Econometric modeling of the influence of economic factors on the volume of construction: Russian impact

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Abstract. The considerable turbulence of the Russian economy has a restraining effect on the development of systemically important types of economic activity, with no exception being construction, in which, starting in 2015, there has been a decline. In this regard, we believe that the assessment of the causes of the emerging trend is an urgent task to be solved in the framework of economic science. The purpose of the paper is to quantify the impact of the main economic factors on the dynamics of the volume of work performed in the construction industry in Russia. Such research methods were used: analysis, synthesis, comparisons, graphical, tabular, correlation and regression analysis. Sources of information were data from the Federal State Statistics service of the Russian Federation. Results of the research: analysis of the main characteristics of construction in the Russian Federation showed their growth in 2017 compared to 2002, while the leading positions are occupied by entities that are part of the Central Federal District, Volga Federal District and South Federal District; assessment of the impact of economic factors on the output of construction works showed a strong impact of the number of people employed in the industry and investment in buildings and structures; econometric modeling of the level of work performed in construction and a forecast for 2018-2020 shows that while maintaining the current conditions, the industry will grow in minor topics. The patterns of development of the industry that we identified may be useful to researchers in the field of construction economics and the housing market, as well as to government officials for shaping the development strategy for construction in the Russian Federation.

Introduction
The development of construction in Russia is one of the factors contributing to the improvement of the situation in the housing sector, the growth in the production of building materials and a number of other related industries. In this regard, a comprehensive study of this type of economic activity in order to identify patterns of its development in time and space is an important task to be solved in a number of such scientific areas as: economic theory, construction economics, statistics and econometrics. Therefore, we believe that conducting econometric modeling of the influence of factors on the volume of work performed in the form of economic activity “Construction” is relevant to the modern development of economic science.

Methodology
The relevance of the chosen research topic is confirmed by the considerable interest in it from scientists, among which one should pay attention to the works of such authors as Ball [1], Chan [3],
De Valence and Abbott [4], Dubois and Gadde [5], Forsythe [6], Halligan [9], Hillebrandt [10], Huang [11], de Valence [14], Runeson [15,16], Shutt [18] and others.

In their studies, the scientists cited the problems of the influence of socio-economic factors on the development of construction, but limited themselves to qualitative analysis and did not go on to quantitative measurement, in this connection we will assess the impact of the main production factors on the amount of work done by construction enterprises.

In this article, the type of economic activity “Construction” was chosen as the object of research, the subject being the relationship between the efficiency of the industry and the main factors of production. As sources of data’s, statistical compilations “Russian Statistical Yearbook” and “Construction in Russia” were used, while it is worth pointing out that the comparability of time series was achieved by correcting information until 2004 in terms of the OKVED, and since 2016 - OKVED2.

Results
Using the information given in these statistical collections we model a number of tables describing the results of the activities of construction organizations.

Table 1. Dynamics of the volume of work performed by type of economic activity "Construction", billion rubles.

| Russian and its Federal Districts | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | Growth coefficient of 2017 to 2000 |
|----------------------------------|-------|-------|-------|-------|-------|-------|----------------------------------|
| Russian Federation               | 503.8 | 1754.4| 4454.2| 7010.4| 7204.2| 7545.9| 15.0                             |
| Central                          | 145.0 | 517.2 | 1159.7| 1780.7| 1842.1| 1930.8| 13.3                             |
| North-Western                    | 52.3  | 229.7 | 679.9 | 1048.1| 1154.8| 1093.2| 20.9                             |
| South                            | 43.0  | 123.2 | 449.7 | 598.5 | 555.1 | 628.3 | 14.6                             |
| North-Caucasus                   | 14.3  | 43.2  | 138.7 | 268.8 | 271.9 | 290.3 | 20.2                             |
| Volga                            | 81.9  | 281.0 | 686.1 | 1329.8| 1307.5| 1289.9| 15.7                             |
| Ural                            | 83.7  | 245.8 | 578.9 | 816.5 | 854.4 | 871.6 | 10.4                             |
| Siberian                         | 51.6  | 166.2 | 411.4 | 779.7 | 789.9 | 788.4 | 15.3                             |
| Far Eastern                      | 27.1  | 142.9 | 339.8 | 388.3 | 428.4 | 495.7 | 18.3                             |

From sources of table 1 it follows that, the volume of work performed by construction organizations has increased significantly, so for the period under review in Russia there is an increase of 15 times. At the same time, the greatest successes were achieved in the North-Western (20.9 times) and in the North Caucasus (20.2 times) federal districts, which is explained by the low comparison base in 2000. Continuous growth is also associated with the influence of inflationary processes on the indicator under consideration. If we take 2016 as the base of comparison, the picture will change, in the North-West Federal District and the Volga Federal District there is a decrease of 5% and 1%, respectively.

As for the structure, the Central Federal District contributes the most to the all-Russian figure (29% in 2000 and 26% in 2017), the Volga Federal District - 16% and 17%, and the Ural Federal District - 17% and 12%. Sustainable regularity is explained by a significant number of the population living in these districts.

The economic difference between residential purpose and non-residential purpose buildings is shown in [13]. Environmental cost-benefit analysis of prefabricated public housing is shown in [17] on the example of Beijing city.

Since cost indicators are distorted by inflationary processes, natural indicators are called upon to more clearly assess the effectiveness of the functioning of the construction industry (Table 2).
Table 2. The Dynamics of the main indicators of the performance of construction enterprises

| Indicators                              | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | Growth coefficient of 2017 to 2000 |
|-----------------------------------------|-------|-------|-------|-------|-------|-------|----------------------------------|
| Number of buildings - total, thous.     | 119.7 | 141.6 | 216.5 | 306.4 | 278.3 | 272.6 | 2.28                            |
| residential purpose                     | 110.8 | 131   | 201.7 | 286.1 | 259.5 | 253.8 | 2.29                            |
| non-residential purpose                 | 8.9   | 10.6  | 14.8  | 20.3  | 18.8  | 18.8  | 2.11                            |
| Total construction volume of buildings - total, million m³ | 172.4 | 265.4 | 397.4 | 622.8 | 608.5 | 599.4 | 3.48                            |
| residential purpose                     | 131.6 | 202.2 | 271.8 | 415.7 | 400.4 | 401.3 | 3.05                            |
| non-residential purpose                 | 40.8  | 63.2  | 125.6 | 207.1 | 208.1 | 198.1 | 4.86                            |
| Total square of buildings - total, million m² | 44.7 | 66.3  | 91.5  | 139.4 | 135.8 | 137.3 | 3.07                            |
| residential purpose                     | 36.4  | 54.8  | 70.3  | 106.2 | 103.4 | 104.6 | 2.87                            |
| non-residential purpose                 | 8.3   | 11.5  | 21.2  | 33.2  | 32.4  | 32.7  | 3.94                            |

The data given in Table 2 shows a more modest growth in 2017 compared to 2000, by 3-5 times. Also, based on the information provided, it is possible to state the domination of housing construction in all respects, in this connection we turn to Figure 1 which shows the retrospective dynamics of the commissioning of residential buildings in Russia.

Figure 1. Dynamics of commissioning of residential buildings in Russia, million square meters

The dynamics shown in Figure 1 indicates a decline until 1999 and further growth, it was possible to exceed the 1990 level only in 2008, and then in 2011 and beyond. The failure in the gray-haired of the 1990s is associated with the general economic decreasing in the country and low incomes of citizens, the rapid development in the 2000s is due to the widespread introduction of mortgage lending, which was the driver of growth in the entire construction sector [7,8].

Discussion

Despite the significant growth in residential construction, it is still not possible to compensate for the gap between supply and demand in the 1990s, as to reach the level of Europe or the United States (in
terms of the level of housing provision) is not yet possible, since the average housing supply in the USA is 3.5 times more [2], and in the EU countries it is more than 2 times more than the average in Russia.

To emphasize the importance of the construction industry for the Russian economy, we turn to the structure of GDP in 2017, since the gross value added (GVA) of construction amounted to 5,286.6 billion rubles, the amount of GVA of all types of economic activity is 83059.1 billion rubles, it follows that The share of the industry under consideration accounts for 6.4%. At the same time, the proportion did not change significantly compared to 2000, decreased by only 0.4 percentage points, which indicates the stability of the positions of the construction industry in the structure a long time period.

Next, we turn to assessing the impact of the main factors of production on the volume of construction work, with the following as independent variables: \( X_1 \) is the average annual number of people employed in construction, thous. People [12, 20]; \( X_2 \) - fixed assets at the end of the year in terms of construction enterprises, mln rubles; \( X_3 \) - investments in housing, million rubles; \( X_4 \) - investments in buildings (except residential) and facilities, mln rub [19].

To begin, let us estimate the influence of factors on the resultant variable. Thus, as a result of evaluating the pair correlation coefficient in all cases, values of more than 0.95 were obtained, which indicates the strong influence of each of the selected factors on the amount of work performed in construction. Also, the variables are interconnected, which imposes a restriction on their sharing in one econometric model (the problem of multicollinearity), therefore, we will include in the model only those factors that do not influence each other, we finally arrive at the model:

\[
Y^* = f(X_1, X_4) + E
\]

As a result of the construction of the regression by means of the STATISTICA software package, were obtained the characteristics presented in Table 3.

**Table 3.** Characteristics of the econometric model of the influence of economic factors on the volume of work performed in construction

| Indicators                  | Meanings   |
|-----------------------------|------------|
| Correlation coefficient     | 0.999      |
| Coefficient of determination| 0.997      |
| Adjusted coefficient of determination | 0.997   |
| Fisher's F-test             | 2542.677   |
| p-level of significance     | 0.000      |

The resulting \( R^2 = 0.997 \) is close to 1, which indicates the high quality of the fit of this model, that is, the regression model by 99.7% describes the intensity of fluctuations of levels of the dependent variable.

The actual value of the Fisher F-test equal to 2542.677 is greater than the table value of the Fisher-Snedecor test \( F (0.05; 2; 15) = 3.682 \), i.e. the estimated regression equation is statistically significant, therefore, the dependent variable under investigation is very closely described by the variables \( X_1 \) and \( X_4 \) included in the regression model.

**Table 4.** Parameters of the econometric model of the influence of factors on the volume of work performed in construction

| Indicators | \( \beta \)-coefficient | Required parameters \( b_j \) | Student \( t \)-test | p-level of significance |
|------------|-------------------------|-----------------------------|-------------------|------------------------|
| Free parameter | -                      | -3578338.32                 | -4.282            | 0.001                  |
| \( X_1 \)   | 0.22                    | 851.34                      | 4.452             | 0.000                  |
| \( X_4 \)   | 0.78                    | 0.84                        | 15.459            | 0.000                  |
The estimated coefficients of the regression equation are statistically significant by Student’s t-test (p-level <0.05). Based on the values of the β-coefficient, it can be concluded that the X4 factor has a significant effect on the effective indicator, since the value of the coefficient is higher in this case.

Summary
The resulting model indicates an increase in the volume of work performed by the type of economic activity “Construction” by 851.34 million rubles as a result of an increase in the number of employed by 1 thousand people, i.e. construction still remains a labor-intensive industry and the number of personnel greatly influences the time of work. With an increase in investment in buildings (except residential) and facilities by 1 million rubles, effective variable will grow by only 0.84 million rubles.

Since the estimated parameters of the model and other characteristics satisfy the requirements of econometrics, the resulting regression can be used to build a forecast of the future state of the analyzed industry. We illustrate the predictive capabilities of the model and estimate the value of the dependent variable in 2018–2020; to do this, we first predict the values of the variables X1 and X4; as the development model for the independent variables we consider, choose a linear trend.

We use the obtained point estimates of factors for the period 2018–2020 and substitute in the regression equation, the result is the predicted values of the dependent variable, shown in Table 5.

Table 5. Expected values of the volume of work performed by the type of activity "Construction"

| Indicators                  | 2018  | 2019  | 2020  |
|-----------------------------|-------|-------|-------|
| X1, [thous. People]        | 6430  | 6549  | 6667  |
| X4, [mln roubles]          | 7514364 | 7937872 | 8361380 |
| Point forecasts Y, [mln roubles] | 8185567 | 8641367 | 9096316 |
| Lower confidence limit     | 8038053 | 8481772 | 8924438 |
| Upper confidence limit     | 8333081 | 8800963 | 9268194 |

It follows from the table that while maintaining the upward trend in the number of employees and the volume of investments, the amount of work performed by the type of economic activity “Construction” will tend to increase (Figure 2).

Figure 2. Actual levels and forecast values for 2018–2020 by type of economic activity "Construction"

We get that, under the influence of two factors, the volume of work performed by construction enterprises in the forecast period will be in the range of 8038 to 9268 billion rubles.

The study of the influence of economic factors on the volume of work performed by the type of economic activity “Construction” allows us to draw a number of conclusions.
Firstly, for the period under review, 2000-2017 the construction industry showed significant growth in absolute value (15 times) and more modest results in physical terms (3-5 times), which is associated with the widespread introduction of the mortgage lending mechanism in the 2000s and as a result, the inflow of investments in this sector has sharply increased.

Secondly, all 4 factors of production (labor, capital and investment capital) have a strong influence on the industry dynamics (the correlation coefficient is more than 0.95). Of which the final model includes the number of employees (characterizes the labor intensity of the industry) and the volume of investment in buildings and structures (shows the direction of demand).

Thirdly, the forecasts of the volume of work performed by construction organizations showed a slight increase in 2019-2020, which is fully consistent with the current economic situation in the country, which has a restraining effect on the development of all sectors of the economy.

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