The Price of Oil as a Pricing Factor of the Residential Real Estate at the Regional Market

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Abstract. The article is to study the influence of oil price variation on the parameters of the residential real estate market, which is a significant factor of the development of the country’s living standards. The analysis of oil price variation as one of the key figures determining price variation of goods and services in Russia, covers the period of the 2008 crisis and the post-crisis period of 2011-2017 (on a quarterly basis). The price variation of living space per square meter in the primary and secondary housing markets in remote federal districts (Central, Siberian, Far Eastern) has been analyzed. That allowed to identify the specifics of the process investigated in far-flung territories with significantly different indicators of economic development. As an assessment tool of the impact of structural changes in the Russian economy on price variation a statistical Chow-test, showing the presence of structural instability during the crisis, has been used. Based on the data, modeling of the interconnection between the oil price variation and a housing square meter price variation has been carried out in the period of 2011-2017. The official data of the Federal State Statistics Service of the Russian Federation have been used.

1. Introduction
The predominant focus of national industries on the use of traditional energy sources contributes to the formation of the dependence of production efficiency on energy prices. Ultimately, this determines the indicators of the country's socio-economic development and the level of the population's well-being. The formulation of the welfare assessment problem was described in the works of the classics (A. Smith, D. Ricardo, K. Marx, J. S. Mill, A. Pigou, V. Nordhaus, E. Clark, and others). Detalization of the welfare components (economic, social, environmental, etc.) was presented in the studies of Russian scientists VN. Bobkov, T.I. Zaslavskaya, N. Volgin, V.S. Bochkov, ON Antipin, E.V. Zhuravskaya, L.A. Rodionov et al. [1, 3-5, 14, 15]. This article focuses on the availability of goods. This makes it possible to identify the groups of the population according to the criteria of income and housing security, access to education and medical care; and also to establish the connection between welfare and the level of socioeconomic inequality, etc. [2, 5, 6, 9, 10].

The importance of the criterion of "housing security" in assessing welfare confirms its involvement in the category of basic services [17]. The level of availability of this category is determined by the ratio of effective demand and the cost per square meter of housing and depends on the state of the national economy, the development of financing mechanisms, the level of incomes of the population and other factors. The impact of oil price fluctuations on the housing market was considered earlier [7, 11,
13, 19], but the reasonableness of the findings in the current economic situation is not sufficient. That is why the study of the dynamics of the relationship between oil prices and the square meter of housing in the primary and secondary real estate market is of scientific interest. For comparison, representatives of the federal districts of the Russian Federation with a significant geographical spread such as Tula Region (Central Federal District), Tomsk Region (Siberian Federal District), and Primorsky Krai (Far Eastern Federal District) have been selected. The choice is not random. It allows to confirm or reject the hypothesis about the difference in price dynamics trends in different territories [12]. The dynamics of the cost of 1 square meter of living space in the primary market is shown in Figures 1 and 2.

**Figure 1.** The dynamics of the cost of 1 square meter of living space in the primary market in 2001-2017, quarterly, in rubles.

Absolute price leader in the primary market is the Primorsky Krai, which has acquired this status in the secondary market. For all regions, the price dynamics of 1 square meter of housing is almost identical in the primary and secondary markets: continuous growth until 2007, the decline in 2008 and subsequent growth (slightly less intensive than the first segment). The presence of a “splash” indicates a high sensitivity of prices to the markers of the financial crisis. A return to the previously formed trend actualizes the task of assessing the impact of structural changes on price dynamics. To study the structural changes in the series, the statistical test of G. Chow [18, 20] is to be applied. It allows to develop a hypothesis about the structural stability of the trend of time series of the average cost of 1 square meter of living space. After calculating the basic characteristics, the residual sum of squares on
the piecewise-linear model $C^{kl}_{ost}$ is calculated as the sum $C^1_{ost}$ and $C^2_{ost}$, and corresponding number of degrees of freedom $n - k_1 - k_2$. The reduction of the residual dispersion upon transition from the trend equation over the entire time interval to the piecewise linear model is defined as the difference of the residual sums of the squares of the deviations. The actual value of Fisher’s F-criterion for variances per degree of freedom of variation is compared with the tabular (Fisher distribution tables) for significance level $\alpha$ and a certain number of degrees of freedom

$$F_{fakt} = \frac{\Delta C_{ost} \cdot k_1 + k_2 - k_3}{C^3_{ost} \cdot n - k_1 - k_2}$$

The required calculations for each area and types of markets are given in Tables 1, 2.

### Table 1. Calculation of indicators for the test G. Chow (primary market).

| Equation № | The form of equation | Number of observations | Residual sum of squares | Number of parameters in equation | Number of degrees of freedom residual variances |
|------------|-----------------------|------------------------|-------------------------|---------------------------------|-----------------------------------------------|
| Piecewise-linear model | | | | | |
| (1) | $y^{(1)} = a_1 + b_1 \cdot t$ | $n_1$ | $C^1_{ost}$ | $k_1$ | $n_1 - k_1$ |
| (2) | $y^{(2)} = a_2 + b_2 \cdot t$ | $n_2$ | $C^2_{ost}$ | $k_2$ | $n_2 - k_2$ |
| The trend equation for the whole set | | | | | |
| (3) | $y^{(3)} = a_3 + b_3 \cdot t$ | $n$ | $C^3_{ost}$ | $k_3$ | $n - k_3 = n_1 + n_2 - k_3$ |

| Tula region | | | | | |
| (1) | $y^{(1)} = 3485.5 + 803.7 \cdot t$ | 24 | 22590070 | 2 | 22 |
| (2) | $y^{(2)} = 40892.0 + 310.9 \cdot t$ | 28 | 73567950 | 2 | 26 |
| (3) | $y^{(3)} = 3090.0 + 1041.6 \cdot t$ | 52 | 1432870630 | 2 | 50 |

| Tomsk region | | | | | |
| (1) | $y^{(1)} = 3485.5 + 803.7 \cdot t$ | 24 | 47061454 | 2 | 22 |
| (2) | $y^{(2)} = 40892.0 + 310.9 \cdot t$ | 28 | 81232071 | 2 | 26 |
| (3) | $y^{(3)} = 3090.0 + 1041.6 \cdot t$ | 52 | 1081600670 | 2 | 50 |

| Primorsky Krai | | | | | |
| (1) | $y^{(1)} = 10743.0 + 881.1 \cdot t$ | 24 | 49860836 | 2 | 22 |
| (2) | $y^{(2)} = 35373,0 + 1446,3 \cdot t$ | 28 | 118105925 | 2 | 26 |
| (3) | $y^{(3)} = 5817.5 + 1304.3 \cdot t$ | 52 | 167966761 | 2 | 50 |

According to the calculations (Table 1) for the primary housing market, the actual values of Fisher’s (F) are as follows:

1) Tula region $F_{fakt} = 333.6$;
2) Tomsk region $F_{fakt} = 178.3$;
3) Primorsky Krai $F_{fakt} = 35.5$. 
Table 2. Calculation of indicators for the test G. Chow (secondary market).

| Equation № | The form of equation | Number of observations | Residual sum of squares | Number parameters in equation | Number of degrees of freedom residual variances |
|------------|----------------------|------------------------|-------------------------|-----------------------------|---------------------------------|
| Tula region                                      |                       |                        |                         |                               |
| (1)        | $y^{(1)} = 2558,9 + 747,0 \cdot t$ | 24                     | 21892349                | 2                           | 22                             |
| (2)        | $y^{(2)} = 37611,0 + 473,0 \cdot t$ | 28                     | 93778953                | 2                           | 26                             |
| (3)        | $y^{(3)} = 775,4 + 1081,5 \cdot t$ | 52                     | 1177292025              | 2                           | 50                             |
| Tomsk region                                    |                       |                        |                         |                               |
| (1)        | $y^{(1)} = 3594,0 + 902,2 \cdot t$ | 24                     | 59703086                | 2                           | 22                             |
| (2)        | $y^{(2)} = 39829,0 + 424,6 \cdot t$ | 28                     | 63562726                | 2                           | 26                             |
| (3)        | $y^{(3)} = 3869,9 + 1047,4 \cdot t$ | 52                     | 105099457               | 2                           | 50                             |
| Primorsky Krai                                  |                       |                        |                         |                               |
| (1)        | $y^{(1)} = 3457,5 + 947,4 \cdot t$ | 24                     | 74273303                | 2                           | 22                             |
| (2)        | $y^{(2)} = 66573,0 + 749,0 \cdot t$ | 28                     | 262243217               | 2                           | 26                             |
| (3)        | $y^{(3)} = -4037,2 + 1992,2 \cdot t$ | 52                     | 5796075172              | 2                           | 50                             |

The actual values of Fisher’s (F) are as follows:
1) Tula region $F_{факт} = 220.3$;
2) Tomsk region $F_{факт} = 180.6$;
3) Primorsky Krai $F_{факт} = 389.4$.

All actual Fisher’s values (F) are considerably higher than the tabulated value equal to 5.08 for the significance level of 0.01 and the number of degrees of freedom equal to 2 and 48, respectively. This allows to reject a hypothesis about the structural stability of the series under consideration and recognize the impact of structural changes on the dynamics of the cost of 1 square meter in both the primary and secondary markets. At the same time, the lowest value F corresponds to the cost of 1 square meter of housing in the primary market of Primorsky Krai, and characterizes the changes in the structure of the series as not significant compared to other series (Figure 3).

In the secondary market, on the contrary, the largest increase in value falls on 2007-2010 (Figure 4).

Figure 3. Dynamics of the cost of 1 square meter of living space in the primary housing market for the period 2001-2017 on a quarterly basis (except for the period of the structure change in 2007-2010), in rubles.
Figure 4. Dynamics of the cost of 1 square meter of living space in the primary housing market for the period 2001-2017 on a quarterly basis (except for the period of the structure change in 2007-2010), in rubles.

The actual value of Fisher (F), equal to 136.1, allows to conclude that there are structural changes in a number of oil prices during the crisis (Table 3, Figure 5)

Table 3. Calculation of indicators for the test G. Chow

| Equation № | The form of equation | Number of observations | Residual sum of squares | Number parameters in equation | Number of degrees of freedom residual variances |
|------------|----------------------|------------------------|-------------------------|-------------------------------|-----------------------------------------------|
| (1)        | $y^{(1)} = 12.7 + 2.1\cdot t$ | 24                     | 906                     | 2                             | 22                                            |
| (2)        | $y^{(2)} = 129.1 - 3.1\cdot t$ | 28                     | 5631                    | 2                             | 26                                            |
| (3)        | $y^{(3)} = 37.1 + 0.98\cdot t$ | 52                     | 43602                   | 2                             | 50                                            |

Figure 5. Dynamics of the cost of 1 barrel of Brent crude for the period 2001-2017 quarterly, in US dollars [8, 16].
Investigation of the relationship between the cost of 1 square meter of housing (a result characteristic) and 1 barrel of Brent oil (a factor characteristic) made it possible to obtain the results presented in Table 4.

**Table 4. Indicators of the interconnection of series.**

| Region               | The regression equation | The value of the Durbin-Watson criterion | Correlation coefficient |
|----------------------|-------------------------|-----------------------------------------|-------------------------|
| **Primary housing market** |                         |                                         |                         |
| Tula region          | $\hat{y}_1 = 51797 - 76.62 \cdot x$ | 0.568                                   | -0.75                   |
| Tomsk region         | $\hat{y}_2 = 51972 - 102.55 \cdot x$ | 0.427                                   | -0.80                   |
| Primorsky Krai       | $\hat{y}_3 = 86107 - 356.44 \cdot x$ | 0.516                                   | -0.87                   |
| **Secondary housing market** |                         |                                         |                         |
| Tula region          | $\hat{y}_4 = 55166 - 128.11 \cdot x$ | 0.618                                   | -0.88                   |
| Tomsk region         | $\hat{y}_5 = 54939 - 107.23 \cdot x$ | 0.376                                   | -0.83                   |
| Primorsky Krai       | $\hat{y}_6 = 94344 - 202.53 \cdot x$ | 0.371                                   | -0.87                   |

Table 4 shows that all the values of the Durbin-Watson criterion for significance level 0.10 exceed its critical value equal to 0.322. This gives grounds for rejecting a hypothesis about the absence of cointegration of the investigated series in the regions under consideration. Coefficients of correlation exceeding 0.7 indicate a close reverse linear relationship between the cost of 1 barrel of Brent oil and 1 square meter of living space.

Thus, as a result of the study, the presence of cointegration of the investigated series on geographically dispersed territories has been established. This creates the prerequisites for further in-depth study of the allocated relationship with the positioning of an additional set of factors.

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