A MACRO MODEL OF GEORGIA'S SOCIOECONOMIC DEVELOPMENT AND ITS USE IN FORMING ECONOMIC POLICY

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Introduction

Macroeconomic modeling of the national economy is an analytical tool based on scientifically proven ideas designed to examine the possible growth rates of the gross domestic product (GDP), its rational allocation into consumable and accumulable parts, investment efficiency, and return on capital and labor employed. It can be used to designate the most important long-term indicators, such as rate of return. And all of this, in turn, provides starting points for drawing up structural and investment policy at the interstate and interregional level for bringing the designated economic growth rates to fruition.

Problem Statement

Scientists have long been engaged in developing the theory of macroeconomic dynamics and its most important element, production functions (PF). But several questions remain unanswered:

1. The interrelations between the branches of the production and nonproduction spheres have not been specifically established, and the benefits of the activity of the latter are still undetermined. However, the nonproduction branches include those that are considered a "productive force" (science, education, and management). So the degree of interaction between the factors of production and nonproductive factors of intensification of the economy must be determined.
2. The main goals of socioeconomic development require clarification and correlation in macroeconomic terms.
3. These elaborations should be directed at defining and resolving the problems associated with the optimal allocation of resources for developing production and intensification factors and with optimizing the rates and proportions for achieving the designated goals.
4. The question of correlating macroeconomic development models for separate regions of Georgia should be analyzed. It is also very important to compare the results obtained in the Caucasian and Central Asian countries.

An economic and mathematical analysis of production at the macro level is based on building and studying PF; it shows in condensed form how the results of the production process are achieved under the influence of the main production factors, which makes it possible to determine the inputs activity ratio.

In particular, PF make it possible to study the labor cost effectiveness and the efficiency of various production assets, as well as the factors substitutability boundary. They also make it possible to determine the most rational proportions (with respect to the end result) and, in so doing, form the most important element of models of macroeconomic dynamics.

PF have great potential when analyzing technical progress (TP) and its contribution to the aggregates of production growth dynamics.

In actual fact, PF should make it possible to assess the cost effectiveness of R&D, study the type of technical progress (labor-using, capital-using, or neutral), and determine the contribution of TP to economic development as a whole.

PF should form the foundation of a macroeconomic theory designed to examine the dynamics of the aggregate quantities of national economic development based on an analysis of quantitative growth and the level of employment of productive resources, as well as the type and rate of technical progress. This theory will help to calculate GDP dynamics (as well as other economic indices) in the future and the proportions of its allocation with respect to different types of consumption and accumulation. This applies to forming basic productive and nonproductive assets, to household property, to the amounts of resources used and reproduced, in particular regarding the state of the environment, and to determining investment efficiency.

Review of the Literature

Studies of PF are accompanied by many difficulties, since their results have almost always been subjected to severe criticism, particularly as far as macroeconomic models are concerned.

Their use in applied studies of microeconomic functions that allow for a quantitative study of the contribution of different factors to industrial output does not usually arouse any major objections (the same also applies to the use of correlation analysis). But macroeconomic functions are not simply equations of correlation. They are economic models that study the most important theoretical and practical characteristics and interrelations in the national economy. Being conceptual

models, PF are based on certain theoretical postulates regarding the driving forces behind economic growth, as well as the characteristics of production efficiency and of extensive and intensive factors of development.

So it seems we cannot wave aside the theoretical criticisms of PF with the simple assertion that these functions study, using methods of correlation analysis, purely technical interrelations in production and have nothing to do with high theory.

Particularly fierce discussions developed around the so-called production factors theory based on a theoretical interpretation of the conclusions obtained using three-input PF, according to which labor, capital, and land resources interact on equal terms and the workers', capitalists' and landowners' incomes should be proportional to the benefits, that is, to a marginal return on the three inputs: labor, capital, and land.

PF are often criticized from the viewpoint of how appropriate they are in terms of the real processes going on in the national economy, although only some of their functions are criticized, primarily the Cobb-Douglas two-input function. And it certainly does have a number of weaknesses: the entire product growth is attributed to the quantitative growth of labor and capital, only neutral technical progress is permitted, and instant transformability and substitutability of the inputs (almost unlimited) and in-singular elasticity-of-substitution, etc. are presumed.

This limitation of a specific function can usually be overcome within the framework of various modernized PF models, where the range of factors is expanded, neutral technical progress is possible, there is constant or variable elasticity-of-substitution which is only possible for newly introduced factors, and so on. However, the PF theory still has many deficiencies.

- **First,** PF are traditionally of an extremely universal nature; their structure presumes a description of the dependence of the production results on constantly changing factors, whereby the boundaries of these changes are not indicated.

  The adequacy of this formulation arouses great doubts. It is obvious that the structure of productive forces, which corresponds historically to small magnitudes of the capital-labor ratio, entirely differs from that which corresponds to large ones. So past, present, and future periods should be characterized by very different technical laws, and we can hardly expect to successfully describe production evolution using one universal function.

  In our opinion, spline modeling in which the PF parameters are not a constant but are determined for individual time paths with a relatively homogeneous technical structure may be very propitious in this respect. Usually the length of these paths is not given in advance, but is determined based on the demand for the best approximation of the entire set of observations.[1]

  In developed countries, basic equipment usually has a lifespan of 5-10 years. In transition economies, equipment is not replaced for another five years in order to coincide with the five-year presidential programs.

  Equipment replacement in the TP age has such an impact on the overall functioning of production that it should evidently have a noticeable effect on PF parameters even at the level of the national economy.

  The calculations presented below confirm this presumption.

  So we think a modification of the spline approach should be used in which the time paths for determining the production laws piecewise are given in advance. We are essentially dealing here with the old technique of localizing correlation parameters by studying the corresponding dependences based on several time paths.

[1] See: D.N. Weil, *Economic Growth,* Second edition, Brown University, 2008, 547 pp.

- **Second,** linear spline PF have revealed the limitation of the traditional presumption which says that their describing surface should pass through the origin of coordinates. At first glance, this presumption is natural: at zero inputs the output should also be zero. But if this specific technical law, which reflects the type of PF, refers only to a certain range of change in inputs, its extrapolation, which comes close to zero, will be incorrect, so it is not correct to demand that it provide legitimate values in this area.

  It is more likely the other way around: if the law in effect at the given time is extrapolated toward lower values of the capital-labor ratio, at a certain critical value, production will cease to function, and its output will be equal to zero.

  At present, economic growth is being generated by an abrupt increase in the capital-labor ratio, but this also has the opposite effect: its decrease (in the same technical structure) will lead to a rapid curtailment of production.[2]

  So regardless of whether the linear or nonlinear spline PF is used, its describing surfaces in no way have to pass through the origin of coordinates, and, as a rule, will not pass through it.

- **Third,** quantitative estimates of inputs are extremely inadequate characteristics of production potential. In the TP age, qualitative characteristics of inputs and the conditions of their interaction are becoming increasingly important: the technical level, professional qualifications of workers, increase in attention to human capital (concern about housing conditions, health, free time, level of personal services, and so on), as well as production organization and management of the national economy.

  This set of inputs is often designated as taking TP into account in PF, although in reality the matter also concerns educational, organizational-management, and socioeconomic progress.

J. Tinbergen[3] was the first to attempt to take the qualitative improvement of inputs into account. He introduced the exponential factor of neutral technical progress. This made it possible to describe the residual (the total factor productivity residual of Abramovitz) growth factors, apart from the quantitative increases in labor cost and used capital. This makes it possible to assess the growth rates of scientific and technological progress and the contribution of other components of TP to an increase in GDP, and so on. But Tinbergen's approach also has serious shortcomings. It fails to make a connection between the TP rate and any of the economic variables, nor is it possible to correlate the comparative efficiency of the extensive and intensive factors or assess the optimal correlation between them.

In addition, the ways in which TP contributes to economic growth are not differentiated, in particular, its contribution to a rise in the technical level of production assets, to an increase in the professional skills of workers, and to improvement of production organization and management.

S.M. Vishnev[4] offered a five-input PF, which, in addition to the traditional factors, also included spending on R&D and education; this, naturally, implies tangibility of TP.

This approach is deficient in that it does not take into account the cumulative nature of forming scientific and technical and education capabilities, in which relatively low costs in developed countries could ensure a larger contribution of intensive factors than high costs in developing countries. In addition, this approach does not take into account the role played by improvement of production organization and management as the main factor of production intensification.

[2] See: R. Solow, "Contribution to the Theory of Economic Growth," in: Quart. I. Econ, Vol. 70, 1956.
[3] See: J. Tinbergen, H. Bos, *Mathematical Models of Economic Growth*, McGraw-Hill, New York, 1962.
[4] See: S.M. Vishnev, *Ekonomicheskie parametry*, Nauka Publishers, Moscow, 1968, 95 pp.

E. Faerman and T. Ogneva[5] took the next step in this direction. They proceeded from concepts of scientific and technical (theoretical and applied), educational, and management capabilities formed cumulatively by accumulating costs in the corresponding spheres taking into account the exclusion of elements that have become obsolete during the spending period. These capabilities have an effect, with the necessary lags, on the quality of fixed assets, personnel, and/or on the efficiency of their interaction, thus forming effective capital, effective human resources, and effective organization, which in terms of their returns exceed the quantitatively measurable values.

In this case, in our view, the main factors of production intensification have been identified and subsequently taken into account, and a link has been established between them and the qualitative changes in capital, labor, and the management system. This approach is flawed because it does not take into account the idea of spline interpretation of PF and does not focus sufficiently on the contribution of intensification factors, each of which could have an effect on all the inputs and on the efficiency of their combination.

In this study, we have attempted to develop the latter approach, combining it with the spline structure of PF. We believe that the intensification potential makes a contribution to the quality of capital and labor and has a direct effect on their overall efficiency, that is, on the output elasticity of inputs and the coefficient of their interaction efficiency. The intensification factor definitely has an effect here on the corresponding input.

We also took into account the effects of forming optimal correlations between the potential of the intensification factor and the production factor; if the potential of the intensification factor is underdeveloped, the production factor might become overdeveloped, but its net output will be low (this is how capital is formed in rapidly industrializing countries: its specific amount may be as high as in advanced countries, but its efficiency, measured in product elasticity, will continue to remain low for a long time).

If, on the other hand, the potential of the intensification factor is much higher than that of the production factor, the production system will be unable to assimilate and process ideas about expedient changes in it.

In order to take these circumstances into account,

- first, by way of the direct intensification factor, we examined the ratio of the intensification potential to that of the production factor; and,
- second, we established the nonlinear dependence (which has a maximum) of the overall efficiency of the production factor (product elasticity according to input) on its intensification factor.[6]

Modeling of the Dependence of Production Results on the Extensive and Intensive Factors of Economic Growth

The easiest way to establish the dynamics of the parameters required for tracing the contribution of intensification factors to it is to use the spline structure of PF. Forming a nonlinear spline produc-

[5] See: E.Iu. Faerman, T.E. Ogneva, "Ob otsenke effektivnosti osnovnykh napravleniy nauchno-technicheskogo progressa s pomoshchiu proizvodstvennoy funktsii," in*: Materialy III Vsesoiuznogo simpoziuma po problemam planirovania i upravleniia nauchnymi issledovaniami i razrabotkami,* Vol. 3, Moscow, 1975, pp. 227-232.

[6] See: M.G. Julakidze, *Modelirovanie osnovnykh faktorov intensifikatsii proizvodstva i ikh vozdeystivie na ekonomicheskiy rost*, Preprint, Central Economic and Mathematical Institute of the U.S.S.R Academy of Sciences, Moscow, 1984, 22 pp.

tion function from paths (as in the Cobb-Douglas function) requires introducing a lag that changes from one path to the next.

Then the cumulative characteristics of development must be calculated—science, education, and management (scientific and technical, education, and organizational capabilities). Comparison of the parameters of the PF obtained with the values of the corresponding capabilities relating to separate paths makes it possible to identify the nonlinear correlation between them.

So we get a PF with three-input TP contribution to the results of economic growth, which makes it possible to present the dynamics of production development in interaction with the nonproduction intensification fields.[7]

Production Macroeconomic Model (Taking Account of TP)

After analyzing the results of the trend, inertial, and production-optimization calculations of the aggregates of economic growth taking into account TP and its basic laws, a balanced macro model can be built.

The following apply to the balanced equations of the model:

1. Balances of the movement of production assets and intensification capabilities.
2. Balances of the movement of nonproductive assets; household property and social infrastructure.
3. Balances of the movement of labor force employed in the nonproduction sector (branches of intensification and social infrastructure) and associated with the movement of assets in these branches.
4. Overall balance of labor force.
5. Overall balance of GDP, taking into account its allocation among all types of household, social, and government consumption and among all areas of accumulation: in production, R&D, education, and management.

Trend-based forecasting implies a forecast that is obtained during autonomous extrapolation of all the indices belonging to the macro model. An inertial forecast is based on extrapolation of only the management variables of the model: consumption and accumulation in GDP, as well as depreciation standards for assets and capabilities. Production optimization is oriented toward forecasting all the sought-for variables of the model, proceeding from the system's requirement for maximizing production output.

Forecasting the optimal economic dynamics with the aid of active management of resource allocation (applied to the development of the Georgian economy) showed that it has significant reserves for raising economic growth rates.

In an extrapolated forecast of the accumulation standards, the GDP index for Georgia in 2030 noticeably increases. At the same time, a source of error in the extrapolated version is found: the unequal efficiency of investments in production and of the intensification factors, and resource re-allocation expediency are not taken into account.

[7] See: M.G. Julakidze, "Faktory intensifikatsii ekonomicheskogo rosta i makroekonomicheskaia dinamika regiona," in: *Kompleksnoe ekonometricheskoe modelirovanie narodnogo khoziaystva strany i regionov*, ed. by: A.V. Koltsov, *et al*., Central Economic and Mathematical Institute of the U.S.S.R. Academy of Sciences, Moscow, 1986, pp. 4-27.

To gain a clearer idea, let's take a look at the efficiency ratios that apply to 2005: production development costs amounted to 14.1 lari (1 lari = 0.6 dollars), scientific development and functioning costs to 16.9 lari, education costs to 10.8 lari, and management costs to 11.4 lari. The unequal cost efficiency shows non-optimal proportions of development. Therefore, an algorithm of gradual re-allocation of resources was built that relatively quickly leads to their equalization (in 5-7 years).

The forecasting results show that the strategy for raising (not reducing) the share of the scientific-educational sphere in generalized accumulations (from 9.1% to 13.4%) is the most effective, with a decrease in the traditional standard of production accumulation from 21.4% in 2005 to 13.8% in 2030. The overall efficiency of optimization according to the integral discounted GDP amounts to 12.4%.

Socioeconomic Optimized Macro Model (Taking into Account TP)

We built a criterion function and integral socioeconomic criterion of the optimality of macroeconomic development. The parameters of the criterion function were estimated for the base section of the path, presuming that the long-range path should be a smooth continuation of it.

In terms of its content, the criterion of optimality should estimate the paths of economic growth primarily in two vectors:

1. Prosperity can be specified as the achievement of certain end levels of nonproductive consumption of material goods and services. In this respect, the criterion function reflecting this category can be built as a weighted aggregate of squared deviations of actual consumption of current and semi-durable goods from their standard levels. To this we should add a similar aggregate that measures the social benefits from deviations of effective provision with durable goods and assets of social infrastructure in physical terms from the corresponding standards.[8]
2. Spiritual development can be examined in the light of two main factors: the per capita asset of work time and development of the scientific-educational and management spheres (relative employment in it). Maximization (in certain proportions) of state consumption should also be added to the social goals of economic development.

Resolution of the optimization problem resulted in obtaining forecasting indices of macroeconomic dynamics that permit an analysis of the main development trends in Georgia's national economy until 2030. The main conclusions drawn from the forecasts produced are as follows:

- First, socioeconomic optimization that forms the consumption goals of economic development leads to surplus growth of GDP and the consumption fund. According to the results of social optimization, when the consumption fund amounts to 16 billion lari, the population's rational demands for goods and services can be met.

  Production optimization, on the other hand, with a constant standard of accumulation led to an increase in the consumption fund to 19.5 billion lari, that is, to unsubstantiated hypertrophy of consumption at this level of production potential.

[8] See: E. Ostrom, *Governing the Commons: The Evolution of Institutions for Collective Action*, Cambridge University Press, New York, 1990, 377 pp.

- Second (and this is closely related to the first conclusion), production optimization disregards the interests of spiritual, scientific-educational, and cultural development. According to its results, the optimal percentage of employment in the scientific-educational and cultural-management sphere in 2030 will amount to 22%; in corresponding conditions this index could be equal to 27%.
- Third, socioeconomic optimization ensures the necessary increase in room for individual development in the form of free time. According to its result, by 2030, it may be possible to have a four-day work week with a 7-hour workday. In this way, long-term forecasts, with clear formalization of social goals, make it possible to predict imminent shifts in structure and proportions of the main national economic and social characteristics.
- Fourth, implementation of socioeconomic optimized forecasts makes it possible to identify imminent shifts in the consumption structure of goods and services. As foodstuffs increase, the percentage of current consumption in the GDP (21%) in 2030 will drop to 12%, while the consumption of semi-durable goods will stabilize (with a small amount of absolute growth related to the increase in population size).
- Fifth, a very favorable forecast can also be made with respect to fixed production asset renewal rates. According to the forecasts, their rate of depreciation should increase from 1.7% in 2005 to 5.7% in 2030, which will make it possible to ensure corresponding TP rates and replace obsolete equipment.
- Sixth, an investment efficiency rate in material production can be obtained from the socioeconomic optimization model; it is defined as the rate of decrease in the dual evaluation of limitations.

The estimates made show that this index will increase from 7.7% in 2005 to 9.5% in 2030.

Results Obtained

To sum up, we will list several conclusions drawn from the study:

1. The spline structure of PF is an efficient tool for establishing the dynamics of its parameters, which, in turn, makes it possible to correlate the efficiency of the production factors and their combination with the potential of the intensification factors: scientific-technical, educational, and organizational.
2. The PF generalized in this way with three-input TP contribution to economic growth forms the basis of the generalized model of macroeconomic dynamics. It is also based on a generalized system of balanced finite-difference equations (equations of motion) and algebraic equations (restrictions on management). Equations of motion characterize the increments of production assets, social infrastructure and household property assets, intensification potential, and employment in the corresponding spheres under the impact of all types of accumulation (productive and nonproductive) and in the intensification factors. The finite equations express the overall balances of GDP and labor force. All of this taken together forms a balanced and generalized macroeconomic model.
3. Use of this macro model in the inertial version, that is, with extrapolative forecasting of the management variables and subsequent solution of the system of equations of motion, reveals several significant shortcomings in trend forecasting related to its lack of balance and failure to take resource limitations into account.

4. The next stage in use of the macro model is estimating the absolute efficiency of investment in production or its intensification fields. The generalized PF and macro model as a whole make it possible to forecast additional (above the inertial version) integral investment efficiency in a particular sphere. The unequal efficiency of the return ratio (per unit of investment) obtained in so doing should be interpreted as proof of the non-optimal allocation of investments in production and its intensification fields.
5. The algorithm of resource allocation management obtained on the basis of the above-mentioned studies is oriented toward gradual equalization of the return ratio and can be defined as production optimization of the macroeconomic system.
6. The most perfect version of a macro model is obtained when the socioeconomic criterion of optimality is added to it, which makes it possible to look for the socioeconomic optimum, rather than a purely productive one. It should be oriented toward increasing state consumption, bringing the development of the social infrastructure and augmentation in household property closer to the standards, and raising the consumption of goods to a level that corresponds to a rational consumer budget. In addition, an expedient decrease in work time and expansion of the scientific-educational and cultural-management spheres are envisaged as criteria that will maintain the required level of production.
7. This type of optimization with the accepted criterion functions of socioeconomic development has shown the extreme consumer orientation of narrow production optimization and the wisdom of shifting the emphasis to spiritual development and intellectual activity (at earlier stages of development) with the creation of the necessary prerequisites and inculcation of a rational attitude toward an increase in "consumption."
8. The characteristics of the efficiency of production and the intensification fields calculated on the basis of the results of socioeconomic optimization also make it possible to draw several conclusions.
   - **First,** according to the forecasts of investment efficiency in the indicated spheres, intensification fields, particularly science and technology, will continue to take the upper hand for several years compared with production as such and so should be financed at a faster rate than material production. The same applies to the labor efficiency and personnel policy in these sectors.
   - **Second,** to our knowledge, this is the first time a development model has been obtained with an incremental capital-output ratio which could not be theoretically explained on the basis of the existing traditional macro models.