Mathematical Principles of the Dynamic Forecasting Model of the Aggregate Demand in the Russian Federation

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Abstract: Today there is a variety of methods and approaches to prognosticating economic indexes. The issue of their application in the Russian reality and satisfaction of clients’ needs is of paramount importance. The selected CGE-model method is conditional upon the customers’ need to have a possibility to not only provide scenario variants of the economic development forecast in the Russian regions, but also to predict consequences by changing regulation characteristics of certain economy management areas. This article exposes the main mathematical functions reflecting the principles of dynamic modeling and forecasting of the economy of the Russian regions.

Key words: GCE-models % Aggregate demand % Economic forecasting % System and dynamic modeling % workforce % Financial resources % Production assets % Investments

INTRODUCTION

The notion of the overall demand is a basic notion in macroeconomic science and the “Model of overall demand – overall supply” was explored by renowned scholars, such as John Keynes, who has elaborated an economic model which whose help he tried to explain the causes of mass-scale unemployment and low rates of output growth. Embedded into such type of models are numerous inter-dependencies, reflecting economic processes in the regions under study, whilst the forecasting of the overall demand is an urgent issue for trade and economic policies of the country [1-4]. As is known, the overall demand in macroeconomics is construed as the overall demand for the workforce, goods and services, for financial resources and industrial funds. One of the ways to model the current overall demand is to construct systems-dynamic models [2, 4-6]. It should be noted, that the notion *Systems dynamics* was first coined by J.Forrester in mid-1950s and the relevant route in the study of complex systems later saw rapid development [7], assisted mostly by the computer-aided modeling [8]. The method of systems of balance equations with the use of the utility of economic agents function and iteration procedures function (CGE-model or the agent oriented model) was selected for the mathematical description and construction of the dynamic model for forecasting the overall demand in Russia [2, 4].

Description of the Model of Aggregate Demand in the Russian Federation: Formulation of models of this type usually begins with sorting out economic agents whose activity and relations determine the structure of the economy under study. In the current variant of the model, the following economic agents are sorted out: regional population (hereinafter “population”), federal government, regional and municipal governments in aggregate (hereinafter “regional government”), foreign countries and organizations grouped by the types of their economic activity and production scale in the regions (hereinafter “organizations”) [1]. According to the current administrative-territorial division in Russia, there are 83 constituent regions. In terms of the peculiarities of the methodological recording of organizations applied by the Federal Service for State Statistics (Rosstat), the model sorts out and prognosticates 30 types of economic activity (Chart 1) [9] which are divided into two groups by the production scale: large and medium organizations and
small and micro organizations with counting up the
organizations’ shadow activity [10]. The last two types of
economic activity shall be recoded as supplemental
information for calculating initial values and calibrating
model values.

Another essential element for CGE-model making is
sorting out the markets through which the economic
agents’ financial resources are redistributed. Each market
determined with a product (an article of goods or a
service) traded thereon, the price for this product and
market operating principle.

The model sorts out two types of market: intermediate market and final market. Each market has two
operating principles mechanisms – state pricing and
market pricing. Depending on the market type, the model
sorts out the following products: intermediate product –
30 articles of goods in accordance with the products
manufactured by the organizations grouped by their
activity type and final product – foodstuffs, nonfoods
and services rendered by producing organizations
grouped by their activity type (total 10 articles of goods).
Besides that, the model sorts out three levels of the
market – intraregional pricing market, All-Russian pricing
market and independently reviewed international market.

The major task of the aggregate demand model in the
Russian Federation, which is a part of the developed
program-technical complex of dynamic models of
economic development forecasting and need for labor
resources for the socioeconomic systems of different
levels ordered by the Ministry for Education and Science
of the Russian Federation, is in labor resources needs
forecasting. In accordance with the classification of
organizations by the type of their economic activity, this
need is determined by the production scale in each
constituent region of the Russian Federation.

The model does not separate the financial activity of
economic agents into separate markets like it is done in
the CGE-model by V. L. Makarov “Computable Model of
the Russian Economy'”[2]. Due to the significant influence upon the Russian economy from the world financial investment climate, the income from financial and investment activity is set by experts. In the future, this model area will be studied in detail with a view to searching for dependences of the financial profit index on the local population’s financial competence, financial activity of the organizations grouped by the type of their economic activity, presence of savings and macroeconomic conjuncture.

The governing characteristic of the CGE-model is the economic agents’ balance sheet total. We determine this value as “economic agent’s budget” equal to the value of the economic agents’ disposable financial resources in the target year. The budget of the economic agents - organizations is equal to the sum of undistributed financial assets of the prior period, mathematically evaluated manufacturing capability of the organizations, total financial assistance from the federal and regional governments and the independently reviewed financial income of the organizations received from their investment and financial activities.

\[ B(t) = B(t-1). Ost(t-1) + Y(t). Oy(t) + U(t) + F(t), \]

(1)

where \( B \) – economic agent’s budget, \( Ost \) – the share of the undistributed financial resources of the prior period, \( Y \) – organization’s manufacturing capability, \( Oy \) – the share of the products sold, \( U \) – total financial assistance to the organization from the federal and regional governments, \( F \) – independently evaluated income of the organization from its investment and financial activity.

From the analysis of the summation of the organizations’ budgets by various types of their economic activity, we can see that the importance of their factors is different. Like this, the foundation of the budgets of the non-budget sector organizations manufacturing goods and services (activity types from 1 to 26) is formed by their production capability which is set with a production function of the following type:

\[ Y = f(k,l,z) \]

(2)

where the main production assets \( k \) serve as production factors, organization’s average number of listed employees adjusted by the share of the unsatisfied labor force need ranked by the importance of its use in the production process \( l \) and the organization’s disposable working resources during the year \( z \). The value of the production function \( Y \) shows the volume of the output of goods and services per year in the value terms of the base year prices. It is advisable to select the year of 2002 to be the base year in the model as Rosstat has been publishing information in the new classification of organizations by the types of their economic activity since 2002.

In the economy under study, the classic approach to economy modeling through a production function of the capital and labor (the Cobb-Douglas production function) [11], was detailed to the object of research – the estimation of the impact of the labor resources upon the output of the final product and determination of scarce jobs in the economic management areas. For these purposes, a survey was conducted among the labor and employment market experts and the results were summarized into importance vectors for each type of economic activity.

For the organizations of such economic activity types as “State Administration”, “Health Care” and “Education”, where the share of state-financed organizations is rather significant, the base for budgeting is formed with redistributed resources of the federal and regional governments \( U \).

Then the economic agent divides the created product \( Y \) into parts depending on which markets this product is sold on:

\[ Y = Qx + Qc + Qex, \]

(3)

where \( Qx \) – intermediate product, \( Qc \) – final consumption, \( Qex \) – exported goods and services.

The demand \( D \) for a certain product is determined by three things: disposable budget \( B \), \( O \) – share of expenditure on a certain product and the product price \( P \) on the market, namely:

\[ D = \frac{B.O}{P}. \]

(4)

Thereby, the problem of the economic agent-manufacturer is in dividing the total budget they dispose into shares (parts) by the number of purchasable products plus a part kept as a reserve, as well as a part for payment of taxes. In the simplest variant these shares for product consumption are fixed, for instance, they may be set as equal to the shares of the prior period. This is so-called absolutely inertial behavior. Inertia lowers if the shares are adjusted in the following period depending of the agent’s target function which the agent is trying to maximize.
The process of redistribution of financial resources between economic agents is achieved with the Arrow-Debreu iterative process which presupposes recalculation of the product price depending on the discrepancy of the demand and supply for a certain product on the market under study.

Mathematically this pricing procedure looks the following:

$$P(t) = P(t-1) + \frac{D(t) - Q(t)}{(D(T) - Q(T)).100}$$ (5)

where \(P(t)\) – price for the product in the iterative process where the initial value of the product price on a certain market is equal to the product price in the prior year \(P(t) = P(T-1)\), \(D(T)(t)\) – the demand for the product in the current period and iterative process is formed similarly to the price in the iterative process, \(Q(T)(t)\) – the supply of the product in the current period and iterative process is formed similarly to the price and demand in the iterative process.

This formula shall be recounted \(n\) times depending on the elasticity of the market under study \(g\) which is determined by retrospective analysis of the markets and independent long-term forecasts. That is, the iterative process continues until the difference between the demand \(D\) and supply \(Q\) of the product is higher than the elasticity figure \(g(|D(T) - Q(T)| > g)\). At a completely inertial model execution, in which the shares of demand and supply of the product do not change and where the market elasticity is not monitored, the number of iterations \(n=100\).

After pricing the goods, they redistribute finances between economic agents, recount the economic agents’ assets and start up the dynamic procedure of calculation of the indexes of the following forecasted period.

CONCLUSIONS

The described algorithm for constructing the dynamic model of overall demand in the Russian Federation allows to understand the logic of constructing a model for forecasting the economic development of the country. The proposed methodics for grouping the organizations in determining the grouping types of the economic subjects – OKVED (National Classifier of the Types of Economic Activity) – allows to state the inclusion of the full circle of organizations into the model complex. The model is helpful in tracking full employment and identifying unregistered unemployment. The applied mathematical apparatus for determining the prices’ indices in the markets singled out in the model allows to finely assess the price fluctuations due to changed preferences in expenses with different economic agents, as well as the alterations in the customs import-export regulation and in the structure of output in the country.

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