

ESTIMATION OF THE IMPORTANCE OF FACTORS AFFECTING THE INVESTMENT ENVIRONMENT

Ashot TAVADYAN

Doctor of Science in Economics, Professor, RAU

Gevorg PETROSYAN

Ph.D. student, Department of Economics, RAU, Yerevan, Armenia

Key words: investment, estimation, gradient boosting algorithm, investment environment, importance

Introduction. Very often, macroeconomic data are scarce and incomplete, which makes it difficult to work with them and carry out analysis that can reveal important ideas related to the subject of study. For this reason, various researchers and analysts face the problem of applying linear regression models. Estimation of linear regression models is subject to several limitations that apply to the data, but the most common are the linearity of the data and the availability of adequate data for the number of variables or factors under study [Maxwell, 1975]. However, macroeconomic data are mostly presented on an annual or quarterly basis, which may not be sufficient to conduct valuable analyses. For this reason, there are many other models and algorithms that can be applied to work with similar data. The choice of models can depend on several circumstances. The first of them has already been partially mentioned: the appearance and quantity of data. Other reasons may be the nature of the dependent variable and the purpose of the study. If the goal is to obtain a specific numerical expression that represents the current situation of the dependent variable depending on the independent variables, then linear regression models of general appearance are used. If the goal is to evaluate the degrees of importance of the influence of independent variables, then linear or non-linear vector or decision methods are used. For this purpose, the gradient boosting algorithm is used in this work, which performs brilliantly with both linear and non-linear data, and the limitation of the amount of data is not so relevant.

Methodology. As mentioned above Gradient Boosting algorithm is used in work to conduct analysis for understanding the importance of the chosen factors which affect the investment environment of Republic of Armenia. Data is taken from the World Bank development database. Data covers the timeline of 1990-2023 and at first is taken as a yearly one. Afterwards exponential interpolation method has been used to artificially enlarge the dataset to make it in a quarterly basis. Overall, 37 factors were taken from the database. Different statistical tests have been conducted to understand the usability of the created dataset, also linear regression models were estimated to have the first glance to the dependent variable which is the FDI inflows to Armenia.

Literature review. The works of various researchers and economists were studied, where attempts were also made to assess the degrees of influence of the factors affecting the investment environment. In 2004, the World Bank initiated a large-scale study in this area by establishing the Investment Climate Study Group. Various analyzes were conducted at both the micro and macro levels, but the author paid great attention to the analyzes conducted at the macro level. Such is the work of O. Ovchynnikova, T. Zavorodnia and M. Ignatyshyn called “Modeling of Investment Processes by Methods of Regression Analysis” (2019), specialists in automated systems and modeling of Khmelnytskyi University, in which the analysis of Ukraine's investment environment is carried out using several artificially created factors. A regression model was estimated. The work of D.Plikynas from Vilnius University and Y. H. Akbar from Central European University of Vienna called “Explaining Foreign Direct Investment Patterns in Central and East Europe: a Neural Network Approach” (2006) also played an important role in the creation of this work. In that work, neural networks were used to perform macroeconomic analysis, which is an exceptional example and has no similarity.

Scientific novelty. With this work, the author aims to develop a model which could predict and estimate at first the importance of the factors which affect the investment environment. To assess the degree of importance of the factors affecting the investment environment in Armenia, such a model as the Gradient Boosting algorithm has not yet been applied. It enables high efficiency as well as logical results with incomplete or non-linear data.

Analysis. The data is divided into 2 parts: 20 percent of the total data is merged exclusively randomly for testing, and the other 80 percent is used for obtaining the actual results and evaluating the model. First of all, the mean square deviation of the data series was estimated, the function of which has the following form:

$$MSE = \frac{1}{n} \sum_{i=1}^n (Y_i - \hat{Y}_i)^2 \quad \text{where}$$

MSE is the mean squared deviation,

n is the number of data,

Y_i are the values to be studied,

\hat{Y}_i - predicted values.

The smaller the mean square deviation, the closer the predicted values of the model are to the actual or studied values. It is an important sign of the high quality of the model. The mean square deviation was calculated for the collected data, which was 0.22 for all factors. In order to understand how small the mean squared deviation is considered a good result, it should be compared with the dimensionality of the dependent variable. It lies in the limit [0,9.98] in the studied series. 9.98 represents that a maximum of 998 million US dollars foreign direct investment was made in Armenia. Thus, having a mean

square deviation of 0.22 in the given range indicates the high quality of the model. However, it is not the only indicator of the quality of the model.

As with the PC method, the quality of the model or the coefficient of determination (R-Squared) to explain the dependent variable of the independent variables was evaluated here. The function of the coefficient of determination has the following form:

$$R^2 = 1 - \frac{RSS}{TSS} \quad \text{where}$$

R^2 is the coefficient of determination,

RSS, sum of squares of residuals,

TSS: total sum of squares.

The estimated model coefficient of determination for all factors is 95%. It is a rather high indicator, which is another sign of the high quality of the model. Compared to 80 percent of randomly selected data, the model's predictions look like this, where the blue dots indicate the actual values, and the red line represents the model's predictions.

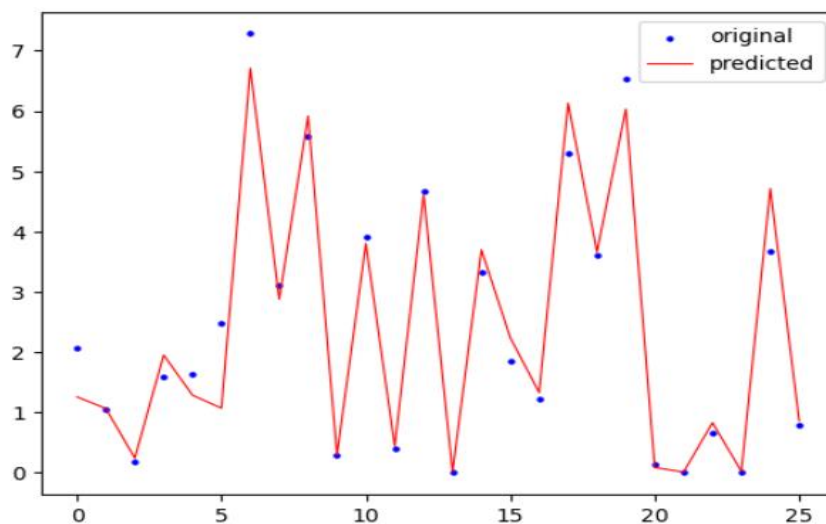


Figure 1. All factored model predictions along with available data

As can be seen from Figure 1, the deviation between predictions and existing values is not very large. Having the above-mentioned results, it is possible to evaluate the degree of importance of independent variables. The importance scoring function looks like this:

$$I = \sum_{f \in F_i} \frac{f \text{ amount of data per node}}{\text{Amount of all data}} x R(f) \quad \text{where}$$

i is the factor number,

f is the factor node,

F_i is the number of all nodes,

$R(f)$ is the root mean square deviation of node f .

First, a model with all factors was estimated. However, the majority of selected factors were unimportant and for this purpose the model was evaluated a second time, this time only with 10 most significant factors.

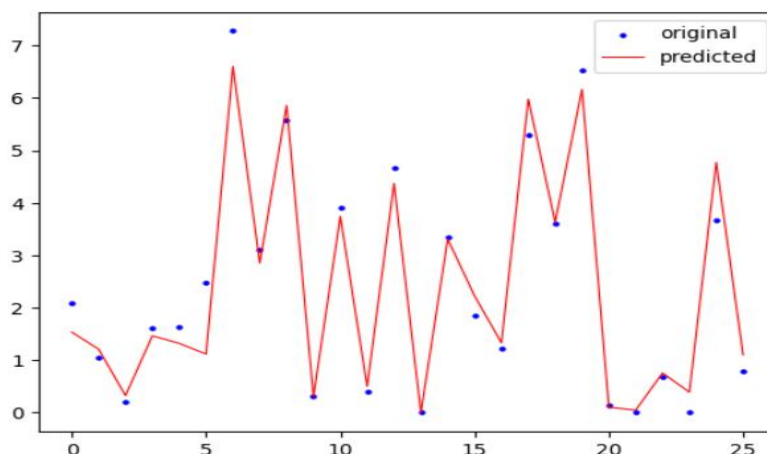


Figure 2. Estimated model predictions by the 10 most important factors along with available data

There is a simple method to check the quality of the model, which is to assign values to the selected factors and predict the value of the dependent variable. If we assign the data recorded as of December 2023 to 10 independent variables, we will get USD 908 million.. Thus, we had a deviation of 90 million US dollars. Since the value of December 2023 for FDI is the maximum in Armenia, it is normal value outside the distribution, but due to its important nature and model type, it was not removed from the data set.

Firms using banks to finance investments (% of all comp.)	0.685
Unemployment rate (national estimate)	0.096
Inflation rate	0.065
GDP volume	0.054
Annual growth of exports of goods and services	0.041
Time to start a business	0.003
Government spending on education (% of GDP)	0.02
Consumer spending (% of GDP)	0.01
Profit tax (% of all commercial profits)	0.008
Gini index	0.013

Figure 3. Final importance ranks of the 10 selected factors

However, it was assumed that such a deviation could be obtained only in the case of 10 variables. All models are evaluated using the Python programming language, scikit-learn and statsmodels statistical packages, and all calculations can be seen in the Appendices

section. Thanks to these calculations, it is also possible to carry out a non-automated, private calculation, where you can download any logical value for each selected factor and make a forecast for the Republic of Armenia. In the case of the 10 selected factors, the coefficient of determination was 95.5 percent. And in the case of the 10 selected factors, the degrees of importance had the following final form, in which the Organizations that use banks for investment financing (% in all comp.) factor has 68.5 percent of total importance.

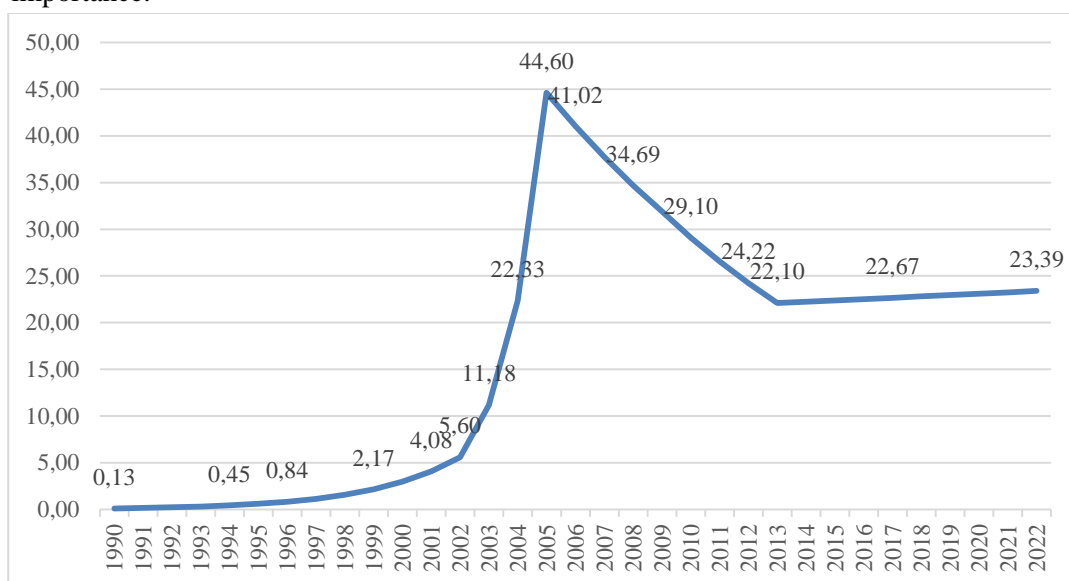


Figure 4. Firms using banks to finance investments (% of all comp.) 1990-2022

Since the independence of the Republic of Armenia, many changes have been implemented in the financial and banking system of the Republic of Armenia. The RA financial banking system is controlled and regulated by the Central Bank. Before the decision No. 15 of November 19, 1993, by which the Dram was adopted as the state currency of the Republic of Armenia, the Soviet ruble was in circulation. It was a legacy of the broken Soviet financial system. Along with that, military operations had started in Nagorno-Karabakh, and there was also a hyperinflationary period in the economy. All this could not leave its impact on the RA investment environment, which one could say did not exist. There were no basic laws that could regulate the RA investment environment and make it attractive for investors. Only in 1996 was the RA Law "On Banks and Banking Activities" adopted. It was one of the first steps in the creation and development of the RA investment environment. In 2002, full-scale amendments and additions were made to the Law of the Republic of Armenia "On Banks and Banking Activities", because of which the powers of the Central Bank Council were expanded, with the aim of preventing the circulation of funds obtained through criminal means in the territory of the Republic of Armenia in banks

and credit organizations. It was a big step in the direction of reducing the risks of banking and investments made through banks. This certainly could not remain inconsequential and as we can see from table 4, the values of the most important factor resulting from the estimated model, Organizations that use banks to finance investments (% of all comp.), start to increase sharply until the financial and economic crisis of 2008. It reaches from 5.6 percent to 44.6 percent. This meant a sharp increase in confidence in the RA financial and banking system. However, after the financial and economic crisis of 2008, as in almost all countries, trust in the financial and banking system began to decrease in RA, which in turn led to a reduction in the volume of investments. During that period, the assets of investment companies in RA began to grow at a slower rate.

If in 2008 the assets of investment companies increased by 24.1 percent compared to the previous year, then in 2009 the assets of investment companies increased by only 7.3 percent. The number of organizations that use banks to finance investments is also sharply decreasing. The downward trend continues until 2014, after which it becomes more static. As early as 2010, the RA Law "On Investment Funds" was adopted. Its purpose is to protect the rights of investors in the Republic of Armenia, to develop a collective investment system and to establish common rules for the creation and operation of investment funds and investment fund managers, to increase financial intermediation and to involve the broad masses of the population in the securities market. After the adoption of this law, since the financial and economic crisis, the first increase in the volume of investments is registered.

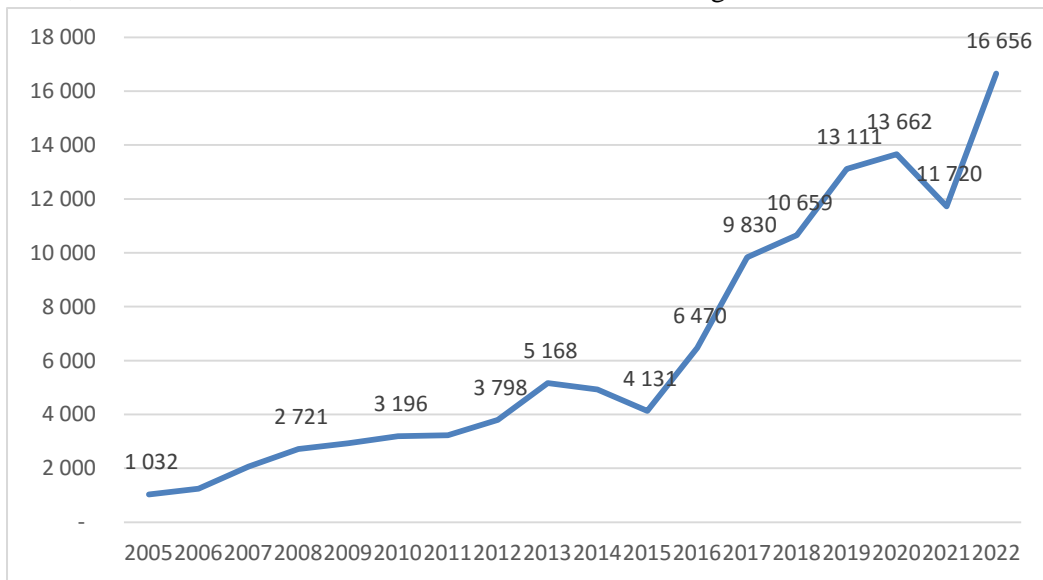


Figure 5. Assets of investment companies in Armenia from 2005-2022

However, the uncertain behavior towards the financial and banking system continues, which leads to a decrease in the volume of investments in the following years. In 2015, the currency crisis of the Russian Federation also had its impact on Armenia, which directly led to a decrease in the volume of investments. However, during that period, it was possible to maintain the increase in the number of organizations that use banks for investment financing. Along with all this, the Law of the Republic of Armenia "On Banks and Banking Activities" was constantly being amended, the purpose of which was to adapt to the current situation. However, the global crisis caused by the coronavirus of 2020 nullified any changes and investment volumes fell due to natural causes only. Due to the steady increase in the number of organizations that use banks for investment financing, it was possible to ensure a sharp increase in the volume of investments, which reached a historical maximum of 998 million USD by the end of 2023.

Conclusions. From this it can be concluded that no matter how many changes are implemented in various RA laws in order to make them more up-to-date, behavioral manifestations are also an important factor. In our example, it is the behavior towards banks and banking activities, which has not yet reached the maximum indicator of 44.6 percent.

The sum of the degrees of importance of the first 5 factors is 94.1 percent and three of them are exclusively macroeconomic indicators, which can be influenced by many other subordinate factors. This shows that the attractiveness of the investment environment is directly related to the behavior of investors towards the economic, political and social aspects of the country.

Studying the obtained results, it can be noticed that the influence of endogenous factors on the investment environment is much greater than that of exogenous factors. Both in the linear regression model estimated by the PC method and in the gradient stimulation algorithm, only one exogenous factor was included, but different exogenous factors. Among the 10 factors selected in the gradient boosting algorithm, the importance of the influence of endogenous factors was estimated at 95.9 percent, and the importance of the only exogenous factor was only 4.1 percent. If we try to estimate the total importance of exogenous factors among all collected factors, it is only 4.65 percent. Of course, this is explained by the number of selected external factors and several factors that indirectly affect the investment environment, unfortunately, it is difficult to find reliable data for these factors or to conduct an analysis with them, because they are more qualitative than quantitative factors.

The evaluated models can be used both by economists and analysts, and by investors, to realize the forecast of the volume of investments expected in Armenia, as well as to evaluate the weights and degrees of importance of various endogenous and exogenous

factors over time. It will give an opportunity to be better prepared for economic, legal and political changes, as well as to reduce risks.

References:

1. D.Plikynas, Y.H.Akbar (May – Jun., 2006), Neural Network Approaches to Estimating FDI flows: Evidence from Central and Eastern Europe, *Eastern European Economics*, Vol. 44, No. 3, pp. 29-59
2. O.Ovchynnikova, T.Zavhorodnia, M. Ignatyshyn (2019), Modeling of Investment Processes by Methods of Regression Analysis, *Advances in Economics, Business and Management Research*, Vol. 95, pp. 420-425
3. A.E.Maxwell (1975), Limitations on the Use of the Multiple Regression Model, *British journal of Mathematical and Statistical Psychology*, Vol. 28(1), pp. 51-62
4. Bevan, A., and S. Estrin. (2000), The Determinants of Foreign Direct Investment in Transition Economies. Williams Davidson Institute Working Paper no. 342, University of Michigan, Ann Arbor
5. G.J.Fraga, Investment Climate and Foreign Direct Investment in Latin American Countries: Firm-Level Evidence, *Estudios economicos*, Vol. 39, No 79, July-December 2002, 103-126
6. Central Bank of Armenia, Development of financial system
7. Republic of Armenia law "On Banks and Banking Activities", 30 June 1996
8. Republic of Armenia law "On Investment Funds", 22 December 2010

Ashot TAVADYAN, Gevorg PETROSYAN

Estimation of the importance of factors affecting the investment environment

Key words: investment, estimation, gradient boosting algorithm, investment environment, importance

In various countries, economic, political, socio-cultural reforms are continuously taking place, which pursue many and various goals and interests. One of the important goals is the creation of the most favorable investment environment. From the theoretical point of view, the study of the factors affecting the social order, legal framework, business activity and investment environment has an important empirical significance. Identifying the factors affecting the investment environment and their coordination in external and internal spheres will enable the strategists to obtain greater information for the creation or improvement of investment opportunities in various spheres. It is also of great importance for reducing and managing negative factors affecting investments. This will lead to a reduction in the level of risks, which will certainly make the country even more attractive for investors, who can more easily evaluate and forecast their investments.