Development of the basic model of digitalization of the Russian economy in relation to the electric power industry

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Abstract. The article presents the development of the basic model of the activity of economic market entities in the context of digitalization. His starting point was the use of a previously developed dynamic probabilistic model of economic systems. With regard to the electric power industry, an analysis of the marginal pseudo-market pricing system used in the Russian economy is carried out. The results of the analysis and modeling of the activities of economic entities in the electric power industry showed the negative impact of marginal pricing on the country's economic system as a whole. An alternative version of direct budgetary support for ineffective market entities is proposed.

Keywords: Russian economy, electric power industry, digitalization, base model, dynamic probabilistic model, marginal pricing.

Introduction

The main goal of reforming the electric power industry of the Russian economy was to attract private investment, create a competitive market with the achievement of stabilization and reduce prices in the foreseeable future. However, the inconsistency of statements about the inflow of private investment was initially obvious due to an order of magnitude gap between the cost of construction and repair of facilities and the current capitalization of companies, due to the low solvency of the bulk of consumers. As a result of the reforms, the inflow of private investment into the industry remained insignificant, while the prices for supplied electricity increased annually.

Main part

Within the framework of improving the digital model of the Russian economy in relation to the electric power industry, the analysis of the impact of specific pseudo-market marginal pricing, which is rather difficult to identify within the framework of classical economic theories, is of greatest interest. In this article, to analyze the negative impact of marginal pricing, a previously developed dynamic probabilistic model of economic systems was used, which is applicable to the economies of individual countries and their industries [1-4].

Description of the model

First of all, we introduce a number of conditions, namely:

1. By the development of the economic system we mean a monotonically growing, on average, accumulation of capital (resources, information, technologies, etc.), measured in some equivalent (money).

2. We believe that all economic subjects of the market are limitedly irrational. This makes it possible to assess the average and limited variances of deviations of their actions, in contrast to the classically rational.

3. We believe that all economic subjects of the market are diverse, in particular, they make different mistakes.

4. We believe that all economic subjects of the market are non-additive and, therefore, the market is not a sum of subjects, but rather their statistical aggregate, which has cooperative properties, in particular, an assessment of the market value.

5. Taking into account the experimentally verified significant discrepancies of economic measurements and estimates, from indistinguishable adequate mathematical descriptions of irrationality, the probabilistic one was chosen as the simplest [5].

6. In the D-T-D scheme, the resource component of the products involved in the exchange does not matter.

Under these conditions, each economic entity is characterized by capital α_j and an error in its use in exchange transactions ξ_j, and the statistical set of economic entities that forms the market is characterized by a collective assessment of market values <c> as a weighted average for all exchange transactions and, therefore, the corresponding summary error in measuring market values. Then the simplest dynamic digital model of the economic system will appear in the form:

$$\bar{A}_{i+1} = \bar{A}_i - diag(\bar{\xi}_i)\cdot\bar{A}_i + \frac{\bar{A}_i^T\cdot\bar{\xi}_i}{\bar{A}_i^T\cdot\bar{T}}\cdot\bar{A}_i \qquad (1),$$

where i – cycle number;

$$[\bar{A}]_j = a_j \qquad (2)$$

$$[\bar{\xi}]_j = \xi_j \qquad (3)$$

Model (1) describes a closed market with the total capital conservation law. As the most important consequences of (1), we note the condition for the development of the economic system in terms of the growth of the accuracy of measuring market values in *i*, as well as the stabilizing role of government regulation in the case of an excessive scatter of solutions according to (1) with large values of errors in the use of capital in exchange operations ξ_j.

The simplest option to make the market open would be the introduction of an additional economic entity with certain resources (capital, labor, information, technology, etc.) In this case, (1) is transformed to the form:

$$\bar{A}_{i+1} = \bar{A}_i - diag(\bar{\xi}_i) \cdot \bar{A}_i + \frac{\bar{A}_i^T \cdot \xi_i + \bar{\Pi}_i \cdot \mu}{\bar{A}_i^t \cdot \bar{I} + \Pi_i} \cdot \bar{A}_i \quad (4)$$

$$\bar{\Pi}_{i+1} = \bar{\Pi}_i - \bar{\Pi}_i \mu + \frac{\bar{A}_i^T \cdot \xi_i + \bar{\Pi}_i \cdot \mu}{\bar{A}_i^T \xi + \bar{\Pi}_i} \cdot \Pi_i \quad (5)$$

where $\bar{\Pi}_i$ - resources available to market agents;

μ - parameter characterizing the ratio of the availability of resources to the efficiency of the activities of economic entities.

In the works [1-4] it is shown that the condition for the development of the economic system in the sense of the accumulation of property can be represented as follows:

$$\mu > \langle \xi \rangle = \frac{\bar{A}_i^T \bar{\xi}_i}{\bar{A}_i^T \bar{I}} \quad (6)$$

Considering that the weighted average by prices <c> is itself a random variable, relations (4) - (6) are minimally sufficient to explain the classic market crises and the slowdown in the development of the economic system without attracting investments due to the finite resources of *П*.

For a qualitative analysis of the impact on the development of the economic system of various pricing mechanisms, we use the assumption of unlimited resources, namely:

$$\Pi_i \gg \bar{A}_i^T \times \bar{I} = Q_i \quad (7)$$

In this case, expressions (4) - (7) are easily transformed to the form

$$\bar{A}_{i+1} \cong \bar{A}_i - diag(\bar{\xi}_i) \times \bar{A}_i + \mu \bar{A}_i \quad (8)$$

Note that for

$$< \bar{\xi}_{i+1} > - < \xi_i > \ll \mu - < \xi > \quad (9)$$

and uncorrelated residuals

$$< (\bar{\xi}_K \bar{\xi}_i^T) >= diag(\bar{\xi}^2) \quad (10)$$

where $\bar{\xi}^2$ – dispersion matrix, expression (8) has an approximate solution

$$Q_j(i) = Q_j(i) \times \exp\left((\mu - <\xi_i>)i\right) \quad (11)$$

Solution (11) for developed quasi-stationary countries describes, on average, the exponential dynamics of economic growth. Note that in formulas (4)-(11) for all economic entities, the market sets one market value and the deviation from it of personal assessments of actions and inactions equally affects the change in the capital of each subject. We also note that formulas (4)-(11) in the development of a dynamic probabilistic model of economic systems made it possible to solve a number of economic problems. Some of them are described below.

Margin pricing model

To solve this problem, we will divide economic entities into energy producers ($\bar{A}$) and energy consumers ($\bar{B}$) with the transformation of expression (8) to the following form:

$$\bar{A}_{i+1} = \bar{A}_i - diag(\bar{\xi}_a) \cdot \bar{A}_i + \mu \cdot \bar{A}_i \quad (12)$$

$$\bar{B}_{i+1} = \bar{B}_i - diag(\bar{\xi}_b) \cdot \bar{A}_i + \mu \bar{B}_i \quad (13)$$

When pricing on a weighted average, which is most consistent with the classical understanding of market value, all of the above formulations remain, but some of the entities - energy producers who evaluate and operate worse than average will lose their capital and become bankrupt.

The marginal system for the formation of pseudo-market values, in essence, presupposes a shift in the price of "energy" for all entities by an amount $\triangle c$, which guarantees the *m*-th (last) producer-entity a non-negative value of the capital change at the *i*-th step.

$$\triangle a_m = a_{m(i+1)} - a_{m(i)} \geq 0 \quad (14)$$

Then, in (12), there appears a systematic addition of capital for subjects of type (a), determined from the expression:

$$\bar{A}_{i+1} = \bar{A}_i - diag(\bar{\xi}_a)\bar{A}_i + \mu \bar{A}_i + \triangle a \bar{A}_i \quad (15)$$

For subjects of type (*в*) – buyers of energy, this operation will lead to a systematic shift of capital in the negative direction, namely:

$$\bar{B}_{i+1} = \bar{B}_i - diag(\bar{\xi}_b)\bar{B}_i + \mu \bar{B}_i - \triangle c \times \bar{B}_i$$

(16)

Margin pricing according to (15)-(16) provides a change in the total capital of the economic system in the following form:

$$Q_{i+1} - Q_i = \overline{A}_i^T \times \overline{I} + \mu \overline{A}_i^T \times \overline{I} - \left(\overline{A}_i^T \times \overline{\xi}_a\right) + \triangle\, c \overline{A}_i^T \times \overline{I} + \overline{B}_i^T \times \overline{I} + \mu \overline{B}_i^T \times \overline{I} - \left(\overline{B}_i \times \overline{\xi}_b\right) - \triangle\, c(\overline{B}_i^T \times \overline{I} = Q_i + \mu Q_i - \left(\overline{A}_i^T \times \overline{\xi}_b + \triangle\right) c(\overline{B}_i^T I - \overline{A}_i^T \times I) \quad (17)$$

Hence, the point of decrease in the rate of development of the economic system $(\triangle Q_i < 0)$ will correspond to the condition:

$$\mu - \langle \xi \rangle - \triangle\, c \times \frac{\overline{B}_i^T \cdot \overline{I} - \overline{A}_i^T \cdot \overline{I}}{Q_i} \geq 0. \quad (18)$$

Taking into account the results of the above analysis, the value of $\mu - \langle \xi \rangle$ can be approximately equated to the annual economic growth rate (0.03-0.05), and the capitalization of all economic entities in the electric power industry should be taken within 0.03-0.1 of the total capital of the system. Then from (18) we obtain the upper bound:

$$0{,}05 - \triangle\, c \times 0{,}8 \geq 0 \quad (19)$$

Further, you can get a rough estimate of the permissible relative to the average bias in electricity prices in the amount of

$$\triangle \mathrm{c} \cong 0{,}06 \quad (20)$$

With the existing scatter of the efficiency of the activities of economic entities, and, consequently, the ratio of the standard deviation to the average value of income, relation (19) is practically impracticable and, therefore, the use of a marginal pricing system in the electric power industry guarantees a slowdown in the development of the entire economic system.

Alternative options for supporting ineffective economic agents

As the simplest, let us consider the option of compensation for losses at the expense of the turnover tax (γ) for all closing economic entities, which guarantees them against bankruptcy. Model (15) - (16) is transformed to the form (21) - (22):

$$\overline{A}_{i+1} = \overline{A}_i - diag\left(\overline{\xi}_a\right) \times \overline{A}_i + \mu \times \overline{A}_i + \alpha \overline{I} - \gamma \times \overline{A}_i \quad (21)$$

$$\overline{B}_{i+1} = \overline{B}_i - diag\left(\overline{\xi}_b\right) \times \overline{B}_i + \mu \times \overline{B}_i + 0 - \gamma \times \overline{B}_i \quad (22)$$

with the addition of the condition of preventing the bankruptcy of the entity:

$$(\mu - \xi_m) \times a_m + \alpha - \gamma \times (a_m) = 0,$$

$$\alpha = a_m \times [\mu - \xi_m - \gamma] \quad (23)$$

Then we write the change in the capital of economic entities in the form:

$$Q_{i+1} = Q_{a_i} - \overline{A}_i^T \times \overline{\xi}_a + \mu \times Q_{a_i} + \alpha \times \mu - \gamma \times Q_{a_i} + Q_{b_i} - \overline{B}_i^T \times \overline{\xi}_b + \mu \times Q_{b_i} + Q - \gamma \times Q_{b_i} = Q_i + Q_i \times (\mu - \langle \xi \rangle) - \gamma \times Q_i + \alpha \times \mu \quad (24)$$

Hence

$$\frac{\triangle Q_i}{Q_i} = (\mu - < \xi >) - \gamma + \frac{m \times a_m(i)}{Q_i}[\mu - \xi_{max} - \gamma]$$

(25)

If $\frac{m \times a_m(i)}{Q_i}$ - small value, then the capitalization of the worst economic entity will be significantly less than the average, that is, $m \times a_m \ll \bar{A}_i^T \bar{I}$. This means that relation (25) sets very modest requirements for the tax addition, which are almost always feasible. Consequently, the direct budgetary support required for the normal operation of an economic entity within the framework of the model looks fundamentally better than marginal pricing.

If it is impossible to abandon marginal pricing for political reasons, it is possible that some economic entities leave the electricity generation and supply market, which is reflected in the model by the appearance of *d*-type agents that are neutral to the Δ*c*-shift.

$$\bar{A}_{i+1} = \bar{A}_i - diag(\bar{\xi}_a)\bar{A}_i + \mu\bar{A}_i + \Delta c \times \bar{A}_i \quad (26)$$

$$\bar{B}_{i+1} = \bar{B}_i - diag(\bar{\xi}_b)\bar{B}_i + \mu\bar{B}_i - \triangle c \times \bar{B}_i \quad (27)$$

$$\bar{D}_{i+1} = \bar{B}_i - diag(\bar{\xi}_d)\bar{B}_i + \mu\bar{D}_i \quad (28)$$

Then

$$Q_{i+1} = Q_i - < \xi > Q_i + \mu\bar{Q}_i - \triangle c \times \frac{\bar{Q}_i - Q_{a_i}}{Q_i} \quad (29)$$

at $Q_{i+1} - Q_i \geq 0$

With significant Q_i the ratio of the development of the economic system becomes feasible with significantly softer requirements for the value of △ *c*.

Conclusion

The analysis of the marginal pseudo-market pricing system used in the Russian electric power industry, carried out as part of the development of a dynamic probabilistic digital model of economic systems, showed that even with insignificant displacements from the weighted average estimates, the rate of development of the economic system decreases. If it is necessary to preserve inefficient economic entities producing electricity, it is preferable to use direct budget support while maintaining the market price.

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