) problems the $u(t)$ control parameters are the specified public policy tools only for *i*-th Region, for the P_{10} problem – those of the five EAEU countries, and for the P_{11} problem – those of all of the nine Regions of the Model in the aggregate.

The restrictions for the endogenous variables of the Model in all the P_i problems look like:

$$QVAP_r(t) \geq \overline{QVAP_r}(t),\ r = 1, \ldots, 9,\ t = 2015, \ldots, 2021. \quad (1)$$

Here: $QVAP_r(t)$ is GDP per capita in the Region *r*, $\overline{QVAP_r}(t)$ are the basic values of this indicator. Meeting the conditions (1) will guarantee that subject to the solving by any Region (or by the 5 countries making up the EAEU, or by all the Regions of the Model) of their P_i problems, the values $QVAP_r(t)$ will not decrease (compared to the baseline forecasts), both in their specific Regions and also in all the other Regions of the Model.

In each of the first formulated P_i problems, ($i = 1, \ldots, 9$), pursuance of the optimal fiscal policy aimed at the economic growth is supposed and the growth of agricultural output during 2015-2021 in their specific Regions is supposed, whereas the behavior of the rest of the Regions of the Model is characterized by the baseline values of the exogenous variables. Therefore, in these problems the K_i criterion is recorded as:

$$K_i = \sum\nolimits_{t=2015}^{2021} \left(TQVA_i(t) + \alpha TQXA_i(t) \right),\ i = 1, \ldots, 9 \quad (2)$$

where $TQVA_i(t)$ is GDP per capita rate, $TQXA_i(t)$ is the rate of output of industry (agriculture, forestry, and fisheries) per capita in the Region *i* in year *t* (in current USD) and α is adjusted factor ($\alpha = 0.3$).

It is assumed that in the P_{10} problem carrying out a coordinated optimal fiscal policy within the framework of the five EAEU countries in 2015-2021 as aimed at the economic growth, the growth of EAEU agricultural output, and the approximation of the per capita GDP values in each of the five EAEU countries to the respective values in the United States. (USA, (*r* = 7) is the Region having the highest value of GDP per capita of all the Regions according to the calculation in the Model until 2021). Therefore, the problem criterion K_{10} was selected as follows:

$$K_{10} = \sum\nolimits_{t=2015}^{2021} \left(TQVA_{10}(t) + \alpha TQXA_{10}(t) \right) - \frac{\beta}{\sum\nolimits_{r=1}^{5} \varepsilon_r} \sum\nolimits_{r=1}^{5} \left(\varepsilon_r \sum\nolimits_{t=2015}^{2021} \frac{QVAP_7(t) - QVAP_r(t)}{QVAP_7(t)} \right). \quad (3)$$

Here $TQVA_{10}(t)$ is the rate of GDP per capita of EAEU in the year *t*; is the rate of output of agriculture, forestry, and fisheries per capita in the EAEU in year *t*; $QVAP_r(t)$ is GDP per capita in the Region r in year t; ε_r is the weighting factor, its value equal to $\varepsilon_r = 0.1$ for medium-developed Regions (Kazakhstan and Russia), and $\varepsilon_r = 1$ - for all other Regions - EAEU members; β is adjusted factor ($\beta = 1$).

In the P_{11} problem it is considered the hypothetical possibility of coordinated optimal fiscal policy within the framework of all Regions of the Model in 2015-2021, aimed at the global economic growth, the growth of world agricultural output, and the approximation of the GDP values per capita in each Region to the respective values in the United States. Therefore, the problem K_{11} criterion was selected as follows:

$$K_{11} = \sum_{t=2015}^{2021}\left(TQVA_{11}(t) + \alpha TQXA_{11}(t)\right) - \frac{\beta}{\sum_{r=1}^{9}\varepsilon_r}\sum_{r=1}^{9}\left(\varepsilon_r \sum_{t=2015}^{2021}\frac{QVAP_7(t) - QVAP_r(t)}{QVAP_7(t)}\right). \quad (4)$$

Here $TQVA_{11}(t)$ is the rate of the world GDP per capita in the year t; $TQXA_{11}(t)$ is the rate of the global output of agriculture, forestry, and fisheries per capita in year t; the value of factor $\varepsilon_r = 0.1$ for $r \in \{1, 2, 6, 8\}$, $\varepsilon_7 = 0$ and $\varepsilon_r = 1$ for all other r values.

The formulated problems were solved numerically using the optimization algorithm provided by GAMS [13]. The results of their resolve as the increments of the average GDP value of and the increments of the average output of agriculture, forestry and fisheries in the Regions for 2015-2021 (per capita, in percent relative to the baseline scenario) are shown in tables 2 and 3.

Table 2. The average value increments of the output in agriculture, forestry, and fisheries in the Regions following the solutions of the 11 P_i problems

Problem	Number of Region								
	r = 1	r = 2	r = 3	r = 4	r = 5	r = 6	r = 7	r = 8	r = 9
P_1	**3.8219**	0.0026	0.0224	0.0007	0.7509	0.0009	0.0012	0.0028	0.0007
P_2	0.0353	**6.7404**	0.5553	0.8582	0.8786	0.0059	0.0078	-0.0008	-0.0056
P_3	0.0107	0.0121	**6.8270**	0.0056	0.7580	0.0014	0.0011	0.0010	0.0013
P_4	0.0047	0.0011	0.0018	**2.8709**	0.0076	0.0000	0.0001	0.0001	0.0000
P_5	0.0095	0.0011	0.0065	0.0002	**1.3197**	0.0000	0.0001	0.0008	0.0001
P_6	0.4617	0.4226	0.8165	0.9414	0.6130	**10.1658**	0.3555	0.1951	0.4326
P_7	0.0582	0.0856	0.0863	0.0586	0.7361	0.1427	**5.7370**	0.0741	0.1958
P_8	0.0767	0.0818	0.0397	0.0370	0.6741	0.0415	0.2032	**6.7602**	0.1166
P_9	0.2160	0.2357	0.1609	0.2441	0.0277	0.1398	0.3250	0.0760	**6.3946**
P_{10}	**4.0196**	**6.8185**	**11.6397**	**3.7374**	**1.3891**	0.0084	0.0082	0.0002	-0.0054
P_{11}	**4.9816**	**7.8776**	**13.1665**	**5.3487**	**4.5170**	**10.9244**	**7.0752**	**7.6066**	**6.8962**

Table 3. The average values of increments of GDP of the Regions following the solutions of the 11 P_i problems

Problem	Number of Region								
	r = 1	r = 2	r = 3	r = 4	r = 5	r = 6	r = 7	r = 8	r = 9
P_1	**0.5949**	0.0008	0.0089	0.0005	0.0000	0.0005	0.0000	0.0007	0.0003
P_2	0.0298	**1.4875**	0.4111	0.6758	0.0574	0.0000	0.0000	0.0000	0.0000
P_3	0.0073	0.0073	**0.7963**	0.0042	0.0000	0.0005	0.0000	0.0000	0.0009
P_4	0.0002	0.0001	0.0001	**1.4413**	0.0000	0.0000	0.0000	0.0000	0.0000
P_5	0.0002	0.0001	0.0000	0.0000	**1.5198**	0.0000	0.0000	0.0000	0.0000
P_6	0.3606	0.4084	0.4073	0.9281	0.8454	**1.9219**	0.1035	0.1062	0.2595
P_7	0.0310	0.0498	0.0448	0.0656	0.0000	0.0611	**0.7446**	0.0265	0.1107
P_8	0.0678	0.0256	0.0210	0.0374	0.8326	0.0390	0.0402	**1.1463**	0.0467
P_9	0.1206	0.1123	0.0630	0.2134	0.2164	0.0885	0.0558	0.0939	**0.9169**

P_{10}	**0.7659**	**1.4433**	**4.3875**	**2.1344**	**3.0802**	0.0000	0.0000	0.0003	0.0000
P_{11}	**1.4083**	**2.0763**	**5.2096**	**3.7368**	**5.9613**	**2.1219**	**0.8123**	**1.4071**	**1.1225**

The obtained optimal values of economic policy tools of the discussed above parametric control problems were tested for the possibility of their practical implementation as follows. The scenario options of the calibrated Model for the specified optimum values of the tools were tested by the three methods referred to in Section 3. In all cases, the results were obtained similar to the above ones specified in Section 3 for the baseline scenario, namely:

- Permissible values of assessments of stability indicators;
- Absence of singular points of the considered mappings in their appropriate domains and the stability of these mappings and
- Coincidence of the results of the 2015-2021 forecast scenarios to the main provisions of the macroeconomic theory.

Analysis of bold type numbers in each column of Tables 2 and 3 shows that within problems P_i, $i=1,\dots,11$, the approach of parametric control at the level of all Regions (the problem P_{11}), as well as at the level of the five countries of the EAEU (the problem P_{10}), for the most part gives greater effects for separate Region in comparison with parametric control at the level of separate Region (problems P_i, $i=1,\dots,9$).

Additionally, as a result of solving the problem P_{11} was reached the alignment of regions economic development, which is characterized by a decrease ratio of the maximum to minimum per capita GDP of all regions to 4.86% in 2021 as compared to the option without control; 4.17% to 2021 compared to 2015. The growth rate of per capita GDP in 2021 was also achieved in comparison with 2015 at 29.32%, 30.86% and 20.10% respectively for Kyrgyzstan, Armenia, and Rest of the World (less developed regions). Generally, across the world, as a result of solving the problem P_{11} the growth of GDP per capita in 2021 is 1.31%, while industry output growth in Agriculture, forestry and fisheries per capita is 7.89% compared to the base case. At that growth of global GDP per capita in 2021 is 22.38%, and industry global output growth in Agriculture, forestry and fisheries per capita is 38.41% compared to 2015.

Analysis of the problems P_i solving results and the results of relevant tests shows the high potential of parametric control approach to make recommendations for optimal coordinated government economic policy at the global level and at the level of regional economic union.

5. CONCLUSION

1. The results of the development of the dynamic global multi-country computable general equilibrium Model are presented. The Model is calibrated using the SAMs, as extracted from GTAP Data Base, and obtained by extrapolation of extracted SAMs.
2. The results of the Model verification with using of the three approaches are presented.
3. There are presented problem statements and the solution results of the 11 parametric control problems which are aimed at economic growth, output growth of agricultural production and reducing the gap in economic development between the rich and poor regions. These results demonstrate the effectiveness of the approach of the parametric control theory to develop recommendations to address global problems.

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