Statistical Research and Modeling of Retail Turnover in the Russian Federation

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Abstract. Retail trade turnover represents one of the most fundamental socio-economic indicators. Constant monitoring of such indicators has a pivotal role in modernization of the Russian economy. Retail trade turnover reflects countries' economic capacity and standard of living. This paper proposes a statistically significant econometric model of the retail trade turnover dependence with respect to different factors. Such factors as consumer prices index, unemployment level and average monthly designed salary were taken as the explanatory variables. The variables were selected based on Granger causality test and time series analysis of several socio-economic indicators. For each explanatory variable, a statistically significant model *ARIMA* (1, 1, 0) was constructed, with the help of which the predicted values of the explanatory variables for October, November and December 2019 were calculated, which were used to forecast the retail turnover for these months.

Keywords: retail trade turnover, time series, econometric model, forecast.

1 Introduction

In Russia today retail trade is one of the fast-developing industries with good prospects. Currently the Russian retail trade sector is characterized by the emergence of new efficient sales techniques, the increase in retail areas, and rapid growth in Internet sales. Big chain stores emerge and intensively develop. The growth in retail turnover gives rise to the profits of commercial organizations, including small business firms. That, in turn, promotes the growth in population wealth and provides new jobs. In 2018 retail and wholesale trade share comprised 12,8% of GDP [1]. That outnumbered the contribution from all other sectors. Standard of living and economic capacity of the country are determined by such indicators as volumes, dynamics and structure of retail trade [2].

Previous research has analyzed the issue of retail trade volumes. In several studies attention has been focused on the modeling and forecasting of retail trade. Those studies differ in methods of modeling, data type, set of variables, and sample size. In [3] the model of retail turnover is examined in relation to consumer confidence indicator, while the authors of [4] suggest taking into account calendar effects. In its turn, [5] provides mathematical statistical analysis of retail trade turnover in the RF considering financial and economic factors. To forecast the retail trade turnover, in [6] it is proposed to use the theory of cointegration, and in [7] – neural networks.

The results of statistical analysis and econometric modeling for retail turnover in the RF are shown in this study. The period represents a decade from 1999 to 2019. The authors of this paper analyze retail turnover in a monthly dynamics for the last 20 years. It allows tracing the dynamics of this indicator. It also provides a sufficient sample that enhances the chances to construct statistically significant models and promotes the quality of forecast. The constructed econometric model takes into account the influence that other socio-economic indicators have on retail trade turnover.

There are several primary aims of this study:

1. To analyze the dynamics and structure of retail turnover.
2. To identify factors (economic and social indicators), that have a significant impact on retail turnover.
3. To build an econometric model of the retail turnover dependence on selected indicators.
4. To make a forecast of retail turnover for the next time periods.

2 Methods

The methodology used in this study was a combination of statistical and econometric methods. For econometric modeling of retail turnover, various indicators were considered. The indicators reflected the state of the construction sector, industry, trade, and employment. The retail turnover was chosen as a performance indicator.

The time series of the retail trade turnover and other indicators in the monthly dynamics for the period from January 1999 to July 2019 were analyzed. The data base for the study was formed on short-term economic indicators from the RF official statistics [8]. The volume of the sample totaled 247 observations (for each time series). Gretl, Excel and EViews programs were used for calculations and analysis.

3 Findings

3.1 Modeling

The retail turnover comprises food turnover (food products, including drinks and tobacco products) and non-food goods. Over the past 20 years, the structure of retail trade turnover has not changed significantly. The share of non-food products was 51-53%, for food products it was 46-48%. A slight increase in the share of the turnover of non-food products, for example, in the crisis years of 2008 and 2014 (53.4% and 53% respectively) was due to the depreciation of the ruble and the following "boom" in purchases of durable goods.

The dynamics of changes in retail trade turnover for 1999-2019 is shown in Fig. 1.The monthly dynamics of the time series for the indicator under study was analyzed and it was suggested that there is a linear trend and a multiplicative seasonal constituent with a period of 12. For the purpose of the study, the seasonal constituent was eliminated.

Generated time series is first-order integrated. This conclusion was made based on the augmented Dickey and Fuller test results (*ADF*-test) [9] with constant for the initial levels (observed value of test statistics $t = -2{,}88$, p-value = 0,1695) and for the first differences (observed value $t = -13{,}34$, p-value = 0,0000).

One purpose of this study was to construct an econometric modeling of retail turnover (Y, billion rubles). To form the set of explanatory variables for the model different socio-economic indicators were taken into account. Those indicators were selected with augmented *ADF*-test (to determine the order of time series integration of variables under study) and Granger causality test (to reveal cause and effect correlation between dependable variable Y and the variables under study). The following indicators were selected:

X_1 – consumer price index (% of the previous month);

X_4 – unemployment level (%);

X_7 – average monthly designed salary (rubles).

The following multifactor linear regression model was chosen for modeling:

$$Y_t = b_0 + b_1 X_{1,t} + b_4 X_{4,t} + b_7 X_{7,t} + \varepsilon \quad (1)$$

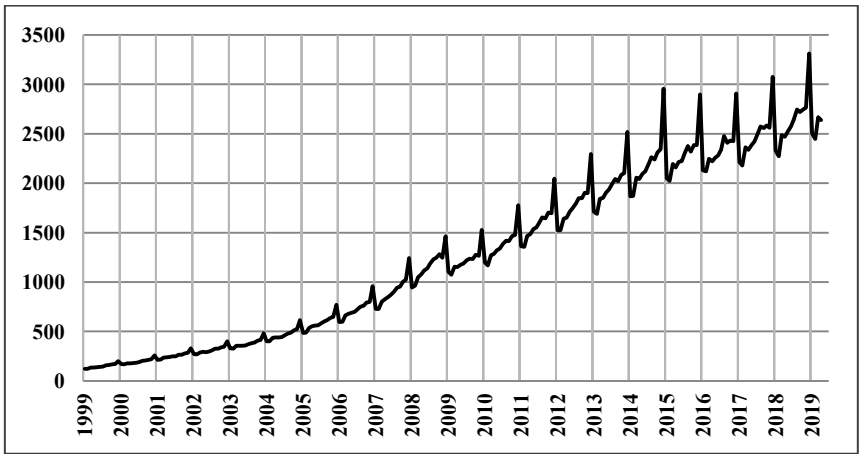

Fig. 1. Retail trade turnover dynamics for 1999-2019 (billion rubles).
Source: Authors' calculations based on [8].

Ordinary least squares method was chosen to evaluate the parameters of the model (1). Table 1 illustrates the results of econometric modeling and the quality indicators of the model that has been built (determination coefficient R^2 and observed value of F-statistics).

Table 1. Results of retail turnover modeling (Y, bln rubles).

Variable	Parameter estimate	Standard error	t-statistics	p-value
const	–476,27	135,09	−3,53	0,0223
X_1	7,09	3,08	2,30	0,0401
X_4	–18,02	−3,16	5,70	0,0183
X_7	0,06	0,001	60,00	<0,0001
$R^2 = 0{,}9862$; $F(3, 243) = 341{,}13$; p-value (F) = 0,000.				

Source: Authors.

Thus, the retail turnover model is written as:

$$\widehat{Y}_t = -476{,}27 + 7{,}09X_{1,t} - 18{,}02X_{4,t} + 0{,}06X_{7,t} \quad (2)$$

Our calculations demonstrate the statistical significance of both the model (2) with 5% significance level and parameters estimates. Determination coefficient R^2 = 0,9862 validates the quality of the constructed model. The results imply that if consumer price index increases for 1%, retail turnover will grow for 7,09 billion of rubles. The growth in unemployment rate of 1% will provoke the fall for 18,02 billion of rubles in retail trade. The growth of average monthly designed salary of 1 ruble could be followed by retail turnover growth for 0,06 billion of rubles on average.

To study of the residues of the model (2), the following statistical tests were used [10]:

1) augmented *ADF*-test (the test resulted in a hypothesis on time invariance of the model residues observed value $t = -14{,}32$, p-value= 0,0001);

2) Q-test by Ljung and Box, which demonstrated the lack of autocorrelation for the model residues (observed value Q = 17,30, p-value = 0,3471);

3) chi-squared test which resulted in hypothesis about normal distribution of the residues (observed value χ^2 = 3,75, p-value = 0,2298);

4) White test for heteroscedasticity of the residues (the results allow hypothesizing on the absence of heteroscedasticity on 5% level of significance: observed value χ^2 = 5,68, p-value = 0,7291).

The residues of the model obey Gauss-Markov theorem for multiple linear dependence. Thus the model could be used for forecasting.

3.2 Forecasting

The stage of forecasting retail turnover by the econometric model (2) was preceded by finding the forecast values of the explanatory variables (X_1, X_4, X_7). For time series every variable was provided with the selected model *ARIMA*(p, d, q) [11], which was the best to describe it. The model *ARIMA*(1, 1, 0) was chosen for the explanatory variables (the same for the majority of the RF short-term economic indicators [12]). Using this model the forecast values for explanatory variables were calculated for October, November and December 2019. Table 2 demonstrates forecast calculation results for retail turnover and forecast values of explanatory variables for the same periods. The results are modified taking into account a seasonal component.

Table 2. Forecast of retail turnover.

Forecast period	X_1 (%)	X_4 (%)	X_7 (rubles)	Y (bln rubles)
October 2019	100,1	4,5	47745,3	2990,4
November 2019	100,1	4,4	47754,1	3000,3
December 2019	100,0	4,4	48172,6	3643,2

Source: Authors.

The results show that providing the same economic conditions and official statistics the trend towards retail turnover growth will remain till the end of 2019.

4 Conclusion

This study has identified that retail turnover for the previous 20 years has been demonstrating the stable trend towards growth. There were some other major results of the research, namely:

- the retail turnover model, which is statistically significant, with good forecasting properties was built in the course of this research;
- consumer price index, unemployment rate and average monthly designed salary were included in the econometric model as explanatory variables (based on the analysis of different socio-economic indicators Granger causality test);
- for every selected variable a statistically significant model *ARIMA*(1, 1, 0) was constructed, that was used to calculate forecast values of explicative variables for October, November and December 2019, which were used to forecast the retail turnover for these months.

The technique presented in this work can be used to modeling and forecasting various socio-economic indicators presented as time series.

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