Ecological and Economic Regulators of Soil Fertility Reproduction

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Abstract. The article reveals the regulators of the reproduction of soil fertility, motivating investment, including technological interest. For the first time, the relationship between technological rent and agrochemical methods of soil cultivation has been revealed. The factors of technological rent have been substantiated and methodological techniques for its calculation have been tested. Recommendations are formulated for the use of natural and technological rent in the regulation of the reproduction of soil fertility.

1. Introduction
Territorial natural-economic systems, formed under conditions of heterogeneity of space, are experiencing the problem of socio-economic and ecological-economic differentiation. As a result, the motives for rational use of natural resources disappear, which contradicts the principle of sustainable development of rural areas. Regional heterogeneity and structural economic differences cause the Balassa–Samuelson effect [12].

The condition for the transition to sustainable development of rural areas is the formation of a “green” economy with the efficient use of natural resources based on the reproduction of soil fertility, which is of national importance.

The reproduction of soil fertility is theoretically a basic condition for the rational use of lands, but in fact the growth rates of disturbed lands in the Russian Federation systematically outstrip the rates of their reclamation [7].

The problem of disturbed lands, which are present in all categories of land, hinders the development of land relations in the Russian Federation [3] (figure 1). The deterioration of the state of the land fund turns into production and financial losses. A decrease in the development potential of the country's economy increases the risks of loss of food security.
Figure 1. Distribution of disturbed lands by land categories in the Russian Federation as of 01.01.2020.

Therefore, in the agrarian sector, measures of state regulation of the reproduction of land fertility are being strengthened in the following areas:

– monitoring and state regulation of fertility;
– development of plans for carrying out activities for the reproduction of fertility;
– financing of measures for the reproduction of land fertility.

As part of the established measures, rightholders are obliged to carry out the production of agricultural products in ways that ensure the reproduction of land fertility.

Agrochemistry as one of the sources of technological modernization of agriculture can significantly increase land fertility. In this direction, new modifications of organic and mineral fertilizers are being developed to improve the quality of soils and get added value.

In agrarian science, the effectiveness of fertilization based on chicken manure has been confirmed [11]. Thus, the local application of Agrovit-Kor promotes an increase in the content of organic matter by 0.1–0.3%, an increase in the number of mobile forms of potassium (from 15.2 mg/100 g of soil to 18.4 mg/100 g of soil) and phosphorus (from 20.3 mg/100 g of soil to 26.1 mg/100 g of soil), exchangeable calcium and magnesium (up to 14.5 and 5.0 meq/100 g of soil, respectively), soil acidity decreases (from 5.7 to 6.5).

The use of composts increases the content of organic matter (by 0.04–0.09%). With unchanged acidity, the content of mobile phosphorus and potassium increased (respectively, 20.3 and 15.2 mg/100 g of soil in the control variant to 24.3–24.4 and 17.1–17.5 mg/100 g of soil when composting), so the same as exchangeable calcium and magnesium (from 13.2 to 13.4 and from 5.1 to 5.5 mg-eq/100 g of soil).

Taking into account the research of the rent methodology, an increase in crop productivity due to fertilizers can be represented as a technological rent, which can be regulated, creating conditions for maximizing the productivity of agricultural enterprises and, accordingly, ensuring an increase in budget revenues [2].

Table 1. Crop productivity of potatoes of the variety Nevsky, (Vyazhischi, Yuryevo 1999–2001, Vyazhischi and technological rent.).

| Option | Average crop productivity, t/ha | Technological rent (crop productivity increase), t/ha | Marketability of tubers, % |
|--------|-------------------------------|--------------------------------|--------------------------|
| Average for 1999–2001 | Vyazhischi | Yuryevo | Vyazhischi | Yuryevo | Vyazhischi | Yuryevo |
| 1. Control | 20.0 | 29.0 | - | - | 80.1 | 82.1 |
### 2. Local application of Agrovit-Kor

| Treatment | Yield (t/ha) |
|-----------|--------------|
| Control   | 78.1         |
| Local     | 92.4         |

### 3. Spraying tubers with Agrovit-Kor aspirator

| Treatment | Yield (t/ha) |
|-----------|--------------|
| Control   | 87.3         |
| Local     | 88.3         |

### 4. Local application + spraying with Agrovit-Kor

| Treatment | Yield (t/ha) |
|-----------|--------------|
| Control   | 92.4         |
| Local     | 93.4         |

LSD<sub>05</sub> (least significant difference): 2.1 t/ha

Vyazhischi, Average for 2003-2004

| Treatment | Yield (t/ha) |
|-----------|--------------|
| Control   | 78.1         |
| Local     | 92.4         |
| Sawdust and manure compost | 88.4 |
| Straw and manure compost | 88.5 |
| Azofoska  | 87.4         |

LSD<sub>05</sub> (least significant difference): 1.78 t/ha

### 2. Research methods

By means of the method of calculating the differences in crop productivity, the calculation of technological rent is proposed. The increase in crop productivity due to agrochemical factors constitutes technological rent, which, subject to the redistribution of natural rent, exhibits motivating functions and economically forces the copyright holder to technological innovations. For the implementation of regulatory functions, methodological techniques for structuring natural and technological rent have been proposed [2].

Methodological techniques for calculating natural rent are reduced to modeling the yield of the base crop by means of correlation-regression analysis with combinations of two groups of factors, which is illustrated by a conditional example (table 2, 3, 4).

#### Table 2. Initial data for calculating the potential performance of a resource.

| Number in order | Crop productivity, kg/ha (y) | Natural factor (x₁) | Economic factor (x₂) | Algebraic extensions | Potential crop productivity, c/ha |
|-----------------|-------------------------------|---------------------|----------------------|---------------------|----------------------------------|
| 1               | 15.5                          | 50                  | 15                   | 2500                | 16.40                            |
| 2               | 25.0                          | 76                  | 35                   | 5776                | 25.09                            |
| 3               | 12.8                          | 30                  | 9                    | 900                 | 11.28                            |
| 4               | 15.2                          | 50                  | 13                   | 2000                | 16.06                            |
| 5               | 15.3                          | 52                  | 13                   | 2704                | 16.47                            |
| 6               | 23.5                          | 75                  | 23                   | 5625                | 22.87                            |
| 7               | 23.4                          | 70                  | 30                   | 4900                | 23.02                            |
Correlation-regression analysis and the use of variable factors allows the modeling of crop productivity under comparable conditions, which ensures the objectivity of the data.

Table 3. Solving a system of normal equations.

| a0     | a1     | a2     |
|--------|--------|--------|
| 3.613463694 | 0.20552257 | 0.16722105 |
| 9      | 535.0  | 164.0  |
| 535.0  | 33689.0 | 10487.0 |
| 164.0  | 10487.0 | 3686.0 |

For a given linear dependence and the results of solving the system of normal equations, the equation is obtained

\[ y = 3.613463694 + 0.20552257x_1 + 0.16722105x_2, \]  

where \( y \) is the productivity of the base crop;  
\( x_1 \) is an indicator of the quality of the natural factor;  
\( x_2 \) is an indicator of the quality of the economic factor;  
3.613463694 is the coefficient that shows the impact on the crop productivity of unaccounted for factors;  
0.20552257 is the regression coefficient showing the influence of the natural factor;  
0.16722105 is the regression coefficient showing the influence of the economic factor;  
By modeling a combination of factors, it is possible to identify natural and technological rent for each user of the resource [2] (table 4).

Table 4. Model for calculating natural and technological rent.

| Number in order | NY (normal yield) at actual soil and minimum economic factors, c/ha | NY (normal yield) at minimal economic and soil factors, c/ha | Natural rent |
|-----------------|---------------------------------------------------------------|---------------------------------------------------------------|--------------|
| 1               | 15.22736048                                                  | 11.11690912                                                  | 4.110451365  |
| 2               | 20.57094726                                                  | 9.45403814                                                   | 9.45403814   |
| 3               | 11.11690912                                                  | no                                                             |              |
| 4               | 15.22736048                                                  | 11.11690912                                                  | 4.110451365  |
| 5               | 15.63840562                                                  | 11.11690912                                                  | 4.521496502  |
| 6               | 20.36542469                                                  | 9.248515572                                                  | 9.248515572  |
| 7               | 19.33781185                                                  | 8.22090273                                                   | 8.22090273   |
| 8               | 19.74885699                                                  | 8.631947867                                                  | 8.631947867  |
| 9               | 17.28258617                                                  | 6.165677048                                                  | 6.165677048  |

Calculation of technological rent
An illustrative model for calculating natural and technological rent under given conditions makes it possible to reveal and substantiate the methodological tools for substantiating the regulators of soil fertility reproduction.

To justify payments for the use of natural resources, it is necessary to assess the production capabilities of the natural resource potential using the natural rent model.

Natural payments, including environmental payments, tied accordingly to the values of natural and environmental rent, ensure the creation of equal competitive conditions and are regulators of competition.

Fertility losses constitute environmental damage that is subject to compensation in full, which will motivate the copyright holder to prevent these losses.

The motives for the rational use of land are generated by rental regulators, for the formation of which rental methods for assessing resource income are proposed.

In these conditions, the trap of competitive contradictions is overcome, in which the principle of joint power is violated [5].

Expansion of competitive opportunities leads to an increase in job satisfaction, which expands the level of organizational communication in the agricultural sector [6].

Technological rent acquires competitive properties in conditions of suppression of natural rent, eliminating the zone of asymmetry [8].

Therefore, technological rent is a regulator of the reproduction of soil fertility.

Thus, a decrease in the unit price of production of products due to technological innovation motivates the use of less fertile lands, since the price of production per unit of production on the worst lands is higher and is the basis for the formation of purchase prices. The guarantee of covering costs and making a profit in the worst conditions motivates the use of the worst land plots.

Land plots of average quality in conditions of domestication provide additional income, which contributes to an increase in the competitiveness and investment activity of their rightholders, which contributes to the growth of employment and the demand for agricultural education [10].

Important determinants of agricultural production, including technological factors, depend on the regulators of macroeconomic policy [1].

But the impact of macroeconomic policies on agricultural production through financial, tax and monetary adjustments depends on consistency with rental indicators.

Rental indicators allow substantiating the opportunity costs of agribusiness entities and confirming the effectiveness of the proposed recommendations [9].

Technological innovations, reproduction of fertility and growth on this basis of incomes make it possible to overcome inequality in farm incomes, contributing to the involvement of lands in production [4].

| Number in order | NY at actual economic and minimum soil factors, c/ha | NY at minimal economic and soil factors, c/ha | Technological rent |
|-----------------|---------------------------------------------------|---------------------------------------------|-------------------|
| 1               | 12.28745645                                       |                                              | 1.17054733        |
| 2               | 15.63187739                                       |                                              | 4.514968273       |
| 3               | 11.28413017                                       |                                              | 0.167221047       |
| 4               | 11.95301436                                       | 11.11690912                                  | 0.836105236       |
| 5               | 11.95301436                                       |                                              | 0.836105236       |
| 6               | 13.62522483                                       |                                              | 2.508315707       |
| 7               | 14.79577216                                       |                                              | 3.678863038       |
| 8               | 11.11690912                                       |                                              | no                |
| 9               | 12.78911959                                       |                                              | 1.672210472       |
3. Conclusion
The technological-rent approach to the distribution of income proposed for use in agricultural policy, including the natural and technological method of structuring rental income, contributes to the formation of investment motives for improving the scientific system of agriculture based on the development of vocational education, science and the introduction of agrochemical, agrotechnical innovations.

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