# Neural Network Analytics and Forecasting the Country's Business Climate in Conditions of the Coronavirus Disease (COVID-19)

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**Abstract**

The prospects for doing business in countries are also determined by the business confidence index. The purpose of the article is to model trends in indicators that determine the state of the business climate of countries, in particular, the period of influence of the consequences of COVID-19 is of scientific interest. The approach is based on the preliminary results of substantiating a set of indicators and applying the taxonomy method to substantiate an alternative indicator of the business climate, the advantage of which is its advanced nature. The most significant factors influencing the business climate index were identified, in particular, the annual GDP growth rate and the volume of retail sales. The similarity of the trends in the calculated and actual business climate index was obtained, the forecast values were calculated with an accuracy of 89.38%. And also, the obtained modeling results were developed by means of building and using neural networks with learning capabilities, which makes it possible to improve the quality and accuracy of the business climate index forecast up to 96.22%. It has been established that the consequences of the impact of COVID-19 are forecasting a decrease in the level of the country's business climate index in the 3rd quarter of 2020. The proposed approach to modeling the country's business climate is unified, easily applied to the macroeconomic data of various countries, demonstrates a high level of accuracy and quality of forecasting. The prospects for further research are modeling the business climate of the countries of the world in order to compare trends and levels, as well as their changes under the influence of quarantine restrictions.

**Keywords** [1]

Business climate, Index, Correlation analysis, Indicators, Taxonomic model, Neural network model, COVID-19.

## 1. Introduction

New economic conditions, in particular under conditions of quarantine restrictions, have determined a range of new requirements for the functioning and development of socio-economic systems around the world. The delay in responding to new challenges, resistance to new changes, and the inability of systems to respond appropriately led to a deterioration in the state and trends of key indicators, which also describe and characterize the business climate of countries. To find adaptation mechanisms, first of all, it is necessary at the level of awareness of problematic issues and only then, from a fundamentally different angle of view, to revise statistical data, the prospects for their changes. The criteria for the accuracy and adequacy of the results of predictions of key indicators remain an unchanged condition, which serves as the basis for making timely management decisions. Unfortunately, the existing methodology for assessing the business climate of countries appears in the

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public domain with a significant time delay. In previous researches, the authors were able to substantiate an alternative approach to calculating the business climate index, the values of which can be obtained earlier than the official indicator [1, 2]. Despite the high closeness of the official and calculated by the authors indicators of the business climate of countries, the similarity of their trends, the practical value of an alternative approach to assessing the country's business climate creates the possibility of ensuring high accuracy of its forecast data, especially if take into account the quarantine restrictions that have formed new conditions for socio-economic development, which have determined the vector of scientific research.

## 2. Related works

The formation of the value of the business climate indicator is carried out using expert assessment of the results of sociological research (surveys) on macroeconomic expectations. The results obtained are considered to be quite valuable for both science and practice [3]. At the same time, the approach is not devoid of disadvantages that relate to the subjective assessments of respondents, the variability of their impressions and thoughts, which generally distorts the actual state of affairs. However, scientists did not stop searching for links between the business climate and other socio-economic indicators, for example, GDP indicators [4, 5, 6, 7] and individual indicators of the monetary system [8]. Most scientists use the method of constructing an index in order to form an integral indicator of the country's business climate [9] and recommend the use of BiLSTM. To implement the task of predicting the state of the business climate, scientists are not limited in the choice of methods and approaches [5, 9]. For example, in the paper [10], a regression analysis of the constructed business climate indices of European countries is carried out. Today, technologies for constructing artificial neural networks for the purpose of forecasting time series are popular [1]. Article [11] demonstrates the results of forecasting the business climate according to the index of the same name, which is a significant indicator of the socio-economic efficiency of the functioning and development of states. The research results can be deepened using the methodology for constructing neural networks, the research potential of which is unlimited.

## 3. Methodical approach to modeling

In this research, modeling of the business climate in Ukraine is proposed to be carried out in several interrelated stages (Figure 1).

The nature of the trends in key indicators of the business climate was determined. A set of input statistical data was formed on the basis of processing and analysis of data from the National Bank of Ukraine [12] and the international website "Trading Economics" [13 - 23]. The study period by the authors is limited from the first quarter of 2018 to the third quarter of 2020 in order to determine the characteristic trends during the period of the influence of quarantine restrictions.

The approach proposed by the authors provides for the assessment of the integral index of business confidence based on the taxonomic model and its forecasting by methods of neural network technologies. The results of the taxonomic analysis of the country's business climate, based on the substantiation of an alternative approach, are presented in the article by the authors [2].

In the course of the study and construction of an alternative indicator of the business climate using the taxonomy method, it was found that the trends and the level of the target indicator most determine the trends in retail sales and indicators of annual GDP growth. The tendencies of the calculated and actual business climate indices are similar, the constructed business climate forecast was made with an accuracy of 89.38%.

Forecasting the business confidence index (BCI) of Ukraine is carried out by two methods: using a taxonomic model and neural network technologies. Based on the taxonomic model, which was built in the previous research [2], the forecast time series of the index of business expectations of entrepreneurs is calculated for all analyzed time periods.

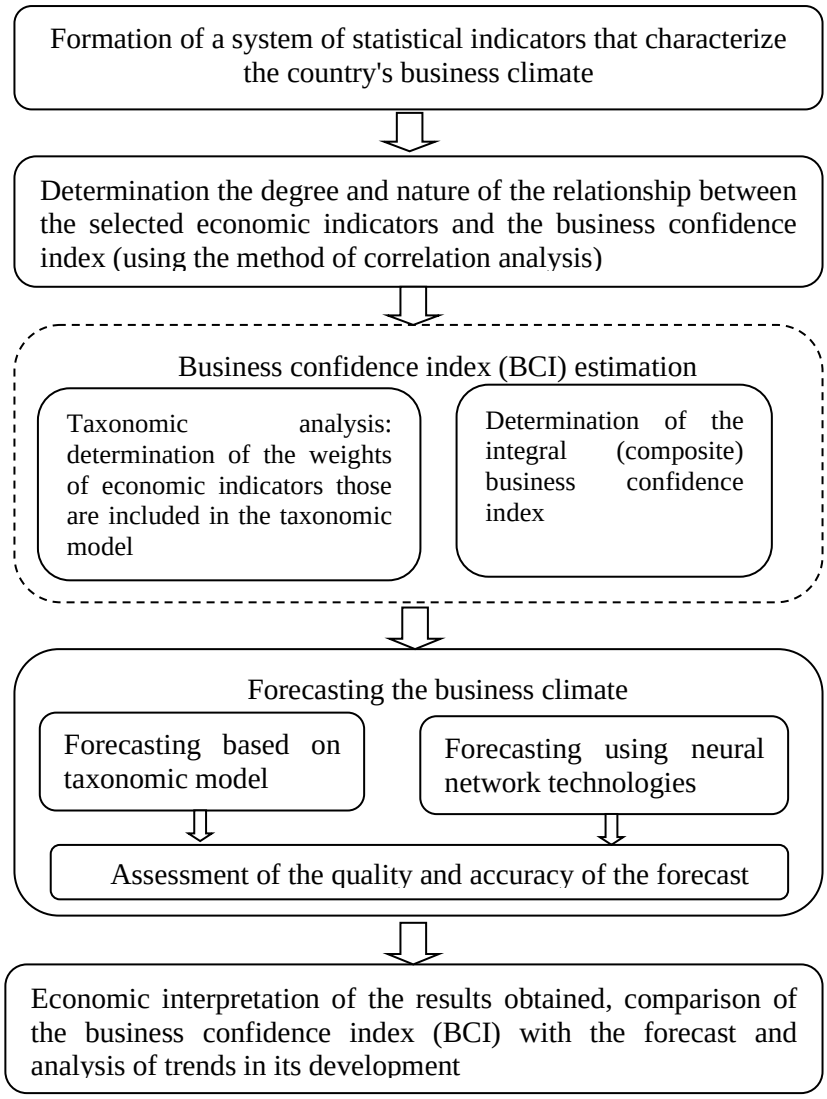


**Figure 1:** Sequence of modeling trends in the business climate indicator in the country under the influence of quarantine restrictions

The neural network is trained on the basis of the training and test sets formed according to the results of the correlation analysis. A certain array of the initial set makes it possible to get the number of inputs of the neural network, and the result is only one – the value of the business confidence index. Next stage is selection of the type of neural network, the mechanism of its training, testing and launch it for forecasting [11].

After obtaining the predicted values using two methods, the results are analyzed, namely, the accuracy and quality of the calculated forecast is established. The forecast quality for a taxonomic model is determined on the basis of the coefficient of determination, and for a neural network model clearly determined from the diagram, taking into account the confidence intervals. The forecast accuracy is established using indicators such as the average error of the training set, the average error of the test set and the absolute percentage error (MAPE).

In order to determine the adequacy of the author's methodological proposals, a comparison of these values of the calculated index and the actual index is made. Forecasting results in conditions of high accuracy are a tool for making management decisions. The advantages of the proposed approach is that it can be used for data from any country. Therefore, the set of explanatory indicators is a variable component. Also, the criteria for choosing a calculation method are the quality and accuracy of forecasting. The obtained modeling results are indicators of business expectations in the country.

## 4. Results

The author's methodical approach is applied to the macroeconomic data of Ukraine under the influence of the quarantine restrictions. The results of previous studies were updated by taking into account the data of key offensive indicators such as Retail sales, Industrial production, Steel production, Export, Imports and GDP annual growth rate) in the period 2008-2020. The forecast result is determined by the formula:

$$\begin{aligned}&\overline{BCI}_i = W_1 \cdot RS_i + W_2 \cdot IP_i + W_3 \cdot SP_i + W_4 \times \\ &\times Exports_i + W_5 \cdot \text{Im}\, ports_i + W_6 \times \\ &\times GDP\_AGR_i = 0,218 \cdot RS_i + 0,176 \times \\ &\times IP_i + 0,128 \cdot SP_i + 0,096 \cdot Exports_i + \\ &+0,096 \cdot \text{Im}\, ports_i + 0,286 \cdot GDP\_AGR_i\end{aligned} \quad (1)$$

Figure 2 shows the tendencies in the values of the indices of business expectations, business confidence, which were built using the taxonomic method. It was determined that the forecast error of the business confidence index slightly exceeds 10%.

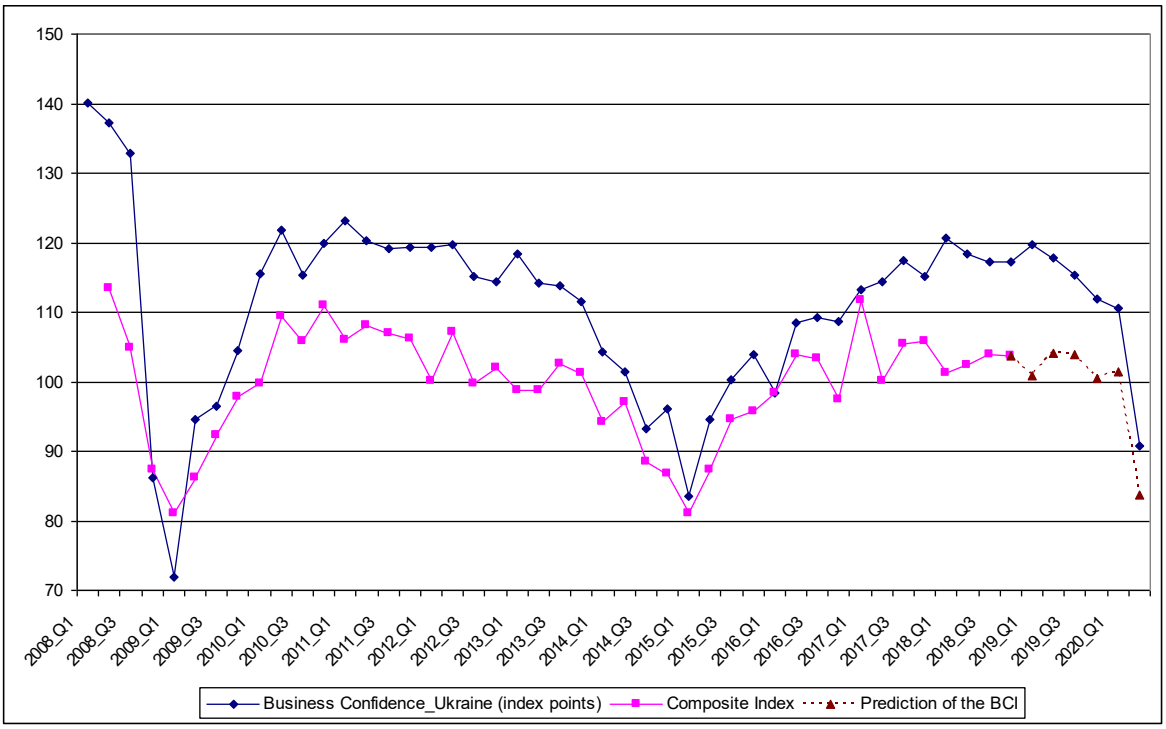


**Figure 2:** Trends in actual and taxonomically constructed business confidence indices in Ukraine

Figure 2 shows that the trends in indicators are similar, the difference in the levels of values of the calculated and actual indices slightly exceeds 9%. Therefore, the calculated index is valuable for determining the nature of the trends in the business climate in the country.

So, in comparison with the corresponding quarter of 2019, the predicted value of the calculated index is 100.8% in the first quarter of 2020, 104% in the second quarter of 2020, 103% in the third quarter of 2020, and 100.41% in the fourth quarter of 2020. For the first quarter of 2020 the index value is forecasted at 101.37% and 83.75% the second quarter of 2020 respectively. The average value of the composite index according to forecast period is 89.4% of the actual business confidence index value.

According to the results of a survey of entrepreneurs of Ukraine by the Department of Statistics and Reporting of the National Bank of Ukraine, in the second quarter of 2020, business assessments regarding further economic growth in Ukraine deteriorated significantly against the background of

anti-epidemiological measures introduced. Accelerating inflationary processes and devalue the national currency are expected by business. The business confidence index in the second quarter of 2020 (90.8%) is the lowest value since the first quarter of 2015. Enterprises expect tougher conditions for taking bank loans and continue to give preference to loans in the national currency. All enterprises expect a reduction in production volumes, and the largest reduction is expected in trade. The financial and economic situation was negatively assessed by enterprises of all spheres of activity, and especially suppliers of energy and water, as well as the transport sector. Most of the spare production opportunities for enterprises in the construction industry and that carry out export and import operations. For the first time since the first quarter of 2016, the business confidence index was less than 100%, which indicates negative economic sentiment among enterprises. Business is expected to reduce investment activity and costs for construction and renovation of equipment and inventory. For the third quarter in a row, businesses are expecting a decline in the number of workers at their enterprises. One of the most significant factors limiting the increase in production by enterprises is insufficient demand.

The scientific and practical value is a certain similarity between the trends of the calculated and actual indices of the country's business climate. The greatest similarity of trends was observed precisely during periods of instability in the socio-economic development of Ukraine: 2009, 2014, 2015, 2020. Thus, it is fully justified to apply a proven approach to modeling the business climate in countries in a crisis and uncertainty of development.

The BCI forecast was obtained by means of taxonomy, in order to develop the approach, neural network technology was further applied in terms of building a neural network. According to a certain density of connections between indicators, the following key set was justified: Retail sales, Industrial production, Steel production, Export, Imports and GDP annual growth rate.

By means of Deductor Studio Academic 5.3, the resulting model was investigated, which is divided in structure into six input factors, hidden layer with neurons and an index of business confidence at the output. Using the sigmoid function, the initial values of which are in the range from 0 to 1 [24], the hidden layer is activated. Back-Propagation is used as a learning algorithm at a rate of 0.1. The real and reference network outputs differ by 0.05. The maximum number of learning iterations is 10000. The choice of the architecture of neural network will be made between models with one, two and three neurons in a hidden layer. The criterion for choosing a model is the value of the standard deviation of the forecast error business confidence index (BCI_ERR). The calculation results are presented in Table 1.

**Table 1**

The architecture of neural network

| Type of the neural network | Percentage of recognized examples | | The number of epochs of optimal network training | Standard deviation CI_ERR |
|---|---|---|---|---|
| | training set | test set | | |
| [6–1–1] | 100 | 100 | 8000 | 0.010103 |
| [6–2–1] | 100 | 100 | 5000 | 0.005633 |
| [6–3–1] | 100 | 100 | 4000 | 0.0115208 |

The minimum standard deviation BCI_ERR was received for architecture of neural network [6–2–1]. Thus, the neural network of the type [6–2–1] used (Figure 3).

The time period for analysis is first quarter of 2008 - second quarter of 2020. The training set consists of 88% of the data and the test set – 12% of data.

At the next stage, the parameters of the forecast are determined, in particular, the quality for confidence intervals and accuracy. Dispersion diagrams are shown in Figure 4 and. Figure 5.

The green dots in Figure 4 and Figure 5 are the actual values of the BCI, and the red dots are the predicted values of the BCI according to the results of neural network modeling. The blue line in Figure 4 and. Figure 5 is the reference value, and the red lines are the boundaries of the 95% confidence interval.

From dispersion diagrams, it can be seen that the predicted data are within the confidence interval, so the model is considered to be of high quality.

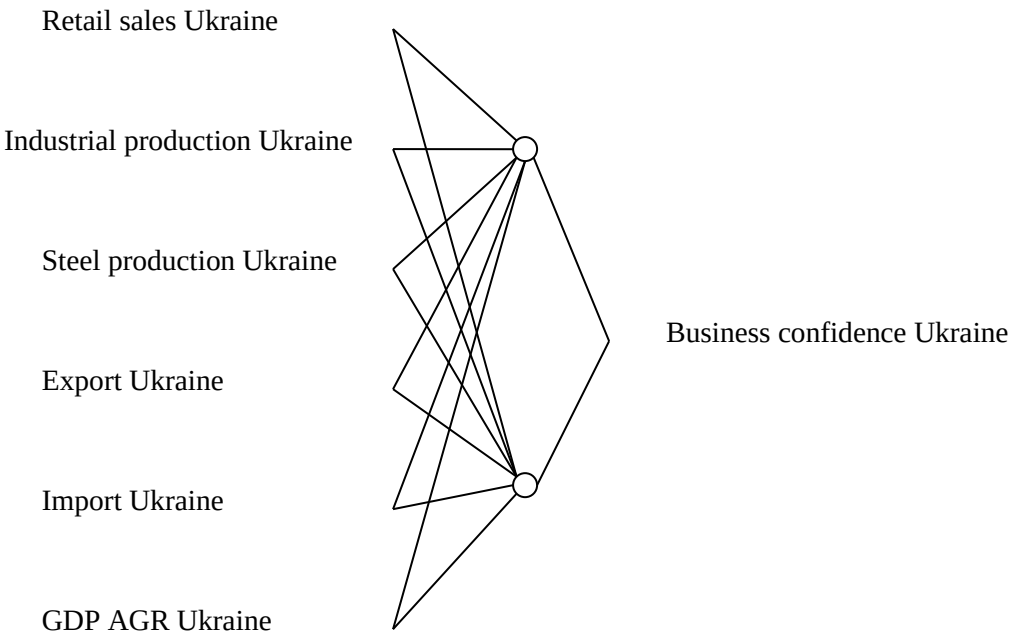


**Figure 3:** Neural network of the type [6–2–1]

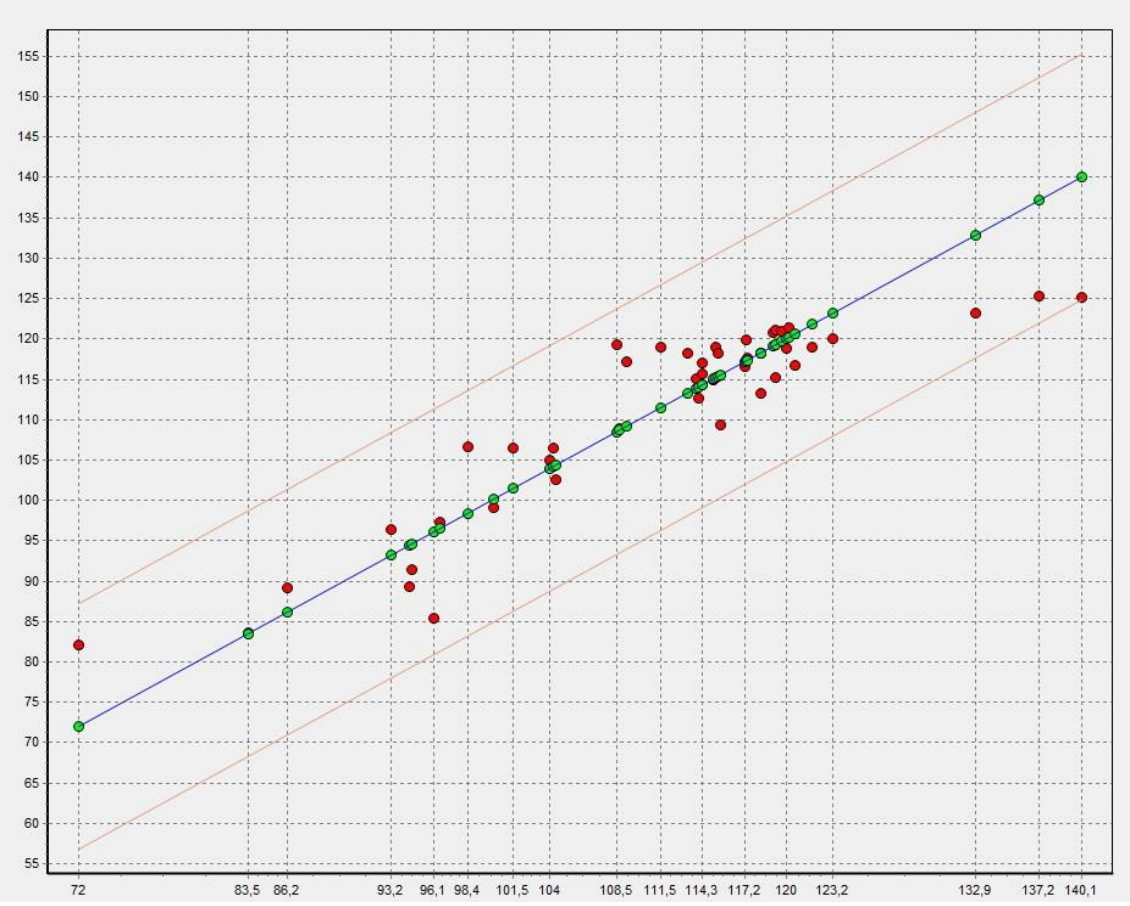


**Figure 4:** Dispersion diagram of the train set of the neural network

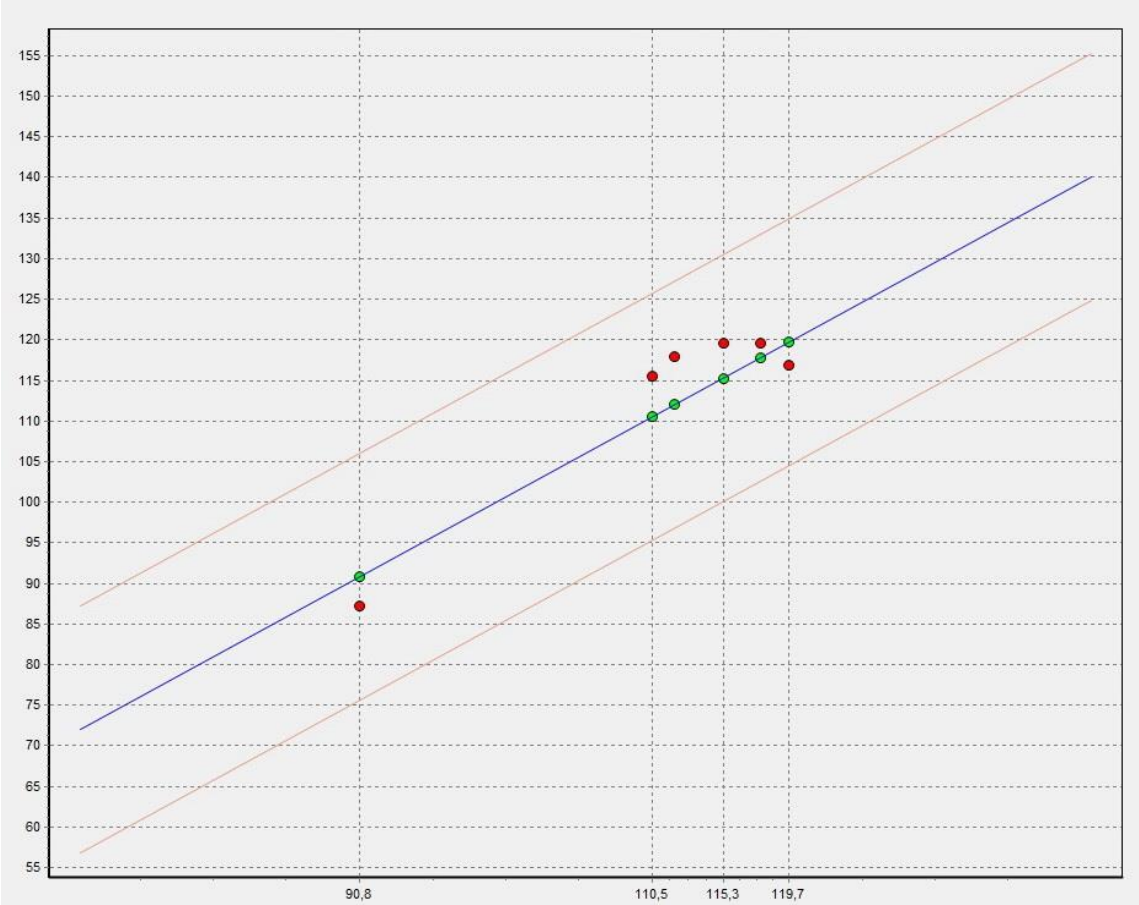


**Figure 5:** Dispersion diagram of the test set of the neural network

It was found that the developed neural network model is valuable for predicting the country's business climate index, since the threshold values of the recognition error (0.05) are not exceeded by the error values of the training and test sets. The quality of the forecast meets the requirements, since the absolute percentage error did not exceed 10% (Table 2).

**Table 2**

Measures of train and forecast sets

| Measures | Value of the measure |
|---|---|
| Average error of the train set | 0.0063 |
| Maximum error of the train set | 0.0490 |
| Average error of the test set | 0.0037 |
| Maximum error of the test set | 0.0076 |
| Absolute percentage error (MAPE), % | 3.8 |

The dynamics of the actual values and the modeling values obtained by the neural network model for Ukrainian enterprises are shown in Figure 6. The research of the data in Figure 6 confirms the identity of the trends and the convergence of the predicted and real values of the business confidence index of Ukraine.

According to Table 2, it can be concluded that the neural network model gives more accurate results compared to the taxonomic model, since the absolute percentage error (MAPE) is 3.8% compared to 10.62%. Therefore, the neural network model will be used for further forecasting of the business climate in Ukraine.

To build the predicted value of the index of business expectations of Ukrainian enterprises for the third quarter of 2020, the predicted values of socio-economic indicators that are included in the

constructed model were calculated. The forecast was made by the exponential smoothing method with a smoothing parameter $\alpha = 0.9$ (Table 3).

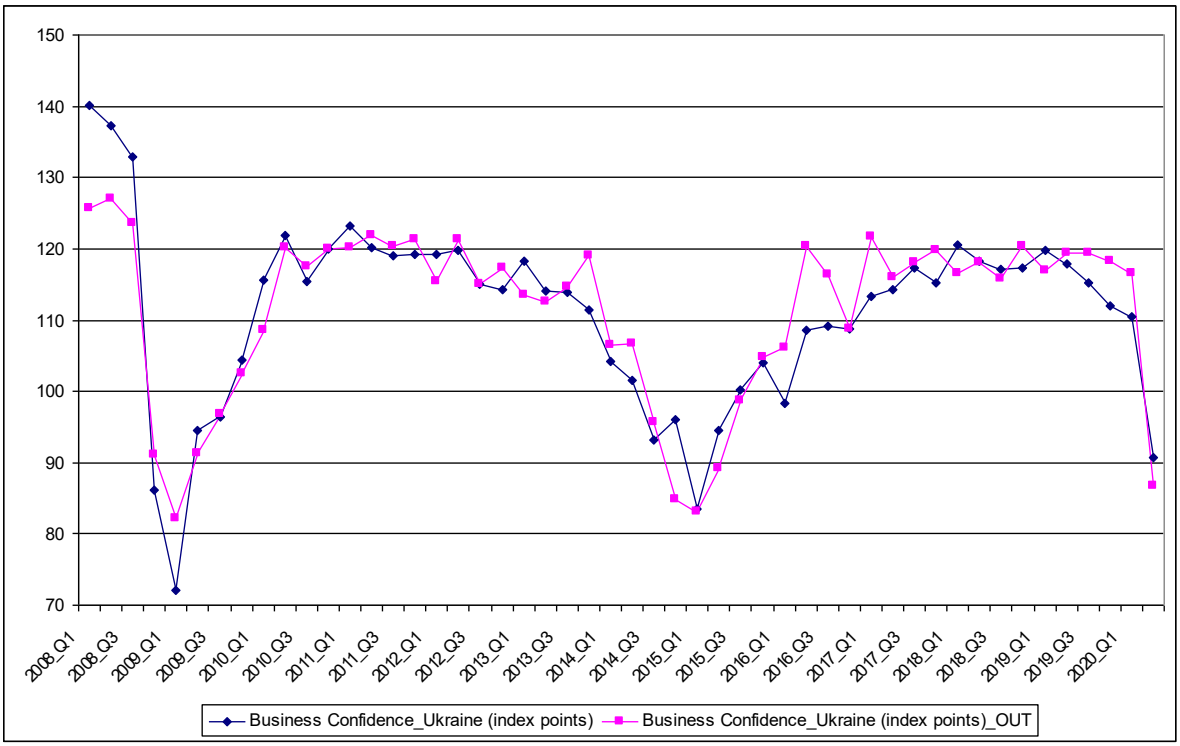


**Figure. 6:** The dynamics of the actual values of business confidence index and the modeling values obtained by the neural network model for Ukrainian enterprises

**Table 3**

Forecast values of socio-economic indicators for the third quarter of 2020

| Economic indicators | Forecast values (index points) |
|---|---|
| Retail sales (RS) | 96.18 |
| Industrial production (IP) | 89.34 |
| Steel production (SP) | 92.61 |
| Export | 63.02 |
| Import | 54.15 |
| GDP annual growth rate (GDP_AGR) | 90.00 |

According to the forecast results, the following changes in the growth rates of socio-economic indicators will occur in the third quarter of 2020 compared with the previous quarter 2020 and the third quarter 2019:

- Retail sales will decrease by 3.82% and 15.92% respectively;
- Industrial production will up by 0.64% and decrease by 3.96% respectively;
- Steel production will up by 2.59% and 11.26% respectively;
- Export will up by 3.58% and decrease by 39.73% respectively;
- Import will up by 3.27% and decrease by 52.58% respectively;
- GDP annual growth rate will up by 1.00% and decrease by 11.50% respectively.

Thus, we can conclude that in the third quarter of 2020 there will be a decline in the growth rate of all socio-economic indicators compared to the same period in 2019, with the exception of Steel production, which will increase by 11.26%. The largest drop (by almost half) will be shown by Import. One of the main reasons for the drop in the growth rate of socio-economic indicators is the introduction of quarantine restrictions in connection with COVID-19, the closure of borders and the postponement of the implementation of previously planned deliveries. Forecast of the business

confidence index (BCI) for the third quarter of 2020 in Ukraine was made using the "What - If" tool of Deductor Studio Academic 5.3. The forecast result is equal to 87.65 index points and shown in Figure 7.

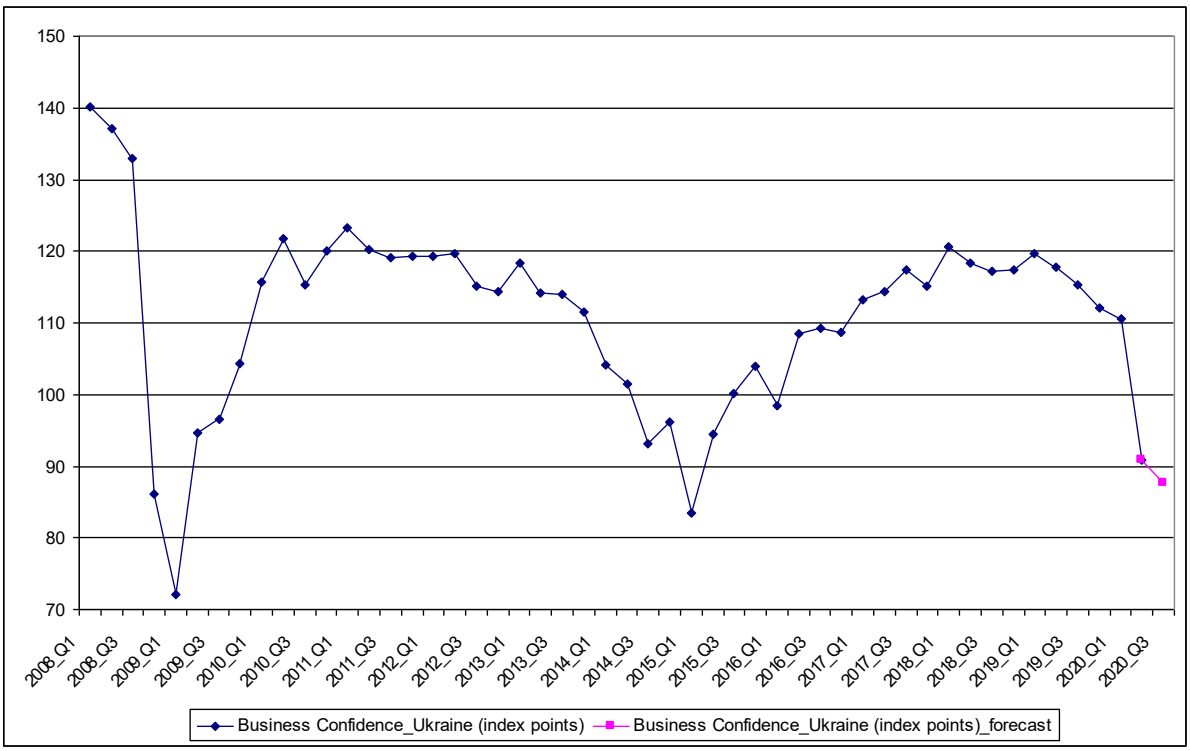


**Figure. 7:** The value of the predictive indicator of the business confidence index, obtained based on the use of the constructed neural network model

According to the results of forecasting using a neural network model, in the third quarter of 2020, the business confidence index (BCI) in Ukraine is expected to decrease by 3.47% compared to the previous period due to the destabilization of business activity, as well as through quarantine restrictions.

The deterioration of the business climate is a completely logical phenomenon in conditions when the current accumulated and unresolved socio-economic problems are superimposed on the consequences of the pandemic and the conditions for the functioning of society and business are sharply limited by quarantine norms. The lack of an effective platform in the state, which would make it possible to ensure the free use of alternative mechanisms and methods of interaction of socio-economic entities, is complicated by the increasing risks of activities in 2020. Thus, the World Economic Forum (Global Risks report 2020) highlighted a set of risky areas in 2020: ecological crisis, political polarity and economic confrontation [24]. Although the leading European countries classify environmental risks as reputational, unfortunately in Ukraine, environmental safety issues are resolved quite formally. However, the above also negatively affects the expectations and behavior of business and society, since any activity is associated to one degree or another with the environment and the health status of citizens strongly depends on the ecosystem in which they are located. Therefore, the issues of environmental impact on the business climate of a developing country should be separately studied.

The risks of economic confrontation continue to evolve and grow [25]. Today, the markets of the European Union are open for Ukraine, but the export of raw materials, and not goods with high added value, continues, which increases dependence on the world market conditions. In addition, the existing value chains require transformation towards extending the cycle based on the principle of self-organization by setting up and expanding the form of cross-interaction between economic sectors and types of economic activity, integrating smart specialization in all areas: from production and consumption to management and coordination. Political polarity as a risk in Ukraine is aggravated by the negative consequences of political populism that has historically developed in the country's

political arena. Too high instability of both legislation and political personnel requires special attention. According to the results of a survey by the European Business Association [3], it was found that the majority of respondents explain the deterioration of the business climate in Ukraine not only by restrictive measures due to COVID-19, but also by the internal imbalances of the socio-economic system of the state at all levels, in particular, the shadow sector of the economy, corruption, instability of the exchange rate, hybrid war, reforms, distrust of power structures, political instability, low living standards, and so on. Experts establish the similarity of the negative sentiments of those surveyed during the quarantine period of 2020 and during the period of the impact of the consequences of the hybrid war in Ukraine in 2014-2015. Thus, the deterioration of the country's business climate is predictable, has a logical nature of manifestation, only accelerated and worsened due to COVID-19.

## 5. Conclusions

The authors managed to develop the results of applying statistics to the study of the country's business climate through the use of neural network technologies. The synthesis of the taxonomy method and the construction of a neural network has shown its advantage in the high quality and accuracy of the forecast data. The deterioration of the business climate in Ukraine in the third quarter of 2020 is predicted as a result of the negative impact of the new business environment on the business activity of business and society. The approach is unified, it can be used for data from different countries, regions, functional territories, since it relies on the density of communication between indicators and high quality and accuracy of the model basis. The obtained calculated and forecast data demonstrate a similar trend, the level of the values of the indicators is as close as possible to each other. The practical value of the proposed approach to modeling the business climate is that it is possible to reduce the amount of funding for sociological research, since it makes no sense to conduct a survey of respondents, the results of which are always subjective, volatile and processed with a delay. The use of macroeconomic indicators that are published in each country in open sources, that is, are available, will make it possible to get the value of the target indicator much earlier and make management and strategic decisions in time. Further unification of the approach will be useful for the formation of a knowledge base about the business climate, its level and trends in different countries of the world. The weak point in the approach of the alternative business climate index is the limited and low reliability of statistical data, which requires further research in the direction of finding ways to improve the quality and information transparency of statistical data of countries.

The article summarizes the main destructive factors of influence that cause the deterioration of the business climate in Ukraine, which proves the need for further scientific research not only for the methodological foundations of modeling the business climate, but also for the fundamental provisions for improving the situation. The issues of the importance of information transparency of statistical data of countries are separately highlighted.

## 6. References


[1] S. Arslankaya, V. Öz. Sakarya. "Time Series Analysis on Sales Quantity in an Automotive Company and Estimation by Artificial Neural Networks." University Journal of Science, Vol. 22, (2018): 1482-1492. DOI: 10.16984/saufenbilder.456518.

[2] D. Ocheretin, V. Los, H. Kucherova, O. Bilska. "An alternative approach to modeling the country's business climate in conditions of limited information." E3SWC 166 (2020): 13024. URL: https://www.e3s-conferences.org/articles/e3sconf/abs/2020/26/e3sconf_icsf2020_13024/e3sconf_icsf2020_13024.html.

[3] European Business Association. URL: https://eba.com.ua/research/doslidzhennya-ta-analityka.

[4] L.A. El'shin. "Mechanisms for the identification of business cycles of regional economic systems based on cross-correlation analysis." Regional Economics: Theory and Practice Vol. 15(8), (2017): 1540-1551. DOI: 10.24891/re.15.8.1540.

[5] V. Los, D. Ocheretin, H. Kucherova, O. Bilska. "Neural network technology forecasting the country's business climate." Proceedings of the 6th International Conference on Strategies, Models

and Technologies of Economic Systems Management (SMTESM 2019) 95, Atlantis Press (2019): 320-324. DOI: 10.2991/smtesm-19.2019.62.
[6] M. R. Safiullin, L.A. El'shin, A.I. Shakirova. "Evaluation of business and economic activity as a short-term forecasting tool." Herald of the Russian Academy of Sciences, Vol. 82(4), (2012): 623-627. DOI: 10.1134/S1019331612040053
[7] S. Feuerriegela, J. Gordon. "News-based forecasts of macroeconomic indicators: a semantic path model for interpretable predictions." European Journal of Operational Research, Vol. 272(1), (2019): 162-175. DOI: 10.1016/j.ejor.2018.05.068.
[8] H. F. Mendonca, A. F. G. Almeida. "Importance of credibility for business confidence: evidence from an emerging economy." Empirical Economics (2018). DOI: 10.1007/s00181-018-1533-5.
[9] H. Sakaji, R. Kuramoto, H. Matsushima, K. Izumi, T. Shimada, K. Sunakawa. "Financial Text Data Analytics Framework for Business Confidence Indices and Inter-Industry Relations." Proceedings of the First Workshop on Financial Technology and Natural Language Processing (FinNLP@IJCAI 2019), Macao, China (2019): 40-46.
[10] V. Los, D. Ocheretin. "Construction of business confidence index based on a system of economic indicators." SHS Web of Conference. The 8th International Conference on Monitoring, Modeling & Management of Emergent Economy (M3E2 2019), vol.65, SHS Web of Conferences (2019): 1-6. DOI: 10.1051/shsconf/20196506003.
[11] V. Los, D. Ocheretin. "Forecasting of the business confidence index of Ukraine on the basis of neural networks technologies." Bulletin Zaporizhzhia national university. Economic sciences. Vol. 3(43), (2019): 55-60. URL: http://journalsofznu.zp.ua/index.php/economics/article/view/89.
[12] National bank of Ukraine. Business expectations of enterprises, URL: https://bank.gov.ua/control/uk/publish/ category? cat_id=58374.
[13] Tradingeconomics.com. Ukraine Exports. URL: https://tradingeconomics.com/ukraine/ exports.
[14] Tradingeconomics.com. Ukraine GDP Annual Groth Rate. URL: https://tradingeconomics.com/ukraine/ gdp-growth-annual.
[15] Tradingeconomics.com. Ukraine GDP Consumer Spending. URL: https://tradingeconomics.com/ukraine/consumer-spending.
[16] Tradingeconomics.com. Ukraine Imports. URL: https://tradingeconomics.com/ukraine/ imports.
[17] Tradingeconomics.com. Ukraine Industrial Production. URL: https://tradingeconomics.com/ ukraine/industrial-production.
[18] Tradingeconomics.com. Ukraine Money Supply M1. URL: https://tradingeconomics.com/ ukraine/money-supply-m1.
[19] Tradingeconomics.com. Ukraine Money Supply M2. URL: https://tradingeconomics.com/ ukraine/money-supply-m2.
[20] Tradingeconomics.com. Ukraine Money Supply M3. URL: https://tradingeconomics.com/ ukraine/money-supply-m3.
[21] Tradingeconomics.com. Ukraine Retail Sales YoY. URL: https://tradingeconomics.com/ ukraine/retail-sales-yoy.
[22] Tradingeconomics.com. Ukraine Steel Production. URL: https://tradingeconomics.com/ ukraine/steel-production.
[23] Tradingeconomics.com. Ukraine Unemployment Rate. URL: https://tradingeconomics.com/ukraine/unemployment-rate.
[24] Global Risks report 2020. URL: https://www.weforum.org/reports/the-global-risks-report-2020.
[25] I.S. Mintii, V. N. Soloviev. "Augmented Reality: Ukrainian Present Business and Future Education." Proceedings of the 1st International Workshop on Augmented Reality in Education, Vol. 2257, CEUR-WS.org (2018): 227-231. URL: http://lib.iitta.gov.ua/712804/1/paper22.pdf.