Evaluation of the Effectiveness of Regional Development Using the Statistical Package for Social Science

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Received May 07, 2021; Accepted August 08, 2021
ISSN: 1735-188X
DOI: 10.14704/WEB/V18SI05/WEB18227

Abstract

The development of Digital Economy has its own requirements for the formation and development of an information base for statistical research. In this regard, there is a problem of harmonization of statistical observation methodologies, optimization of their quantity without loss of quality and comparability requirements in the conditions of multitasking and conflict of departmental and federal statistics. This article presents the results of constructing a multi-factor econometric model of the dependence of indicators of socio-economic development of the region on a number of indicators in the framework of the project "Development of a methodology and software platform for building digital twins, intelligent analysis and forecasting of complex economic systems". The simulation was performed for one of the largest subjects in Russia - the Moscow Region in the Statistical Package for Social Science (hereinafter referred to as SPSS). The modeling was done for one of the largest Russian subjects – the Moscow region. Six regressions were selected from a variety of indicators of regional socio-economic development: the average monthly nominal wage of employees in an organization, in rubles; gross regional product per capita, in rubles; investment in fixed capital, in mln rubles; unemployment rate, per cent; per capita retail trade turnover, in rubles; per capita consumer expenditure on average (per month), in rubles. The importance and statistical significance of the parameters in them are confirmed by a number of statistical and mathematical criteria.

Keywords

Regional Socio-economic Situation, Development Indicators, Regional Development, Statistical Analysis.

Introduction

Statistics are valuable only when they are reliable, temporary, and internationally comparable. Government statistical systems in the world are increasingly using big data and special data analysis packages, identifying areas where they will play a crucial role in the future (for example, the macroeconomic forecast) (Eurostat, 2018; Baldacci et al., 2016). In Russia, statistical information flows are organized in such a way that at the federal level it is distributed in an aggregated form. This limits the possibility of its secondary processing, the calculation of analytical and predictive indicators necessary for management bodies, experts, and businesses. Nevertheless, there is a need to identify key indicators of the socio-economic development of the regions. The integration of statistical data from various sources opens up new opportunities for the integrated measurement of socio-economic phenomena. Due to the fact that the regional variability of the set of key indicators is large, the results are presented only for the Moscow region. The tasks set in this paper are solved using the capabilities of the Statistical Package for Social Science (SPSS).

The authors have built six models on the basis of which point and interval predictions of the dynamics for selected indicators are given. The previously known integrated measure of the socio-economic situation in Russian subjects makes it impossible to assess the close relationship between these indicators and the level of social and economic development of the Moscow agglomeration and make a forecast. Most of the studies conducted either assess the degree of regional differentiation of the integrated indicator or consider the interconnection of only some regressions in certain Russian subjects (Ajvazjan, Afanas'ev, 2018; Gagarina et al., 2017).

Literature overview revealed that, for example, the variety of work on assessing the impact of selected factors in the relationship between wages and economic development can be divided into two groups: those that claim, that there is a moderate correlation between these indicators and those that deny the link. The former argue that such a relationship is often implicit. Some authors link wage dynamics to regional development, through the possibility of attracting foreign direct investment (Khachoo, Khan, 2012; Lavrinenko et al., 2018) asserts that connectivity enhances agglomeration.

The authors' view that increasing productivity is a necessary condition for raising the level of social and economic development of a country is confirmed by other researchers: Dieppe (2020); Vertakova (2020). But this is exactly a “bottleneck” The Russian economy has a significantly lower productivity than that of developed countries ($25.9/hour compared to $55.9/hour in the euro area). At the same time, the number of hours worked is one of the highest in Europe. In 2019, the figure was 1,975 hours in Russia with a 5-day working week, compared to 1,742.2 hours in the United States, 1,452 hours in Sweden, and 1,368.8 hours in Germany (recall that hourly labour productivity in the country is $73.2) (Level of GDP per capita and productivity: Labour productivity levels - most recent year, n.d.). Even the labour force employed in the economy is underutilized. The existing wage differentials are overestimated by factors independent of a worker’s efforts and skills, and underestimated in terms of labour input and skills (Xu, Huo, Shang, 2015) asserts that the economic cycle can also have an impact. The influence of these factors can be seen in the evolution of the indices of changes in wages, labour’s share in GDP and labour productivity (Fig. 1).

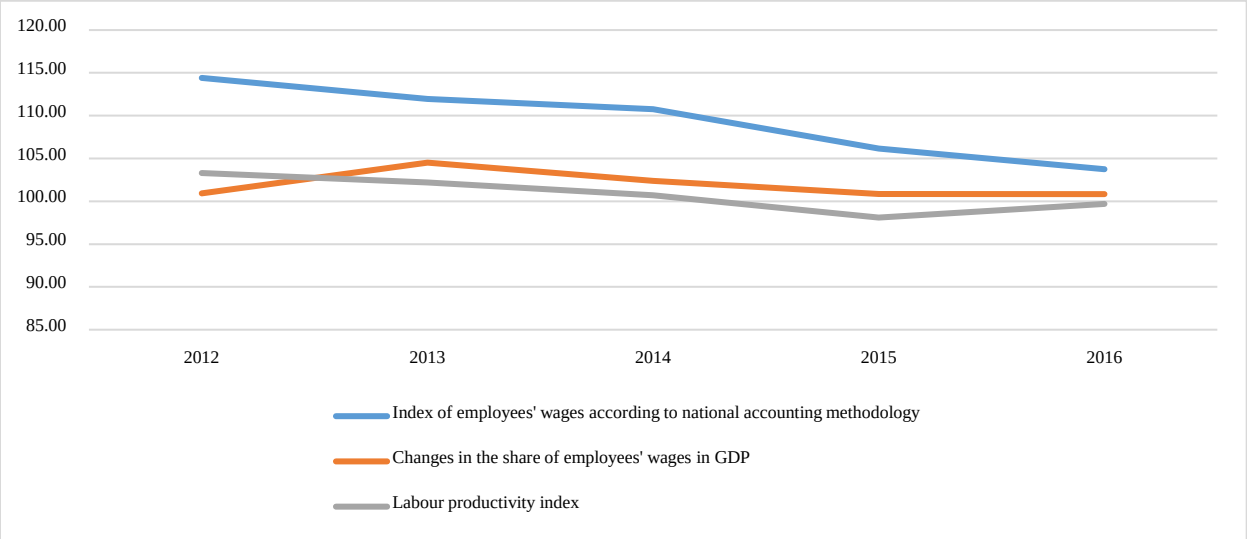

Figure 1 Indices of changes in wages, the share in GDP, and labour productivity (compiled by authors based on the Federal State Statistical Service data https://rosstat.gov.ru/folder/210)

Similar conclusions were reached for other regressions. Thus, the authors reaffirmed the previously identified relationship between regional development and domestic trade. This relationship is evident in terms of trade liberalization (Fedyunina, 2016) and government regulation (Gichiev et al., 2017).

However, there is no comprehensive study aimed at constructing a multi-factor econometric model for assessing the impact of these factors on regional socio-economic indicators, which shows that the issue remains open and needs further study, both in theoretical and empirical terms. In this connection, the authors put forward a hypothesis on the possibility of constructing a statistically significant model of the dependence of the social and economic development indicators of the Moscow region and the level of wages, unemployment and investment in fixed capital, retail turnover per capita and consumer spending. The observed trend in time series will lead to high and low forecasts of the selected indicators.

Methodology

Aiming at reaching this goal, the authors have constructed multi-factor econometric models of the dependence of regional socio-economic development and the selected indicators on the basis of connected time series for 2002-2017. To find the desired coefficients of the regression equations, the SPSS Statistics 20 software package was used. The object of the study is the Moscow region. The study considers the following as indicators of the socio-economic development of the Moscow region, which have an impact on wages in the region:

- The average monthly nominal wage of employees in an organization, in rubles;
- Gross regional product per capita, in rubles;
- Investment in fixed capital, in mln rubles;
- Unemployment rate, per cent;
- Per capita retail trade turnover, in rubles;
- Per capita consumer expenditure on average (per month), in rubles.

In practice, it is difficult to identify components in the time series of wages and other socio-economic development indicators, as individual subsequent time series values are dependent on previous series. Nor is it correct to assume that the factors influencing fluctuations in levels are independent. In addition, the statistical population studied over a long period ceases to be the same population, as the main factors influencing its formation may change.

In studying the time series of socio-economic development indicators in the Moscow region, the authors faced the following challenges:

- Time series of vacancies typically contain long- or short-term development trends related to the elimination of random fluctuations affecting them;
- The socio-economic development indicators of the Moscow region may be subject to regular fluctuations due to periodic fluctuations.

Taking all the above into account, the analysis and modelling of the trend of the time series of socio-economic development indicators of the Moscow region and the level of wages, it was decided in particular to begin with the identification of a trend in general. For this purpose, the study uses the Cumulative T-criterion, which allows to determine the existence of not only the trend in an indicator change itself, but also its mathematical expression - the trend.

The T-criteria obtained show that there is a trend in all the indicators for the whole period considered (Table 1), which will make it possible in the future to determine the predictive characteristics of the indicators.

Table 1 Results of the implementation of the Cumulative T-criterion in assessing the trends in the socio-economic development indicators in the Moscow region in 2002-2017

No	Indicator	Unit of measurement	Cumulative T-criterion	
			value	result
1	the average monthly nominal wage of employees in an organization	rub.	72.1	existing
2	gross regional product per capital	rub.	93.1	existing
3	investment in fixed capital	mln rub.	23.4	existing
4	unemployment rate	per cent	12.1	existing
5	per capita retail trade turnover	rub.	32.7	existing
6	per capita consumer expenditure on average (per month)	rub.	44.9	existing

The identification of the type of trend was carried out by comparing average levels of the time series. Under this method, the initial time series is divided into two approximately equal parts by the number of members in the series, each of which is treated as a separate, independent sample with a normal distribution.

Most models use extrapolation, that is, the extension of trends and regularities, relationships and relations between the past and the present to the future. At the same time, the most significant problem in forecasting wage levels and other socio-economic indicators of the Moscow region on the basis of trend models is the accuracy of the forecast, which is conditional for the following reasons:

- The function chosen for forecasting is not the only one possible and does not describe 100 per cent of the actual trends and patterns;
- The presence of an inadvertent component in time series levels results in any projection being carried out with a certain degree of probability.

In order to obtain reliable forecasts of wage levels and other social and economic development indicators in the Moscow region, it is significant what kind of information is used to obtain forecasts. Evidence shows that information at the most recent levels is most valuable for accurate and reliable projections. Consequently, there is a need for different assessments of the underlying information: the most recent information needs to be evaluated better than the trend information of the past. Such an assessment of the information can be made by discounting based on adaptive forecasting techniques.

Results

The application of the mean-level comparison method has shown that in almost all indicators it is possible to form a trend (excluding Average monthly nominal wage of employees of an organization» - the trend of variance and the indicator «Investment in fixed capital» - the trend of average) (table. 2).

Table 2 Results of implementing the method for comparing the average levels of time series of socio-economic development indicators in the Moscow region in 2002-2017

No	Indicator	Unit of measurement	Method for comparing the average levels of time series	
			trend of average	trend of variance
1	average monthly nominal wage of employees in an organization	rub.	+	-
2	gross regional product per capital	rub.	+	+
3	investment in fixed capital	mln rub.	-	+
4	unemployment rate	per cent	+	+
5	per capita retail trade turnover	rub.	+	+
6	per capita consumer expenditure on average (per month)	rub.	+	+

The application of the extrapolation method enabled the authors to build trend models of selected socio-economic development indicators in the Moscow region: nominal assessed wages, gross regional product per capita, investment in fixed capital, unemployment rate,

per capita turnover of retail trade and average per capita consumption expenditure of the region's population.

The step-by-step implementation of the study is given as an example of the estimation of the average monthly nominal wage of employees in the organizations of the Moscow region for 2018-2022. The trends from the first stage of the models are extrapolated in table 3.

Table 3 Trend models of average monthly nominal wages of employees in the Moscow region's organizations

Trend model	Accuracy criterion	Elasticity
Y(t)=-516.129+2942.355*t	1,406.625	1.021
Y(t)=+194.437+2705.497*t +13.933*t*t	1,429.250	1.034
Y(t)= +5476.268*exp(+0.151*t)	32,367.000	1.283
Y(t)= -6896.429+16374.782*ln(t)	32,744.000	0.582
Y(t)= (+3409.350)*(+1.362)**t*(+0.991)**(t*t)	1,599.750	0.000
Y(t)= +3675.530+3613.513*t-3560.825*sqr(t)	1,196.625	1.063

An analysis of the accuracy and elasticity indicators showed that the best approximation among the equations listed in Table 3 was given by the following model:

$$Y(t)= +3675.530+3613.513*t-3560.825*sqr(t)$$

The study also constructed and analysed the adaptive models presented in table 4.

Table 4 Adaptive models of average monthly nominal wages for employees in the Moscow region's organizations

Model	Adequacy	Accuracy	Quality
Brown's method (+0.135)	89.479	66.735	72.421
Holt's model (+1.000, +0.407)	69.685	65.837	66.799
AR (2, 1)	76.104	0.000	19.026
ARIMA(1, 1,0)	83.389	62.348	67.608
ARIMA (1, 1,1)	71.287	69.201	69.723
ARIMA (2, 1,0)	90.440	72.366	76.884
ARIMA (2, 1,1)	94.972	78.190	82.385

The analysis of adequacy, accuracy and quality indicators of adaptive models of average monthly nominal wage of employees in the organizations of the Moscow region showed that the best approximation among those listed in table 4 gave the ARIMA model (2, 1, 1) with the following parameters: $a_1 = -0.48;\ a_2 = 0.349;\ a_3 = 0.932$. The accuracy of the selected model is presented in the table 5.

Table 5 Characteristics of adaptive model residues in estimating average monthly nominal wage of employees in the Moscow region's organizations

Characteristics	Value
Average residue module	545.725
Relative error	2.682
Darbin-Watson criterion	1.811
Determinism	0.999
F - value	217.167
Adequacy criterion	94.972
Accuracy criterion	78.190
Quality criterion	82.385

The accuracy and adequacy of the selected additive model made it possible to arrive at forecast values of average monthly wage for employees in the organizations in the Moscow region (table 6).

Table 6 Forecasts of average monthly nominal wages of employees in the organizations in the Moscow region in 2020-2022

Years	Forecast		
	Value	Lower Border	Upper Border
2020	56,464.348	54,464.008	58,464.688
2021	59,397.398	57,396.809	61,397.988
2022	62,475.223	60,474.629	64,475.816

Analyzing the prospects of the increase in average monthly nominal wage of employees in the Moscow region's organizations in 2020-2022, it can be noted that its values in 2021 in the region will range from 57,396.809 to 61,397.988.

This approach has since allowed for the construction of different trend models (table 7), high and low projections (table 8).

Table 7 Models of trends in socio-economic development indicators developed for the Moscow region

Model Name	Trend Model	Accuracy criterion	Elasticity
Gross regional product per capita	Y(t)= +55903.690+40311.835*t-49753.849*sqr(t)	237.702	1.066
Investment in fixed assets	Y(t)=-14903.462+64316.117*t -1335.500*t*t	2,611.301	0.813
Unemployment rate	Y(t)= +4.193-0.437*ln(t)	0.449	-0.134
Retail turnover per capita	Y(t)= +17747.475+21048.770*t-19688.750*sqr(t)	52,233	1.079
Consumption expenditure per capita on average	Y(t)= +2629.653+2462.349*t-2823.913*sqr(t)	345,808.813	1.097

Table 8 Projection values of the modelled indicators for the Moscow region

Years	Value	Lower Border	Upper Border
Investment in fixed assets			
2020	728,463.313	654,761.938	802,164.688
2021	721,618.125	647,916.500	795,319.750
2022	739,906.000	666,204.250	813,607.750
Unemployment rate			
2020	2.944	1.214	4.673
2021	3.143	1.261	5.026
2022	3.259	1.070	5.448
Retail turnover per capita			
2020	331,273.063	314,377.063	348,169.063
2021	349,409.125	332,513.125	366,305.125
2022	367,454.594	350,558.594	384,350.594
Consumption expenditure per capita on average			
2020	36,972.348	35,237.375	38,707.320
2021	39,008.078	37,273.105	40,743.051
2022	41,044.129	39,309.156	42,779.102

According to the models developed, most indicators (excluding unemployment) are expected to grow.

The presented results of the Correlation Coefficient Pair Matrix (Annex 1) showed a weak correlation between the average monthly nominal wage and the unemployment rate, so the indicator was excluded from further analysis.

The high level of autocorrelation revealed led to the construction of autoregression models with the inclusion of an additional time factor along with indicators of the socio-economic development of the region, the determination of which order depends on the choice of the trend form in the change of wages and other social and economic development indicators of the Moscow region. The simulation is performed for both cases: when the time series levels are missing, and for the case of autocorrelation.

The preliminary assumptions made it possible to build two models for assessing the impact of socio-economic development indicators in the Moscow region on the salary level:

1. The autoregression model of the dependency of the average monthly nominal wage of employees in an organization and gross regional product per capita and fixed investment, including the time factor, where Y is the average monthly nominal wage

of employees in an organization, in rubles; X_1 - gross regional product per capita, in rubles; X_2 - investment in fixed capital, in mln rubles:

$$\hat{Y}_{x,t} = -856.871 + 0.047\ X_1 + 0.009\ X_2 + 1561.215\ t$$

Regression coefficients are statistically significant by the Student's T-criterion at a value of 0.05. The estimates of regression coefficients, adequacy criteria and statistical significance correspond to acceptable values.

As a test period, the last three levels of the initial temporary series of the average monthly nominal wage of employees in an organization were considered in the retrospective (table 9).

Table 9 Retrospective forecast of the average monthly nominal wage of employees in the Moscow region's organizations

Prevention	Actual	Projection	Lower Border	Upper Border	Absolute Deviation	Relative Deviation
2015	40,643.000	41,774.570	39,927.152	43,621.988	-1131.570	-2.784
2016	42,656.000	45,528.516	42,582.691	48,474.340	-2872.516	-6.734
2017	46,836.000	47,510.055	45,233.512	49,786.598	-674.055	-1.439

The parameters of the model show that if the gross regional product per capita increases by 1 rub., the average monthly nominal wage of employees in an organization increases by an average of 0.047 rubles. The increase in investment in the capital stock of the Moscow region gives an average increase in the level of wages by 0.009 rubles.

2. The autoregression model of the dependency of the average monthly nominal wage of employees in an organization on per capita retail trade turnover and consumer spending on average per capita, as well as the time factor, where Y is the average monthly nominal wage of employees in an organization, in rubles; X_1 - per capita retail turnover, in rubles, and X_2 - per capita consumer expenditure (per month), in rubles:

$$\hat{Y}_{x,t} = 111{,}863 - 0{,}060\ X_1 + 2{,}052\ X_2 + 112{,}691\ t$$

Regression coefficients are statistically significant by the Student's T-criterion at a value of 0.05.

The results of the retrospective projection are presented in table 10.

Table 10 Retrospective forecast of the average monthly nominal wage of employees in the Moscow region from per capita retail trade turnover and per capita consumer spending on average

Prevention	Actual	Projection	Lower Border	Upper Border	Absolute Deviation	Relative Deviation
2015	40,643.000	41,589.070	40,811.656	42,366.484	-946.070	-2.328
2016	42,656.000	44,678.906	43,742.129	45,615.684	-2022.906	-4.742
2017	46,836.000	48,417.781	47,259.887	49,575.676	-1581.781	-3.377

The analysis of the absolute and relative deviations shows that the obtained retrospective characteristics are fairly accurate, which, in turn, demonstrates the high quality of the resulting model of the dependence of the average monthly nominal wage of employees in an organization and per capita retail trade turnover and per capita consumer spending on average.

The parameters of the model show that when retail turnover per capita increases by 1 rub., the average monthly nominal wage of employees in an organization declines by an average of 0.060 rubles. The increase in consumer spending per capita in the Moscow region results in an average increase in the level of wages by 2.052 rubles.

Thus, the average monthly nominal wage of employees in the Moscow region is influenced by the gross regional product per capita and by investment in fixed capital, per capita retail turnover and per capita consumer spending on average.

Discussion

The results of the study confirmed the authors' hypothesis that there is a connection between the average monthly nominal wage of employees in the organization, in rubles; gross regional product per capita, in rubles; investment in fixed capital, in mln rubles, unemployment rate, per cent; turnover of retail trade per capita, in rubles per capita consumer spending on average (per month), in rubles, and the socio-economic development indicators of a Russian subject. The advantage of the presented approach is that the models based on it make it possible to quantify the relative change in the level of socio-economic indicators of a region when six significant indicators are changed. The point-to-point and interval forecasts will allow for more accurate indicative planning for regional development, and are of interest to business and government agencies.

The heterogeneity of production activities in the Moscow region is due to certain factors among which: natural and climatic differences, resource endowment, economic specialization, innovative and technological level of production, transport logistics and

human capital development. All these factors determine the identity and characteristics of the spatial socio-economic development.

The authors note that the regulatory role of the federal and municipal authorities in managing economic processes is diminishing and requires further research.

The purpose of such an analysis should be to assess the extent of intra-regional differences, to identify trends in them, and to identify and systematize the factors (internal and external) that have the greatest impact on these trends.

It has also been observed that, in the long run, there is an inverse relationship where the characteristics of social and economic development affect the reproduction process.

Conclusion

The paper presents the results of modeling the values of selected regional socio-economic in relation to the changes in average nominal wages in the region. The proposed model underlies the implementation of the concept of sustainable development of the region's space. To find the desired coefficients of the regression equations, the SPSS Statistics 20 software package was used

Acknowledgment

This study was carried out as a part of a state task in the field of scientific activity of the Ministry of Science and Higher Education of the Russian Federation on the topic "Development of a methodology and software platform for building digital twins, intelligent analysis and forecasting of complex economic systems", project number is FSSW-2020-0008.

References

Ajvazjan, S.A., & Afanas'ev, M. Ju. (2018). Indicators of the socio-economic development of the Russian subject in the framework of regional differentiation characteristics. *Herald of CEMI, 1*(2). https://cemi.jes.su/s111111110000133-9-1/

Baldacci, E., Buono, D., Kapetanios, G., Krische, S., Marcellino, M., Mazzi, G.L., & Papailias, F. (2016). *Big data and macroeconomic nowcasting: From data access to modelling.* Luxembourg: Publications Office of the European Union.

Dieppe, A. (2020). *Global Productivity: Trends, Drivers, and Policies International Bank for Reconstruction and Development.* The World Bank.

Eurostat. (2018). Annual Work Programme 2018. *Strategic Priorities.* https://ec.europa.eu/eurostat/web/ess/-/annual-work-programme-2018

Fedyunina, A. (2016). Trade Liberalisation and Its Impact on Regional Development: Theoretical and Experimental Studies. *Baltic region, 8*(3), 70-83.

Gagarina, G.Y., Dzyuba, E.I., Gubarev, R.V., & Fayzullin, F.S. (2017). Forecasting of Socio-Economic Development of the Russian Regions. *Economy of Region, 13*(4), 1080-1094. https://doi.org/10.17059/2017-4-9

Gichiev, N.S., Shabanova, M.M., & Surakatov, N.S. (2017). Economic growth of the border region: methods for assessing the impact of foreign trade relations. *Scientific journal Fundamental research,* 11.

Khachoo, A.Q., & Khan, M.I. (2012). *Munich Personal RePEc Archive: Determinants of FDI inflows to developing countries: a panel data analysis.* https://mpra.ub.uni-muenchen.de/37278/1/MPRApaper37278.pdf

Lavrinenko, P.A., Romashina, A.A., Mikhailova, T.N., & Chistyakov, P.A. (2019). Agglomeration Effect as a Tool of Regional Development. *Studies on Russian Economic Development, 30*(3), 268–274. https://doi.org/10.1134/S1075700719030109

Level of GDP per capita and productivity: Labour productivity levels - most recent year. (n.d.). OECD Statistics. https://stats.oecd.org/Index.aspx?DataSetCode=LEVEL

Vertakova, Y., & Maltseva, I. (2020). Labor productivity: analysis of the current level and identification of opportunities for its growth. *Revista Espacios, 41*(27).

Xu, S., Huo, L., & Shang, W. (2015). The Impact of Wage Distributions on Economics Growth Based on Multi-agent Simulation. *Procedia Computer Science, 55,* 809-817. https://doi.org/10.1016/j.procs.2015.07.155

Cheshmeh Sohrabi, M., & Dashtaki, N.A. (2019). Ask search engine: Features and performance identification. *Webology, 16*(1), 77-85.

Annex 1

Correlation Coefficient Pair Matrix between socio-economic development indicators of the Moscow region

Variable	Average monthly nominal wage of employees in an organization	Gross regional product per capital	Investment in fixed capital	Unemployment rate	Per capita retail trade turnover	Per capita consumer expenditure on average (per month)
Average monthly nominal wage of employees in an organization	1.000	0.994	0.969	-0.340	0.997	0.998
Gross regional product per capital	0.994	1.000	0.964	-0.368	0.996	0.997
Investment in fixed capital	0.969	0.964	1.000	-0.495	0.969	0.968
Unemployment rate	-0.340	-0.368	-0.495	1.000	-0.350	-0.354
Per capita retail trade turnover	0.997	0.996	0.969	-0.350	1.000	0.999
Per capita consumer expenditure on average (per month)	0.998	0.997	0.968	-0.354	0.999	1.000